Management Systems Theory, Applications, and Design

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PREFACE

In this document, I use the STOP Method (Sequential Thematic Organization of Publications). The STOP Method organizes this document into two-page test-and-figure modules. The document is structured so the two pages face each other. By opening the document anywhere, you expose a complete module. The STOP Method produces a topical rather than a categorical outline and turning the page means changing the topic. If a module goes beyond two pages, you may find a blank page before the next module begins. The modular construction helps you find the topic you're interested in, and you can start reading there. You don't have to read modules in sequence.

Each module begins with a topic followed by a thesis sentence. I hope the thesis sentence will satisfy your primary needs and elicit the desired attitudes. The module follows with text and, where appropriate, a figure. The figure relates to the text of the module, and its placement at the bottom of page two of the module helps you tie in the figure to what you're reading.

The STOP Method makes the Table of Contents more important than usual, because the Table of Contents is the structure of the topical arrangement and becomes the map by which you find what you want to read.

0.0. CLOSED-LOOP PROCESSES—THOMAS EAKINS (THE SWIMMING HOLE)

With closed-loop processes consisting of sequential functions and associated tools and techniques, we can gain continuous improvement and organizational learning only if humans interact based on mutual trust.

Figure 0.0. shows *The Swimming Hole* painted by Thomas Eakins during the years 1883 to 1885. The painting is 27 inches high by 36 inches wide and is hung in the Amon Carter Museum in Fort Worth, Texas. Edward Coates, who commissioned the painting, later exchanged it for Eakin's *The Pathetic Song*.

Born in 1844 in Philadelphia, Eakins was financially independent and painted what and how he wanted. He was passionately devoted to the portrait; to him the human being was central. The centrality of the human to the workings of the world and to an organization in particular is the key to the management process today.

During his painting years (1870 to 1910), the world was full of astounding social change, and many people suggested the increasing mechanization would cause people to lose their central place in their own world. (Whenever we consider the meaning of a painting we must consider the artist and where he or she was from, the time in history when the painting was done, and the size and setting of the painting.) Today, we face continuing forces for dehumanization as we gain automation. The question becomes whether we can use automation to humanize the workplace. Within the onward rush of computer and automation breakthroughs, how do we accomplish what Weisbord calls a productive workplace with dignity, meaning, and community?

The people in the painting were Eakin's friends (his art students) who appeared in many of his paintings. Eakins painted his friends in a setting in which he often saw them. Women weren't in this painting or in one like it because he never saw them naturally in this setting.

A person's underlying philosophy will influence what they have to teach us. Eakins thought of himself as a "scientific realist."

Let's consider the scene in *The Swimming Hole* as representative of any human group activity. I'll obviously draw parallels to organizations as human group activities. The group dynamics are stressed here in that Eakins was interested in the depiction of motion in the figures in the swimming hole. He used motion photographs to help with his painting.

My bet is you'll remember this painting; and, because you remember the painting, you'll remember the points it makes symbolically. You'll remember the painting and the points because of the richness of the information portrayed in visual art. Visual art is a rich but biased form of information. Information and the conversion of data to information is what this class is ultimately about— both building and using tools for providing information for decision making. However, management and measurement to get data to make information depend on the human element—empowerment and trust. Among other things, this painting portrays some critical principles behind the concept of trust. I'll use this painting to discuss management systems.

What's going on in the painting? What are the people doing? Are we seeing a process, a system, or both? A group of friends are enjoying nature and each other's company in play, or in a work process. (Play is a work process for recreation.) Thomas Eakins has painted himself as the swimmer at the lower right and five of his art students from the Pennsylvania Academy of Fine Arts in Philadelphia together as functions of a work process associated with a system.

What is the system? We'll learn two views of a system—one as a thing and the other as an approach to the world. This system as a thing includes the components of the water, dock, weather, people, and perhaps more. From the system perspective, each component is necessary for the system to meet its purpose.

What's the purpose of the components and their relationship that Eakins has pictured here in his painting? What's the reason for the system being like this? The answers to these questions get to this system as an approach to the world. The aim of the system is most likely one of relaxation and enjoyment instead of exercise or learning how to dive and/or swim. The aim involves the components (The weather is more important for the enjoyment aim rather than the exercise aim. Weather would also be important for an aim to cool off.) but reaches above the components for the meaning of the system. This meaning begets the holistic perspective in the systems approach.

What's the process shown in the painting? The process for play or work consists of a series of steps getting the system toward its aim. The steps get the people into and out of the water in a timely, graceful, and safe way. These steps I'll call functions.

What are the functions for enjoying the swimming hole? The functions include diving, surfacing and swimming, climbing out of the water, resting and relaxing as desired, getting up, and preparing to dive. Each person in the painting represents one of the steps. Notice how Eakins shows each of the people, or functions, in sequence. (Does the dog participate in a function?) Each function makes the process work. Each function involves different tools and techniques. You can use different tools and techniques to carry out the swimming functions. However, the best tool or technique depends on the process and the system with its aim in which the swimming functions are a part. You can use different tools and techniques to teach someone how to dive if the aim of the system is learning. The management tool for learning how to dive is usually a procedure. However, we would want to observe (measure) and gather data on the characteristics of a particular dive so we will do better for the next try.

Notice how Eakins shows the functions of the process not as a once-through process, more popular in the management of years ago, but as a closed loop, or cyclic process. You have to get in the water before you can swim, swim before you can get out, and get out before you can dive. Closing process loops is what managing quality today is all about. The so-called Plan-Do-Study-Act (PDSA) Cycle is about closing process loops. By closing process loops, we get continuous improvement, a learning organization, creativity, and empowerment. The PDSA Cycle represents the management process. The process in the painting is a closed-loop work process. We would apply the management process, or the PDSA Cycle, to this work process to achieve results like continuous improvement and learning.

If the aim of the system was more to learn to dive and/or swim, we'd see more of the need for observation and feedback inherent in the management process. (Maybe observation and feedback are the functions of the dog.) In management systems engineering, we apply the engineering process to the management process, which overlays the work process. Since there's no question of improvement either for competition or for self-renewal in the painting, we don't see the engineering process or the management process highlighted. However, both the engineering process and the management process are closed-loop processes. And this painting emphasizes the closed-loop work process.

If the aim of the system was learning or improvement, we'd want to focus on observation to gain data to convert into information to support decision making. Through our decisions, we'd feed back what we learned to the process. And through our conversion of data to information, we'd feed back to the decision maker what the process was doing. Decision making is the key function in the management process.

Now let's consider the situation in this swimming process where the people aren't wearing suits. Why not? People skinny-dip. Why? For the freedom of it. Because they enjoy the weather and the water more without clothes. Now look at the people. Do they look embarrassed or vulnerable? Why not? Because they have mutual trust—perhaps because they've all exposed themselves. We find that empowerment and trust in an organization come through submerging your ego and exposing yourself. We can't get quality in an organization without mutual trust and mutual exposure. While we don't expose ourselves physically in an organization, we expose even greater vulnerabilities. For quality in an organization, we must expose appropriately what we feel and what we think—even if we haven't perfected our feelings or thoughts yet. Through mutual exposure and mutual respect we build trust. The new concept of leadership is built on trust and intimacy, not intimidation and fear.

I've discussed the content of Eakins' painting to help hold the memory of several concepts important to management systems engineering. Now, let's look at the structure of the painting. What shape is built into the key people in the painting? A triangle or, in three dimensions, a pyramid. What's so good about a triangle? Simplicity, robustness, and strength. We know about these qualities of triangles from studying structures. How about the painting and the message it sends?

Do you see the engineering process in this painting? Do you see the management process in this painting? Do you see the systems approach in this painting? I suspect that at this early stage of the class the answer to all three questions is no. I have more than 80 class periods to get you from not seeing the engineering and management processes and the systems approach in a painting like this into being able to see those processes and approach in this painting and in other group interactions, like in organizations. I intend for the paintings to help highlight and help you remember class concepts I associate with the painting content or style. In this case, the painting content as opposed to style carries most of the class concepts. The concepts I intend for you to remember and I will reinforce during the course are:

- The human being is central in group interactions and in organizations.
- Trust is important to the management of organizations today.
- Exposure is part of empowerment and trust.
- Systems and processes are different.
- Processes include a series of functions, or steps, with their associated tools and techniques.
- Closed-loop processes promote continuous improvement and organizational learning.

- Managers need rich information to make decisions with; and visual art is extremely rich information.

- The pyramid brings both visual and structural simplicity, robustness, and strength and, as such, is useful as a modelling tool.

Eakins achieved a paramount place among American artists "not only because of the novelty of his particular vision of the world or his formidable technique as a painter but because of the penetrating truth of his statements." (Donelson F. Hoopes, *Eakins Watercolors*, Watson-Guptill Publications, p. 12.) "Although, from the beginning, Eakins was recognized as a dedicated and inspiring teacher, his methods were controversial. .... While Eakins' emphasis on the study of the nude figure was not an unusual part of an academic curriculum, the presence of both male and female students at the Academy as well as Eakins's insistence that the women follow a course of study identical to that of the men—including life-study classes from both nude male and female models—was a constant source of tension." (Darrel Sewell, *Thomas Eakins: Artist of Philadelphia*, Philadelphia Museum of Art, 1982, pp. xiii - xiv.) Because of his unusual teaching techniques, Eakins was fired from the Academy. The outcry from his dismissal resulted in forty of his students forming the Art Students' League in Philadelphia, where Eakins taught without pay until 1892.

Figure 0.0. *Eakins' "The Swimming Hole" helps us visualize a system of people interracting together through a work (or play) process. An organization is also people interracting through a work process governed by a management process. We apply the engineering process to the work and management processes.*

1. BACKGROUND

1.1. INTRODUCTION

1.1.1. Art and Science as Foundations for Management Systems Engineering

In management systems engineering we must understand, balance, and blend the human and technical elements of the organization and apply tools and skills to relationships and to work processes based on foundations learned from art and science.

"Management is an art. You can't structure or teach good management. You're either born with it or you aren't." These often-stated excuses for not analyzing, learning, and improving the principles and techniques of management are used to justify not putting the needed effort into managing well. Not too long ago, old-time, real-world engineers were making similar statements about engineering. "Engineering is an art." "You must be a born engineer." Now in engineering we pretend engineering is all science and no art. This book will emphasize the absolute necessity of balance between art and science, between qualitative and quantitative thinking, and among human, technological, and economic issues in both engineering and management. This book is based on the premise that we can learn and improve management and engineering, that both management and engineering spring from the same root—the scientific method, and that art with science makes both engineering and management work in the real world by bridging imagination and reality.

I've found that visual art (paintings, sculpture, photography) has opened doors for better understanding and use of science in the engineering and management processes. Engineers understand the significance of physical science as the underpinning of their engineering courses. Engineers need to know that the application system they're working on sometimes involves physical science, but always involves other sciences such as life science and especially social science. Leonard Shlain in his book on art and physics gives evidence of visual art as the precursor to discoveries in physics that are fundamental to engineering. I'll use engineering principles like the First Law of Thermodynamics and control theory to build bridges between engineering and management, to develop a structured approach to management, and to emphasize the need for engineers and managers to understand both the engineering process and the management process. Shlain's discussion of art and physics helps open new ways of thinking for understanding management systems engineering.

Leonard Shlain, a surgeon, argues that artists have led physicists in discovering the mystery of nature. As in the profession of medicine, the profession of engineering or the profession of business is done best when we balance art and science. In his book *Art and Physics: Parallel Visions in Space, Time, and Light,* Shlain says, "Art and physics are a strange coupling. Of the many human disciplines, could there be two that seem more divergent? The artist employs image and metaphor; the physicist uses number and equation. Art encompasses an imaginative realm of aesthetic qualities; physics exists in a world of crisply circumscribed mathematical relationships between quantifiable properties. Traditionally, art has created illusions meant to elicit emotion; physics has been an exact science that made sense." (p. 15)

In management systems engineering we must recognize the emotional component of organizational effectiveness. Culture, motivation, trust, and teamwork are important for stability and synergy in the organization. We must bring both art and science to the productive workplace.

Shlain further says, “While their methods differ radically, artists and physicists share the desire to investigate the ways the interlocking pieces of reality fit together. ..... Èmile Zola’s definition of art, ‘Nature as seen through a temperament,’ invokes physics, which is likewise involved with nature. The Greek word *physis* means ‘nature.’ ..... The physicist, like any scientist, sets out to break ‘nature’ down into its component parts to analyze the relationship of those parts. This process is principally one of reduction. The artist, on the other hand, often juxtaposes different features of reality and synthesizes them, so that upon completion, the whole work is greater than the sum of its parts. There is considerable crossover in the techniques used by both. The novelist Vladimir Nobokov wrote, ‘There is no science without fancy and no art without facts.’” (p. 16) When Schlain talks of “reduction,” “synthesizes,” and “the whole work is greater than the sum of its parts,” he’s indicating that the artist practices the systems approach and must balance understanding and abilities in analysis, synthesis, and synergy. So should the engineer and the manager.

Shlain further says, “In the case of the visual arts, in addition to illuminating, imitating, and interpreting reality, a few artists create a language of symbols for things for which there are yet to be words. ..... When we reflect, ruminate, reminisce, muse, and imagine, generally we revert to the visual mode. ..... ‘Imagine’ literally means to ‘make an image.’ ..... who then creates the new images that precede abstract ideas and descriptive language? It is the artist. ..... Artists have mysteriously incorporated into their works features of a physical description of the world that science later discovers. ..... Both art and physics are unique forms of language. Each has a specialized lexicon of symbols that is used in a distinctive syntax. ..... ‘Volume,’ ‘space,’ ‘mass,’ ‘force,’ ‘light,’ ‘color,’ ‘tension,’ ‘relationship,’ and ‘density’ are descriptive words that are heard repeatedly [in art and in physics].” (pp. 17-20) These descriptive words are also extremely familiar to the engineer and, as we get into this book, the manager. An important idea in this quote and in Shlain’s book is that art has often paved the way for science. I believe an important lesson from Schlain’s discussion is: You have to imagine something before you can discover it. Also, the important things in an organization are abstract—unmeasured and immeasureable. We have to measure what can be measured and imagine what can be imagined. Often, we have to blend measurement with imagination.

In talking about how a surgeon could write a book on art and physics, Shlain says, “... a surgeon is both artist and scientist. The craft demands a finely honed sense of aesthetics: A maxim of the profession is if an operation does not ‘look’ beautiful it most likely will not function beautifully. Thus, surgeons rely heavily on their intuitive visual-spatial right-hemispheric mode. At the same time, our training is obviously scientific. Left-brained logic, reason, and abstract thinking are the stepping-stones leading to the vast scientific literature’s arcane tenets. The need in my profession to shuttle back and forth constantly between these two complementary functions of the human psyche has served me well for this project.” (p. 8)

Management systems engineers must shuttle back and forth at a moment’s notice between qualitative and quantitative thinking. You must learn to be good at both and at shuttling. One moment you work on a technical issue, the next a human one. Truly, art and science are complementary foundations of the engineering process. Just ask Leonardo DiVinci, one of the first engineers. The same can be said for the management process.

1.1.2. Art, Physics, and Engineering—Imagination, Reality, and Envisioning

"The history of mankind has taught us that if we can imagine it, we can make it." (p. 2, Kiyoshi Suzaki, *The New Manufacturing Challenge: Techniques for Continuous Improvement.*)

If you can imagine something, you can do it. Imagination is crucial for successful engineering and for successful management. We must balance imagination and reality so we can make our imagination become reality. When we deal in the art of engineering and management, we're dealing in imagination. In this book, I'll balance the art and the science of engineering and management in a discipline I call management systems engineering. To help understand the balance we'll look at visual art.

I'll later discuss communication, message content, language variety continuum, and information richness. A primary focus of this book is the conversion of data to information and the use of that information for decision making, where information is converted into action. Visual art exceeds language in information richness. Painting and sculpture exceed photography in information richness because painting and sculpture aren't limited to reality and because painters and sculptors aren't limited to a single eye. Art contributes to the ability of the engineer or the manager to think beyond the limit of the rules. Art is also a tool to support people in conceptual blockbusting.

Engineers and managers must be able to envision for problem solving and for leadership. Perhaps the greatest contribution of descriptive geometry is to gain skills in envisioning hidden reality and envisioning possibilities, alternatives that could become reality. When we imagine what the object looks like when we intersect it with a cone, we get a lesson in envisioning. The object and the cone are real. I used to carve soap to help in descriptive geometry so I could see better what I was supposed to envision. When I got good at descriptive geometry, I didn't have to carve soap and I could envision what would happen if I built a house or reorganized a group of people. By later comparing the reality of what I built or organized, I improved my envisioning skills.

In summarizing the philosophy of a leader of the quality movement today, W. Edwards Deming, W.W. Scherkenbach says we're striving for "joy of ownership through joy of workmanship." Now there's an emotion that makes sense. When we engineer the management process, we must deal with emotion.

Is emotional energy greater than, or just different from, physical energy? As we deal with synthesis, systems thinking, and synergy in management and engineering, does the First Law of Thermodynamics apply? When we first converted mechanical or chemical energy to electrical energy to light a bulb, we felt like we got so much out of the bulb. The magic of the newly-experienced conversion could imply we got something more out than we put in. The First Law tells us that isn't so. The energy is conserved even though most of the bulb's energy is "lost" to heat energy rather than "gained" in light energy. Now we operate computers on tiny batteries. What seemed like a lot in the bulb was new, not more. We weren't used to or good at electrical energy.

When the members of a basketball team, a symphony orchestra, or a business organization gain synergy and the whole seems larger than the sum of its parts, perhaps we're dealing with the conversion of physical to emotional energy—a conversion we aren't used to or good at. We're converting physical exertion to feelings of trust, confidence, and motivation. Just as energy conversion is fundamental to engineering, energy conversion is fundamental to management.

Management systems engineering is about skills for analysis and synthesis. For example, analysis helps us build good management tools and synthesis helps us use management tools well. Management systems engineers must understand both. We readily accept physics as fundamental to engineering. I consider art, other humanities, life science, and social science to be equally important—especially when engineering a management system.

I believe we don't teach either the engineering process or the management process to managers or engineers very well. We've tried to separate the art from the science when they need to be interwoven to the point they're indistinguishable one from the other. I'll discuss our failures in teaching the engineering process in Modules 1.1.11.6.3. through 1.1.11.6.5.—where I discuss the engineering process and its fundamentals and I discuss teaching and learning the engineering process.

To drive home the interplay between art and science in engineering and management, throughout this book I'll use examples of visual art and the artists who did them. Of course, the best I can do is show examples of the art in photographs. Photographs of visual art are as unsatisfactory to those who really want to experience the art as are paintings from photographs. The camera has but one eye and the human has two. Between a camera and a human, the perception is totally different. Seeing the visual art in person is far superior to what I can provide in this book. The frame of a painting affects what you see and so does the setting of the visual art. Michelangelo's David in front of the Palazzo Vecchio isn't the same as David in the Academia. (I'll prove this point in Module 1.1.19.) The Musee d'Orsay in Paris is new and each painting has been thoughtfully placed in its setting. The result is overwhelming. Seeing science as an art is a function of both the observer and of the context, or setting.

A painting contains a message. I'm not discussing a painting as an art expert but as an art enthusiast. I'll discuss a painting in terms of its message to me—my own interpretation so I can highlight important qualitative concepts of management systems engineering supported by images of rich information. The power of art is its ability to send rich information. As a receiver of rich information, you must develop strong assimilation and interpretive skills to capture and use all that information. The richest information is also the least repeatable, verifiable, and quantitative. My interpretation of visual art, then, is one of many, which I hope adds something to the understanding of management systems engineering.

Visual art is an expression of envisioning. You can envision what a soap carving is to look like, or how you want your new car to look, or the house you're building, or the new structure for your organization. When envisioning your new organization or product, you can envision the result or the steps of the process for getting that result. When you consider building the new house, you can envision how you want to solve the problem of enlarging the living room. The power of envisioning is being able to review many alternatives rapidly in your mind.

1.1.3. Bending Time and Space—Salvador Dali

Managers have to make the most out of time and space; and to do so, they have to envision beyond the laws of Newton, which are so familiar to engineers.

Albert Einstein developed his special theory of relativity early in the twentieth century. Minkowski used the special theory to define the fourth dimension. Few people have successfully conquered the ideas that seem to violate what we believe about time and space. As a nuclear engineer, the contributions of Einstein were some of my foundations for designing nuclear reactor cores. However, Einstein forever shook our devout faith in the universality of $F = ma$. We took $F = ma$ as absolute truth, something we could clearly build anything from and never have to worry.

About the time of Einstein, there lived another revolutionary by the name of Sigmund Freud and a number of revolutionary artists like Picasso and Salvador Dali. Freud was interested in the unconscious and the meaning of dreams. Dream time doesn't obey sequence and linearity of clock time and dream space doesn't follow Euclidean axioms. "Relativity, Cubism, and psychoanalysis share this feature: Profound distortions of everyday time and space occur regularly in each theory. ..... The dream mode soon became the means certain artists used to plumb the depths of their own unconscious, mining them for symbols and juxtapositions that violated all rational sense. In 1917 Apollinaire named this new movement *surrealism*, which means *above* reality. Surrealism worshipped at the altar of the unconscious. Surrealism, Andre Breton, the poet and the movement's chief spokesman, wrote, ' is based on the belief ... in the omnipotence of dreams, in the undirected play of thought.' Despite their apparent lack of connection to the crisp blackboards of science, the dreamlike paintings of surrealist artists reveal many crucial images that can help people understand the vision of reality wrought by modern physics." (Leonard Shlain, *Art and Physics: Parallel Visions in Space, Time, and Light*, William Morrow and Company, 1991, p. 224.)

As an engineer, how many times can you build a bridge in a twenty-minute nap or daydream? More times than you can count. You can get materials not easily accessible. You can build the bridge right and you can build it wrong—and you can learn from your dream mistakes. As a manager, how many times can you reorganize your unit in a twenty-minute dream? Related to dreams is your imagination—about real things and unreal things—and your ability to envision. If you can't have a vision, you can't lead well, you can't manage well, and you can't engineer well. Your descriptive geometry course helps you learn to envision. Engineers and managers don't get enough courses in how to envision and how to break conceptual blocks and old paradigms. Without these skills, you can't create and you can't innovate. We're entering a time in history where we need the creative juices of every person. Our big problems with the environment, transportation, housing, and other engineering-related problems won't be solved with old approaches. We'll have to dream up new ones.

As a manager, two of my most important concerns are time and space. I use facility layouts to figure out where to put people and equipment to streamline the work process (reduce steps). I use Gantt charts and time logs to help deal with the elusive resource of time (save time). I redesign information formats and information processes (reduce paperwork).

We teach courses on time management, which can't be done by the way. Time refuses to be managed—it marches on. We deal with management approaches like Just-In-Time. In their book, *Competing against Time: How Time-Based Competition Is Reshaping Global Markets*, Stalk and Hout claim time is the cutting edge; time is the equivalent of money, productivity, quality, even innovation. They introduce the time-based organization. "The characteristics of a time-based company are best explored under three headings:

- How work is structured
- How information is created and shared
- How performance is measured

..... People in time-based—or fast-cycle—companies think of themselves as part of an integrated system, a linked chain of operations and decision-making points that continuously delivers to customers. In such organizations, individuals understand how their own activities relate to the rest of the company and to the customer. They know how work is supposed to flow, how time is supposed to be used. Also, work that is not critical to delivery of value in real time is taken off-line so it doesn't slow down delivery. ..... Time-based companies create more information and share it more spontaneously. For the information technologist, information is a fluid asset, a data stream. It is an object itself, something to be carefully measured and handled. But to the manager of a business, information is something less elegant, less separate from the employees who create and carry it. ..... Time-based companies go back to basics when they decide how they are going to keep track of their performance. Time is already widely used to measure performance in business. Managers use terms like *lead-time*, *on-time delivery*, and *response time* almost instinctively in describing how well a company is serving its customers. But, time-based companies go a step further. They use time-based metrics as diagnostic tools throughout the company and set basic goals of the operation around them. In effect, they use time to help them design how the organization should work." (pp. 172-190, George Stalk, Jr. and Thomas M. Hout, The Free Press, 1990)

A major division of Asea Brown Boveri uses the concept of time-based management as their direction in the quality movement. However, to develop new work structures, share information more readily, and get accurate measures of performance, we must deal with trust, mutual respect, and motivation among people who act out, are responsible for, and support these activities.

I'll consider two of Salvador Dali's paintings. Dali is a surrealist. The first painting is discussed in Shlain's book. "In one of his most famous paintings, *The Persistence of Memory* (1931) [Figure 1.1.3.1.], Dali juxtaposes two ordinary symbols of time: clocks and sand; but in Dali's arresting vision the clocks are melting over a vast and lonely beach that resembles the sands of time. To emphasize the painting's temporal images, he also incorporates a swarm of crawling ants, whose uniquely shaped bodies resemble hourglasses. Sand, hourglasses, and watches all connect below the threshold of awareness till the viewer's mind swings around to focus on the very nature and meaning of time. Dali's gelatinous timepieces, crawling with patient ants, ooze and melt upon an immense beach stretching into the distance. The molasses-like plasticity of his watches suggests the possibility of slowing to sludge the flow of the invisible river of time.

The key revelation enabling Einstein to revise the fundamental constructs of space, time, and light was understanding the nature of time's dilation at close to the speed of light. Had someone asked Einstein or any of his contemporaries to represent the dilation of relativistic time in one visual metaphor, he could not have produced a more strikingly appropriate image than *The Persistence of Memory*. If a work's symbolic content strikes a chord deep within our collective psyche, then it will continue to resonate for us indefinitely. Mention the name Dali to a sampling of people and more often than not, melting watches will be included in the response. This surrealistic painting mesmerizes us because it translates an idea into symbols when conventional words and phrases have never been sufficient." (pp. 228-230.) Time is a wonderous dimension. Today is yesterday's tomorrow. Depending on where you stand and which way you look, all time is relative.

Figure 1.1.3.2. is Dali's *The Sacrament of the Last Supper*, dated 1955. Many paintings from western culture artists, exemplified by the art of Europe and the United States, reflect content from Greek and Roman mythology and from Christianity. Some of the most popular topics are the last supper, the crucifixion, and the resurrection of Christ. The topics provide a wealth of imagery and search for reality and thereby innovative expression. Dali balances reality and imagination in a symmetrical geometric framework. "The Christian subject matter, the simplicity of organization and the lack of shock value separate *The Sacrament of the Last Supper* from almost all of Salvador Dali's other works. Dali's reputation from the late 1920s to the mid1940s was founded on his use of themes reflecting anarchy or agnosticism and interpretations in a surrealistic manner derived from subconscious, Freudian dream imagery. ..... The Italian High Renaissance of the early 1500s was another major source for Dali's new classicism. As in the harmonious presentation of Renaissance schemes, the composition here is clearly defined into two main planes: foreground action and background scenery. The placement of men around the table is symmetrical, the same figures being repeated in perfect mirror-image on both sides of Christ. Moreover, the entire nine-foot-long picture is constructed according to complex mathematical ratios devised by Renaissance scientists and such ancient Greek philosophers as Pythagoras. Dali explained the reliance upon this elaborate geometric patterning just after completing his nine-month labor on the picture:

> ... I wanted to materialize the maximum of luminous and Pythagorean instantaneousness, based on the celestial Communion of the number twelve: twelve hours of the day—twelve months of the year—the twelve pentagons of the dodecahedron—twelve signs of the zodiac around the sun—the twelve Apostles around Christ.

Thus, *The Sacrament of the Last Supper* is not an attempt to re-create the Passover but a symbolic presentation of the eucharistic ritual. The men at the table, rather than being specific apostles, are idealized participants in the continuing dogma of Christianity. The strange enclosure, part earthly, part celestial, is not the 'large upper room' of the Bible but an abstract concept embodied by the dodecahedron, a twelve-sided volume sometimes signifying totality.

Just as the surrounding cupola is only partially real, Christ is not corporeally present because his body is transparent, too. The actual, tangible allusion to Jesus' long hair: just above his left shoulder, the irradiated strands of hair suggest the silhouette of a perching bird. If indeed, this half-hidden configuration was intentional, it must indicate the dove of the Holy Ghost. The whole Trinity would be represented if the arms outstretched overhead were those of God the Father.

This ethereal torso, however, is much too youthful for the standard conception of the Creator, who is normally portrayed as a patriarch. The all-embracing arms might represent the Resurrected Christ, but the nail holes are absent from the hands, and the wound does not appear in the side. The enigma of *The Sacrament of the Last Supper* might be rationalized if this disembodied presence signifies the encompassing spirit of heaven, for Dali maintains that '... heaven is to be found exactly in the center of the bosom of the man who has faith!'" (quoted from a handout received during my first visit to the National Gallery of Art in Washington D.C. during 1960).

The concepts I intend for you to remember and I will reinforce during the course are:

- You can imagine, dream about, create a vision for things that don't exist—and then do them.
- Good engineering requires envisioning.
- Symbols bring out feelings.
- As the world moves faster, we'll have to bend time and space.
- A model is like a metaphor. Engineers develop models.
- We'll live up to the expectations of us.
- We can fill empty space with our mind.
- These are treasures in the human mind. We have to tap them.

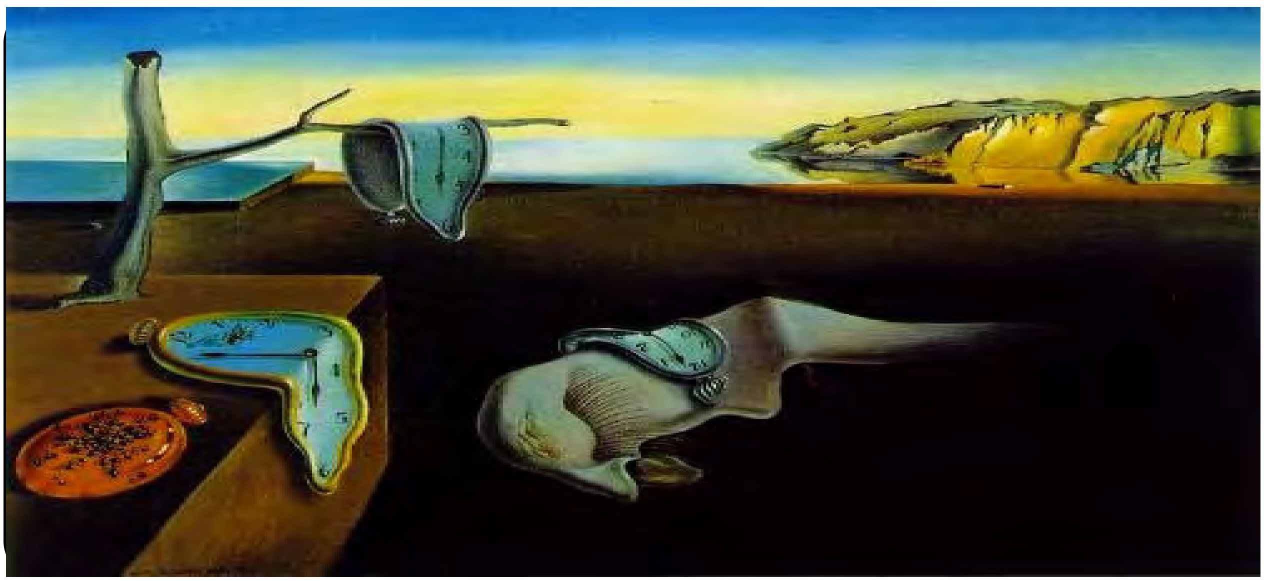

Figure 1.1.3.1. *The Persistance of Memory*

Figure 1.1.3.2. *The Sacrament of the Last Supper*

1.1.4. Time-honored, Fundamental Management *Questions*

How do we apply the principles, models, and techniques of the engineering process to time-honored, fundamental management questions and open avenues for significant improvement in management tools and their use?

All discovery begins with a questioning attitude leading to penetrating, substantive questions. As we begin our discovery of applying the engineering process to organizations, let's sample the questions people responsible for organizations have been asking for years and can't seem to successfully resolve. The fundamental questions are the ones you seem to keep coming back to every time you try to figure out how to manage an organization and its people.

Since we'll be looking at the organization as a management system, the important questions will be systems-oriented. Weisbord says, "For the past forty years productive workplaces on several continents have been evolving another way entirely of thinking and acting. First, they have been moving away from problem solving toward whole-systems improvement as the secret for solving great handfuls of problems at once." (Marvin Weisbord, *Productive Workplaces,* Jossey-Bass Publishers, 1987, p. xiv) .... "A 'whole system' includes *economics, technology, and people*—including all of ourselves. (italics added) I urge students to see the workplace as a 'whole brain' adventure involving values, thought, and action. I would like to see that notion in more academic curricula." (p. xvi) Systems thinking will underpin our understanding of both the engineering and the management processes.

In discussing Frederick Taylor, the creator of the industrial engineering role, Weisbord parallels his notion of whole-system components including economics, technology, and people by saying, "He started a new profession in 1893—'consulting engineer'—because he saw that captains of industry, caught in a swirl of change, did not know how to untangle *cost, productivity, and motivational* problems (italics added). Taylor was a systems thinker of sorts, the first person to realize that workplace problems must be solved together, not piecemeal, although he never figured out to anyone's satisfaction how to do that." (p. 22)

"It is not generally appreciated how modern Frederick Taylor's core values were. He knew the importance of productive workplaces. He was working on the right problems—*social, technical, economic*—even when he did not have the right solutions." (p. 57) (italics added)

So, the source of time-honored, fundamental questions comes from these problems for which Taylor couldn't find answers and which still are unanswered today. And, what are Taylor's core values, and how do those relate to fundamental questions for managing productive workplaces? Weisbord lists Taylor's core values as "labor-management cooperation, higher output, improved quality, lower costs, higher wages, the rule of reason, questioning old habits, experimentation, clear tasks and goals, feedback, training, mutual help and support, stress reduction, and careful selection and development of people." (p. 59) What a rich place from which to start asking important questions!

I'll use Weisbord's figure for *reward, work, and human systems* (See Figure 1.1.4.) as an analytic tool, hopefully used in a systems approach (I'll develop definitions for analytic and systems approach later.) for developing categories to show a representative list of time-honored, fundamental management questions. Throughout this discussion, I've used italics to highlight the references to these three systems, because in each case Weisbord has used slightly different terminology. Since we're considering the organization as our system of interest, or, in Weisbord's terms, the whole system, the systems of Figure 1.1.4. are really the important *subsystems* of an organization. The whole system of economics, technology, and people; Taylor's cost, productivity, and motivational problems; and Figure 1.1.4.'s reward, work, and human subsystems all help set up three categories of questions.

As we analyze to help deal with the situation, we must recognize that questions can't be completely separated into subsystem categories because most questions are interconnecting among the subsystems. However, some questions seem to start in one subsystem or another. Consider Taylor's dilemma as a question: How do we untangle cost, productivity, and motivational problems? Perhaps we can untangle the problems to list or discuss them and to ask questions. But we'll have to leave the problems tangled to answer the question. Another broad question is: How do we get high-quality, high-quantity work from people working in a satisfying atmosphere with the least resources and expense? You can see the three subsystems interplaying in this question.

Reward-subsystem-oriented questions include:

How do I rate, rank, appraise, recognize, and pay people?

How do I ensure my stakeholders get a good return on their investment?

How do I get the most for my money for materials and facilities?

How do I get the creative and commitment energies from much of the workforce, when the reward system doesn't reflect these priorities?

Work-subsystem-oriented questions include:

How do I deal with the crises, surprises, disturbances, or disruptions that seem to keep me from accomplishing my planned work?

How do I know I'm working hard on the right things?

How do I gain visibility of my work?

How do I gain and maintain control of my work?

How do I get useful information (the right, high-quality information on time) about my work to support the decisions I make?

Human-subsystem-oriented questions include:

What are successful supervisor and subordinate roles?

What are roles for purposeful meetings?

How do I replace fear with trust and teamwork in the workplace?

How do I motivate people to find joy in the workplace?

How do I get the best out of people without harming their personal and family lives?

How do I balance toughness with affection in the workplace?

Even though these questions are hard to answer, we must think about the questions and the principles behind potential answers. For example, consider the question, "How do I know I'm working hard on the right things?" When a supervisor thinks, "I don't believe that person is working hard," they mean "I don't believe that person, who's working hard, is getting the results I expected," which translates to "I don't believe that hard-working person is working on the right things." Who should know what the right things are? How do we find out what the right things are? Who sets expectations? Whether or not you think through these questions can make the difference in success in getting the work out, your financial return, and the contributions of you and your subordinates.

You can add to this too-short list. The categorization scheme represented in Figure 1.1.4. and the short list described earlier should start you thinking.

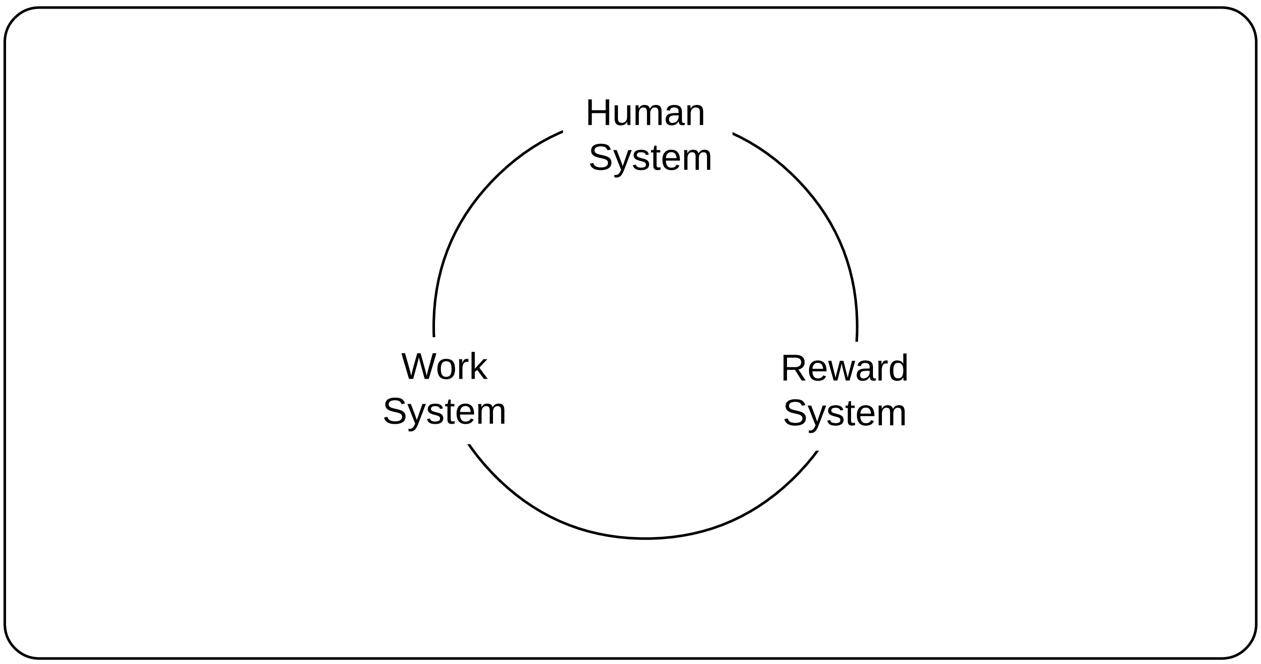

Figure 1.1.4. *For whole-systems improvement of management tools and organizations, we must answer management questions that include interrelated aspects of economics, technology, and people shown here as reward, work, and human subsystems. One way to dig into the questions and their answers is to consider the subsystems. (taken from Weisbord)*

1. Background

1.1. Introduction

1.1.5. The Output: How the Book Flows

1.1.5.1. Book Description

The five sections of this book will lead you through the theory for management systems engineering into the models you can use to help build and use management tools, the machinery supporting decision making.

This book scopes management systems engineering as an engineering discipline. The book defines the systems approach, the engineering process, and the management process in language understandable by engineering students, non-engineering students, and practicing managers. The flow of the book starts with background concepts and models and works toward building-tool functions applied to general categories of tools and using-tool functions applied to specific tools for continuous performance improvement. The focus of the book is the machinery to support decision making—management tools. (Examples of management tools include the organization structure, schedules, operations research methods, plans, policies, vision statements, management information systems, and many more. I'll discuss the different management tools at length later.)

Figure 1.1.5.1. shows the structure of the book in five major sections. I've shown the book sections on the left side of the figure with major content listed below each section topic. In the two-semester course using this book, the background takes more than half the first semester (class periods 1 - 34) and the building tools section takes less than half the first semester (class periods 35 - 43). The sections on using tools, synergy from building and using tools, and conclusion takes the second semester.

The concepts of management, engineering, and system; the discussion of the art and science of management; and the research process relating to the discovery of what management systems engineering is leads to the theory illustrated in the top box on the right of Figure 1.1.5.1. The theory includes the systems approach with its three perspectives as the overarching philosophy for both the engineering process and the management process. We apply the engineering process to the management process to get management systems engineering. All of the processes are developed and understood within the context of balance, the proper mix of the issues being balanced.

Based on these concepts, I develop a series of models that I offer together with models developed by others to help us understand how to build and use management tools. I'll describe the frameworks used to diagnose an organization in terms of the needed management tools in the next group of modules. These models and frameworks yield a coordinated set of models shown in the middle box on the right of Figure 1.1.5.1. Based on the Management System Model, management system analysis (MSA) and management system synthesis (MSS) lead us to the models in the engineering process and management process frameworks.

The tools with their guides (e.g., a procedure or set of instructions can be a tool or can be a guide for another tool, like procedures for a management information system.) and the skills for using the tools fit within the frameworks for the engineering and management processes and apply to the work management systems engineers do. To build and use tools well, we need knowledge, skill, and ability. I can't give you ability in this book. But I will describe the knowledge and skills you'll need. When you apply the tools and skills to building management tools, you'll develop generic tools, like management information systems, organization structures, and plans. When you apply the tools and skills to using management tools, you use specific tools, like scoping agreements, Gantt charts, and control charts. The situation here is analogous to designing and using an automobile. You design and build a type of automobile, like a Ford Taurus. You use that red automobile parked over there by the curb.

When I talk about building management tools, I'll define categories of management tools, like guides, and general types of tools within the category, like policies, plans, procedures, or instructions. The topics for building management tools apply to management tools in general, like system analysis and information flow.

When I talk about using management tools, I'll describe how to use specific tools, like an action plan or a scoping agreement. To put the specific tools in context, I'll use culture, quality, and changing to a quality culture to help set the scene for the philosophy and structure of the management process functions and rules for using management tools.

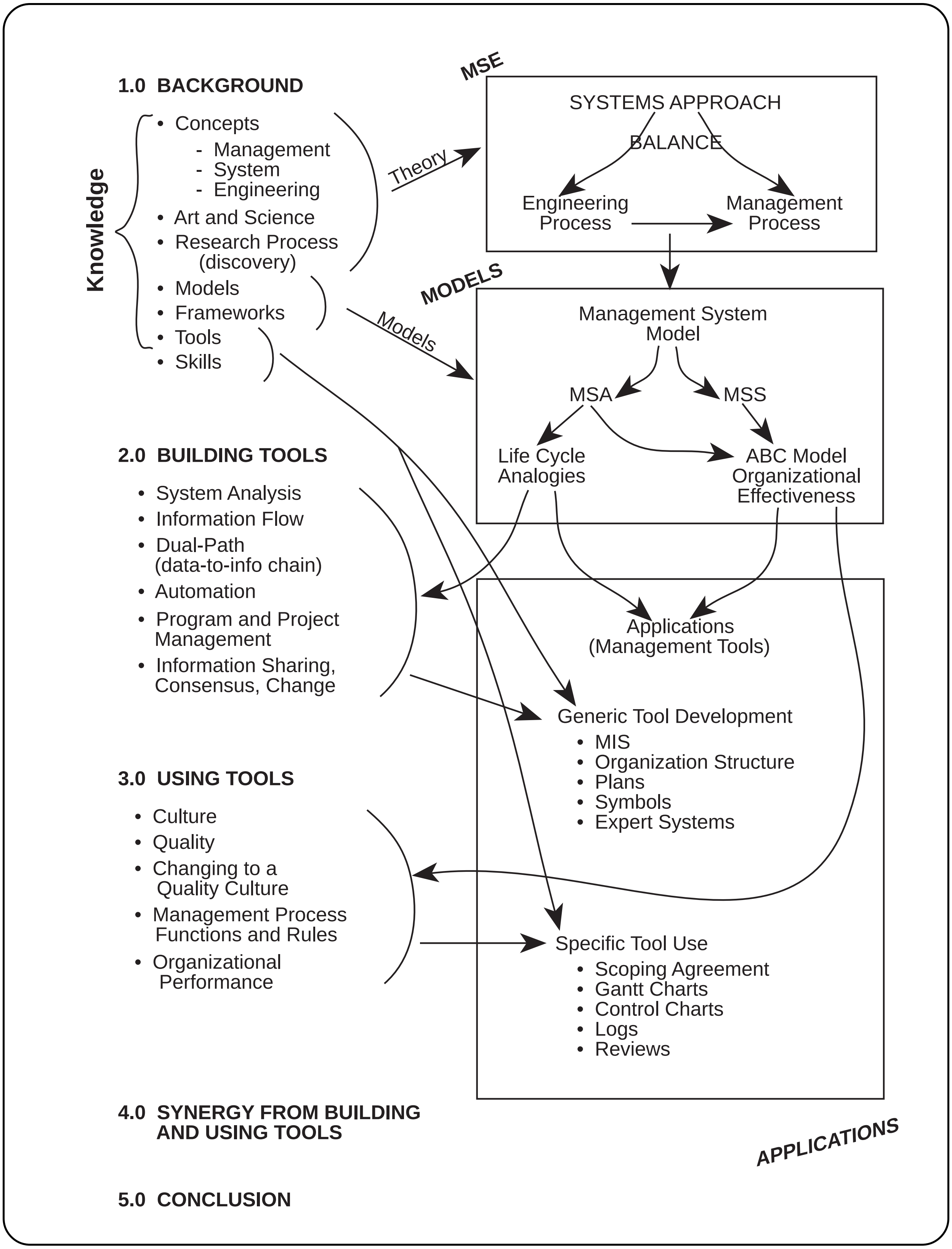

Figure 1.1.5.1. *The book contains five sections, the first three of which carry you through the theory of management systems engineering to models we'll use to best build and use management tools in given applications.*

1.1.5.2. Use

This book gives you a roadmap and tools with their guides and the skills for using the tools, all to use as you build management tools or manage builders of management tools, and as you use management tools to improve the performance of your organization.

In Section 1.1. of the book, I'll set out the engineering process and the management process with their respective frameworks and with their underpinnings in knowing the application, or domain or unit of interest, and their philosophical "overpinnings" through the perspectives of the systems approach. These frameworks form a roadmap to use throughout the rest of the book. I'll discuss examples of tools to use to help accomplish each of the 21 engineering process functions and the 14 management process functions. You're apt to lose the forest for the trees. The roadmap lays out the forest.

Like all roadmaps, the scale, or level of detail, dictates whether you can find a specific landmark when you get lost. Sometimes you have to wander a bit until you find a landmark that happens to be on your map. Since your roadmap has more roads than landmarks, you may find a road but not know exactly where you are on the road. In short, the functions I'll give you in your roadmap are large scale. You'll have to fill in some details as you find your way in engineering a management system.

In the later sections of the book, I'll expand some on the roadmap and its concepts, like the Management System Model (MSM) and the ABC Model, but I'll concentrate on discussing tools and skills to use to accomplish the functions of the engineering and the management processes.

In the theory section, I'll give you tools, or frameworks, to help you diagnose your organization or another organization so you can build or use the right tools successfully. The theory section is to help you develop a wonderful solution to the *right problem*.

The building tool section and the using tool section of the book focus on the tools and the skills for using the tools. An example tool is the scoping agreement used to set expectations on project-like pursuits. Notice that the scoping agreement is one of the outputs of the Survey function (the first function) of the engineering process shown in the framework for the engineering process in Figure 1.1.20.1.1.a. Also, the scoping agreement is a tool for setting expectations, the first function in the using management tool functions of the management process shown in Figure 1.1.21.5. I'll discuss scoping agreements in great detail in the using management tool section of the book. I'll describe the scoping agreement and give a guide for using the scoping agreement.

Communication is an example skill for building and using the scoping agreement and for building and using almost all the tools. I'll discuss communication skills (writing, reading, speaking, and listening) in some detail in the building management tool section of the book. Clearly, the placement of the discussions of tools and skills in the book is a bit arbitrary. The skills are pretty universal and the tools can be widely applicable. Soon, I'll develop frameworks to identify and classify tools and skills. Then, I'll develop a matrix to show the tools and the skills and where they're discussed in the book and where they're useful in the engineering and management processes.

1. BACKGROUND

1.1. INTRODUCTION

1.1.6. SOLVING THE RIGHT PROBLEM

1.1.6.1. Color—Perception and Reality—Paul Cézanne

If you put the right color on things, form becomes substance and perception becomes reality—in management as well as in art. In management, these ideas can work for or against you, and as you gain skill you must use these ideas with conscience.

Artists understand the importance of light in portraying and perceiving information. Color is the vehicle they use. In science, light is quantifiable reality. Color is a specific wavelength of light, and the speed of light is our prevailing constant.

In James M. Carpenter's *Color in Art: A Tribute to Arthur Pope*, Howard Fisher's introduction states, "Color is a psychological phenomenon. It exists exclusively in the mind of the beholder. There is no color as such in nature. Just as there is no sound when a tree falls or lightning strikes in an uninhabited land, so there is no color when the sun rises and flowers open.

The sensation of color is usually caused by variations in the length of light waves radiated by self-luminous sources, reflected from objects, or transmitted through them. The rays enter the eye and through receptors in the eye their nature is communicated by the optic nerve to the brain. Because no two eyes and no two brains may operate in exactly the same way, no two persons are likely to sense color in exactly the same way." (p.13, Fogg Art Museum of Harvard University, 1974.)

If we consider color to be a form of information, the information has a portrayal vehicle and a perception vehicle and, until we match the two, we have no information. Since managers use information to make decisions with, we'll have to worry about both portrayal and perception to get information.

Without light we have no color. Color is light. Shlain puts into perspective the importance of light in relating the constructs of reality, we as engineers write and solve equations for every day. "In our present paradigm we still acknowledge four basic constructs of reality: space, time, energy, and, matter. Space and time constitute the gridwork within which we conduct our lives, while inside their frame, energy, matter, and various combinations thereof create our world of appearance. These four elemental constructs form a mandala of totality. All perceptions created in the dream room of our minds are constructed from these four building blocks. .....Whether it was the miracle of fire or the life-giving rays from the sun, light in and of itself has always been the most mysterious element. .....In some strange way light is the link connecting space, time, energy, and matter. The symbol for the speed of light in physics, c, plays a prominent role in the key equations connecting the other four." (p. 26.)

In discussing color, Shlain continues, "Until the mid-nineteenth century, materialist scientists like Newton, who only described color, affirmed that it was a unique property of matter. Idealists like Goethe, who wrote a treatise on color's effects on the emotions, propounded the opposite view: that it existed chiefly in the mind of the beholder. By the early nineteenth century, scientists strengthened the position of the materialists by demonstrating that color is light of varying wavelengths, thereby reducing to number what had always been a sensation. .....Infants respond to brightly colored objects long before they learn words or even complex purposeful movements.

Most evaluations of reality depend upon a synergy of two or more senses. Sound can be heard and felt. Mass can be seen and touched.

Liquid can be tasted and smelled. Color alone defies corroboration by a sense other than sight. Color cannot be described to someone who has been blind all his life. I cannot even be sure that the color I call green is the same color you call green. While a consensus can be built about most other features of the world, there is only an uneasy, unspoken agreement among people about color. It is both a subjective opinion and an objective feature of the world and is both an energy and an entity. Color is tied to emotions as well as being a fact. .....There are many [examples] throughout history of those in authority harnessing the power inherent in color and using it in the service of their policy. One has to think only of the patriotic surge of emotion that is evoked by the red, white, and blue for Americans. Observing how the spectators respond to a home team's colors or counting the lives of young men who sacrifice themselves in battle to protect their battalion's colors are just three examples of color's potency." (pp. 170-172.) (I prefer to use pronouns and other references to people that reflect both genders unlike the author of this statement; eg., the discussion of men in battle or the pronouns he or she and him or her. I also prefer to quote other authors directly. So, quotes may or may not reflect my first preference, depending on the preference of the author quoted.)

How do we characterize color so we can use it? "In 1898, an artist and teacher named Albert A. Munsell organized the information discovered by Isaac Newton by creating a color charting system that not only allowed us to see the colors of the spectrum but to use them for planning, mixing, etc. Since we can now see these colors by referring to the Munsell System, a complete understandable sequence of color study can be developed. Today the Munsell System is the most widely accepted system in the world. It is accepted by the Bureau of Weights and Standards and is used by artists and colorists throughout the world. Through the years there have been many variations of color organization conceived, but almost all of them are based on the principles of the Munsell System. (William F. Powell, *Color and How to Use it,* Walter Foster Publishing, 1984, p. 8.)

Powell defines the three qualities of color as 1) hue: the name of the color, 2) value: the lightness or darkness of color—add white to get tint and add black to get shade, and 3) intensity: the purity or strength of color. He says, "The three qualities above are known as the three different dimensions that can be applied to each color. These were discovered by a scientist named Helmholz and were later used as a basis for the Munsell System." (Powell, p. 8.)

So, what does color have to do with management systems engineering? What one person sees in conceptualizing ideas like management, engineering, system, process, data, or information is a matter of perspective and perception. When you see blue, do I see blue or do I see red? Since we agree to call what we each see blue, we can talk to each other with some measure of consistency. But each of our realities is different. The issue of reality is crucial to communication. Communication is crucial to management and leadership. We'll find that distinguishing one person's reality from another person's reality is necessary to truly communicate.

Go ahead and define management. Then have someone else define management. Compare your definitions. Chances are the definitions will be different. Therefore, you each have a different reality about management. You can't communicate about management until you understand both realities.

Management is such a common term, I'll have a hard time getting you to convert your sense of reality about management to agree with mine. I'll define management as decision making. I may be able to get you to accept my definition and have some feeling of what I mean when I use the term management. But, will you perceive what I perceive when I look for management in an organization? Can you apply the qualities of hue (name), value (degree), and intensity (strength) to the idea of management?

The form of what is management to you depends on how you perceive management. The form of what is in a painting depends on how you perceive color.

An important issue in solving the right problem is knowing the perception and the context of the problem. To the person who has the problem, perception is reality and the context in which the problem fits makes a difference in determining whether this problem is the right one to deal with.

We'll find that the biggest part of solving a problem is knowing whether the problem is a technical, social, political, economic, esthetic, or other type of problem. We want to spend our energy on the right problem, not the wrong one. When we solve the problem, our effort usually requires a balance, or mix, in perspectives and we usually have to mix, or blend, our activities so the activities are indistinguishable one from the other.

As we discuss problem identification and resolution in effective management, we'll raise the issues of perception, context, balance, and blending. For now, we'll consider these issues in terms of color and in terms of a person's perception being that person's reality. In management, perception is critical.

I'll use Paul Cézanne to illustrate the use of color to create perception and communicate reality. "'Color *is* perspective,' Cézanne once said, and its function was to structure space. .....He discovered that warm colors advance and cool ones recede, and so was able to create a sense of depth and mass without using line or perspective. .....He was able to show how pure color without an outline could create a sense of something's existence in space, which implied the subversive idea that light was the preeminent element of reality. .....Cézanne substituted color for the crucial elements of line, shading, and perspective." (Shlain, p. 176.)

And what's the relationship between color and form? "For the painter colour is therefore also form. This is the meaning of Cézanne's famous equation 'form = color.' Linear design in itself must not exist, for it does not exist in nature. Line is implicit in the rounded form. The more colour grows and gains in precision and harmony, the more the 'line' of objects will appear, but it must appear through form. The painting of Cézanne cannot therefore be graphic or linear, but is a painting of volumes. His urgent need to 'produce form' resulted in that flat, dry, structural brushstroke which is one of the basic elements of his style, and in the slowness of execution which has become legendary." (Mario de Mecheli, *Cézanne*, Thames and Hudson Ltd., London, 1968, p. 21.)

"Less concerned than Monet or Pissarro with the scintillation of light or haze of atmosphere, he stressed the tangible substance of objects and gave a more definite compositional structure to his paintings. .....[Cézanne was] deeply absorbed in the search for a way of painting that would combine the luminosity of impressionism with the grand stability and harmony of classical art. .....He painted landscapes, still lifes, and figure compositions that rank among the highest achievements of 19th-century painting. .....Like the impressionists, Cézanne needed the experience of nature; unlike them, he did not try to record momentary visual sensations, fleeting effects of light and atmosphere. Instead, he studied the permanent structures and relationships of objects." (Bernard S. Myers, *Dictionary of Art*, Volume 2, McGraw-Hill Publishing Co., pp. 3-4.)

Figure 1.1.6.1. is Cézanne's *Marseilles Bay seen from L'Estaque*. Do you see anything in

the bay? If you answer “boats,” look closely. Cézanne meant for you to see his simple white shape as a boat. The sail is the right color and the right form and in the right context to be a boat. You fill in the missing information in your mind. Perception is reality. You see reality according to your perception. The form becomes substance. What else do you see in the painting? How does Cézanne use color to separate foreground from background?

What people perceive to be the truth becomes their reality. As an engineer and a manager, you must make sure that the information you portray is perceived the way you wanted to communicate the information. Don’t just think that because you portrayed the information, you’ll make your audience understand the essence of your communication. Much of management is communication and being ever-vigilant of the interface between information portrayal and information perception will spell the difference between failure and success.

I learned a great lesson from a Department of Energy contracting officer by the name of Don Drennon. I was justifying a research grant overrun. He explained how he wanted me to prepare the cost figures. When I returned with my justification document, he decided not to reject the request for funds out of hand but rather to give me another chance. He wrote down the form he wanted for the justification. He told me to put my numbers and explanation in exactly that form. “That’s the form we use,” he said “and, in that form, I’m more apt to believe your numbers and justification. Remember form becomes substance.” Can you apply this lesson to your classes in terms of how you act and dress and how you prepare your homework? How do you feel about that? Do you think some people abuse the ideas of form and substance and perception and reality for their own selfish gain?

How do we get the right color and the right understanding from a painting? We blend the color from the fundamental (primary) colors. We can do that physically or visually. I’ll talk about visual blending later. In physical blending we lose the original colors, never to be retrieved from the mix. This absolute blend represents how management systems engineers need to mix the principles of the systems approach, the management process, and the engineering process. You can start with the components but must end up with the blend.

The concepts I intend for you to remember and I will reinforce during the course are:

- Form becomes substance.
- Perception becomes reality.
- Your context when you observe something influences the reality of what you observe.
- No two people sense things (color) in exactly the same way.
- To get information to support decision making, we must match information portrayal to information perception.
- Without light, we have no color: without information and knowledge, we have no interpretation and decision.
- Color and information have 1) hue: name or type; 2) value: lightness or darkness; 3) intensity: purity or strength.
- Light (and information and knowledge) is the most mysterious element.
- Most evaluations of reality depend on a synergy of two or more senses—measurement of reality takes more than observation.
- What you see or understand depends on your perspective.
- Make sure the information you portray is perceived the way you wanted to communicate the information.
- We have to understand blending to be good integrators.

Figure 1.1.6.1. *Marseilles Bay Seen from L'Estaque*

1.1.6.2. *PROBLEM STATEMENT*—WHAT'S THE PROBLEM?

The aim of this book is to lay out and demonstrate a structured systems approach and skills for building and using a complete, comprehensive set of management tools to help managers get the information they need about their responsibilities to make good decisions. In doing so, this book defines and scopes the discipline of management systems engineering.

System Failures Are Often Due to Management Failures.
Many of our seemingly technical failures today are really management failures. The Three Mile Island and Challenger disasters are good examples. Each had a technical component to the failure. But each was primarily a management failure.

In addition to dramatic disasters like these, the United States' slide in competitive position in the world is more a management failure than a technical one. I believe a major part of this failure comes from not understanding the principles, fundamentals, tools, and skills for managing responsibilities and from not having an integrated, synergistic process for the tools and skills to work through.

As you think about large or small failures in government, business, industry, and academia, scrutinize situations for the types of failures involved. You'll find system failures, often with technical components, but largely due to errors in management. (If you feel failure is too strong a term for the results of the errors you find, try the terms frustration and waste.)

I'll describe systems as comprising components with their attributes and relationships, or interfaces. Components fail because of technology. Systems fail because of management. (The components versus systems idea was given to me by Mike Maddox.) The internal sources of failure come from the components of a management system; the external sources come from the system's environment. We can describe the types of failure in organizations by considering the interfaces between pairs of components in a management system.

We Can Apply Engineering Fundamentals to Managment.
In business, we want our organization to do something well and to do the thing better than our competitors do. That ability depends on the availability of the right tools and skills and our ability to use them in an effective process. A process interconnects the uses and results of the tools and skills. Whether you're a carpenter, an artist, an engineer, or a manager, to be successful, you must learn the principles, fundamentals, tools, and skills needed for the work you do. In this book, my objective is to lay out and demonstrate how to build and use tools for management. I'll use engineering fundamentals to accomplish my objective. My premise is that the advantages of the engineering process will help us unlock some of the doors to better tools for managers. In doing so, we'll apply the engineering process to the management process under the purview of the systems approach.

Contrast Engineering and the Engineering Process.
Engineering is a discipline that connects a builder to a user, as shown in Figure 1.1.6.2. The engineer is the builder. Engineering is what he or she does to meet the needs of the user. Any person who builds something using the engineering process is doing engineering.

Only some people get degrees that classify them in the engineering profession. I distinguish between the engineering process and the engineering profession.

My interest is in building and using management tools—tools for providing information to a manager. I believe to practice engineering responsibly, we need to close the feedback loop between the user and the builder to ensure the builder meets the user's needs. The management systems engineer is the builder who practices engineering process fundamentals to meet the needs of the manager. To do so, the management systems engineer must understand how to build management tools, how the manager uses management tools, and how well the user's needs are met so the builder can improve his or her performance.

As the builder, the management systems engineer forms a composite whole (a complete integrated solution) by ordering and uniting ingredients (materials or components) according to a systematic plan (or design) to accomplish a defined purpose (serve an application to benefit people). As the user, the manager needs the result of the builder to accomplish a specific goal or objective.

As I expand my discussion of engineering and the engineering process, I'll expand Figure 1.1.6.2. I'll continually disclose more detail as I develop the ideas behind the additional details about the engineering process and its fundamentals and the application system we apply the engineering process to. The next expansion of Figure 1.1.6.2. is in Module 1.1.9.3.

To Optimize a System, We Need Tools and Skills.

Most people recognize the need to optimize the system, not optimize the component parts. However, they don't understand the principles and don't have the skills and tools that work in their specific responsibilities to help them continuously improve their work and to get the most out of their organization. To gain this understanding, we need a systems approach. We must apply the systems approach to the work and management processes and to the engineering process. We use tools to help us with our work (operations tools) and management (management tools) processes. We use the engineering process for building and using the tools.

We want to do analysis and synthesis activities on systems and their processes. When we learn analysis and synthesis skills and tools, we might call ourselves systems analysts and/or systems synthesists. Our analysis and synthesis skills and tools will help build good management tools.

To take on the challenge of giving managers the tools they need, we must use the systems approach. The systems approach requires us to think from system, holistic, and generalist perspectives *in addition* to the analyst and specialist perspectives most of us already practice. The subtle differences among the system, holistic, and generalist perspectives are important to learn for understanding how a system works and can be managed.

We'll Consider Management Systems Engineering as a Discipline.

As an academic discipline, management systems engineering comprises more than management tools. The management tools are part of a system including the manager and the work processes he or she is responsible for. The perspective of this book focuses on management tools within the systems context recognizing the manager's need for information from the tools and the need for the tools to reflect what's going on in the work processes. In this book I'll define and scope the discipline, recognize the manager's responsibilities as a system, and focus on the system from the management-tool perspective. Other management systems engineering approaches would start with the total system understanding but could focus on the manager's responsibilities as a system from other perspectives, such as the manager's personal effectiveness or the operation's productivity.

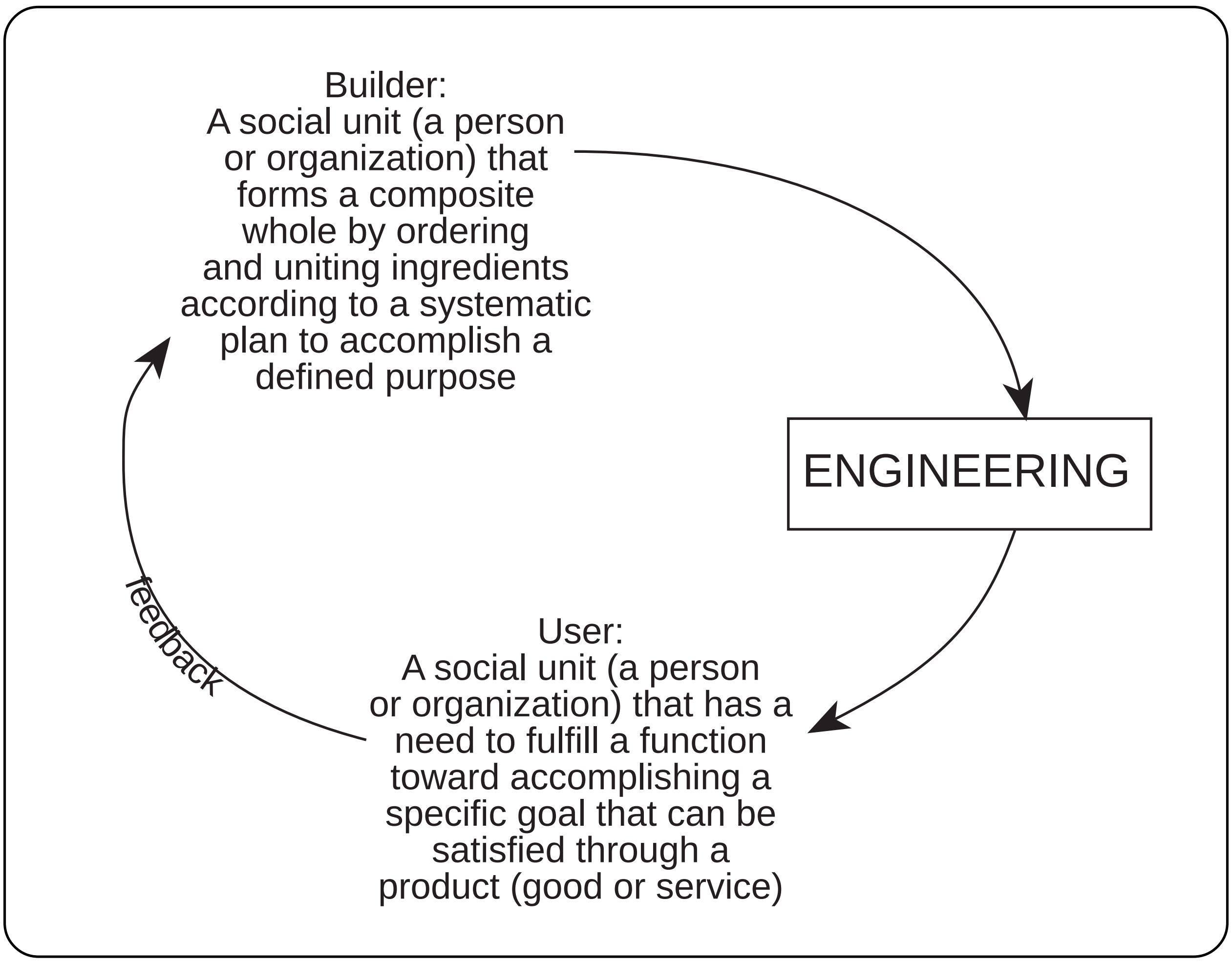

Figure 1.1.6.2. *The management systems engineer is the builder who practices engineering to meet the needs of the manager and who determines how well he or she meets that need.*

1.1.7. The *Motivation* for and *Relevance* of Management Systems Engineering.

To reduce crises, we need good information from good management tools to help make good decisions so we can convert the energy we spend on crises into creative energy.

In Your Unit, You Make Decisions about Your Responsibilities.
For your responsibilities, your job is to make decisions—all kinds of decisions. You make decisions about what to do next, when to do it, what you need to do it, why to do it, and so on. If you make decisions about a responsibility, you manage that responsibility.

You need information to make a good decision. Without information, your decision is really a guess. Management tools can give you information about your responsibilities to help you make good decisions. Good management tools give you accurate, timely, and relevant information.

You don't want to have to make decisions about existing problems. You want to make decisions to head off problems and to move your responsibilities ahead successfully, enjoyably, and effortlessly. You want to be proactive. To be proactive, you have to be able to predict what's going to happen to your responsibilities, not only from your efforts and the efforts of the people you work with but from outside influences. So you need good information about where you are, where you want to be, and how to get there from here.

Can We Head Off Crises of Our Own Making?
I believe that with the right tools, skills, and process and the knowledge and ability to use them, you can significantly reduce unnecessary effort on crises and replace that frustrating effort with creative, stimulating energy to get more done and feel the joy of your work. Each of us has a number of responsibilities we manage each day. These responsibilities fall into relatively-convenient groupings—our work responsibilities, our family responsibilities, our community responsibilities, and so on. How often when you look forward to your efforts on any set of responsibilities do you know what you'll accomplish that day and, in fact, accomplish what you expected? The answer I usually get is seldom or never. Clearly, the reason you didn't do what you expected is because something came up you didn't expect. This something, I call a crisis. A crisis is an unexpected occurrence. Even if the unexpected occurrence has a positive effect, I call it a crisis. Other terms for an unexpected occurrence might be surprise, disturbance, incident, problem, and so on.

Crises take up physical and mental energy you planned to devote to productive work. Most of the time this diversion of energy is unnecessary. Usually, directly or indirectly, the crisis is of your own making. (For the responsibilities of a fire fighter, a fire isn't the type of crisis I'm talking about. The fire fighter is prepared for a fire and sees fire fighting as integral to his or her work process. The fire fighter sees improperly given directions to the fire, failure of the truck or communication system, or debilitating interpersonal squabbles as the kind of crisis I'm talking about.)

To Solve Problems in Organizations, We Must Penetrate to the Cause without Threatening People.
When you have a problem in your work, you first see the result you don't want. The result is a symptom of the problem. To fix the problem, you have to get to the root cause. If you fix the

symptom, the problem will reoccur. Like physicians, engineers find causes using the symptom as a window to the cause. Finding causes is a necessary, but not sufficient, condition for problem solving. The cause is almost always embedded in the process for generating the result. You need tools to penetrate to the root cause, to learn the reason for the cause, and to prevent the cause from reoccurring. You need tools aimed at the process not the result.

In a management system, you almost always need the person doing the process to help you find the cause of a problem. If that person feels threatened, you'll not find the cause. A key question then is: How do I penetrate to the root cause in nonthreatening ways? Penetrating requires an understanding of the work and management processes and the help of the potentially-threatened person. Understanding the work process and the technology behind it gives you the ability or driving force to penetrate. Understanding people and teamwork helps you reduce barriers and resistance to penetration. You move a problem toward resolution by increasing drives or reducing restraints. The latter is better because driving forces attract more restraints while reducing restraints permits existing forces to prevail (Marvin A. Weisbord, *Productive Workplaces*, p. 78).

If you increase the drive of the force of technical knowledge on the problem of penetrating to root cause, you can attract the restraints of fear and covering up. However, if you reduce the fear of being open and honest, whatever technical knowledge you have will prevail and you'll have more success in moving the penetration problem to resolution.

We Head off Crises by Being Proactive.

Being proactive includes heading off crises, or disturbances—those occurrences from inside or outside your control that you don't expect and don't want. Think about the disturbances you face each day. Most of them are of your own making; you could have kept them from happening. How much time do you spend in rectifying poor communication? When you think of communication problems from your supervisor to you, from you to your subordinates, from your customer to you, and from you to your customer, how much time do you think you could save on misspent effort if the communication had been better? How much time could you save if the communication were more efficient? How much time would you save if you and the people you work with enjoyed working together, trusted each other to share all information readily, and didn't need to explain interpersonal frustrations to yourself or to others?

Think of the time you spend on rework and other consequences of nonconformance to requirements or expectations. (Crosby defines quality as conformance to requirements.) In the United States, most manufacturing operations spend 40% of their time on rework. (Kosaku Yoshida, *Made Wholistically in Japan*, a video tape and Crosby tape) Service operations spend almost as much time on rework. How much time is wasted when we rush around at the last minute trying to meet a forgotten or put-off-to-the-last-minute assignment or milestone? Do you spend time looking for something you misplaced or never received? Do you spend time waiting for someone or something that's late? You don't go to work in the morning saying, "I intend to spend an hour looking for something I forgot," or "I intend to do a job that won't meet expectations and will have to be redone." You want to head off these frustrating, wasteful efforts and do productive work using your creative abilities.

The ABC Model Relates the Time We Spend on Crises to What Else We Do.

If we start with approximately 40% of our time spent on rework, clearly we spend more time on disturbances, or crises, than we spend on everything else we do altogether. The crises are shown in Figure 1.1.7. as the large slice of the pie called C, for catering to crises.

Figure 1.1.7. is one simple, but robust, look at our performance or success criteria. I argue that a manager spends all of his or her time administering his or her work and management processes (A), building the business (B), or catering to crises (C). How do you want to spend your time? Surely not catering to crises. Most likely, you want to spend as much time as possible exercising your creativity and using your education and abilities to better serve your customer, add customers and products or services, and learn with your coworkers; that is, building the business. Since we spend most of our time on crises, we have less than half of our time for the A and B slices of the pie. Since A (administer the process) is the time you spend on your productive work—your work process—and the time you spend on your management process, if you have a large C (cater to crises), you don't get much time to do B (build the business). Doing C is no fun. Doing a good job at A is some fun. Doing B is the most fun. We all want to be creative and build our responsibilities so we can see what accomplishments our abilities, education, and experience will support in our professional life.

Our motivation is simply to reduce crises of our own making. I'll discuss the ABC Model and how to address that problem in Section 1.3. on the ABC Model, which simply says you need to focus on work and management processes to get the business you have under control and reduce crises before you think about expanding the business.

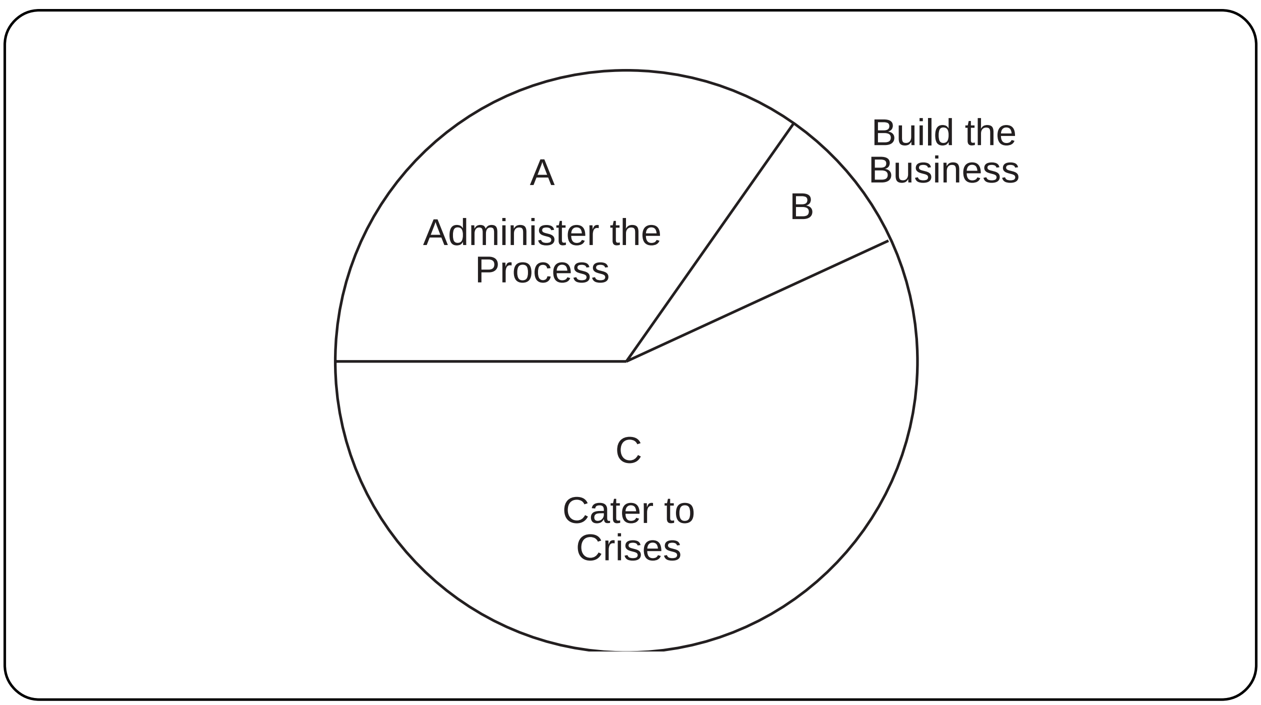

Figure 1.1.7. *Given that we spend time on our productive work, when we spend more than half our time on wasteful efforts, we have little time left in our day to be creative. That's why we need good management tools to give managers good information to help make decisions.*

1.1.8. The Solution Is to Engineer the Management System—How Do You Solve the Problem?

We approach management from the systems approach when we understand balance—balance between the art and science of management, balance between the qualitative and quantitative parts of our work, balance between the important and urgent parts of our work, and balance between the technical and human relationship competencies in our work.

In management systems engineering we engineer a management system, an organization. The system we're engineering has many special characteristics that make management systems engineering challenging. Our outcome is to help managers do their job. The manager is responsible for the management system. For the engineer, the engineering process defines the action they take, which centers around design. For the manager, the management process defines the action they take, which centers around decision making.

Three decades ago, Jay Forrester, in his landmark text, *Industrial Dynamics*, recognized the challenge of the action of management as compared to other actions, such as engineering. In his introduction, he says, "The manager's task is far more difficult and challenging than the normal tasks of the mathematician, the physicist, or the engineer. In management, many more significant factors must be taken into account. The interrelationships of the factors are more complex. The systems are of greater scope. The nonlinear relationships that control the course of events are more significant. Change is more the essence of the manager's environment. ..... Management is in transition from an art, based only on experience, to a profession, based on an underlying structure of principles and science. Any worthwhile human endeavor emerges first as an art. We succeed before we understand why. The practice of medicine or of engineering began as an empirical art representing only the exercise of judgment based on experience. The development of the underlying sciences was motivated by the need to understand better the foundation on which the art rested." (p. 1) "Without an underlying science, advancement of an art eventually reaches a plateau. Management has reached such a plateau." (pp. 2-3.) Forrester's thinking and his models and techniques for industrial dynamics form one of the pillars underpinning management systems engineering.

In solving the problem discussed in Module 1.1.6.2., we must be eternally vigilant of recognizing the balance between art and science in management—and in engineering. We can't yet solve complex systems of equations involving human beings as parts of the machine we call an organization. But we can model the organization, recognize fundamental relationships in it, and study the sensitivity of the cause-and-effect interactions of the organization and its people. Most of all, we can better structure and design the many tools managers use to help them make decisions and we can determine which tool fits a particular situation. You'll find that many of the management tools, especially the computer-based ones, reflect science, and the skills for using the tools reflect art. You must balance the science of the tools with the art of using them.

We can measure variables in an organization and develop better measures, tools, and guides to give managers better data and information to support their decision making. Lord Kelvin said, "When you can measure what you are speaking about and express it in numbers, you know something about it, but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind." (Walter A. Shewhart, *Statistical Method from the Viewpoint of Quality Control*, p. 80.) In management systems engineering, we must learn what to measure and how to measure it.

We face balance issues in everything we do. We all find a tendency to put the urgent in front of the important. Unfortunately, crises or short deadlines don't define priority. So, you'll have to work to take some time out for the important. But, you can't ignore the urgent. The answer again is to find the right mix (balance) in the amounts of time you spend on the urgent and the important. When we figure out the mix, we'll work on the right things. Figure 1.1.8. illustrates the problem of balance.

To solve fundamental management problems using management systems engineering, you must be able to not only work in qualitative as well as quantitative modes, but you must be able to switch at a moment's notice. You'll want qualitative approaches to address the human component of a management system. Typically, engineers feel at home with quantitative analyses and solutions. To engineer a management system, you must feel at home also with qualitative approaches and solutions, because you must balance qualitative and quantitative issues and approaches. Many complex situations are mixtures of qualitative and quantitative issues and approaches. Often, you'll address a quantitative issue and immediately switch to addressing a qualitative issue. Balance means mix, not equality. How much time should you spend on qualitative versus quantitative issues? The answer is the right mix, not an equal amount of time to both.

From either a management or an engineering perspective, whether we engineer management systems or we manage engineering or technology, we need both quantitative and qualitative skills. Part of the failures (in my opinion) in both management and engineering is that we emphasize the quantitative perspectives and skills at the expense of the qualitative perspectives and skills. If this book seems to emphasize the reverse, it's not intended but rather an overreaction to what I consider an unbalanced approach to the world. To be successful, we must mix our quantitative and qualitative approaches just right.

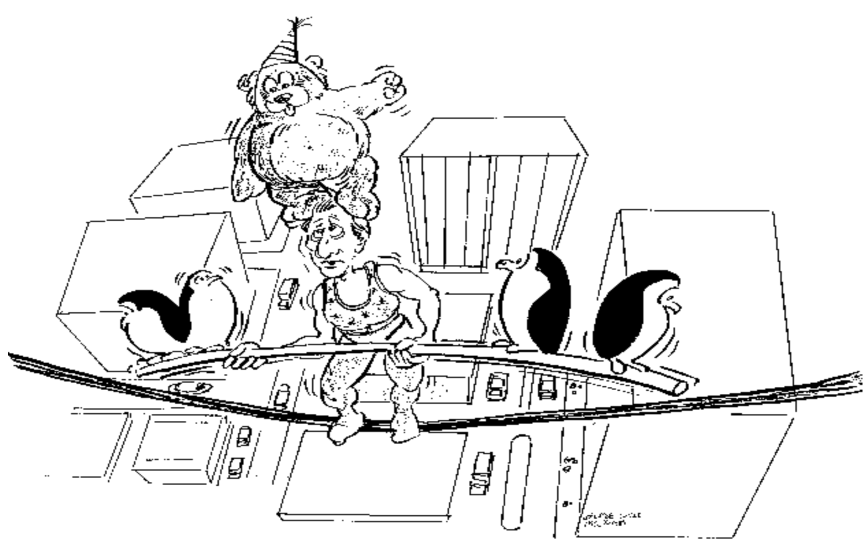

Figure 1.1.8. *Balance is difficult to achieve, but worth the effort.*

1. Background

1.1. Introduction

1.1.9. Management Systems Engineering

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1.1.9.1. Define Management Systems Engineering

Even though management systems engineering is the harmonious, robust *blend* of 1) the systems approach, 2) the engineering process, and 3) the management process, people who understand and practice these concepts aren't necessarily in the engineering or management professions.

Management systems engineering is concerned with researching, designing, building, operating, and improving a management system, and draws upon knowledge of the natural laws of the physical, social, and life sciences. A management system comprises any person or group of people making decisions about and taking action on a set of responsibilities, the work process for meeting those responsibilities, and the management tools for converting data from measurements of the work process into information for decision making. Management systems engineering applies the fundamentals of the engineering process, which centers on design, to the management process, which centers on decision making and leads to continuous improvement. Management systems engineering integrates principles of human interaction with principles of processes, problem solving, and systems under the purview of the systems approach.

Much of our effort in understanding management systems engineering will focus on understanding and integrating concepts like engineering, engineering process, engineering process fundamentals, natural laws, principles, management, management process, management tools, work process, decision making, data, information, processes, systems, systems approach, problem solving, and responsibilities with enough depth and precision that we can understand the interplay of these concepts within the framework of a way of thinking. (I discuss engineering and the engineering process in section 1.1.11. I discuss management and the management process in section 1.1.11.)

In management systems engineering, we apply the engineering process to the management process under the purview of the systems approach. I'll describe the engineering process and its fundamentals in Modules 1.1.11.6.3. and 1.1.11.6.4. I believe we don't teach the engineering process in the engineering schools today. (I also believe we don't teach the management process in the business schools today.) I'll discuss that concern in Module 1.1.11.6.5. I define management in Module 1.1.11.2. and outline the framework for the management process in Module 1.1.11.4. Sections 2. and 4.3. of this book describe the management process in detail. I describe the systems approach in Module 1.1.16.2.

We're comfortable with the idea of engineering a chemical system, or process, or a mechanical, transportation, or electrical system. To learn how to generalize engineering for any system, we study systems engineering. In management systems engineering, we learn how to engineer a management system.

Once you understand the management tools and how to use them and learn the skills for using the processes, functions, tools, and rules, you can get better and better at using the management tools well and using them in the right places. (Later, I'll discuss organization structure, management information systems, plans, and many more examples of management tools.) However, to be truly successful at management systems engineering and at the engineering and management processes, you must be able to do more than practice the skills for using the tools and guides as a mechanical walk through the steps of a process. You must live by the rules and exhibit (manifest) the systems approach.

In this book, I'll lay out 14 management-process functions, five to make sure management tools are designed and built right and nine to make sure management tools are used right. The nine using-management-tool functions reflect Deming's Plan-Do-Study-Act cycle. I'll also lay out 22 engineering-process functions.

In scoping management systems engineering as a discipline parallel to chemical, mechanical, civil, or electrical engineering, I'll address the systems approach, both the engineering and management processes, and the functions, rules, and ways of thinking of the two processes. I'll show both processes as learning, cyclic processes capable of continuous improvement. I'll also show that in practicing management systems engineering we recognize frequent bridging between the two processes so we can learn from one process to improve the other.

Figure 1.1.9.1. shows first the idea of a simple, three-step cyclic process and second how repetitive cycling through a learning process provides for continuous improvement toward the aim of the system the process is associated with. In the past, we've exercised our processes typically as linear processes. In engineering, when we designed a system, we were interested in its installation. We didn't follow through to the end of implementation to include the engineering process steps of upgrade, obsolescence and replacement, and/or clean-up, restoration, and remediation. We never closed the cycle. We never took full advantage of how to learn the lessons of our practices and how to use what we learned to do better the next time. Both the engineering and the management processes have more than the three process steps shown in Figure 1.1.9.1. Therefore, its easy to neglect follow-through steps. But there's more to learn from taking the steps.

Management systems engineering is extremely broad. After setting the stage for management systems engineering, this book emphasizes the tools and guides and skills needed for building and using the tools and guides. Many of the approaches of engineering and management are the same or overlap, making our job of understanding management systems engineering somewhat easier and implying that the management and engineering processes aren't too different. We'll find both the management and engineering processes are rooted in the scientific method.

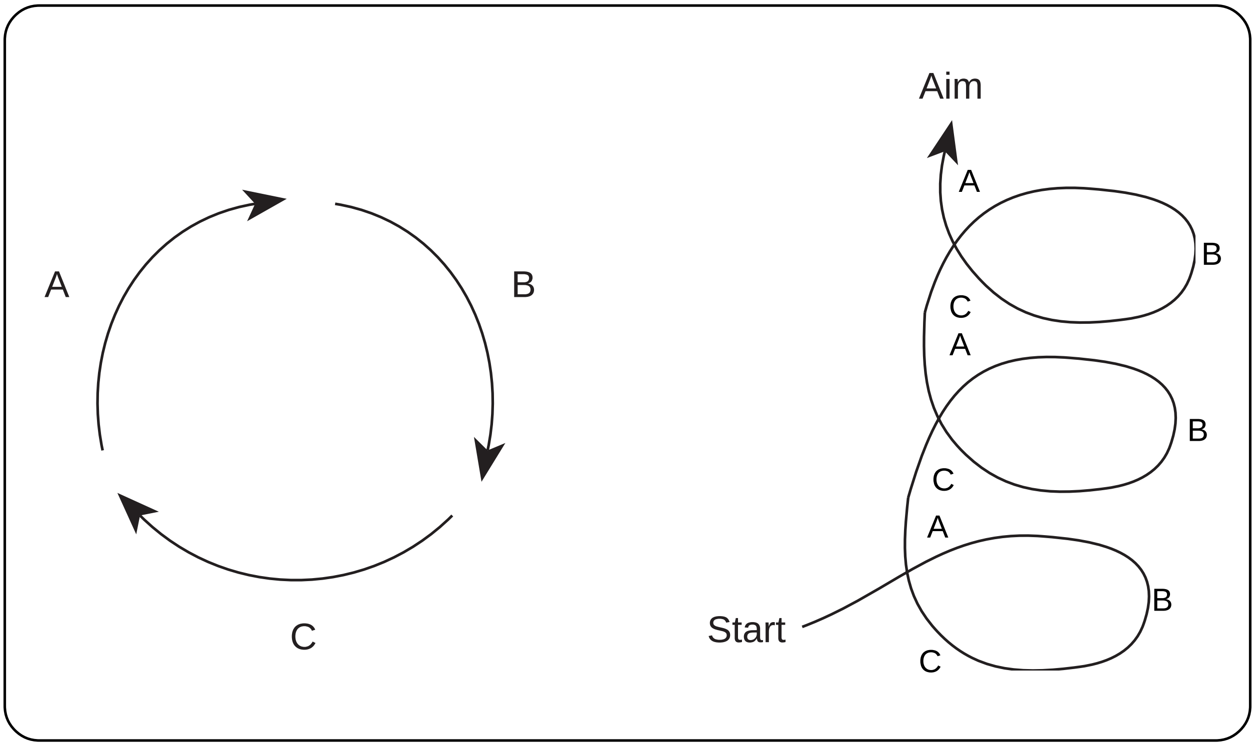

Figure 1.1.9.1. *Processes for learning and improving tend to be cyclic sequences of steps toward an aim.*

1.1.9.2. Blending Concepts of Management Systems Engineering

To do management systems engineering well, you must blend the engineering process, the management process, and the systems approach so the concepts are indistinguishable one from the other.

Management systems engineering is the harmonious, robust *blend* of 1) the systems approach, 2) the engineering process, and 3) the management process. The sequence is important in that the systems approach is the glue among the functions and we're working with engineering management systems here, not managing engineering or technology. All three involve ways of thinking. Processes are more conducive to analysis and defining functions and sequences of steps or stages. Approaches are more conducive to synthesis than processes and drawing ideas together into a direction or objective, but also support analysis.

Project management is a combination of engineering and management that exemplifies the overlap. As a result, project management is the career step most engineers go through in transforming from engineering activities to management activities. Project management heavily intermingles the management and engineering processes. Usually people enter project management educated and trained in either engineering or management and have to deal with the other through hard knocks. In working toward an understanding of both management and engineering processes, this book intends to structure the tools and guides and the skills for using them so the reader can perform engineering and/or management activities in the context of management systems engineering.

Trying to develop an integrated model combining the systems approach, the engineering process, and the management process to get a conceptual model for management systems engineering isn't as useful as we'd hope. Just like you won't find an integrated model or process including both the engineering process and the chemical process in chemical engineering, I won't try to integrate the engineering and management processes into an overall model. Rather I'll model first the engineering process and then the management process and keep the models separate. Both of the processes include functions. I'll intermingle the functions as I discuss them.

When I think about how to blend the systems approach and engineering and management processes of management systems engineering, I think of blending colors in a painting. We don't connect the colors and show their linkages like components in a mechanical system. We blend yellow and blue to get green. There's yellow and blue in green, but to look at the green you can't separate the yellow from the blue. Depending on how you blend yellow and blue, you get a different green. And you want just the right green (the right blend) to capture what you envision to be reality. An artist knows the technique for blending to get the green that best represents the image he or she wants the audience to see. As we blend colors in art, we blend the approaches and processes in management systems engineering.

We blend to get crisp images, not to get fuzzy ones. At first glance, you might think an artist blends color to give a general fuzzy image of the subject being painted. In Tucson, I met a watercolorist who showed me that the detail is in the color. He'd put a brushstroke of green on his paper and you'd see a cactus. He didn't paint in detailed outlines or texture or components. When the color was right within the context of the entire painting, you saw a cactus. Likewise blending the management and engineering processes and the systems approach doesn't make things fuzzy. Rather the blend brings out the contributions of all three. The detail is in the blend.

In management systems engineering, you must not only have profound knowledge of systems, engineering, and management, you must understand how to blend the three to get the harmony that makes the mix work and the robustness that makes the mix work well.

1.1.9.3. Compare Management Systems Engineering to other Engineering Disciplines

Like traditional engineering disciplines; management systems engineering applies the engineering process to an application system, in this case to an organization. The engineering process has advantages to help us manage better than ever before. Other management-related engineering disciplines practice the opposite approach by applying management principles to technological enterprise.

Traditional Disciplines

How do we engineer a management system? Consider a management system to be like a mechanical, electrical, or chemical system. How do we engineer those other systems? Your answer will lead you to the answer for engineering a management system. First, we must understand thoroughly the system where the solution we're engineering fits into—the application system. Whereas we don't know what the solution looks like, we must thoroughly understand the body of knowledge governing the use and benefit of our solution, which I will call the object of our engineering effort. For chemical engineering, we must understand chemistry, chemical processes, and tools and facilities for operating the chemical processes. For management systems engineering, we must understand organizations, the management process, and tools for managing the organization. Second, we must understand thoroughly how to engineer. Just as successful chemical engineering requires us to understand both the chemical process and the engineering process, successful management systems engineering requires us to understand both the management process and the engineering process.

Recall Figure 1.1.6.2., which shows the cycle between the builder and the user, where engineering connects the beneficial effort of the builder to the need of the user. In Figure 1.1.9.3., I've expanded the idea of engineering into the engineering process and the object of the engineering process—the application system. The application system converts capital, labor, equipment, and materials (CLEM) and energy and information into beneficial orientations to meet the needs of the user. The builder forms the beneficial orientations. Any system produced by rational people has an aim; and every system is associated with a process. (I'll discuss and contrast systems and processes later.)

For chemical engineering, the application system is a chemical plant or plant component. The chemical plant has an associated chemical process including the functions of the plant and an associated management process for managing the chemical process. The chemical engineer applies the engineering process (I'll describe the engineering process and its fundamentals later.) to the chemical process under the purview of the systems approach. The management systems engineer applies the engineering process to the management process under the purview of the systems approach. Unfortunately, when we teach an engineering discipline, we focus on the application system to the detriment of both the engineering process and the management process—both of which are needed to engineer the system. In Figure 1.1.9.3., I've extended the ideas from Figure 1.1.6.2. I'll expand Figure 1.1.9.3. further to continually disclose the details of the engineering process and the application system. The next expansion of Figure 1.1.9.3. is in Module 1.1.11.6.1.

In chemical engineering, the engineer participates both in designing the application system and its components and in operating the application system. (The engineer can be the chemical plant manager.) In management systems engineering, the engineer participates both in designing the organization and its components and in operating the application system. If the organization—the application system—were a chemical plant, the engineer could be the chemical plant manager. I believe that understanding the management process overlaying the chemical process in the plant—the management system—requires knowing the management process and the engineering process in addition to the chemical process. In this example, I call the chemical process the work process, or the core application system.

Non-Traditional Disciplines

In management systems engineering, we engineer a management system; that is we apply the engineering process to the management process. We apply engineering principles and techniques to organizations. This point of view is different from engineering management where we manage engineering, typically thought of in terms of technology. In engineering management we apply management principles and techniques to engineering or technology firms. People in the business schools consider engineering management to be managing technology. So, if we have to consider departmental barriers, I claim engineering management is part of the management perspective, whereas management systems engineering is part of the engineering perspective. In management systems engineering, we're considering management engineering, *not* engineering management.

Fabrycky and Blanchard introduce the idea of another term—systems engineering management—by saying, "[Systems engineering management] is the management of systems engineering functions that leads to the successful birth of a system." (Benjamin S. Blanchard and Wolter J. Fabrycky, *Systems Engineering and Analysis*, Prentice-Hall, Inc., 1990, p. 20.) They list the systems engineering functions as 1) system planning, 2) system research, 3) system design, 4) production and/or construction, 5) system evaluation, and 6) system use and logistic support. (p. 25-30.) They say, "There are variations in the application of engineering functions to the system life cycle, depending on the size of the system and the extent of new design and development required." (p. 25.) Managing these functions is managing engineering or technology and therefore is more like engineering management. It's a matter of perspective. Systems engineering management and engineering management see engineering or technology as the object of management activities. Management systems engineering sees management as the object of engineering activities. The nomenclature isn't important. The perspective is.

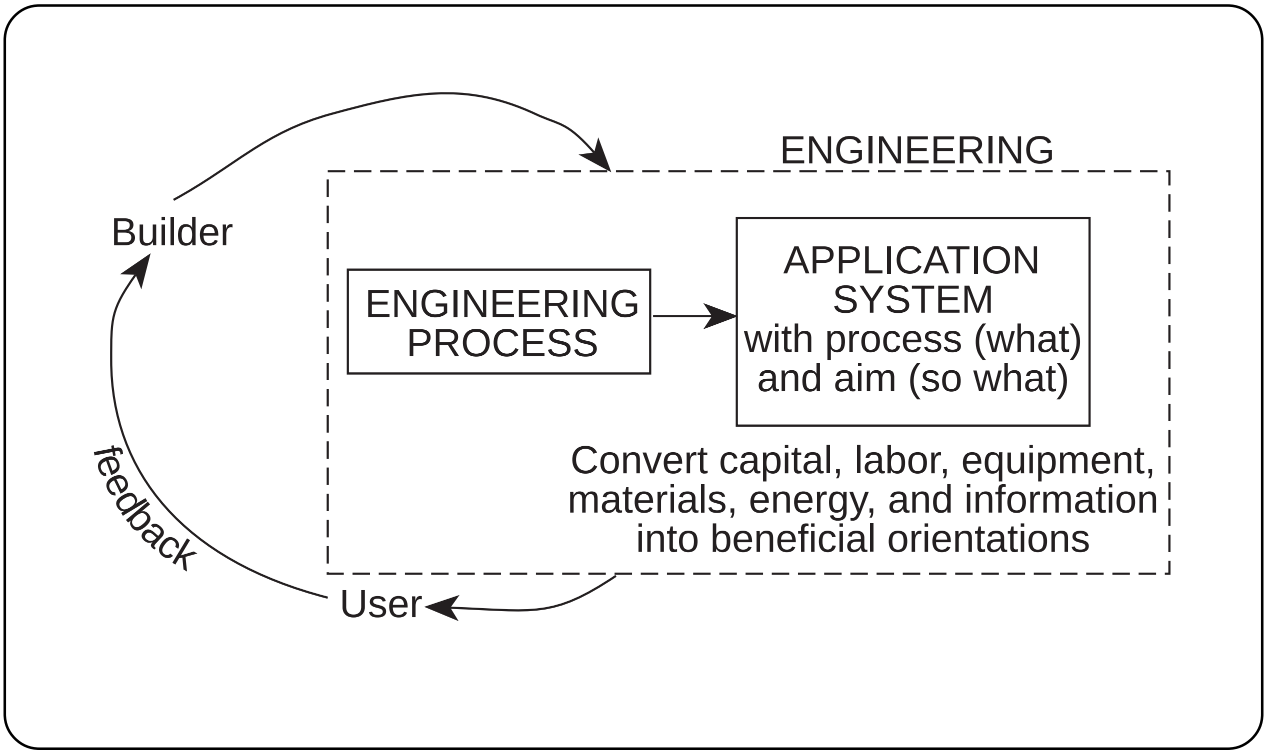

Figure 1.1.9.3. *In engineering, we must understand how to apply the engineering process, not just how the application system with its processes works.*

1.1.10. Perspective the Engineer's Way—Leonardo DaVinci

1. BACKGROUND

1.1. INTRODUCTION

1.1.11. A NEW (OLD) DISCIPLINE

1.1.11.1. What's Unique about Management Systems Engineering?

Management systems engineering is a structured systems approach, based on engineering principles, to building and using means to help organizations improve their performance.

Applying the engineering process to the management process represents a new discipline. Or, if we look closely at the beginnings of industrial engineering, perhaps management systems engineering re-initializes the original meaning of industrial engineering.

Management systems engineering is centered on systems thinking and systems integration. In management systems engineering, we apply engineering fundamentals of design and gathering, conversion, and conservation of energy to an organization, whose key ingredient is its human resources. Management systems engineering stresses the perspective of the generalist in balance with typical engineering specialties.

As engineers, we work to improve the performance of the system of interest. Instead of a bridge, engine, electrical generator, automobile, heat exchanger, or other system commonly thought of in the engineer's domain, our system of interest is the organization. If we consider a given organization, the manager of that organization is responsible for that system and its performance and, in fact, is part of the organization. The manager is an important component of the management system. As engineers, we work to design means to support the performance of all organizations and to work with the manager to apply those means to improve the performance of his or her organization. (In patents, the word *means* refers to the mechanism employed to carry out the purpose or objective of the patent. Here, I intend means to be the theories, tools, techniques, or skills the engineer develops for the organization to use or the organization to improve its performance.) To be successful, we must be able to think like an engineer and like a manager and to integrate the two.

Let's put our objective in perspective using Figure 1.1.11.1. The focus of our attention is the organization, in the center of the figure. The engineer and the manager want to make decisions and act on the organization in ways to improve its performance. As engineers, we'll want to represent the organization in ways we can observe it, learn about it, and work on it. We'll represent the organization by using one or more models. We can model the organization in a variety of ways. In engineering terms, the organization looks like a transfer function for converting interventions into performance changes.

We evaluate the performance of an organization through performance criteria. Performance criteria are shown as the output of the organization in Figure 1.1.11.1. We'll learn about a number of sets of criteria; however, the A, B, and C criteria for how we spend our time is one such set. Note that the output of the organization in the figure is data or information, not the product or the service of the organization. Obviously, the product or the service is an output of the organization; however, this figure focuses on data and information about the organization and about the organization's work process and its product or service. Information is the stuff we use to make decisions with.

We act on the organization through any number of means. These means include management tools and their guides and the skills to use the tools well. In Figure 1.1.11.1., I show the means acting on the organization yielding performance criteria. As engineers, we contribute by analyzing, designing, building, implementing, and following up on the means for improving the performance of the organization. The arrows in the figure show that different means affect parts of the organization in ways to change certain performance criteria. By developing the details in the three sections of Figure 1.1.11.1., we can trace cause-and-effect through the system. Knowing cause and effect we can learn from what we do and continually improve our interventions.

One way to use Figure 1.1.11.1., is to view the organization from inside. From the inside view, a person uses management tools as interventions on the organization's work process. The work process is in the organization block in the figure. Alternatively, you can view the organization from outside as the person building management tools so you can intervene on the entire organization, including the manager, the work process, and the management tools. To do management systems engineering well, you must be good at both views. Then you can make sure the right tools are built, the tools are used right, and the tools are built better based on what we learn from their use.

Figure 1.1.11.1. gives us a global view of the organization. Figure 1.1.11.1. also gives us a framework to tie in our contributions to help manage the organization. As we look toward building and using management tools, we need a complete, comprehensive package and roadmap for showing how those tools and other interventions affect the organization and its performance. The means we use for interventions includes tools and guides and skills for building and using tools and guides so we'll get continuous performance improvement.

As I expand my discussion of the management process, I'll expand Figure 1.1.11.1. I'll continually disclose more detail as I develop the ideas behind the additional details about building and using management tools to support the management process. The next expansion of Figure 1.1.11.1. is in Module 1.1.11.4.

Figure 1.1.11.1. was first shown to me by Betty Koball in relation to developing the structural equation model, or the holistic construal, for doing path analysis for organizational research. I've borrowed the figure to show the relationship between the interventions we make in an organization and the results we hope to achieve through the interventions.

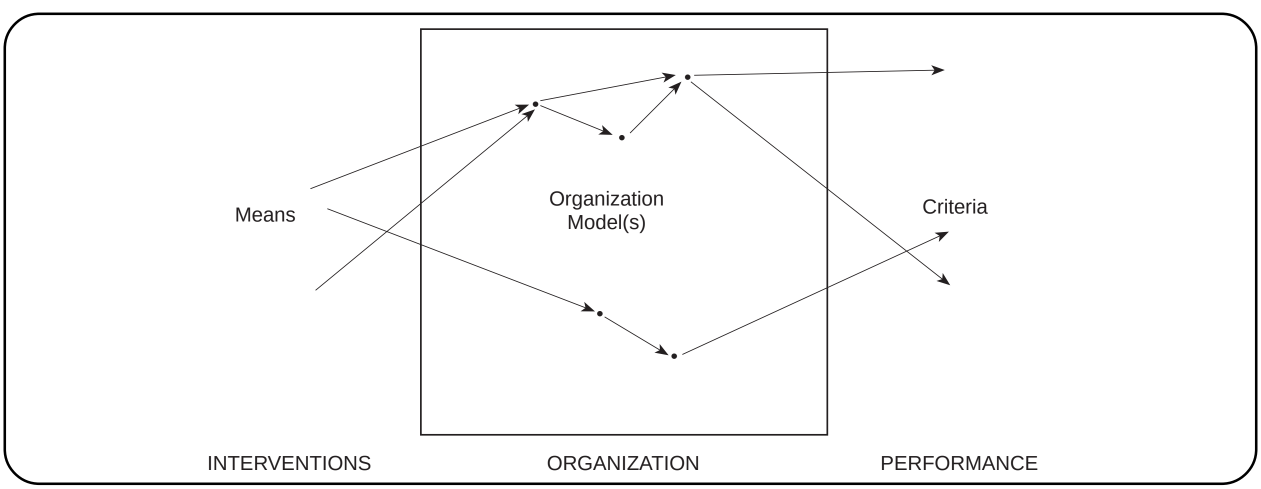

Figure 1.1.11.1. *The contribution of management systems engineering is to take a broad systems view of the organization and how interventions affect performance so we can build and use means to help the organization improve its performance.*

1.1.11.2. DEFINE *MANAGEMENT*

"Decision making [is] synonomous with managing." (Herbert A. Simon, *The New Science of Management Decision)*

Management is one of those words that you can get as many definitions for as you ask people to write definitions. However, the definition we choose will underpin our understanding of the management process. I choose the definition made by Nobel-laureate Herbert A. Simon on page 1 of his landmark book, *The New Science of Management Decision*. I choose this definition because it gives us a foundation upon which we can build a discipline and because we can use it most easily to observe and document the action, or behavior, of management.

Managing is decision making. Decision making involves a process that reflects the scientific method and ends in an observable behavior of choosing among alternatives. We string a series of related decisions together to do problem solving. The people we look to for management engage in functions and activities to prepare for, carry out, and evaluate their decisions. The processes for decision making and problem solving make up the management process.

In the end, managing comes back to the act of decision making. Who makes decisions? Everyone. You've been managing since the day you were born. We'll talk about how well you've been managing later. When a one-year-old child uses information to decide which toy to play with, he or she is making decisions. If you will, the toy is one of the physical things in the child's set of responsibilities, and the child's decision results in an action affecting that toy. Either they chew on it or they don't.

Simon says, "In treating decision making as synonymous with managing, I shall be referring not merely to the final act of choice among alternatives, but rather to the whole process of decision. Decision making comprises three principal phases: finding occasions for making a decision; finding possible courses of action; and choosing among courses of action. These three activities account for quite different fractions of the time budgets of executives. The fractions vary greatly from one organization level to another and from one executive to another, but we can make some generalizations about them even from casual observation. [Simon uses the word *executive* for *decision maker,* or *manager*. He, of course, is writing for decision makers with extreme sets of responsibilities, not for a one-year-old child. So do Peter Drucker in his book, *The Effective Executive*, and Chester Barnard in his book, *Functions of the Executive*.] Executives spend a large fraction of their time surveying the economic, technical, political, and social environment to identify new conditions that call for new actions. They probably spend an even larger fraction of their time, individually or with their associates, seeking to invent, design, and develop possible courses of action for handling situations where a decision is needed. They spend a small fraction of their time in choosing among alternative actions already developed to meet an identified problem and already analyzed for their consequences. The three fractions, added together, account for most of what executives do." (pp. 1-2.)

Compare the economic, technical, political, and social environment comment of Simon to the reward, work, and human subsystems we discussed in module 1.1.4.

Simon further says, "The first phase of the decision-making process—searching the environment for conditions calling for decision—I shall call *intelligence* activity (borrowing the military meaning of intelligence). The second phase—inventing, developing, and analyzing possible courses of action—I shall call *design* activity. The third phase—selecting a particular course of action from those available—I shall call *choice* activity." (pp. 1-2.)

Notice the centrality of the design activity in decision making. In Module 1.1.11.6.2. I'll discuss the centrality of the design activity in engineering. In that both the engineering and the management processes come out of the scientific method, they show similarities. The decision making process is cyclic and recursive.

Simon continues, "Generally speaking, intelligence activity precedes design, and design activity precedes choice. The cycle of phases is, however, far more complex than this sequence suggests. Each phase in making a particular decision is itself a complex decision-making process. The design phase, for example, may call for new intelligence activities; problems at any given level generate subproblems that, in turn, have their intelligence, design, and choice phases, and so on. There are wheels within wheels within wheels. Nevertheless, the three large phases are often clearly discernible as the organizational decision process unfolds. They are closely related to the stages in problem solving first described by John Dewey, (*How We Think*, New York: D.C. Heath & Company, 1910, chapter 8):

> What is the problem?
> What are the alternatives?
> Which alternative is best?

It may be objected that I have ignored the task of carrying out decisions. I shall merely observe by the way that seeing that decisions are executed is again decision-making activity. A broad policy decision creates a new condition for the organization's executives that calls for the design and choice of a course of action for executing the policy. Executing policy, then, is indistinguishable from making more detailed policy. For this reason, I shall feel justified in taking my pattern for decision making as a paradigm for most executive activity." (pp. 3-4.)

Note the cyclic, recursive nature of the decision-making process. Clearly, the management process is cyclic and recursive. Note also the similarity between decision making and problem solving. Sequences and hierarchies of decision making processes make up the problem solving process. Many would argue that the engineering process must reflect the problem solving process. The engineering and management processes come from the same roots. They employ different functions.

Simon further says "A good executive is born when a man with some natural endowment (intelligence and some capacity for interacting with his fellow men) by dint of practice, learning, and experience develops his endowment into a mature skill. ..... There is no reason to expect that a man who has acquired a fairly high level of personal skill in decision-making activity will have a correspondingly high skill in designing efficient decision-making systems." (pp. 4-5.)

Simon's work provides another pillar for management systems engineering.

When Barnard, Simon, Drucker and others focus on executives, they're addressing an audience of managers who have broad responsibilities. As long as they equate executives and the act of decision making, I see beyond the glamour of the word executive and call each of us an executive. I believe that when we look into what Deming and others say about quality, we look to everyone in the organization to be an executive. No one really should be considered more glamorous than any other in our mutual responsibility to make good decisions together in our organization. We each make decisions about our responsibilities and wherever possible we make decisions together about our mutual responsibilities.

In his book *Industrial Dynamics*, Forrester says, "Management is the process of converting information into action. The conversion process we call decision making. Decision making is in turn controlled by various explicit and implicit policies of behavior.

As used here, a 'policy' is a rule that states how the day-by-day operating decisions are made. 'Decisions' are the actions taken at any particular time and are a result of applying the policy rules to the particular conditions that prevail at the moment.

If management is the process of converting information into action, then it is clear that management success depends primarily on what information is chosen and how the conversion is executed. The difference between a good manager and a poor manager lies at this point. ..... The manager sets the stage for his accomplishments by his choice of which information sources to take seriously and which to ignore. When he has chosen certain classes of information and certain information sources to carry the highest priority, the manager's success depends on what use is made of this information. ..... In this book we shall look upon the manager as an information converter. ..... He receives incoming information flows and combines these into streams of managerial instructions. ..... An industrial organization is a complex interlocking network of information channels. ..... Every action point in the system is backed up by a local decision point whose information sources reach out into other parts of the organization and the surrounding environment. ..... Figure 1.1.11.2. shows a decision stream in the simplest framework of an information-feedback system." (pp. 93-94.)

Figure 1.1.11.2. was taken directly from Forrester. I see the manager as occupying the decision box in the figure. The manager receives information from management tools to make decisions with and generates actions from the decisions to affect the work flow, or operation, of his or her responsibility.

You'll see Figure 1.1.11.2. again as several of the ingredients in the Management System Model described in Module 1.1.18.1. Both the components and the feedback loop are important foundations of a model that describes a management system. In Module 1.1.11.5., when I describe a system, you'll find the need for identifying the components and the relationships among the components in a system.

As we think about Forrester's words, we deal with the issue of good decisions—how to do decision making well. Clearly, a necessary, but not sufficient condition for good decision making is good information. Another necessary condition is a good decision making process that acts on good information.

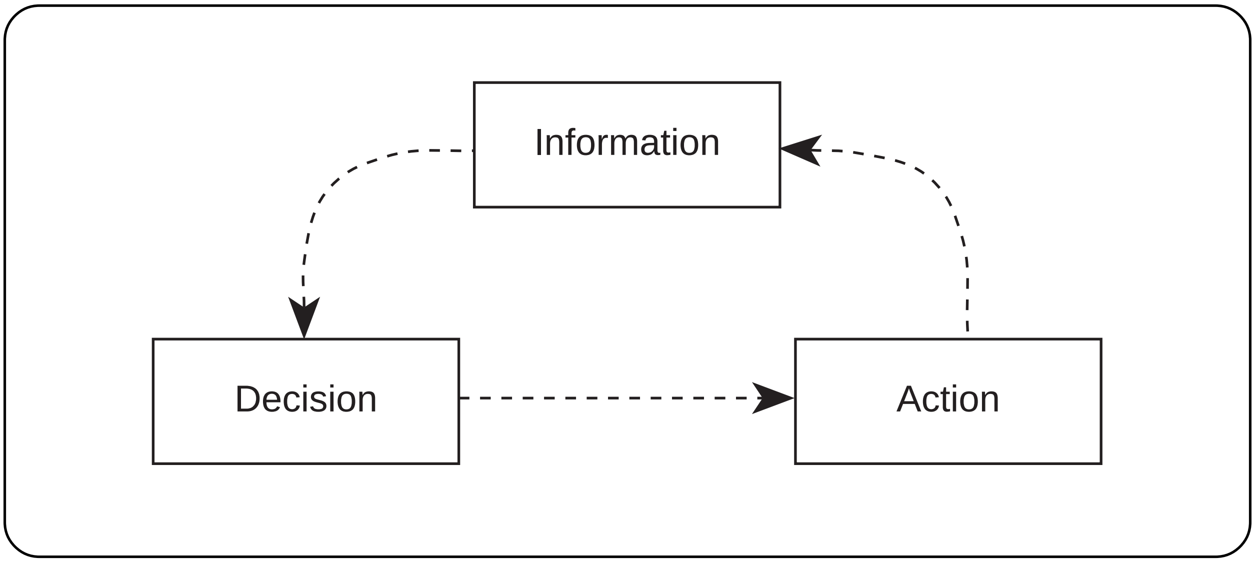

Figure 1.1.11.2. *Forrester's figure shows a decision stream in the simplest framework of an information-feedback system. He places the decision maker squarely between the information the manager needs and the action resulting from the decision.*

1.1.11.3. Consequences of Defining Management as Decision Making—Other Definitions.

Of the dozens of declared definitions of management, managing equals decision making is most useful to us; yet we must know the other definitions to understand and communicate management systems engineering concepts.

The consequences of defining managing as decision making are important. Because of this definition, we can't contrast management and leadership as many authors do—just like we can't contrast apples and automobiles. Managers make decisions. Decisions, when made in a certain role I'll define later provide leadership. Other roles we play as we make decisions include administration, liaison, figurehead, and many others developed by Henry Mintzberg in his landmark paper, *The Manager's Job: Folklore and Fact*, in which he says, "The classical view says that the manager organizes, coordinates, plans, and controls; the facts suggest otherwise." (p. 49.) "... I [define] the manager as that person in charge of an organization or one of its subunits. ..... The manager's job can be described in terms of various 'roles,' or organized sets of behaviors identified with a position. ..... formal authority gives rise to the three interpersonal roles, which in turn give rise to the three informational roles; these two sets of roles enable the manager to play the four decisional roles." (p. 49, HBR 53:4, 1975)

I support Mintzberg's idea of the roles we play as we make decisions. I disagree with Mintzberg's definition of manager. I believe a manager is a decision maker. A supervisor is in charge of an organization. Supervising is another role we play as we make decisions. When supervisors make decisions, they are then managers.

By defining managing as decision making, I lay the foundation for a structured or engineering approach to management. Through the structured approach, you can easily identify the act of decision making and then link decision making acts together in problem solving processes to analyze, design, implement, and follow-up—the activities of engineering. Notice the relationship between and the difference between decision making and problem solving. I'll discuss problem solving in detail in Module 1.5.5.6.

As is the case with Mintzberg, not all authors define management as Simon does. Deming defines management as prediction. (Notes from *Quality, Productivity, and Competitive Position*, a workshop by W. Edwards Deming, September 1992.) Deming's roots begin in the teachings of Walter Shewhart. Shewhart sees prediction (or Deming's management) as one of the components of knowledge. Shewhart says, "In line with the statement quoted from C.I. Lewis at the beginning of this chapter ('... knowing begins and ends in experience; but it does not end in the experience in which it begins.' C.I. Lewis, *Experience and Meaning, The Philosophical Review*, vol. xliii, p. 134, 1934.), I shall assume that knowledge begins and ends in experimental data but that it does not end in the data in which it begins. From this viewpoint, there are three important components of knowledge: (a) the data of experience in which the process of knowing *begins*, (b) the prediction P in terms of data that one would expect to get if he were to perform certain experiments in the *future*, and (c) the degree of belief p_b in the prediction P based on the original data or some summary thereof as evidence E. ..... Knowledge begins in the original data and ends in the data predicted, these future data constituting the operationally verifiable meaning of the original data. Since, however, inferences or predictions based upon experimental data can never be certain, the knowledge based upon the original data can inhere in these data only to the extent of some degree of rational belief. ..... What has just been said about the three components of knowledge may appear to the practical engineer or statistician as being abstract and somewhat formal until he considers how they are met in everyday experience. For example, I might say, 'It's going to rain the day after tomorrow.' That statement has a definite predictive meaning in the sense that you can test it in the future. However, it doesn't convey much knowledge, since I have no standing as a weather prophet. You may therefore ask what makes me think that it's going to rain the day after tomorrow. That is, you *ask for my evidence*. Given the evidence, there is presumably a certain degree of belief p'_b, however small, that may rationally be held in my prediction. *The evidence as well as the prediction must be considered*.

This simple example shows how one may make a perfectly definite scientific statement—one that is meaningful—without conveying much if any knowledge. In fact, I should say that the statement that it is going to rain the day after tomorrow, free of any supporting evidence and the source of the statement, conveys no knowledge at all. The results of experimental work may also be summarized in terms of meaningful statements that do not transmit knowledge, in that the one who reads the summary may not know how much belief to place in it. Likewise one may present a set of original data without making any interpretative statements. Hence, in what follows we must consider ways and means for presenting experimental data in three different ways: (a) as original data, (b) as interpretive predictions, and (c) as knowledge." (Walter A. Shewhart, *Statistical Method from the Viewpoint of Quality Control,* Dover Publications, 1986, pp. 85-86.)

Shewhart's work and the follow-on work of Deming and Juran provide another pillar for management systems engineering. Now we're not only talking about managing but we're talking about managing well. To make good decisions, you'll need good information based on good data in a foundation of knowledge.

Many people like to equate managing with supervising. I don't. When you have people, whom you hire, fire, and adjust salary for, who report to you to spend your defined budget to meet the objectives of the organization your title reads you're the head of, I say you're supervising. You're the supervisor and those who report to you and those who report to them are your subordinates. Those who report directly to you are your direct reports. When you make decisions, you're managing. When your subordinates make decisions, they're managing. When you organize, direct, and control people, you're supervising. Supervising is a role you play as you make decisions; and organizing, directing, and controlling involve making decisions.

Peter Drucker says, "A man who knows only the skills and techniques, without understanding the fundamentals of management, is not a manager; he is, at best, a technician.

Management is a practice rather than a science. In this, it is comparable to medicine, law, and engineering. It is not knowledge but performance. Furthermore, it is not the application of common sense, or leadership, let alone financial manipulation. Its practice is based both on knowledge and on responsibility.

The management boom has proven that the manager must be more than a *technocrat*. He cannot be confined to his discipline, cannot be content with mastery of his skills, his tools, and his techniques.

Management is not culture-free, that is, part of the world of nature. It is a social function. It is, therefore, both socially accountable and culturally embedded." (Peter Drucker, *Management*, Harper and Row, Publishers, Inc., 1973, pp. 17-18 .)

Drucker seems to contradict Forrester when he says management is a practice rather than a science. Forrester says management is moving from an art to a science. Because in management we must deal with people, I believe management will always be a mix, or balance, of art and science. As we understand the science more, we can devote more energy to the art. That's what we want to do in management systems engineering. We want to apply science where science fits so we can gain time and resources to apply art where art fits. Drucker further says, "The question, *What is management?* comes second. First we have to define management in and through its tasks.

There are three tasks, equally important but essentially different, which management has to perform to enable the institution in its charge to function and to make its contribution:

—[defining] the specific purpose and mission of the institution, whether business enterprise, hospital, or university;
—making work productive and the worker achieving;
—managing social impacts and social responsibilities." (pp. 39-40.)

Drucker implies the possibility of a fourth task when he says, "One complexity is ever-present in every management problem, every decision, every action—not, properly speaking, a fourth task of management, and yet an additional dimension: time." (p. 43.)

Drucker adds the dimensions of administration and entrepreneurship to managerial performance. (p. 45.)

He comes closest to a specific definition when he says, "Each of these tasks and dimensions has its own skills, its own tools, its own requirements. But the total management task requires their integration. And this too requires specific work and its specific tool. The tool is management; and the work is managing managers.

The tasks—economic performance; making work productive and the worker achieving; managing social impact and social responsibilities; and doing all this in a balance between the demands of today and the demands of tomorrow—are the things in which the public at large has a stake. The public has no concern with—and only mild interest in—what managers have to do to accomplish their tasks. It rightly is concerned with performance. But managers must be concerned with the means to the accomplishment of their tasks. They must be concerned with managerial jobs, with the work of the manager, with the skills he needs, and with his organization.

Any book of management that does not begin with the tasks to be performed misconceives management. Such a book sees management as something in itself, rather than as a means to an end. It fails to understand that management exists only in contemplation of performance. It treats management as an independent reality, whereas management is an organ which derives existence, identity, and justification from the function it serves. The focus must be on the tasks.

To start out discussing management with the work of the manager or with managerial organization—as most books on management do—is the approach of the technocrat, who soon degenerates into a bureaucrat. But it is even poor technocracy. For, as will be stressed again and again in this book, management work, management jobs, and management organization are not absolutes, but are determined and shaped by the tasks to be performed. *Structure follows strategy* is one of the fundamental insights we have acquired in the last twenty years. Without understanding the mission, the objectives, and the strategy of the enterprise, managers cannot be managed, organizations cannot be designed, managerial jobs cannot be made productive." (pp. 47-48.)

We must separate in our minds the act of decision making and the corresponding action from roles the people with responsibilities play and the tasks they do within their work and management processes. Decision making is the key ingredient in all the roles and the tasks and is the fundamental act in the roles and tasks. The roles and tasks then define the decisions to be made. Drucker is asking not that we just make decisions as management but that we make the right kinds of decisions. This point is very important. I, however, want to separate the decision making act from the roles, tasks, and processes. The reasons are that we don't force management on only a few people playing certain roles and we can easily identify a decision (the act of management) through the consummation of the decision process—a choice.

Montana and Charnov have a much shorter definition of management in their book, *Management*. "In 1969, the President of the American Management Associations (AMA) used this definition of management: 'Management is getting things done through other people.'

Now look at a current definition: '**Management** is working *with and through* other people to accomplish the *objectives* of both the organization and its members.'

What are the differences between the two?

There are three key differences that should be highlighted. The more recent definition

1. places greater emphasis on the human being in the organization

2. focuses attention on the *results* to be accomplished, on objectives, rather than just things or activities

3. adds the concept that accomplishment of the members' personal objectives should be integrated with the accomplishment of organizational objectives.

In looking at the current definition, we come to the conclusion that management is both a science and an art. We also have to view the manager as an individual." (p. 2.)

Once I limit management to the act of decision making, I also emphasize the significance of the decision maker and the decision making process. I consider supervision as the act of working with and through other people. In fact, one of the pillars of the management process is the relationship among people. In this regard, Autry's definition of management is crucial and ties directly to what I choose to call supervision. Autry says, "*Management is, in fact, a sacred trust in which the well-being of other people is put in your care during most of their working hours. It is a trust placed upon you first by those who put you in the job, but more important than that, it is a trust placed upon you* after you get the job *by those whom you are to manage*...A promotion to manager can give you authority, but not power. It is the people you are to manage who will give you power; by their actions and response, they will bestow power on you, but only if they trust you to use it well.

So management is a matter of being 'in relationship.' This is one of the most overlooked and misunderstood principles in management.

Wherever did we get the notion that, in management, there is a reasonable and acceptable separation of the intellect and the spirit—that, in our work-world terms, the intellect controls the rational work life and the spirit is relegated to the soft stuff of romance, family, and religion? Where did it come from, all this hiding of emotion, of the spirit, of passion, behind some cool mask of macho detachment? I wonder if it is that business is considered too important to be diluted by all those feelings, or is it that business is not considered important enough to deserve them? Either way is wrong." (James A. Autry, *Love and Profit: The Art of Caring Leadership*, Avon Books, 1991, p. 19.) So, you'll not manage (or in my terms, supervise) if you don't have trust. You won't get trust if you aren't trustworthy.

In considering the several definitions and what managers do, be careful to distinguish results, performance, objectives, tasks, and process. I'll discuss these ideas later as we get into successful management and engineering.

In his article on the management theory jungle, Harold Koontz describes six major schools of management theory. (Harold Koontz, The Management Theory Jungle, *The Academy of Management Journal*, December 1961, pp. 174 - 188.) His first school, the management process school is the traditional or universalist school of Fayol and Taylor and mixes the art and science of management. His second school, the empirical school relies on experience and anecdotal evidence as viewed through cases. These two schools support the idea of a management system, which I'll model in Module 1.1.18.1.

Koontz's third school, the human behavior school, recognizes the importance of people as individuals in organizational settings. His fourth school, the social system of March and Simon and of Barnard sees people acting in groups. These two schools relate to the importance of people and their social system in organizations. People both manage and are managed in organizations.

Koontz's fifth school, the decision theory school focuses on the decision process and is the center of the management process associated with a management system. His sixth school, the mathematical school is the foundation of operations research and management science and supports at least one category of management tools managers use to support their decision making.

In his discussion on disentangling the management theory jungle, Koontz's says, "...I have come to the conclusion that management is the art of getting things done through and with people in *formally organized groups*, the art of creating an environment in such an organized group where people can perform as individuals and yet cooperate toward attainment of group goals, the art of removing blocks to such performance, the art of optimizing efficiency in effectively reaching goals."

I'll end what could become an indefinitely long discussion of other definitions of management by quoting Babcock's discussion. "McFarland traces the meaning of the words *manage* and *management* as follows:

The word *manage* seems to have come into English usage directly from the Italian *maneggiare*, meaning 'to handle,' especially to handle or train horses. It traces back to the Latin word *manus*, 'hand.' In the early sixteenth century *manage* was gradually extended to the operations of war and used in the general sense of taking control, taking charge, or directing .... *Management* was originally a noun used to indicate the process for managing, training, or directing. It was first applied to sports, then to housekeeping, and only later to government and business." (Dalton E. McFarland, *Management: Foundations and Practices*, 5th ed., New York, Macmillan Publishing Co., 1979) *Mane* means with your hand. *Giare* means guiding. Then *maneggiare* means guide with your hand as in training horses. (Personal communication with Gery Patzak.)

McFarland continues by identifying 'four important uses of the word *management*, as (1) an organizational or administrative process; (2) a science, discipline, or art; (3) the group of people running an organization; and (4) an occupational career.' Sentences illustrating each of these in turn might be (1) 'He practices good management'; (2) 'She is a management student'; (3) 'Management *doesn't really believe* in quality'; and (4) (heard from innumerable college freshmen) 'I wanna get inta management.' Of these four, most authors of management textbooks are referring to the first meaning (the *process*) when they define 'management.' According to some of these authors, management is:

- The work of creating and maintaining environments in which people can accomplish goals efficiently and effectively (Albanese)

- The process of achieving desired results through efficient utilization of human and material resources (Bedeian)

- The process of reaching organizational goals by working with and through people and other organizational resources (Certo)

- The process of planning the decision making, organizing, leading, and controlling an organization's human, financial, physical, and information resources in an efficient and effective manner (Griffin)

- The process by which managers create, direct, maintain, and operate purposive organizations through coordinated, cooperative human effort (McFarland)

- The process of acquiring and combining human, financial, informational, and physical resources to attain the organization's primary goal of producing a product or service desired by some segment of society (Pringle, Jennings, and Longbecker)" *(Managing Engineering and Technology*, Prentice-Hall, 1991, pp. 8-9.)

Notice the frequency with which these authors classify management as a process. I consider management to be decision making within a process I call the management process. The management process contains a series of functions, some for building management tools and some for using management tools.

In this book, managing is decision making—nothing more, nothing less.

1.1.11.4. The Framework for the Management Process

When we act on the organization, we change its performance and we should monitor that change and feedback what we've learned to improve our interventions.

The management process is keyed to the decision making of the manager. The management process is a cyclic, recursive set of steps for continuously improving performance. Figure 1.1.11.4. shows the framework for the management process. In Figure 1.1.11.4., I've extended the ideas from Figure 1.1.11.1. I'll expand Figure 1.1.11.4. further to continually disclose the details of the management process and building and using management tools. The next expansion of Figure 1.1.11.4. is in Modules 1.1.21.2., 1.1.21.4., and 1.1.21.8. in preparation for the illustrative model in Module 1.1.29.1.

The framework in Figure 1.1.11.4. has a dual personality. Understanding the dual personality is crucial for dealing with the management process. The center block of the figure is the organization. The duality comes from the question of whether the organization (center block) is just the physical operation of the organization or, on the other hand, includes the physical operation, the manager, and his or her management tools. The first view is good for studying the productivity and the work flow of the organization. The second view is good for studying decision making and the conversion of data to information to support decision making. In a way, the second view is from outside the organization (the view of a consultant using consulting interventions) and helps work on the organization. This view helps build management tools for the decision maker. The first view is from inside the organization (the view of the manager using management interventions) and helps work within the organization. This view helps use management tools by the decision maker.

Building management tools isn't just an outside job. Building tools is a cooperative effort between the user/manager and the information specialist (expert), with the information specialist playing a key role in between the analysis and implementation stages of building tools. For building management tools, the manager provides understanding of himself or herself and of the physical operation of their responsibilities. To do this well, the manager with the information specialist view the organization from outside. Likewise, using management tools isn't just an inside job. Using tools is also a cooperative effort between the user/manager and the information specialist (expert), with the information specialist playing more a monitoring, evaluation role.

As you look at Figure 1.1.11.4., you'll see dual views by placing yourself on the feedback arrow in the figure. The feedback arrow closes the loop between performance criteria and interventions for continuous performance improvement. When I discuss the 14 management process functions, they'll be in the organization block. You'll view the five building-management-tool functions from outside the organization and see the functions as being inside the organization block. For building management tools, the interventions of the left block are aimed at everything in the organization, including the decision maker and the tools of interest. The performance criteria of the right block for this view are organizational performance, a synergistic combination of operational, personal, and tool performance.

You'll view the nine using-management-tool functions from inside the organization and, as in the case for building tools, see the functions as being inside the organization block. For using management tools, the interventions of the left block are aimed at the physical operation (capital, labor, equipment, materials), not including the decision maker and the management tools. The performance criteria of the right block for this view are operational performance criteria.

Figure 1.1.11.4. is the fundamental system or input/output model, where the input is interventions (not capital, labor, equipment, or materials) and the output is data and information (not capital, labor, equipment, or materials). The left block for interventions has been expanded to show that theory, tools and their guides, rules for using the tools, skill for using the tools, and technique for putting theory, tools, and skill together are the interventions we'll apply to the organization. The arrows from the interventions show that the tool and skill we apply affect the organization in different ways in different places. The effect of the intervention can have a rippling effect in the organization. The intervention can affect one part of the organization, which, in turn, can affect another part of the organization. The arrows from the organization to the performance criteria show that effects on the organization will affect the performance of the organization, which is the objective of making the intervention. Later, I'll discuss a number of different sets of performance criteria. For now, the figure just shows the criteria as numbers.

In Figure 1.1.11.4. we should consider interventions to be decisions and actions affecting the organization. The performance criteria start as indicators, reference points, and standards. To accomplish the feedback, we'll need to measure the indicators to yield data and information for decision making. Note that the cycling of decisions, actions, and information as shown in Forrester's model in Figure 1.1.11.2. is preserved in this figure.

The cycling replicates the psychologist's ABC (antecedent, behavior, and consequence) model. This consistency reinforces the working of the management process framework. The organization model(s) embody the functions of the management process and the behavior of the organization.

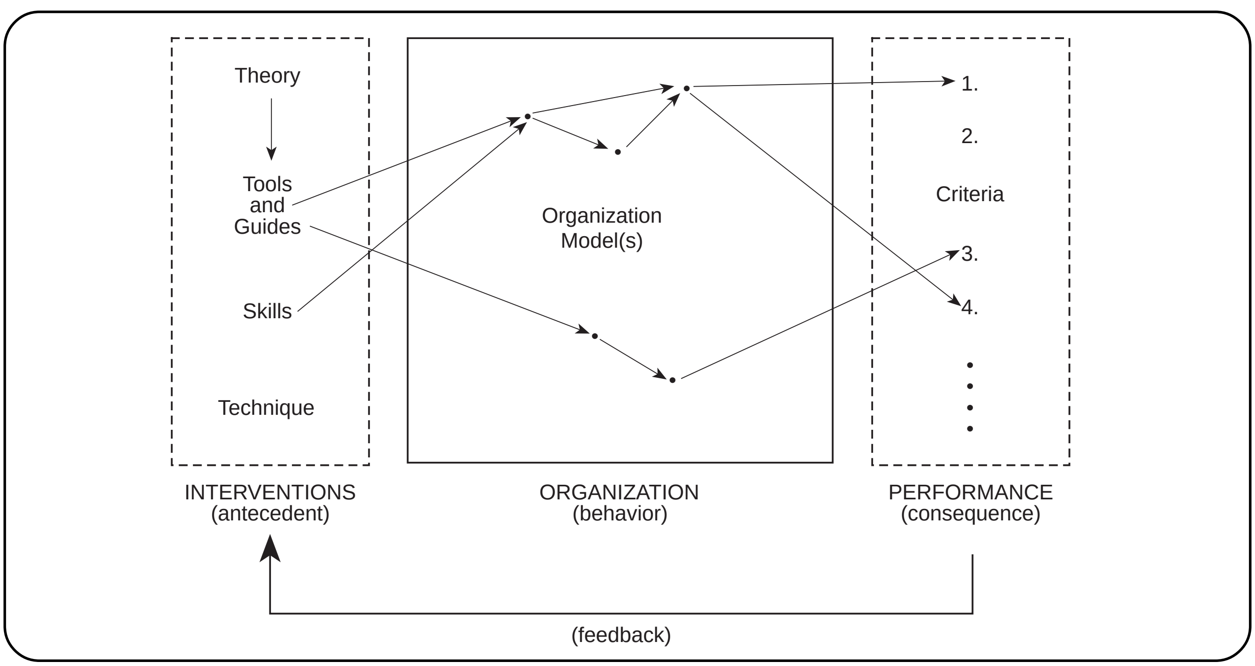

Figure 1.1.11.4. *The management process framework is a traditional system or input/output model with interventions as input and data on performance as output. The manager converts the data and information into improved interventions for the organization. Depending on viewpoint, the manager/decision maker can be the builder or the user of the tools and guides.*

1.1.11.5. Define *System*

The organization is a system involving one or more processes for changing input into output, resulting in throughput, with all components working toward a common aim and with performance measures to determine progress toward the aim.

Systems understanding is a way of thinking, involving the closely related but subtly different concepts of a system, a process, and the systems approach. In management systems engineering, we're looking at the organization as a system. I'll define a system here and flesh out the systems understanding in later modules when I discuss a process and the systems approach.

In their book, *Systems Engineering and Analysis*, Blanchard and Fabrycky define systems. "A *system* is an assemblage or combination of elements or parts forming a complex or unitary whole such as a river system or a transportation system; any assemblage or set of correlated members such as a system of currency; an ordered and comprehensive assemblage of facts, principles, or doctrines in a particular field of knowledge or thought, such as a system of philosophy; a coordinated body of methods or a complex scheme or plan of procedure, such as a system of organization and management; any regular or special method or plan of procedure, such as a system of marking, numbering, or measuring. (This definition was adapted from J. Stein, ed., *The Random House Dictionary of the English Language*, New York: Random House, Inc., 1966.) Not every set of items, facts, methods, or procedures is a system. A random group of items lying on a table would constitute a set with definite relationships between the items, but they would not qualify as a system because of the absence of unity, functional relationship, and useful purpose." (Benjamin S. Blanchard and Wolter J. Fabrycky, *Systems Engineering and Analysis*, Prentice-Hall, Inc., 1990, p. 2.) The inclusion of purpose is especially applicable for systems made by people. Experts debate whether natural systems are purposeful.

Blanchard and Fabrycky describe the elements of a system. "Systems are composed of components, attributes, and relationships. These are described as follows:

1. *Components* are the operating parts of a system consisting of input, process, and output. Each system component may assume a variety of values to describe a system state as set by control action and one or more restrictions. [I prefer *represented by* to *consisting of* in the definition of components.]

2. *Attributes* are the properties or discernible manifestations of the components of a system. These attributes characterize the parameters of a system.

3. *Relationships* are the links between components and attributes.

A system is a set of interrelated components working together toward some common objective. The set of components has the following properties:

1. The properties and behavior of each component of the set has an effect on the properties and behavior of the set as a whole.

2. The properties and behavior of each component of the set depends upon the properties and behavior of at least one other component in the set.

3. Each possible subset of components has the two properties listed above; the components cannot be divided into independent subsets.

The properties given above ensure that the set of components comprising a system always has some characteristic or behavior pattern that cannot be exhibited by any of its subsets. A system is more than the sum of its component parts. However, the components of a system may themselves be systems, and every system may be part of a larger system in a hierarchy." (pp. 3-4.)

Figure 1.1.11.5. illustrates a system. You can see the general form for Figures 1.1.11.1. and 1.1.11.4. in this figure. The previous figures had specified inputs and outputs. In Figure 1.1.11.5., you see the system as a box acting as a transfer function from the inputs to the outputs. Within the system, you see three subsystems, or components, depending on your perspective. Each of the subsystems has inputs and outputs and with a defined purpose meets the definition of a system. The relationships are the arrows and the only defined attribute of the components in the figure is their number. If they had color, size, age, or responsible person defined for them, those would also be attributes.

For organizations, we often characterize the inputs and outputs as CLEM, for capital, labor, equipment, and materials. Some people add information and energy as inputs and outputs. Because of our interest in management tools, we'll focus on information within the system, so we'll handle that particular input with care. For example, we'll distinguish between information generated internal and external to the organization.

Blanchard and Fabrycky also talk about purpose, function, and hierarchy of systems. "The objective or purpose of a system must be explicitly defined and understood so that system components may provide the desired output for each given set of inputs. Once defined, the objective or purpose makes it possible to establish a measure of effectiveness indicating how well the system performs. Establishing the purpose of a man-made system and defining its measure of effectiveness is often a most challenging task.

The purposeful action performed by a system is its *function*. A common system function is that of altering material, energy, or information. This alteration embraces input, process, and output. Some examples are the materials processing in a manufacturing system or a digestive system, the conversion of coal to electricity in a power plant system, and the information processing in a computer system. .....

Every system is made up of *components*, and yet any of the components can be broken down into smaller components. If two hierarchical levels are involved in a given system, the lower is conveniently called a *subsystem*. For example, in an air transportation system, the aircraft, terminals, ground support equipment, and controls are subsystems. Equipment items, people, and information are components. Clearly, the designations of system, subsystem, and component are relative, since the system at one level in the hierarchy is the component at another.

In any particular situation it is important to define the system under consideration by specifying its limits or boundaries. Everything that remains outside the boundaries of the system is considered to be the *environment*. However, no system is completely isolated from its environment. Material, energy, and/or information must often pass through the boundaries as input to the system. In reverse, material, energy, and/or information that passes from the system to the environment is called *output*. That which enters the system in one form and leaves the system in another form is usually called *throughput*." (pp. 4-5.)

When dealing with continuous performance improvement in organizations, W. Edwards Deming treats the organization as a system. He says, "A system is an interconnected complex of functionally related components that work together to try to accomplish the aim of the system.

A system must have an aim. Without an aim, there is no system. The aim of the system must be clear to everyone in the system. The aim is a plan for the future. The aim is a value judgment. [Of course, I consider an organization to be a system made by people.]

There will be a conflict of interests in setting the aim of a system. The buyer of an automobile seeks low cost, safety, economy of operation, comfort, room, speed, style. There must be judicious compromises in settling on the aims of the system that consists of the maker of the automobile, his suppliers, the customer that buys the automobile, regulations of speed and traffic signals.

Every living being has two aims. Does the tiger [have] an aim? Yes. He has two aims: 1. the good life for today; 2. propagate—ensure that there will be tigers in the future. He is accordingly a component in a system. In fact, he is the only component, if we think of only the tiger. If we think of tigers as one member of wildlife, then he belongs to a larger system. With human intelligence, might translate into English his aim for the good life today:

1. To become a great hearth-rug.
2. To stabilize the number of deer in the forest.
3. To stabilize the number of inhabitants of the village.

Is your organization a system? A company or other organization may have buildings, desks, equipment, people, water, telephones, electricity, gas, municipal services. But is it a system? In other words, is there an aim?

With some companies, because of short-term thinking, the only aim is survival for the day, with no thought about the future. They fall short of the aims of the tiger." (pp. 35-37, handout from *Dr. Deming's Plan for Action for the Optimization of Service Organizations*, May 1992, Washington, D.C.)

Deming also says, "A system must be managed. The bigger the system, the more difficult it is to manage it for optimization.

The performance of any component within a system is to be judged in terms of its contribution to the aim of the system, not for its individual production or profit, not for any other competitive measure." (p. viii, Deming's foreword in Sherkenbach's *Deming's road to Continual Improvement*.)

In discussing systems, components, and optimization Deming says, "If the parts are optimized, the system will not be. If the system is optimized, the parts will not be." (notes from *Instituting Dr. Deming's Methods for Management of Productivity and Quality*, January 1992.) This idea of optimization has profound effects on how to manage an organization as a system.

In this book, we're going to look at the organization as a system, with its components, attributes, relationships and subsystems. We're also going to look at the organization with the systems approach, including process, purpose, and models.

The definition of a system isn't all there is to understanding systems. I'll round out (add to) our understanding of systems later when I discuss the complementary notions of the systems approach and a process.

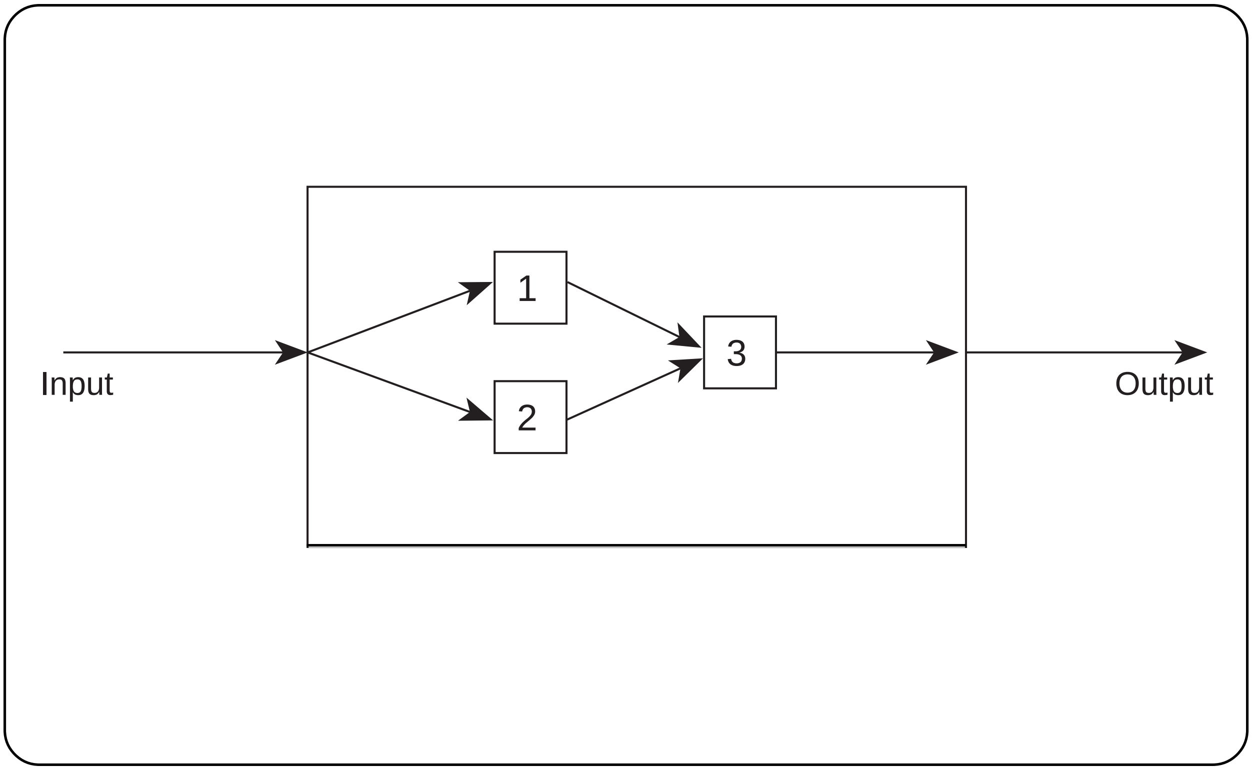

Figure 1.1.11.5. *A system converts input into output and contains subsystems or components with attributes and relationships. The aim of the system is hard to show in a diagram, but the aim is important too, especially for a system made by people.*

1. BACKGROUND

1.1. INTRODUCTION

1.1.11. A NEW (OLD) DISCIPLINE

1.1.11.6. RELATE ENGINEERING TO THE ENGINEERING PROCESS

1.1.11.6.1. DEFINE *ENGINEERING*

Engineering is a profession involving people who profess the engineering process for analyzing, designing, implementing, and following-up applications for the benefit of people based on natural laws and structured procedures for collecting, converting, and conserving energy.

Engineering is a profession. Engineering also defines a process based on using natural laws to create, understand, describe, and be responsible for application-oriented products and services from which people derive benefit. Someone in the engineering profession should be able to engineer something. We need to distinguish between the profession and the process at least to the point we can determine if those people we know in the engineering profession are in fact practicing the engineering process. Simply stated, someone in the engineering profession has a degree in engineering or is certified as an engineer. An important question is whether or not the person is good at the engineering process.

Engineering is providing a new solution while science provides more insight into the world. Science deals with discovery and engineering deals with creation of solutions for applications.

All engineers deal with energy or its related variables—force, power, and work. For electrical engineers, it's electrical energy. For mechanical engineers, it's mechanical or thermal energy. For chemical engineers, it's thermal or chemical energy. For management systems engineers, it's motivational or human energy. As a result, we can consider forces on an organization, power within an organization, and work of an organization. As engineers, we understand the natural laws so we effectively collect, convert, and conserve energy.

Descriptions of engineering include derivatives from ingenuity to engines. The Random House Dictionary defines an engineer as, "a person versed in the design, construction, and use of engines or machines, or in any of the various branches of engineering; a person who manages an engine or a locomotive; a skillful manager." The verb is "to arrange, manage, or carry through by skillful or artful contrivance." Webster's Ninth New Collegiate Dictionary adds, "to guide the course of."

The action of engineering implies a process for doing that action. We would assume anyone in the engineering profession to be proficient at the engineering process. But this isn't always the case. For this reason, I've separated my discussion of engineering (the profession) from the engineering process. I'll discuss the engineering process in Modules 1.1.11.6.3. and 1.1.11.6.4.

Figure 1.1.11.6.1. extends the ideas from Figure 1.1.9.2. In Figure 1.1.11.6.1., I've expanded the representation of the application system, because I believe the engineer focuses on the application he or she intends to benefit people. I believe the engineer focuses on the application system to the detriment of the engineering process. I believe the benefit to the application system would be greater if the engineer put more energy into the engineering process. If the application system is a mechanical system, the natural laws and science are most likely those of physical science. If we expand the mechanical system to include its environment or the people involved in building or operating the system, the natural laws and science include the life or social sciences. The human-made system has an aim related to meeting the needs of the user. In Figure

1.1.11.6.1., I've shown a process associated with the application system. The process brings steps or functions containing components, parts, tools, and guides to work together to meet the system's aim. (The dotted lines for boxes representing some of the steps signify that not all processes are cyclic; but the best ones are.) I'll further expand Figure 1.1.11.6.1. in Module 1.1.11.6.3.

To describe engineering, I'll start with definitions and statements from a standard engineering fundamentals textbook: Arvid R. Eide, Roland D. Jenison, Lane H. Mashaw, and Larry L. Northup, *Engineering Fundamentals and Problem Solving*, McGraw-Hill Book Company, 1979. They say, "In the 1963 Annual Report of ECPD, the following definition of engineering appears.

Engineering *is the profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practice, is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind*.

In the National Council of Engineering Examiners' Model Law, the following statement is found.

Engineer *shall mean a person who, by reason of his special knowledge and use of mathematical, physical, and engineering sciences and the principles and methods of engineering analysis and design, acquired by education and experience, is qualified to practice engineering*. [The problem with this definition is that it's circular. As such, we don't learn what engineering is all about from it.]

Both the engineer and scientist are thoroughly educated in the mathematical and physical sciences, but the scientist primarily uses this knowledge to acquire new knowledge, whereas the engineer *applies* the knowledge to design and develop *usable devices, structures, and processes*. (italics added) In other words, the scientist seeks to know, the engineer aims to do." (pp. 6-7.)

Definitions of engineering always stress the application orientation of the profession and the aim to benefit humankind. They also always stress the practice of design. The focus of this book on management systems engineering is on the design and development and the implementation of management tools and processes to benefit organizations and decision makers.

Eide et al further say, "You might conclude that the engineer is totally dependent on the scientist for the knowledge to develop ideas for human benefit. Such is not always the case. Scientists learn a great deal from the work of engineers. For example, the science of thermodynamics was developed by a physicist from studies of practical steam engines built by engineers who had no science to guide them. On the other hand, engineers have applied the principles of nuclear fission discovered by scientists to develop nuclear power plants and numerous other devices and systems requiring nuclear reactions for their operation. The scientist's and engineer's functions frequently overlap, leading at times to a somewhat blurred image of the engineer. What distinguishes the engineer from the scientist in broad terms, however, is that the engineer often conducts research, but with a definite purpose in mind." (p. 7.)

Disciplines and professions are based on fundamentals. Fundamentals are the ideas, principles, and vision of the discipline. I believe the fundamentals of engineering relate to the engineering process. I'll describe the engineering process fundamentals in Module 1.1.11.6.4. I think the profession doesn't practice the fundamentals of the process very well.

The fundamentals and the need for dealing with energy are generally similar but specifically different among a nuclear reactor, an automobile assembly plant, and an insurance company. The fundamentals, structure, natural laws, science and math, and aim you need to learn are those of the domain, or the application system. In a petroleum refinery, you need chemistry and physics. In a controller's office you need finance, psychology, and sociology.

The technical specialization and the application characteristics of the traditional image of an engineer can be constraining to people who want to practice engineering. This constraint is highlighted in a paper by Frederick Nils Bennett, when he discusses what he calls the engineering career trap and says, "Engineering is an honourable, and for some, fully satisfying profession, but for others it can be a career trap. I have often found engineers without other strings to their bow to be in the position of the 'expert' on tap, but not on top. To fulfill their potential or to satisfy their ambition many engineers will have to go beyond engineering into management or administration. To climb to the top of the business or government ladder they will find it necessary to make the transition to management and management is a multi-disciplinary activity; no task for a 'Johnny One Note' engineer.

'That is no problem' you may say. There are any number of engineers who have successfully made the transition to management of large business enterprises and government agencies. It is true that some gifted and highly motivated persons succeed in that way but for every one of those there are a dozen more trapped in their specialization, frustrated that their advice is not accepted, and complaining bitterly that in their field of work important decisions are controlled by the dreaded 'bean counters'." (Frederick Nils Bennett, "Beyond Engineering", *The Australian Project Manager,* vol. 12, no. 1, February/March 1992.)

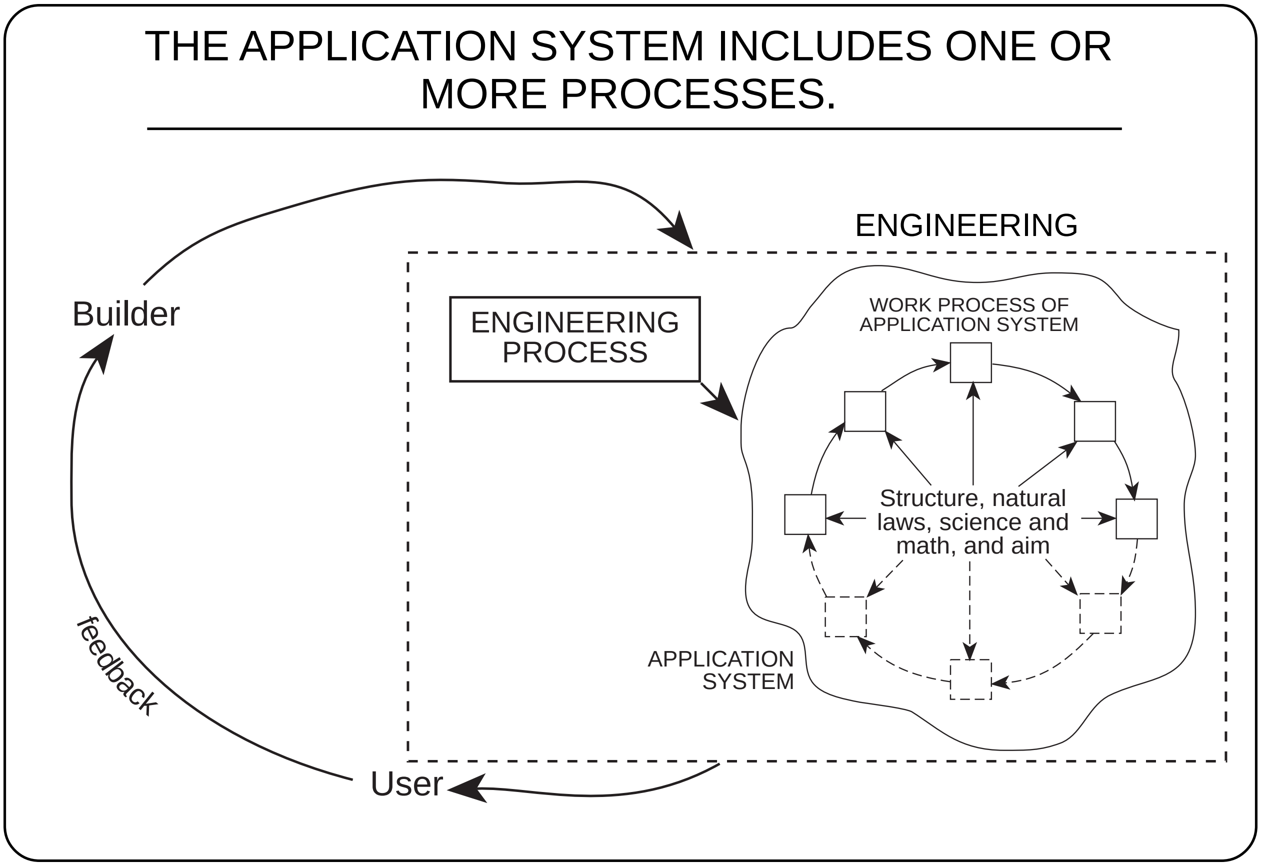

Figure 1.1.11.6.1. *The engineer focuses on the application system distinguishable by its structure, aim, and the natural laws, science, and math needed to understand cause and effect within the application.*

1.1.11.6.2. The Centrality of Design

At the centers of both the engineering process and the decision making process, the design process is a cyclic, recursive process based on the scientific method allowing for learning and continuous improvement.

Many engineers believe the end result of their effort is design—both the process and the product. However, engineers do much more. First, if there is an end result, I believe the result must involve the satisfaction of the user's need. Second, if the engineering process is cyclic and recursive, like the process shown in Figure 1.1.9.1., then design is a step, or function, in the cycle. I will say that design is central to the engineer's activities. Design is what engineers do. The rest of the functions in a cyclic engineering process, which I'll describe in Modules 1.1.11.6.3., 1.1.11.6.4., and 1.1.11.7., prepare for design, apply the design, follow up on the application, and learn from the application.

The design process within the engineering process is similar to the decision making process within the management process. Each is central to the other functions in a learning cycle for continuous improvement. Just like engineers do design, managers do decision making. Recall my discussion of the centrality of decision making in management in Module 1.1.11.2. Recall also Simon's discussion of the centrality of design in the decision making process, also in that module.

Eide et al say, "The end result of an engineering effort—generally referred to as design—is a device, structure, or process which satisfies a need. A successful design is achieved when a logical procedure is followed to meet a specific need. The procedure, called the *design process* (italics added) is similar to the scientific method with respect to a step-by-step routine, but it differs in objectives and end results. The design process encompasses the following activities, all of which must be completed.

1. Identification
2. Definition
3. Search
4. Establishment of criteria
5. Consideration of alternatives
6. Analysis
7. Decision
8. Specification
9. Communication

In the majority of cases, designs are not accomplished by an engineer's simply completing the nine steps shown in the order given. As the designer proceeds through each step, new information may be discovered or new objectives may be specified for the design. If so, the designer must backtrack and repeat steps. For example, if none of the alternatives appear to be economically feasible when the final solution is to be selected, the designer must redefine the problem or possibly relax some of the criteria to admit less expensive alternatives. Thus, because decisions must frequently be made at each step as a result of new developments or unexpected outcomes, the design process becomes iterative." (pp. 7-8.)

Later, I'll place the design process within the engineering process. In dealing with systems and processes, we'll always deal with subsystems and subprocesses. The design process is similar to the engineering and the management processes in the cyclic, recursive nature of the process.

Eide, et al list the functions of an engineer as: research, development, design, production and testing, construction, operations, sales, management, consulting, and teaching. (p. 17-22.) You'll find some overlap with my functions of the engineering process. However, I consider the engineering process to consist of more than just functions. Also, notice that design is but one function of the engineer.

Eide et al define design and process by saying, "A simple definition of design is: to create according to a plan. A process, on the other hand, is a phenomenon identified through step-by-step changes that lead toward a required result. Both these definitions suggest the idea of an orderly, systematic approach to a desired end. Figure [1.1.11.6.2.] shows the design process as continuous and cyclic in nature. This idea has validity in that many problems arise during the design process that generate subsequent designs. You should not assume that each of your design experiences will necessarily follow the sequential steps without deviation. Experienced designers will agree that the steps as shown are quite logical; but on many occasions, designers have had to repeat some steps or perhaps have been able to skip one or more." (pp. 326-327.)

I've used Eide et al's figure for the design process here as Figure 1.1.11.6.2. to show the cyclic, iterative nature of the processes in engineering and management. The engineering and management process are similar in that they both relate to the scientific method.

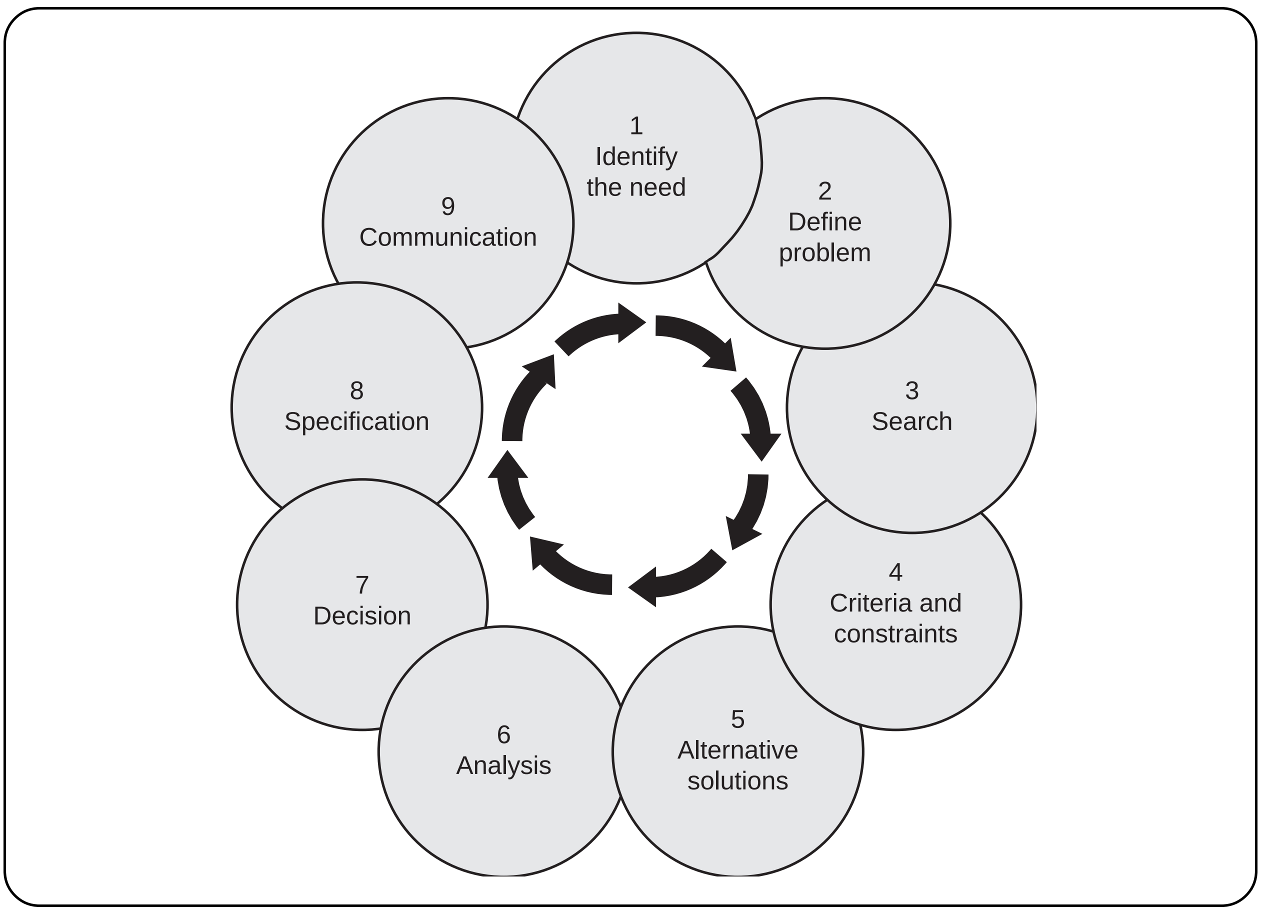

Figure 1.1.11.6.2. *The engineer's design process shows the cyclic, iterative nature of processes we use for continuous improvement in meeting a system's aims. (taken from Eide et al)*

1.1.11.6.3. The Engineering Process

There's a difference between the engineering profession and the engineering process. The same can be said for management and the management process.

The Engineering Process and the Total Application System

Engineer is used here as a verb. Engineering is something we do to analyze, design, build, use, improve, and retire systems. All systems should be engineered with a balanced approach. Management systems especially need to be engineered with a balanced approach because the key components of the management system are human beings. To carry out the action of engineering, we can develop and use a generic process—the engineering process—tuned to the type of system we're engineering.

The application system is the object of the verb. We always engineer a system. The question is: What kind of system are we interested in, how does it differ from other systems, and what does the difference mean in terms of natural laws and applicable science (e.g., physical, life, and social sciences)? We must understand what we're working on. What is the unit of interest? That is, what is the system we're going to engineer? We don't want to suboptimize or misoptimize by engineering a part of the system of interest or by engineering some other system than the system of interest.

Management is the adjective telling us the kind of system we intend to engineer. The solution this book proposes for addressing the time-honored, fundamental management questions described in Module 1.1.4. is to recognize and characterize the organization as a management system, or an application system, and to apply the engineering process to that system and to the management tools used in that system. This book proposes management systems engineering.

In Figure 1.1.11.6.3., I expand the concept of the application system I showed in Figure 1.1.11.6.1. I've highlighted the difference between the management process and the work process. The work process is what you manage and the management process is what you do to manage. Therefore, the plant components of a chemical process, including capital, labor, equipment, and materials (CLEM) working according to natural laws form functions, or steps, of a chemical process we manage to produce products. I call the work process the core application system, because I'll argue later that we want to apply the engineering process to more than just the work process. We want to apply the engineering process to the management process too. So, I've shown the management process acting on the work process, or the management process acting on the core application system, all comprising the total application system. The point of Figure 1.1.11.6.3. is that to do the engineering process right we must apply that process to the entire system we're trying to benefit—the total application system.

Note the following considerations from Figure 1.1.11.6.3. 1) You'll have systems within systems. 2) The core application system specifies the structure, natural laws, science and math, and aim of the object of the engineering process. 3) The example chemical system has one or more chemical processes and, like other systems in other disciplines, can, and should, include environmental system processes. 4) The example chemical system is a component of a management system, which has a management process. 5) You apply the engineering process to the core application system or the management process, depending on the unit of interest. I'll discuss the importance of the unit of interest in Module 1.1.14.3.

The engineering process aims to convert matter and energy guided by fundamentals and governing natural laws into beneficial orientations within the application system to serve a user by supporting, joining with, and assuming the nature of the application system.

Just as the chemical process includes a number of operations, which we can neatly categorize into functions, the management and engineering processes also include functions. Learning the functions of a process is a necessary but not sufficient condition for becoming good at the process. To complete our understanding of these processes, we must learn about ways of thinking, like the systems approach, and we must learn the rules for conducting the functions. Processes include functions and rules guiding the functions and a way of thinking oriented to the aim of the process.

The functions of the management process involve both management tools and the guides for using the management tools. The work process, or the physical operation you manage, also includes tools: operations tools. What we do in the management and engineering processes is supported by tools. The rules and the functions, embodying the tools and guides, are conducive to steps of a process, the most effective of which are cyclic, recursive steps to promote learning and improvement. You'll find both the engineering and management processes involve cyclic, recursive steps. Figure 1.1.9.1. illustrates the cyclic nature of the management and engineering processes that is so important for learning and continuous performance improvement. Sequences of steps are relatively easy to visualize and draw and to scrutinize for repeatability, completeness, and validity. The rules and approaches that embody or overlay the functions aren't as easy to visualize, and take dwell time to absorb as part of our understanding.

My job in this book is to include an understanding of both the engineering and management processes, their functions, rules, and their ways of thinking. In management systems engineering, you don't first do a management process and then an engineering process, or vice versa; the functions and approaches of both are intertwined. Therefore, I'll disclose the functions and approaches of the management and engineering processes in the sequence I feel best supports learning management systems engineering.

The Difference between The Engineering Profession and the Engineering Process

I claim there's a difference between the engineering process and the engineering profession (and a difference between the management process and the management profession). Many people not in the engineering profession practice the engineering process very well and many people in the engineering profession don't practice the engineering process very well. Of course, I feel this situation is unfortunate. Engineers ought to be very good at the engineering process.

Lou Middleman, the author of the writing text, *In Short*, likes to tell the story that one time I told him he was an engineer. When he tells the story, he feels he needs to explain why I would call a person with degrees in math and English an engineer. He says, "Harold thinks anything dealing with engineering is good. He likes me and thinks I do good work. Therefore, he calls me an engineer." The truth is: Lou Middleman practices the engineering process but he isn't part of the engineering profession.

Some of the people who are best at the engineering process are physicists. I feel the reason they're so good at the engineering process is because they understand the laws of nature in their gut. They really learned sophomore physics. As a consequence they could walk through a plant and smell out the relationships and consequences of the many laws and principles intertwined at play in the workings of the plant. They could design, build, and follow-up with tools and equipment based on the principles to meet the needs of the plant. They practice the engineering process but aren't part of the engineering profession.

A good engineer, and also a good manager, must be able to walk the workplace and see how natural laws work together to get the best performance from the application system. This engineer or manager must understand cause and effect among all the system's parts and between the parts and the whole. Understanding cause and effect requires profound knowledge.

I believe there are sociologists, psychologists, and teachers who can walk through an organization and smell out the relationships and consequences of the many intertwined laws and principles at play in the human-oriented workings of the organization. When they apply these principles through the scientific method to the design, implementation, and follow-up of improvements in the organization within the context of the systems approach, they're practicing the engineering process.

I had a dentist who practiced the engineering process. I've known artists, clergy, physicians, and farmers who practiced the engineering process. In my heart, I believe the engineering process is more important than the engineering profession. I would like for this book to contribute to making the engineering process more a part of the engineering profession and to convince engineers they can learn and practice the engineering process in cooperation with people of different educational and certification backgrounds.

In the engineering process we holistically mix (balance) the system life cycle functions guided by the systems approach. The systems approach is based on a deep-rooted understanding for and appreciation of the laws of nature (both science and environment) under the objective of making application for the benefit of people. We consider the application throughout its life cycle.

The problems we address in the world are complex combinations of many factors. We can identify a number of good solutions to the problem. Because of the complexity of the problem, finding the very best solution is difficult if not impossible. In practicing the engineering process, we know the balance for choosing one of the short list of good solutions and for searching for the best solution. Often, we can use a good solution and solve a problem for less time and energy than we would spend finding the best solution.

Who has an understanding of and appreciation for the laws of nature? Under the risk of generalizing, I'll argue I've met three groups who excel at the laws of nature. First, the indigenous people, and then physicists and farmers.

I'm learning of the artists from Leonardo to Cézanne to my oil painting teacher who understand that before you can paint a tree well you must know how a tree works and how and why trees differ among species, during seasons of the year, during their life cycle, what grows in and on them, and so on. To paint a building, bridge, automobile, or person, you have to have the same depth of understanding of the laws of nature applying to what you're painting. Now we know why artists like Rembrandt, Leonardo, Durer, and Michelangelo studied and painted cadavers—so they could learn the workings of the human body and paint live people.

Apply the Engineering Process Properly to the Right Thing

I discuss the domain of responsibility as a management consideration and the unit of interest, or application system, as an engineering consideration. They're really similar issues. Both are intended to ensure you focus on the system, subsystem, or component you're responsible for. You don't want to work on the wrong thing.

Understanding the aim of the application system and how all the components of the system fit together to serve the whole and the cyclic, recursive relationship of all the functions in the engineering and management processes are prerequisites for applying tools and techniques effectively and efficiently. If you don't know the fundamentals of the engineering process, the structure, natural laws, science and math, and aim of the core application system; and the fundamentals of the management process, you'll confuse techniques with principles and not use the technique based on a principle that reflects the needs of the user.

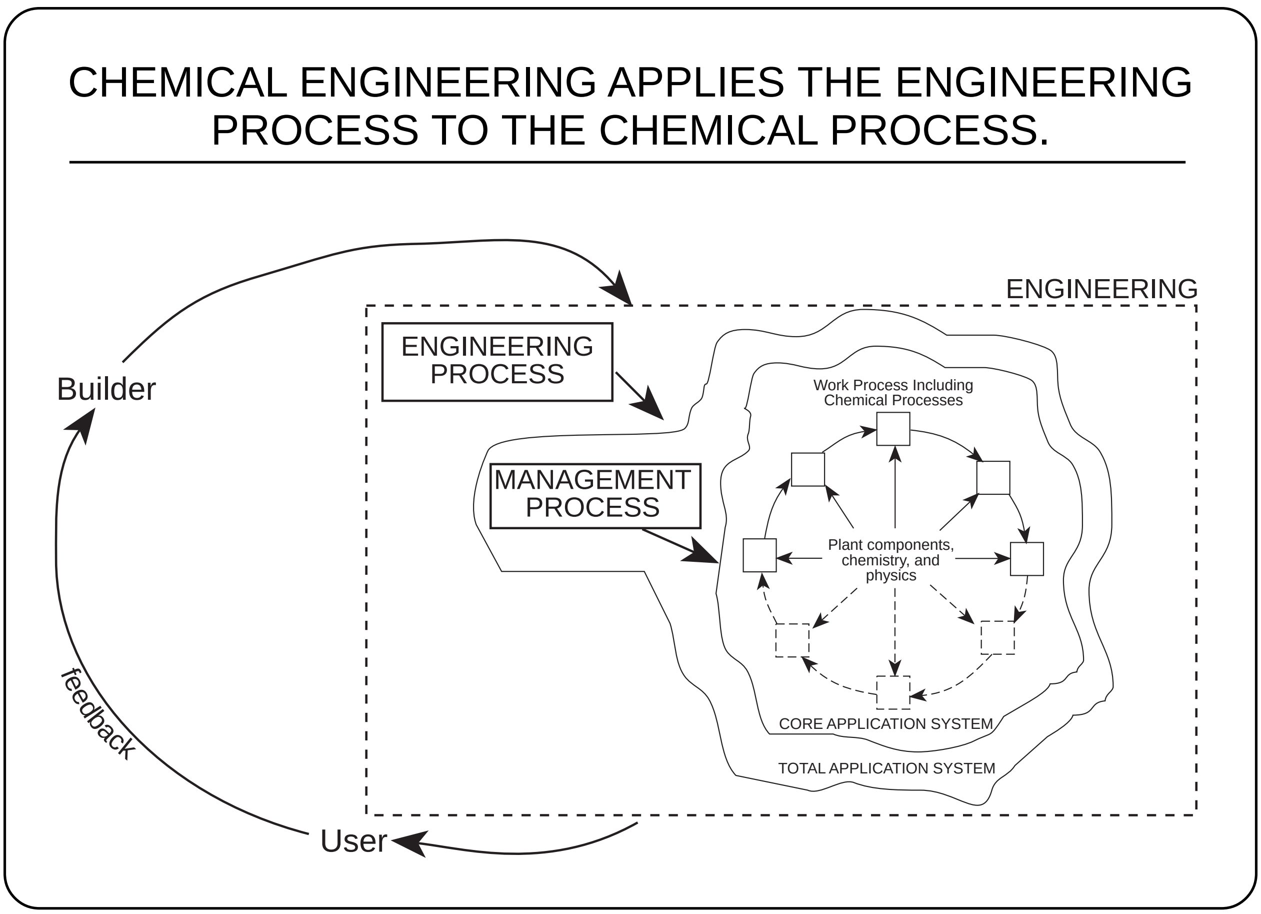

Figure 1.1.11.6.3. *We must apply the engineering process to the total application system we're working to benefit, comprising both the work process, or core application system, and the management process that overlays the work process.*

1.1.11.6.4. Fundamentals of the Engineering Process

You must know and practice the fundamentals first, most, and best to practice the engineering process because the fundamentals are the threads that weave throughout the fabric of the engineering process.

Webster defines a fundamental as, "one of the minimum constituents without which a thing or a system would not be what it is; serving as a basis supporting existence or determining essential structure or function." (Webster's Ninth Collegiate Dictionary) The Random House College Dictionary adds, "a basic principle, rule, law, or the like, that serves as the groundwork of a system; essential part." The fundamentals of the engineering process are the building blocks, without which we wouldn't have the engineering process. We can't practice engineering without understanding the fundamentals of the engineering process.

One way to characterize engineering is through its fundamentals. We use the fundamentals to understand specialties we synthesize through the design process. We use the fundamental of an energy balance to understand thermodynamics we synthesize with mechanics and other specialties into the design of a steam engine.

What are the fundamentals of the engineering process? Or, what knowledge and skills do you need to practice the engineering process? I list twelve: 1) language for communication, 2) problem solving and the scientific method, 3) drawing and understanding connections, 4) the systems approach as a way of thinking, 5) walking the workplace (application system), 6) the system life cycle as the framework of the engineering process, 7) envisioning and imagination, 8) the collecting, converting, and conserving of energy, 9) knowledge of the lessons of the past, 10) the philosophy of the aims of the engineering process and the application system, 11) teamwork, professionalism, and empowerment, and 12) dedication to continuous, vigorous, life-long learning. I'll expand on each of the fundamentals in the following paragraphs.

Language for Communication

We learn language through mathematics and English (I'll include art as a language for us in this book.) We also learn graphics (engineering drawing) and computer languages for communication. Language is a system we use in conjunction with the process of communication, whose aim is the transfer of information. Language is the system by which you capture ideas and information and transfer the ideas and information to others.

Because you're applying natural laws for the benefit of humans and their environment, you must understand language for communication. Engineering is the link between the builder and the user as shown in Figure 1.1.6.2. And the user must provide feedback to the builder for evaluation and improvement of the application system. The engineering process, which is crucial to the practice of engineering as shown in Figure 1.1.11.6.1., requires a cycle, and the cycle requires communication. You must be able to communicate using mathematics and models, graphics and other visual displays, computer programming, and verbal sending (writing and speaking) and receiving (reading and listening). This thread is the largest (We spend the most time on it.) and most tightly interwoven of all threads in the fabric.

In communication, you must be able to "write it down and write it up." When you use words (text) or symbols (math) to think through a situation, you're "writing it down." When you use words or symbols to communicate a situation, you're "writing it up." Because they have different purposes, "writing it down" and "writing it up" are quite different activities. "Writing it down" takes a good deal of "scaffolding" to set up and hold up ideas until you get the kernel built. When you find and complete the kernel, you must strip away the "scaffolding" before you can communicate what you have ("write it up"). Communication is itself a process. Language is a system we use in conjunction with the process of communication, whose aim is the transferring of information. "Writing it down" is transferring information from the recesses of your mind into some more-tangible form and "writing it up" is transferring information from you to someone else.

Problem Solving and the Scientific Method
Because you're making things better by taking action, you must know how to diagnose and solve a problem, know how to use the scientific method and design experiments, and practice and balance deductive and inductive reasoning (including strong inference). In diagnosing a problem, you have to identify and define the problem. Most "problem solvers" work up elegant solutions to the wrong problem. The user prefers a mediocre solution to the right problem over an elegant solution to the wrong problem. The engineering process requires the ability to focus on the application system and distinguish the problem to be solved. To be this kind of problem solver, you must have a responsible attitude, be open minded, and have an open and honest approach. The Arizona State report on engineering education plays on Peter Drucker's distinction between effectiveness and efficiency by saying "engineering undergraduate curricula prepare engineers to deal almost exclusively with [the question 'Are we designing the thing right?'] while seriously neglecting [the question 'Are we designing the right thing?']" (*Engineering Education: Preparing for the Next Decade*, A Study by The Engineering Curriculum Task Force, p. 47.).

Drawing and Understanding Connections
Through connections you can integrate and synthesize. The ability to consider technical, social, economic, environmental, and many other aspects of a problem is valuable. To see relationships and decipher cause-and-effect relationships among the aspects is even more valuable. Most valuable is to be able to connect components or ideas at an even deeper level. In her book *Leadership and the New Science*, Margaret Wheatley tries to shift our focus from things toward connections and systems. "Donella Meadows, a systems thinker, quotes Sufi teaching that captures this shift in focus: 'You think because you understand *one* you must understand *two*, because one and one makes two. But you must also understand *and'* (1982, 23). When we view systems from this perspective, we enter an entirely new landscape of connections, of phenomena that cannot be reduced to simple cause and effect, and of the constant flux of dynamic processes." (Margaret J. Wheatley, *Leadership and the New Science: Learning about Organizations from an Orderly Universe*, 1992, Berrett-Koehler Publishers, San Francisco, p. 9.) To be a generalist or think like a generalist, you must start by drawing and understanding connections. (I discuss the generalist perspective in modules 1.1.27.7. and 1.1.27.8.)

In the engineering process you must integrate as well as differentiate. You must synthesize as well as analyze. The systems approach involves both analysis and synthesis, both the Newtonian model of the world and the new holistic view of the world. (See my discussion on the role of integrator in Module 1.1.27.2.).

The Systems Approach as a Way of Thinking
Because all applications are systems, you must know how to think in systems terms, including

the system, holistic, and generalist perspectives. The system perspective emphasizes the components, their relationships, and the necessary role each plays in meeting the system's aim. The holistic perspective emphasizes the gestalt in the system and its aim. The generalist perspective emphasizes consistency among systems and the transferability of lessons learned from one system to another. In practicing the systems approach, the three perspectives are harmoniously blended into one integrated way of looking at the world. With the three perspectives, we recognize the importance of each component, the supremacy of the aim or purpose, and the significance of learning. Under the systems approach, you must perform both analysis and synthesis activities and you must balance synthesis with analysis. (By balance I mean get the right mix, not make equal). The engineer must see the total system and be able to strip out the confusing, nonessential complexity to get to the essence of the situation.

Walking the Workplace (Application System)

Because the application system embodies the aim of the engineering process, you must know the structure (components, attributes, and relationships), natural laws, science and math (physical, life, social, mathematical sciences), and purpose (or aim of the application system) of the application system so well you can "feel" the cause-and-effect relationships of the application processes.

The System Life Cycle as the Framework of the Engineering Process

Because we always engineer a system, the system life cycle is important. Everything is a system with a process. The framework of the engineering process shows the steps, or functions, you must be able to do to carry out the engineering process. The framework is supported by rules and ways of thinking that show how to do the functions. The framework includes the system life cycle functions and the design process functions. Design is the stage of the system life cycle the other stages support. The closure of the cycle allows the concepts of re-engineering and green engineering in the engineering process. To do the framework functions of the engineering process, you must know project management. Project management is required for application process and for performance improvement. Completion and improvement of the application process and its performance is the reason for the engineering process. You must be able to design an application system or its products and services to perform throughout the system life cycle. You must design the system to operate. You must design the system to manufacture. And you must design the system to decommission, disassemble, decontaminate, restore, and remediate.

Envisioning and Imagination

Because the engineering process requires ingenuity, innovation, and creativity, you must be able to envision and to imagine. When we learn descriptive geometry, we learn to envision. We have to see in our minds what the intersection looks like when we intersect an object with a cone, for example. Suzaki says, "The history of mankind has taught us that if we can imagine it, we can make it." Envisioning and imagination are needed throughout the engineering process.

The Collecting, Converting, and Conserving of Energy

All application systems function by collecting, converting, and conserving some form of energy. Mechanical systems include mechanical and thermal energy. Chemical systems include chemical, mechanical, and thermal energy. Biological systems include these forms of energy. Organizational systems include motivational energy. By viewing energy in its broadest context, no system functions without energy. For example, in the engineering process, you have to be able to transfer the idea of entropy and the First Law of Thermodynamics to biological and organizational systems. Consider also that collecting, converting, and conserving energy should be extended to mass, momentum, electrical charge, etc.

Knowledge of the Lessons of the Past
You perform the functions of the engineering process better because of knowledge of lessons of the past. That's why experienced users of the engineering process are better problem solvers. You gain lessons of the past through history, case studies, and anecdotes related to both the engineering process and to the application system. When you learn from history, you understand more than events; you learn societal perspective of the impact of technology and the engineering process and you learn the economic perspective of financial issues related to events. In short you balance technical, societal, and economic perspectives.

The Philosophy of the Aims of the Engineering Process and the Application System
If you don't know the purpose, aim, or meaning of the application system, you can't improve it. You'll most likely work up an elegant solution to the wrong problem. Without the philosophy of the engineering process and the application system you can't diagnose the problem.

Teamwork, Professionalism, and Empowerment
Because the engineering process seldom is an individual activity, you must know and practice teamwork, professionalism, and empowerment. Teamwork carries the need for interpersonal skills and an understanding of group dynamics. A successful team functions as a cooperative community exhibiting team spirit and mutual goals. (See, for example, James A. Autry, *Love and Profit: The Art of Caring Leadership*, Avon Books, 1991, pp. 79-81.) For success in teams, you must work well with diversity and have a sense of grace, style, and civility. You must feel a genuine caring for and intimacy with the work, the user, nature and its laws, and, most of all, the people involved in the application and its engineering. Caring and intimacy relate to affection for, and trust of, people and nature. You must be able to distinguish and balance cooperation and competition, especially in relation to quality. You must know and practice professional and ethical standards, requiring an understanding of social, ethical, political, and human responsibility. To succeed at these practices, you must display integrity, maturity, judgment, responsibility, and caring.

For teamwork and empowerment, you must be able to confront issues with yourself and others. You must be able to understand and resolve conflict (between one person and another, one workflow and another, or one material and another).

You must achieve balance between your relationship competency and your technical competency. You must exercise passion and intimacy in balance with your competence and integrity.

Dedication to Continuous, Vigorous, Lifelong Learning
Because the engineering process must be cyclic to be successful through continuous performance improvement, you must have a motivation and capability to continue the learning experience on the job and through extracurricular readings, meetings, workshops, and degree programs. The concepts of quality and total quality management enter the engineering process through the cycle of continuous learning and improvement.

How Well Do We Know or Teach the Engineering Process?
If you accept all or part of my twelve funda-

mentals of the engineering process, the question now is whether anyone can do the engineering process without them. Or at least do the process well. Can a person only learn these fundamentals on the job through experience, or can we supply the principles and knowledge behind these fundamentals in college so the learning curve isn't so steep on the job? Consider the fifth fundamental: the framework of the engineering process. I believe we can teach the system life cycle and its 21 functions. I believe we can teach the basics and the tools of project management. Sure, you'll learn these faster on the job; but I remember my embarrassment and frustration when I found a book on project management after I'd spent two years being a project manager and learning the hard way. With the principles and basics in hand before I started, I believe I'd have learned more and faster on the job.

I've listed a series of questions below to test whether we now produce graduates who have any understanding of the engineering process.

1) Can he or she envision (for problem solving and for leadership) and imagine (prerequisite for doing)?

2) Can he or she communicate—both "write it down" and "write it up?"

3) Can he or she do synthesis as well as he or she does analysis?

4) Can he or she make connections among things or ideas and see beyond cause and effect?

5) Can he or she design for disassembly and clean up as well as he or she designs for assembly (for operation and manufacture)?

6) Can he or she practice the systems approach (system—with integration and differentiation, holistic, and generalist thinking)?

7) Does he or she understand system concepts like: "If the parts are optimized, the system won't be."

8) Can he or she figure out what problem to solve so he or she solves the right problem?

9) Can he or she intelligently select when to go with a good solution rather than putting more time and energy into searching for the best solution?

10) Can he or she walk the workplace and understand cause and effect (government offices, banks, hospitals, and insurance companies as well as manufacturing plants and chemical processing plants)?

11) Can he or she logically construct an approach to a problem founded on basic principles stemming from the laws of nature in addition to transferring the experience of solving a similar problem to the problem at hand?

12) Can he or she manage a project to improve a process or performance?

13) Can he or she balance art and science?

14) Can he or she figure out the system of interest so he or she doesn't suboptimize or misoptimize the system by engineering the wrong thing?

15) Can he or she rapidly switch between working in qualitative modes and quantitative modes?

16) Does he or she understand the effect of the management process on the application system, thereby affecting the engineering process (e.g., increasing the amount and rate of change and the diver-

sity of the problems)?

17) Does he or she understand, or have the potential to understand, human nature and the beauty and laws of nature?

18) Can he or she contribute to a team working as a community, bound by a fellowship of endeavor, committed to goals, and dedicated to the quality of commitment and effort in which people take care of one another?

19) Can he or she think and act on an ethically moral level?

20) Can he or she see useful purpose in what he or she is doing?

21) Can he or she balance lessons of history or experience with theory, innovation, and imagination?

22) Does he or she practice standards of ethics and professionalism?

23) Does he or she intend to continue learning forever because he or she is excited and enthusiastic to do so?

If we understand and can practice the fundamentals well, we can learn to do well at the engineering process, which requires the integration and synthesis of the fundamentals. I'll argue that the same twelve fundamentals are the ones for the management process, although the techniques might be different. Instead of converting mechanical or electrical energy, supervisors convert human energy in the form of motivation. Supervisors see human energy dissipate from friction in the form of conflict. The fundamentals are the same and the processes are similar. However the functions and the application systems are different. When we learn the fundamentals and the application system and their sameness for engineering and management and when we learn the functions of the engineering process and of the management process, we'll be able to fulfill our potential or satisfy our ambition as engineers, managers, or management systems engineers.

The twelve fundamentals and associated skills are diffuse and are best suited to teach throughout the curriculum, starting with freshmen. Possible exceptions to this diffuseness include project management skills, which can be taught as a course as well as throughout the curriculum. In either case, the relationships among and the principles behind the project management tools as they work in a complete project management process are more important than training the use of specific tools. When the skills for the twelve fundamentals are taught, they're spot taught and students forget them after a semester or two because they're not reinforced throughout the curriculum. People learn them better on the job because the organizational culture reinforces them. To teach the engineering process, we must overcome compartmentalized learning.

The fundamentals of the engineering process are the roots of the tree. We use the roots for stability and sustenance. If we build a good root system, the tree will bear fruit. The engineering process can be applied to any application system. Instead of concentrating only on the core application system, graduates will be stronger and more productive if they understand the engineering process fundamentals.

Where do you see the fundamentals of the engineering process practiced? If you answer activities like scouting, the hospitality industry, school systems, and other practices considered to be outside the engineering profession, you can see how much we have to learn from others about our discipline.

Figure 1.1.11.6.4. extends Figure 1.1.11.6.3. by showing the engineering process as a cycle of functions, all being driven by the engineering process fundamentals. By applying the engineering process through its fundamentals

to the total application system, we can engineering either applications of traditional disciplines like chemical and mechanical engineering or the management systems by which we manage the core application systems. In Module 1.1.20.1., I'll describe the 22 functions of the engineering process as a closed cycle. In Module 1.1.11.7., I'll group the engineering process functions into five categories showing the ability of the engineering process to achieve continuous improvement.

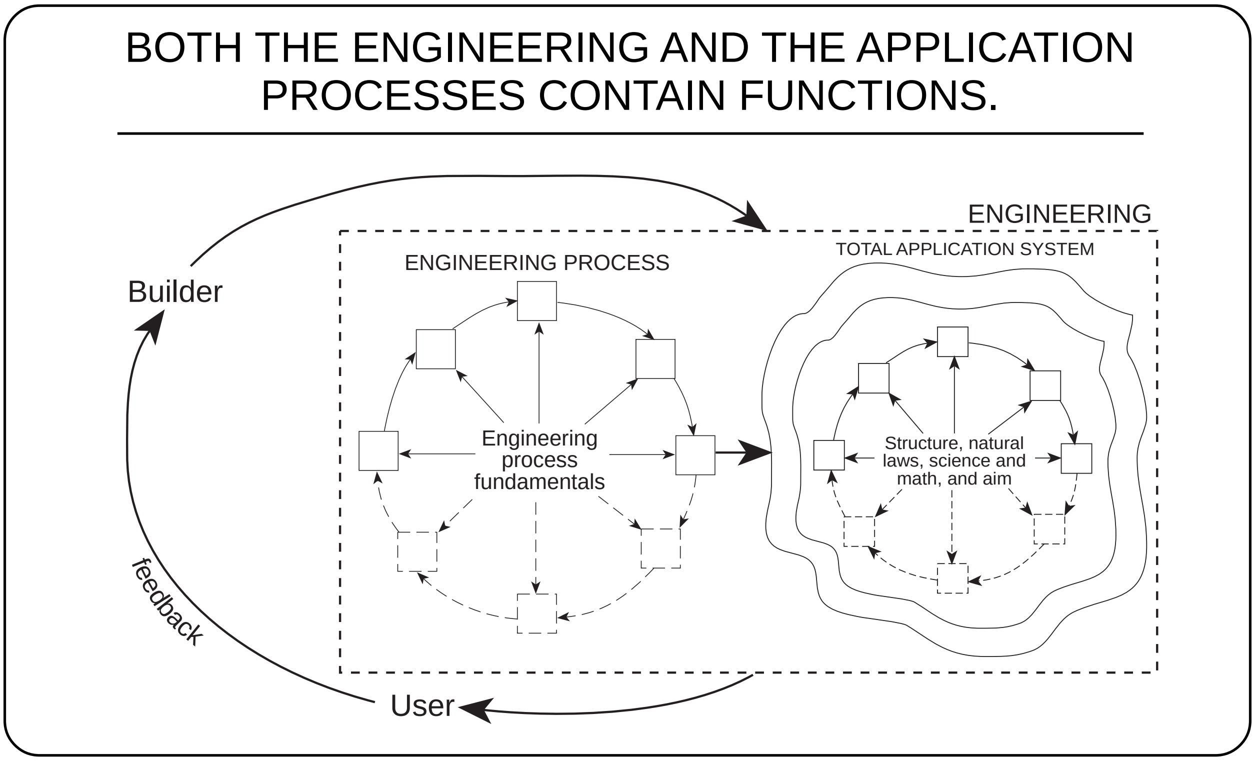

Figure 1.1.11.6.4. *Through its fundamentals, we apply the engineering process to the application system to benefit the user. The engineering process, the application process, and the builder-user feedback loop provide for learning and improvement.*

1.1.11.6.5. Teaching and Learning the Engineering Process and Management Systems Engineering

Unfortunately, engineers aren't necessarily educated or trained to be good at the engineering process or to understand management systems engineering.

Given the amount and importance of technology in our daily lives, engineering should be the liberal education of today. But engineering won't be if we teach engineering more as a profession than as a process balancing art and science. I believe a liberal education is one where we prepare a student for the world they'll inherit by instilling a thirst for the learning process and introducing them to a comprehensive understanding of fundamental laws and principles behind people, technical, and economic systems. The world they'll inherit surely includes technology and everything from the refrigerator at home to the computer in the workplace. In engineering we're requiring courses in humanities. The only problem is that we don't show the connection and importance to the engineer's world and we don't practice the connections as role models.

In education in the United States, we do too much training of the discipline as a professional school and not enough education of the approach and the process as an evolving stage of thinking in dealing with the world and its problems and opportunities. The engineering approach is today's liberal education and needs art for engineers and technology for social scientists to be implemented successfully by people in those professions.

In chemical engineering, we learn both about the chemical process and the operations making up a chemical process and about the engineering process. In management systems engineering, we must learn about both the management process and about the engineering process. I claim (with some degree of support in the literature) that management schools don't teach management students the management process very well and engineering schools don't teach engineering students the engineering process as well as they should. The consequence is that the people we expect to have profound knowledge of these crucial processes don't. I believe we have to support and learn from those who do know and practice the processes. We also need to make sure we don't neglect the fundamental processes when we teach engineering and management. I worry that in our effort to teach the fundamental knowledge and practices we fail to teach the process.

I'm concerned that our design courses don't adequately teach the fundamentals of the systems approach. One of the tenets of a system is that it must have an aim—a purpose. The aim carries us beyond the *what* to the *so what*. The aim is philosophical. All our systems ultimately involve people; that's where the application part of engineering is consummated. We need to know the psychology and sociology of people as individuals and in groups.

The issue of focusing on the right unit of interest, or right application system, is a huge issue. I believe as engineering faculty most of us turn out extremely bright, hard-working young people who go out into the world and work diligently to produce perfectly elegant solutions to the wrong problem. We never teach young professionals how to figure out what the problem really is or what to focus on. So they reach into the quiver of solution techniques we teach them and pull out the arrow that they understood best in school or the arrow that was the favorite of their best teacher.

For the most part, engineering faculty do teach tools and techniques for solving a wide range of problems. However, we don't teach how to select the right technique based on determining the absolutely right problem and how to integrate the right tools and techniques to solve the more-complex problems of today. We depend on on-the-job-training to teach these things. But what about the education behind the on-the-job-training? We have to teach the principles and fundamentals behind figuring out the right problem and using the right techniques. We won't be able to teach this understanding of the right problem, selecting the right technique, and integrating tools and techniques until we teach the systems approach, the engineering process, and the management process.

Management systems engineering is a discipline, like electrical engineering, and as such needs courses focusing on the core application system—the organization, the management system, the management process, management tools, and performance improvement. When these discipline-oriented courses are combined with the traditional mathematics, physical science, and applied with math and science courses of engineering and with management, social science, and applied statistics and business courses, we have a management systems engineering discipline. However, these courses or this type of instruction doesn't improve our understanding of the engineering process.

The fundamentals of the engineering process are best learned when integrated—really when they are subsumed or dominate—into the existing courses of the engineering (or other disciplines) curriculum. The system life cycle should be learned early and continuously. The cycle applies to everything. Learning how to communicate comes when we change the way students participate in class and on homework and tests. The systems approach must be disclosed continuously throughout all courses. Most engineering process fundamentals won't be learned well without effective role models. You can't help a person learn a way of thinking or a way to approach the world if you don't think or approach the world that way yourself. Most engineering process fundamentals aren't recipes to follow (Plug numbers into this formula and get the prescribed answer.) or tasks to do. The fundamentals are ways of being that must be shown through attitudes and behavior in all facets of our life. Those who are good at the engineering process don't just practice those fundamentals part of the time in their office or on the job in the field.

As we consider the way to teach the engineering process, I must share a lesson I learned from my father. He said, "We can't teach anything. We can only help people learn." Today I recognize there's more to the story. If we help someone do something, we can cause more harm than good. Therefore, I say we must *support* people as they learn. Peter Senge, in his book, *The Fifth Discipline* (The book introduces organizational learning; but the fifth discipline is systems thinking.) quotes Bill O'Brian of Hanover Insurance, who says, "[Hunger for learning] is as fundamental to human beings as the sex drive.' (p. 14.) If people are driven to learn, our job is to support them and to remove barriers. When we help them we stifle their hunger, their individuality, and their self-empowerment. When we teach them, we do nothing. (I learned the concept of supporting versus helping from Kellie Wells of First Union Bank.)

How do we support people as they learn? Most of all we set good role models and demonstrate the fundamentals through our attitudes and behaviors. Then we provide information and experiences from which people can derive their own understanding of the fundamentals. Then we provide opportunities for people to try out the fundamentals so they can study the results and the process of what they tried.

The consequences of not supporting people as they learn the engineering process and its fundamentals are frightening. In engineering education, we fixate on the core application system to the detriment of everything else. We ignore the management process. Therefore, we don't understand the total application system we're dealing with. We short-shrift the engineering process. The consequence of these practices is that engineers have trouble switching core application systems. That is, aeronautical engineers can't switch to mechanical engineering applications when the aeronautical industry is depressed. Chemical engineers wouldn't think of applying their abilities and experience to manufacturing engineering needs. Mechanical engineers and electrical engineers don't see the similarities between the control systems they work on and the organizational systems that are trying to deal with disturbances and optimize their operation. (I'll discuss the organization as a control loop in Module 1.1.21.9.) If we emphasize the engineering process and its fundamentals, we empower the flexibility to apply that process to any application system.

I believe management systems engineering tends to emphasize the engineering process because of the wide range of seemingly different application systems we deal with. While banks, chemical plants, government offices, and manufacturing plants are all organizations with similar characteristics, they seem different because of their markets and products. Also, management systems engineering is influenced by the more-qualitative and social science differences in the application system, thus focusing attention on the broad nature of the engineering process fundamentals.

In Figure 1.1.11.6.5., I've emphasized the engineering process by indicating the groups of functions in the engineering process framework. The framework doesn't show the fundamentals or the philosophy behind the process. We see the process here as a series of steps. Since the steps are shown as a cycle, we see that we never finish the sequence. We continually improve. We stop when we abandon the process.

I wasn't taught about life cycles for bridges or sanitation plants in civil engineering and I wasn't taught about life cycles for nuclear reactors or nuclear fuel in nuclear engineering. In short, I was never taught the framework for the engineering process. I wasn't taught the systems approach either. I was another engineering professional who didn't know the engineering process.

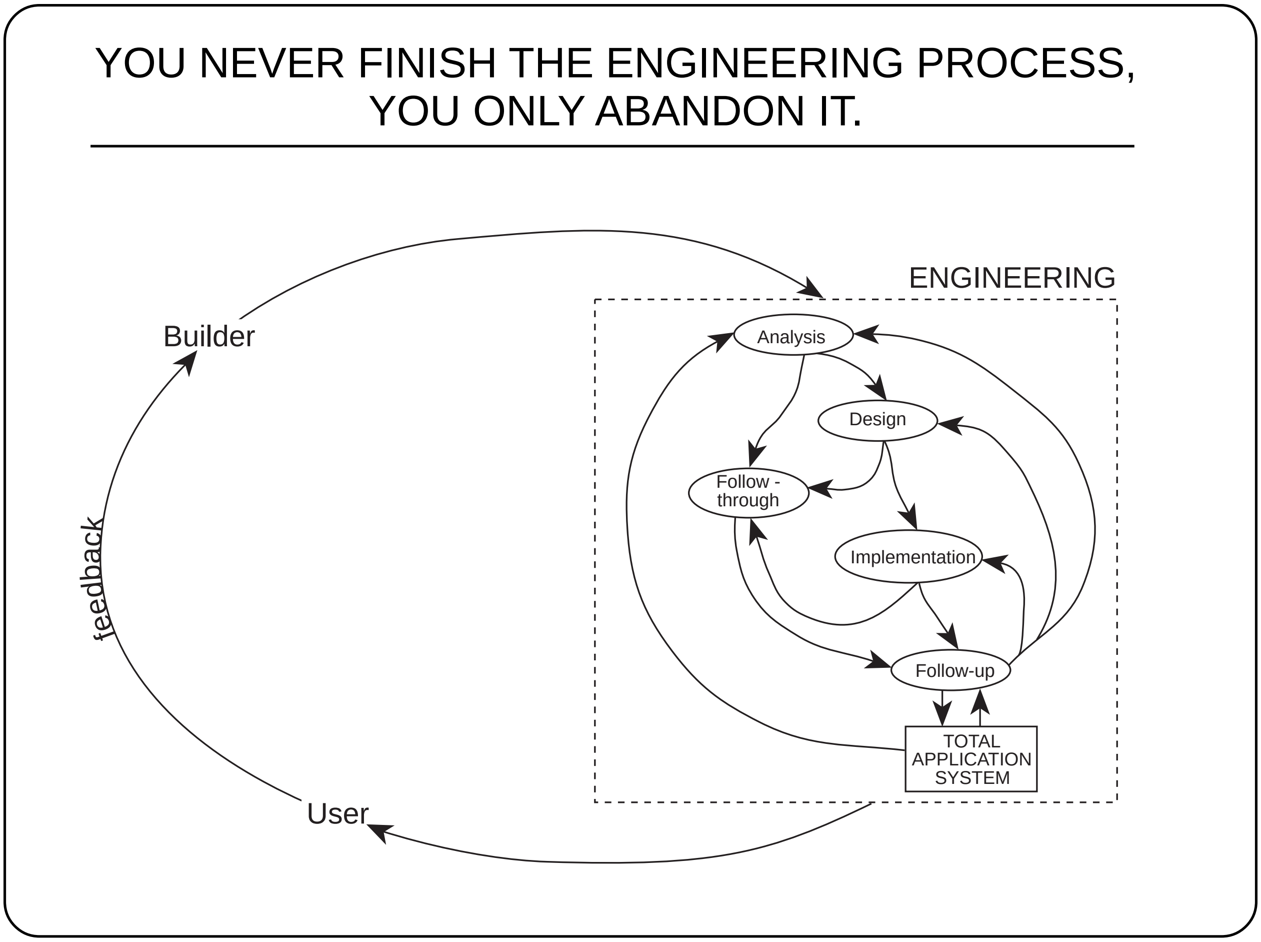

Figure 1.1.11.6.5. *The steps of the framework for the engineering process show the functions for the engineering process but don't show the fundamentals or philosophy of the process. Traditionally, in school we learn about analysis and design, but all the rest is left to on-the-job training.*

1.1.11.7. The Framework for the Engineering Process

Many people with varied backgrounds practice the engineering process when they use fundamental principles to analyze a need and convert the analysis into the design, implementation, and follow-up of a solution to meet that need within the context of the systems approach.

The engineering process is part a way of thinking and part a series of functions as steps toward an end guided by rules. The functions display a cyclic, recursive nature. I can show the functions in a framework. The rules and the way of thinking must be discussed and thought through. I'll show an overview of the framework now. I'll develop the engineering process in later modules.

Figure 1.1.11.7. shows as ovals five categories of functions of the engineering process. I'll expand the categories into 21 functions later. In Figure 1.1.11.7., notice how each category of functions is tied to the other functions. The engineering process isn't something you start at the beginning and end at the end. The engineering process is a continuing flow of learning, doing, and improving steps. When we apply the engineering process, we never finish it, we only abandon it—hopefully only for a short time to be picked up and worked yet again.

The engineering process, as I've shown in Figure 1.1.11.7. and will expand later, reflects a model I call the system life cycle, Blanchard and Fabrycky's system engineering functions listed in Module 1.1.9.2., the design process in Figure 1.1.11.6.2., and the project management process. The functions of the framework are important to the user and the builder of the result of the engineering process. The people involved are shown as rectangles in the figure. The engineering process is as important to the user of the result as it is to the builder of the result. In management systems engineering, we'll apply this engineering process to the management process.

Figure 1.1.11.7. identifies categories of functions of the engineering process. Figure 1.1.11.7. is a framework because it shows neither the rules governing the functions nor the overarching philosophy directing the functions. In the engineering process, we analyze a need and design and implement a solution. We've learned that implementing a solution isn't the end of the process. We must follow-up with maintenance, upgrade, retirement, or cleanup. Also we must follow through as we work the other categories with documentation, evaluation, and project management. The framework emphasizes the cyclic and highly-recursive nature of the engineering process. We never absolutely finish the job. We sometimes put the process on hold for a time, especially after a new implementation, to come back to continue the job later.

Figure 1.1.11.7. includes the analysis and design steps (actually groups of functions) many people think constitute engineering. The process also includes the implementation step to study the results of our design and the follow-up step to use the lessons learned from our study to do better analysis and design. The follow-through step includes documentation and project management functions that we do throughout the other steps. I'll provide details for the general framework in Module 1.1.20.1. When we consider the design step as what engineers do, the analysis (plan), design (do), implementation (study), and follow-up (act)

steps of the engineering process parallel the famous plan-do-study-act steps of the management process. The parallel is reasonable since both cycles derive from the scientific method.

One of the most complete published versions of the system life cycle is that of Blanchard and Fabrycky. I've listed their functions in Module 1.1.9.2. They allude to follow-through type activities and follow-up type activities in their discussion. For follow-through they ask, "How is the system to be supported throughout its life cycle? This includes a definition of levels of maintenance, functions at each level, and anticipated logistic support requirements (i.e., test and support equipment, supply support and spare/repair parts, personnel and training, transportation and handling requirements, facilities, and technical data)." (Benjamin S. Blanchard and Wolter J. Fabrycky, *Systems Engineering and Analysis*, Prentice-Hall, Inc., 1981, p. 23.) I see follow-through functions as those you do for each of the other functions in analysis, design, implementation, and follow-up to make sure you support or follow-through on all the steps of the life cycle. I'll include functions like project management, documentation, and evaluation in the follow-through step because you need to perform each of those functions continuously throughout the life cycle.

For follow-up, Blanchard and Fabrycky ask, "When the system becomes obsolete and/or when items are removed from the inventory, what are the requirements for disposal? Can specific items be reclaimed and recycled? What are the effects on the environment?" (p.23.) In their diagram of the life cycle they include a dotted box for "phase-out, disposal, reclamation, and/or recycling" (p. 22.), but don't include that box as one of the functions they list for the life cycle. I see follow-up as perhaps the most important step, because it's the learning step. With follow-up, we learn from functions like operation; maintenance; upgrade; obsolescence and replacement; and clean-up, restoration, and remediation so we can continuously improve our analysis and design and to better serve the user. To me, follow-up means after we install the object of our analysis and design we must continue our attention to meeting the needs of the user and follow-up to ensure we do what is needed.

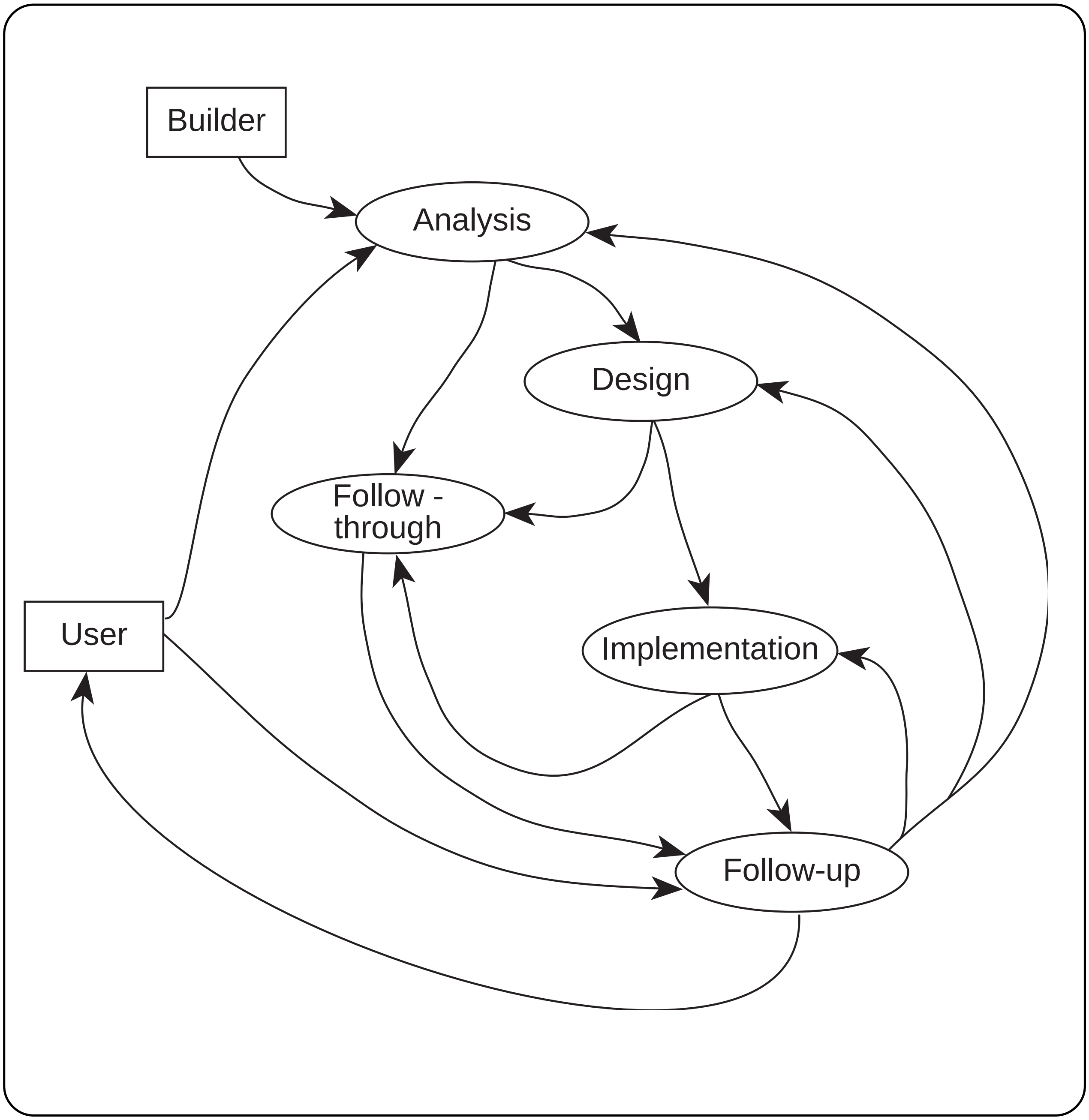

Figure 1.1.11.7. *The cyclic, recursive nature of the engineering process serves the user of the results of the process as well as the person who conducts the process, whom I call the builder. The process serves the user and builder over the life of the need or the solution.*

1.1.12. Perspective through Illusion—Sandro Botticelli

1.1.13. *PURPOSE* OF THE APPROACH—THE VISION

I intend for this book to describe and explain a systems-oriented paradigm for understanding and implementing processes for engineering and management, focusing on the role and improvement of management tools and their use within a discipline having the ability to do and teach 1) describing and evaluating the organization as a system that incorporates management tools, 2) determining what tools will work, 3) prescribing how to get or build the right tools, 4) prescribing how to use the tools best for that organization, 5) predicting the resulting organizational performance from using the tools, and 6) practicing the skills and techniques to get the most out of the tools and the organization.

Background

For a total of 35 years, roughly equally divided between university research and industrial involvement in management systems, processes, and tools, I've worked with managers frustrated by unsuccessful tasks trying to fix their situations. The great lesson learned is, no matter what the industry or agency, unless management tools fit each other, the manager, and what is managed, they overwhelmingly fail. And unless the manager, the managed, and the tools reflect the internal and external forces on the organization, the organization cannot meet its goals and objectives. The fit is a function of the tool and associated guide and of the process the tool works through. The tools must work together and support the manager or they work at odds with each other and against the manager.

Anecdotal evidence, corroborated by reaction from managers and information specialists, indicated that, unfortunately, 70 percent of all management tools fail. MIS's are unused, plans sit on the shelf, and no one believes the organization structure chart. Furthermore, the people in the organization don't buy into the tool or the process using the tool. The result is a loss in confidence in the tool(s), the process, the manager, the organization, and the organization's aims.

Foreground

Private and public sector managers need tools to do their job. What they have are tools that work both against one another and collectively against managers. Indeed, many managers are slaves to some modern management tools. Today's computer-based tools or participative management techniques don't work equally well (if at all) in every situation. To manage today's uncertain, rapidly-changing organizations, we must evolve the science of building effective tools and the art (skill) for applying them. The future manager will apply tools across interdependent groups of highly-specialized professionals in a world with immediate communications involving huge amounts of rapidly-changing data and with international, if not interterrestrial, scope. The concept of interdependency carries the idea of and the need to manage cooperation for continual performance improvement. The environment, work force, and technology are changing to force success or failure based on our ability to build and use management tools.

What we need is a paradigm (engineer's systems approach to management) with associated methodologies (integrated sets of tools for representation, analysis, and prescription consisting of models, frameworks, theories, and procedures); operational strategies (general sequences of activities designed to achieve some end); and techniques (discrete procedural sequences resulting in outcomes of a prespecified form) with which any manager can evaluate any set of responsibilities and prescribe with predictable levels of confidence the best management tools, guides, and processes, and from which an academic discipline of management systems engineering can be taught—all within the future world just described.

The individual, old-time furniture maker folds art into his or her work, but his or her basic tools have been painstakingly understood, documented, taught, and improved for generations. The science of the right tool for the piece being worked, fitting comfortably in the carpenter's hands, will get the prescribed results. The master craftsperson can make a tool work in less-than-optimum situations, whereas for the rest of us, put the wrong tool in the wrong hands and the piece gets butchered or the handler injured.

Today's furniture maker is different. He or she doesn't use one-person tools to completely make one piece of furniture by himself or herself. He or she works in teams, sharing tasks, tools, and information to make large numbers of pieces of furniture. Much is automated where he or she deals more with information about what is being done to the furniture rather than doing that thing to the furniture himself or herself.

Carpentry tools can be grouped by function, with dozens of different saws, for example, to ensure the right one fits each nuance of the function. We also can master our management tools and leave room for the creativity and flexibility of the artist. Like the carpenter, we can understand our work so well that we know all the nuances before they arise and are prepared with just the right tool to do the job. Without the luxury of generations of time for evolving tools and teaching their use—and with breakthroughs in terms of years as opposed to centuries—we also must group our management tools by function and perfect each one for its specific purpose. Building or using a tool for the tool's sake doesn't lead to a successful application. For success, each tool must be built and used as part of a process in a productive system.

The skill by which the master carpenter applies the proper technique is learned and performed by the carpenter alone, for the object of his or her skill is mere matter—albeit for a human customer. Management skills and techniques, however, must be learned and applied by both the supervisor and his or her subordinates—human beings. Thus, the variables of interest increase geometrically as we consider the relationships between the supervisor and the subordinates.

Today's (and especially tomorrow's) manager is less apt to work alone. With modern data and information sharing tools (e.g., networks and shared data bases) and participative management, the manager works with and makes decisions with others. Working together requires reaching consensus on many broad-ranging and diverse issues affecting many different people with many different agendas. An understanding of the various organizations managers deal with and their cultures helps managers understand the processes, rules, and precedents that guide organizational behavior and decision making. The complex and dynamic nature of the information needed to support these decision-making processes requires a thorough understanding of the organization's stakeholders and systems to assemble, integrate, and portray this information effectively to managers. This information gathering, manipulating, and portrayal becomes especially important when managing in situations of large, rapid change.

Vision

Imagine a management systems engineer in the future addressing a new set of responsibilities that needs improvement. By asking the right questions and observing the right indicators, the management systems engineer scopes the situation and classifies the organization according to a number of parameters that will characterize the organization in terms relating to management tools and their use. Based on the classification of the organization and its decision maker, the management systems engineer identifies which management tools are working well and which aren't and why. Then the management systems engineer determines which new management tools can be selected and which need to be built to help make the needed improvement. The management systems engineer helps select the right person to build the new tools or builds them himself or herself. The management systems engineer supports the manager in prescribing how to use the tools in that unique situation. Then the management systems engineer predicts the resulting organizational performance from using the tools and the extent of other improvements directly or indirectly affecting performance. The management systems engineer either helps find or provides training and advice to identify and teach the needed skills and techniques to get the most out of the new and continually improving set of tools and out of the organization.

1. Background

1.1. Introduction

1.1.14. Foundation Concepts I

1.1.14.1. Some General Concepts Defined Quickly

To help communicate ideas and models for management systems engineering, discussions of fundamental concepts need to show definitions of terms, relationships to other terms, and meaning of the terms for a) semiotics; b) domain; c) responsibility, authority, accountability, and delegation; d) organization; e) decisions and problem solving; f) manager and management; and leader and other roles.

In addition to obvious concepts and their associated definitions, like management, system, and engineering, a number of other concepts mean different things to different people. To make sure we're all on the same wavelength, I'll discuss and define fundamental concepts before you'll need them to understand the ideas and models in this book. Introducing a new discipline brings a lot of new concepts. So, I'll try just-in-time definitions to keep from having to deal with too many new concepts or concepts with slightly different meaning than you're used to by spacing out a number of fundamental concept modules. However, the concepts are cumulative and you'll have to carry a concept throughout the rest of the book.

To have profound knowledge of any subject, we need operational definitions. W. Edwards Deming says, "An operational definition puts communicable meaning into a concept. .... An operational definition is one that reasonable men can agree on." (W. Edwards Deming, *Out of the Crisis*, Massachusetts Institute of Technology Center for Advanced Engineering Studies, 1986, pp. 276-277.) In scoping the management systems engineering discipline, I must set up new concepts and revisit old concepts. So I can communicate and we can agree on meanings, I'll need to establish operational definitions for many concepts. Deming further says, "An operational definition is one that people can do business with." (p. 277.) So we can do business with the engineering process, the management process, and the systems approach, I'll provide definitions progressively throughout the book, starting with this module.

Deming derived his understanding of operational definitions from Shewhart's idea of operational meaning. (Walter A. Shewhart's, S*tatistical Method from the Viewpoint of Quality Control*, Dover Publications, Inc., 1986, pp. 130-132.) Operational meaning leads to consistency, reproducibility, accuracy, and precision. We can translate those objectives into communication for profound knowledge.

Beware of circular definitions. Such definitions are non-operational. If I say management is something done by a manager or a manager is someone who does management, I might be correct, but we can't understand management any better from the definition.

The concepts in the next several modules following this one take relatively more discussion. The concepts in this module take relatively less discussion, and I've grouped them in this general heading.

We have to have a foundation (concepts) to build on. Foundation concepts have the characteristic of an assumption. Another person might assume differently. Like all models, you must know the assumptions from which the model is derived before you can use the model. I'll put a definition module (glossary of terms) at the end of the book. The difference between the glossary and the foundation concepts modules is the difference between semantics and semiotics.

Semiotics

I'll borrow the concept of semiotics from language. Semiotics comprises semantics, syntactics, and pragmatics. The definition of semantics is: "the study of meanings, including theories of denotation, extension, naming, and truth." Terms are semantics. So, the glossary defining terms is like semantics. The definition of syntactics is: "the study of the rules of syntax, which is an orderly or connected system of arranging words or symbols as in language or calculus." Constructing rules of the relation between a term for a notion and terms for other notions is syntactics. Models are the syntactics. Sentences, statements using the terms, make up syntactics. The definition of pragmatics is: "a branch of semiotics that deals with the relation between signs or linguistic expressions and their users." Purpose, or what I want to do, is the pragmatics (the message—what I want to say). So, the modules on foundation concepts will include definitions, relationships of terms, and meaning. The foundation concept will include the notion (words), the model (relations), and the meaning (purpose). The definitions of notion are: "(1) an individual's conception or impression of something known, experienced, or imagined; (2) an inclusive general concept; (3) a theory or belief held by a person or group."

I'll use the foundation concept of "manager" as an example. 1. Define the notion: The manager is a decision maker. 2. Relate the notion to other notions: Problem solving is a set of related decisions made by a manager. The manager makes decisions about his or her responsibilities using his or her management tools. 3. State the purpose or meaning; state the message: Managers make decisions to get insight and improve their domains; the manager must fit within the domain of responsibility and be balanced with other components.

I'll use flow charting as another example. Defining symbols and their meaning is semantics. (Rectangle is action, diamond is decision.) Stating the rules for what to do and what not to do in combining the notions is syntactics. (One arrow from an action to a decision is OK. Two arrows from the same action to the decision isn't OK.) Telling why we do this is pragmatics. (We use the symbols and relations to show work flow; to show start, end, and direction; and to clarify.)

Domain

Generally speaking, a domain is a sphere of influence or activity. We say the king's domain. In mathematics, a domain is the set of elements to which a mathematical or logical variable is limited. A domain implies elements, components, or parts, as in a system. A domain implies boundaries, across which things flow. For example, capital, labor, equipment, or material (CLEM) can flow from outside your domain to inside your domain, or vice versa. If you're responsible for everything inside your domain, whatever flows in becomes your responsibility.

I'll use domain to clearly distinguish sets of responsibilities. I want to use the idea of boundaries, flowing in and flowing out, and influence and activity to help define what is inside a domain and what is outside.

Responsibility, Authority, Accountability, and Delegation

I've taken definitions of responsibility, authority, accountability, and delegation from the glossary in *Management* by Patrick Montana and Bruce Charnov: "**accountability** the obligation to give account for the results expected ..... **authority** the power to act for someone else ..... **responsibility** the duty or task to be performed ..... **delegation** the art of assigning responsibilities to others together with the delegated authority commensurate with the responsibilities for the accomplishment of results." (pp. 441-449, Barron's Business Review Series, 1987) (Notice the circular definition of accountability.)

Adizes says, "*Delegation* is the process of transferring tasks down the organization hierarchy and creating a sense of commitment for carrying them out. The task can be to make decisions or to implement the decisions. When the task is to implement a decision that has already been made, and the authority given is only tactical in nature, it is called delegation. If the task is to initiate decisions, that is to make decisions as to what *should* be implemented, it is *decentralization."* (Ishak Adizes, *Corporate Lifecycles*, Prentice-Hall, 1988, p. 40.)

Accountable relates to account as in financial account and reasoning as in setting an account.

I have someone build steps to my house. I delegate authority to bring people and materials together to do the job. They are responsible to use people and materials to meet specifications on time within cost. Someone falls on my steps. Who pays? Me. I'm accountable.

Max DePree says, "At the heart of being accountable is the matter of caring." (Max DePree, *Leadership is an Art*, Dell Publishing, 1989, p. 41.) When you're accountable, you need to care. When you care, you'll want to hold yourself accountable.

The concepts of responsibility, authority, accountability, and delegation are related and work together as described by Daniel L. Babcock in his book, *Managing Engineering and Technology* (Prentice Hall, 1991). "Three interrelated concepts of importance are the *assignment of duties, delegation of authority*, and *exaction of accountability,* as shown in [Figure 1.1.14.1.1.]. Managers use their authority to *assign duties* to subordinates, making them *responsible for* carrying out the specified activities. This assignment proceeds in stages from top management down. A company president may assign responsibility for all technical matters to the vice president for research and engineering; the vice president may assign responsibility for all project matters to a chief project engineer, who in turn assigns the duty of carrying out a specific project to engineer X.

Once a subordinate has been assigned tasks to perform, it is important to provide him or her with the resources needed to carry out the assignment. This is called *delegation of authority* and can include authority over people who will be needed to carry out the assignment, financial authority to acquire the equipment, perform the travel, or make other commitments of resources needed. Like assignment of duties, delegation of authority proceeds in stages from top management down. It is an essential management precept that 'authority should be commensurate with responsibility,' so that a subordinate has enough authority to carry out assignments effectively. Unfortunately, in many cases (especially in managing projects) the engineer is not given enough authority, and must rely on personal influence, persuasion, or the threat (veiled or not) of appeal to higher authority.

When the manager has assigned duties to a subordinate and delegated authority to carry them out, he or she is still not through. The manager must *exact accountability* from the subordinate by making the subordinate *responsible to* the manager for carrying out the duties and reporting progress periodically. The manager has now made the subordinate 'responsible for' the task and 'responsible to' report progress, but the manager is still accountable (responsible) to the next higher level of executive to assure that the task is effectively carried out—hence the saying 'you can't delegate responsibility.'" (pp. 111-112.)

I prefer to use supervisor for the word manager in Figure 1.1.14.1.1. Both the supervisor and the subordinate are managers, or decision makers. Now, in addition to providing subordinates the resources to carry out an assignment, the supervisor has to ensure the subordinate has and knows the process for using the resources, or as Deming would say, "Know the method."

Define Organization

"The word *organization* is used to describe two very different aspects of getting work done: the structure and the people who inhabit the structure." (Gabriel A. Pall, *Quality Process Management*, Prentice-Hall, Inc., 1987, pp. 182-183.)

We use the organization structure aspect of getting the work done to help us assign (delegate) and communicate responsibility and authority and to access accountability. The organization structure typically is functional, sorting people and responsibility by the kinds of work people do so they can share the operations tools they need to do their work. The people in a given box in the classical organization structure do similar kinds of work, have similar backgrounds, and use similar tools. We use the people who inhabit the structure aspect of getting the work done to move the product or service through the organization to satisfy our customers. People's work tends to be cross functional. That is, we depend on people in a different function from ours, and those who depend on us are in a different function from ours. Therefore, the difference between the classical structure and the logic of people's work is the difference between functional (considered to be a vertical look at the organization) and cross functional (considered to be an horizontal look at the organization). (See Modules 3.4.1.1.1. through 3.4.1.1.3.)

Decisions and Problem Solving

I discussed the concepts of decisions and problem solving in Module 1.1.11.2. Since management is decision making and engineering is problem solving and the two are closely related, these concepts are important in and of themselves and in relation to other concepts, like responsibility, domain, and leadership. Figure 1.1.14.1.2. shows a decision making process model. The manager uses information from decision or management tools to render decisions regarding a problem. The decision maker should make decisions that lead to actions only on those things for which he or she has authority.

"The contingency model of decision making states that the selection of a decision strategy is contingent upon problem characteristics and decision maker characteristics. Kurstedt, Polk, and Hughes (1989) have expanded this model by adding decision tool characteristics and decision characteristics." (Thomas E. Polk, *Decision Making Strategies: The Influence of Task Complexity, Decision Importance, Decision Maker Impulsivity, and Decision Maker Gender*, p. 7.) "Figure [1.1.14.1.2.], The Decision Making Process Model, shows the model with its four components. The problem, manager, and decision components are essential for all decision making. This is consistent with Gorry's (1971) model where he shows only one component, the manager, with information as input and decisions as output. The decision tools component is considered an auxiliary component.

Kurstedt et al divide the problem component into two subcomponents: decision task and constraints. Decision task is further divided into a question (or series of questions) and a set of available information external to the decision maker. Comparing this with Gorry's model, the question, information, and constraints are all information input to the manager. Another point worth noting is the Kurstedt et al model makes the components of the problem explicit. In the real world, one piece of information might trigger the manager to realize there is a problem. Representing such a case in the Kurstedt et al model might indicate the question, set of information, and constraints are sometimes implicit in the initial presentation of the problem to the manager.

Managers are complex and there exist a number of ways to view a manager as a component in a process. Kurstedt et al emphasize two subcomponents: resources and personality. The resources include knowledge, experience, ability, and intelligence. Kurstedt et al say the manager's personality 'determines how the (manager) uses the resources' (Kurstedt, et al, 1989, p. 59).

'The decision component contains a plan of action designed to answer the question or questions set forth in the task' (Kurstedt, et al, 1989, p. 59). It's not clear in the literature what is a decision and what is the result of a decision. Webster's (1989) definition includes the word 'the act or process' which would indicate a decision is a process. Kurstedt et al use the term as a 'plan of action' which results from a process.

The decision tools component may or may not be used by the decision maker. The decision tools consist of devices external to the manager, used to manipulate or store data and information to support the manager. The decision tools might include a wide range of tools from pencil and paper to sophisticated computer models for cost-benefit analysis. The decision tools also might include people: experts, analysts, and information coordinators who support the manager.

Information constitutes the interface between the manager and the decision tools. The manager may request information of and/or provide information to the decision tools. The decision tools provide information to the manager." (R. Martin Jones, *The Strategic Decision Processes and Information Needs of Nuclear Government-Oversight-Agency Managers*, 1990)

Manager and Management

I discussed the concepts of manager and management in Modules 1.1.11.2. and 1.1.11.3. I'll tie one and only one manager to a domain. If one manager passes responsibility and decision making authority on a task to someone else, that task is in the someone else's domain. A manager may share authority but, until accountability passes, the task remains in the original domain. Of course, domains are hierarchical. There's a one-to-one correspondence between a domain and a manager. If domains overlap, expect problems. Since domains are hierarchical, your domain is also part of the domain of your supervisor.

Leader and Other Roles

Leadership is a role people play that typically has certain types of decisions that go along with the role. All leaders are decision makers. Therefore, they're managers. As a manager you may or may not play a leadership role at a particular point in time.

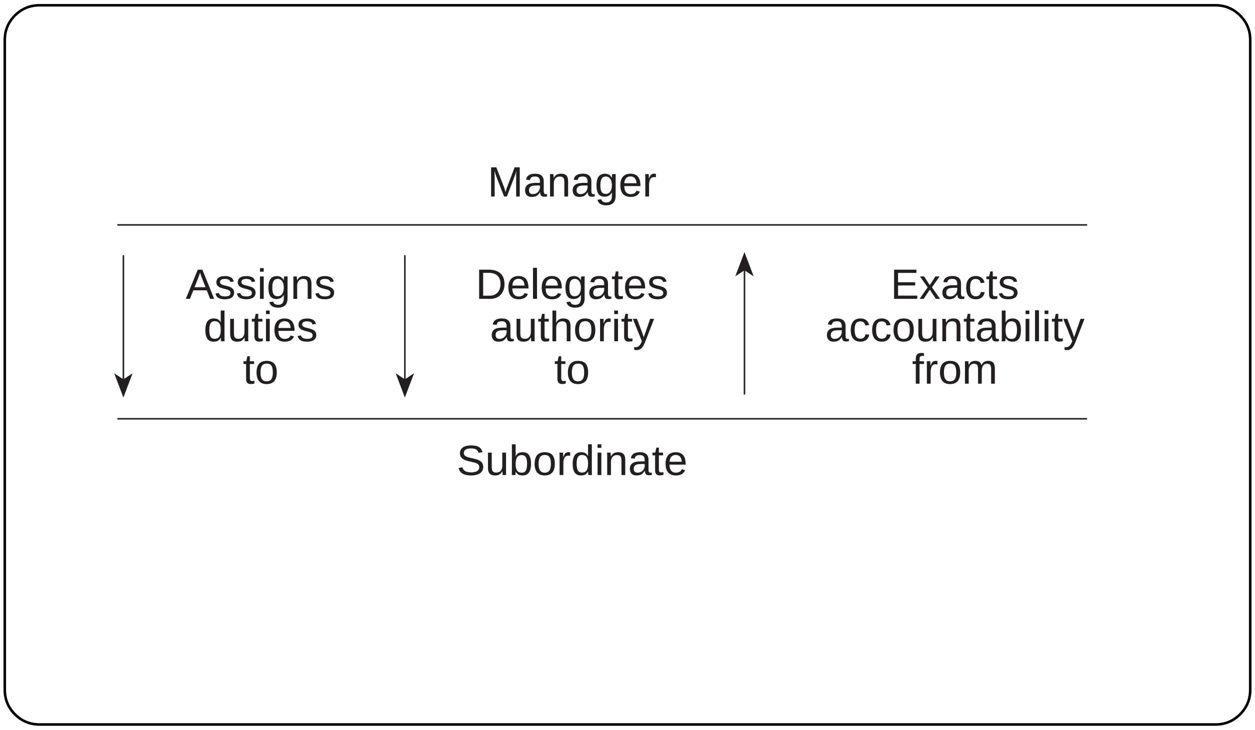

Figure 1.1.14.1.1. *Delegation, authority, and accountability (taken from Daniel L. Babcock)*

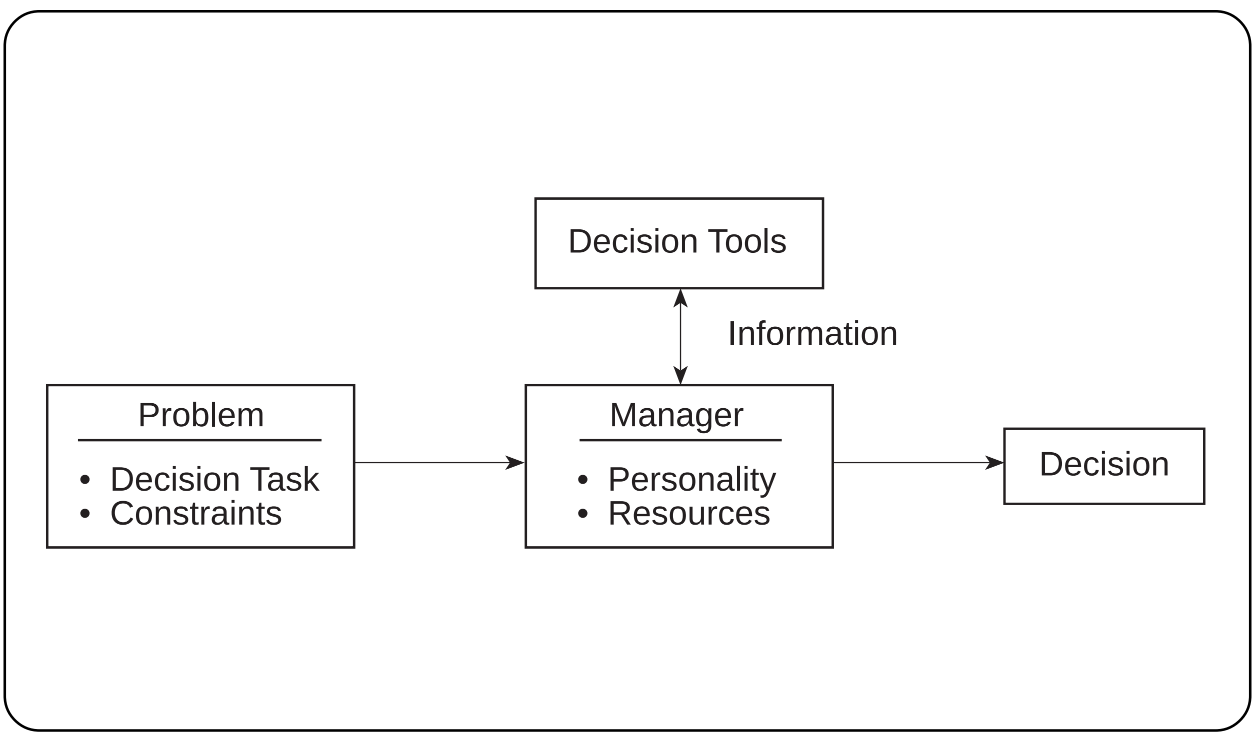

Figure 1.1.14.1.2. *The decision making process model (adapted from Kurstedt, et al, 1990). This figure came from Martin Jones on our work together on his PhD dissertation during his tenure at Virginia Tech.*

1.1.14.2. Exercise on Responsibility

Responsibility is at the heart of our work; and, if we depend on others and others depend on us, responsibility is at the heart of those dependencies.

Situation Description

Consider the quote in Figure 1.1.14.2. from Admiral Hyman G. Rickover. Rickover was very successful in the startup and direction of the nuclear energy programs. His personality and style are largely held in question today. However, his success isn't disputed. Today, we look to people to be self-motivated and we search for dignity in a productive workplace. (Consider Weisbord's book: *Productive Workplaces*.)

Exercise

Evaluate Rickover's quote on responsibility. What are the important components of responsibility? From where does responsibility originate in an organization? How many people can be responsible for the same thing at the same time? What thoughts do you find questionable or objectionable in the quote? Rewrite the definition of responsibility to be more in line with thinking like that of Weisbord.

RESPONSIBILITY

Responsibility is a unique concept: It can only reside and inhere in a single individual. You may share it with others, but your portion is not diminished. You may delegate it, but it is still with you. You may disclaim it, but you cannot divest yourself of it. Even if you do not recognize it or admit its presence, you cannot escape it. If responsibility is rightfully yours, no evasion or ignorance or passing the blame can shift the burden to someone else. Unless you can point your finger at the man who is responsible when something goes wrong, then you have never had anyone really responsible.

H.G. Rickover

Figure 1.1.14.2. *What are the parts of Rickover's definition of responsibility that support modern thinking like that of Weisbord?*

1.1.14.3. Define Domain of Responsibility

You can't manage well if you don't know exactly what you're responsible for.

Simon says management is synonymous with decision making. Decision making about what? Forrester says management is the conversion of information to action; and the conversion process is decision making. Information about what? Action on what? I call the *what* in all these questions a person's domain of responsibility.

Domain implies limits and scope. That is, we can lay out a domain and figure out what's inside the domain and what's outside. A responsibility requires an agent. That is, a human being who has the power to act and who's answerable or accountable for something. And this assumes that person has some measure of power, control, or authority over that something. A responsible person has some burden or obligation. So, a domain of responsibility must have an accountable person tied to it—a manager who uses information to make decisions leading to actions affecting the domain.

Each domain has only one person accountable for the responsibilities in the domain. That one person may practice teamwork, seek participation, and delegate responsibility within the domain. However, that one person will ultimately be held accountable for the domain.

A domain of responsibility is a connected, identifiable object of authority—a set of responsibilities—for which a person is accountable. Everyone has one or more domains of responsibility; and, using Peter Drucker's idea of an executive (see *The Effective Executive*), each such person uses information to make decisions resulting in actions affecting what is managed within that domain.

I subscribe to the meaning of management, and of manager, characterized by Simon and Forrester. Precisely, management equals decision making. A manager is a decision maker. In this context, every person is a manager of something. In Figure 1.1.14.3, the young boy is using information to make decisions about his marbles. He is responsible for them, what is done to them, and the outcome of using them. His actions have a purpose or aim; perhaps enjoyment or to win a match. In this case, the boundaries of his domain of responsibility are clear. He's drawn a line around his marble game. He has delimited his domain of responsibility.

Later, we'll treat the boy's delimited domain as a system—a management system. And, as such, the boy's system is part of a larger system—in this case, his father's farm. The father's domain of responsibility is also easy to delimit. Just look for the boundary fences. The father is responsible for everything inside the fence and nothing outside the fence. Let's look one more step. The father's management system is part of a larger system—the domain of the king in Figure 1.1.14.3.

Most management systems, or domains of responsibility, are not so easy to delimit. Perhaps one of the hardest things in management, in addition to dealing with personnel, is delimiting clearly and concisely our domain—exactly what it is we're responsible for. Often our professional domain comprises many seemingly unconnected subdomains. Each subdomain can be considered a domain of responsibility if we're interested in doing something to improve that subdomain or our management of it. We can make matters more confusing by including one or more of our personal subdomains for which we're responsible, together with our professional domain. In an organization, we must clearly understand what is our domain and what is somebody else's. In Citibank, they've built into their culture a handy way to distinguish among many domains of responsibility. If you walk around the halls of Citibank (literally distributed all over the world) you'll hear someone talk about Joe's world, or Jane's world, or whomever's world. "George is in Pete's world." That is, Pete is responsible for George. "Our accounting function is in Sally's world." That is, Sally is responsible for our accounting. "The building on Fifth Avenue is part of Anne's world." That is, Anne is responsible for that building.

The use of the word *world* works for Citibank. Citibank people are forever distinguishing among their responsibilities. So, they make fewer mistakes in not carrying out a responsibility somebody thinks is theirs. And they don't act on something that isn't their responsibility. (Later I'll talk about problems resulting in suboptimization when you isolate your world by drawing boundaries around it. However, I believe you build bridges best between yourself and others after you understand and feel good about yourself and what you do. In a real world, sometimes you have to concurrently define your domain and bridge your domain to others.)

Not only in managing something do you need to know exactly what you're dealing with. Also, in the business of building management tools, you need to know precisely what the tool is supposed to work on and whom the tool is to work for. Assume you manage, among other things, people; and you decide to hire someone and bring an additional person into your domain of responsibility. Now everything you use to manage that reflects numbers and types of people, locations, and arrangements has changed. Many more changes and your management tools won't work like they did before. Your world has changed.

Your domain is connected to other domains, just as a subdomain within your responsibility is connected to other subdomains in your domain. If you draw a line around your domain, you can find other similar domains (in many ways similar to but not identical to yours) that you're horizontally (functionally) related to. You can also find different types of domains yours is related to. And you can find domains accountable for everything in your domain, and more. Your domain relates to these vertically or hierarchically (structurally). As we think about management tools and how they should help the manager, we'll worry about all these other domains the domain of the manager is related to. Thus, our domain of responsibility is an open system with many interactions with its environment.

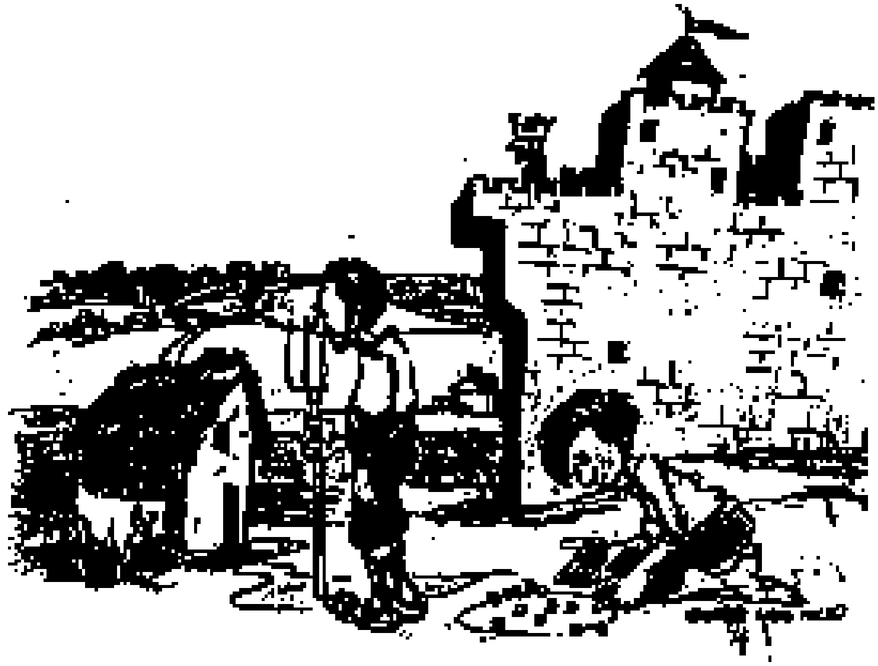

Figure 1.1.14.3. *The domain of the young boy is within the domain of the farmer, which, in turn, is within the king's domain.*

1.1.14.4. Determine Your Unit of Interest

Most engineering faculty turn out extremely capable graduates who work hard and produce wonderfully elegant solutions to the absolutely wrong problem.

I'm discussing the domain of responsibility as a management consideration and the unit of interest as an engineering consideration. They're really similar issues. Both are intended to ensure you focus on the system, subsystem, or component you're responsible for. You don't want to work on the wrong thing. What makes a thing wrong is 1) when you work up a perfectly wonderful solution to the wrong problem or 2) when you and someone else are unknowingly working and acting on the same or overlapping problems, which leads to errors of omission or contradiction.

We don't teach young people how to determine the unit of interest. Part of the problem is that the things engineers and managers work on are systems. Systems have subsystems and are part of larger systems. The confusion over unit of interest can be either the wrong system or the wrong level in the hierarchy of systems and subsystems. By the way, figuring out what the right problem is, or determining the unit of interest, is a strategic endeavor (as opposed to a tactical or operational endeavor). That's why determining the unit of interest or delimiting the domain of responsibility seems hard to do. Strategic endeavors aren't as well defined and we have fewer automatable tools to help. But more about that later when I discuss strategic decision making.

Understanding the aim of the system and how all the components of the system fit together to serve the whole and the cyclic, recursive relationship of all the functions in the engineering and management processes are prerequisites for applying tools and techniques effectively and efficiently. If you don't know the theory, you'll confuse techniques with principles and not use the technique based on a principle that reflects the theory.

A good engineer, and also a good manager, must be able to walk the workplace and see how everything fits and works together to get the best performance from the unit of interest. This engineer or manager must understand cause and effect among all the system's parts and between the parts and the whole. Understanding cause and effect requires profound knowledge.

Some people might use the term unit of analysis for unit of interest. I choose unit of interest on purpose. We will do analysis, synthesis, and any other scrutinizations on the unit of interest. Perhaps, unit of focus is a good alternate term.

An important issue behind my unwillingness to use the term unit of analysis is that analysis, synthesis, and other scrutinizations can work within the systems approach. There is a difference between analysis within and not within the systems approach. Analysis looks at the components of a system. In the systems approach, you look at each component in terms of how that component works toward the whole—how it works toward the aim of the system. You must coalign the aim of each part and the whole. Even though the aims may not be the same (I'm considering intensive and extensive qualities as described in Module 1.1.16.2.), they must work together. For example, the accounting department (component) organizational culture may be different from the culture of the larger organization (whole), but the aims must work together. Specifically, the accounting department aim must work toward the aim of the larger organization.

You can do analysis where you look at each component in a vacuum. This isn't the systems approach. If you optimize the component, you get the best out of the component. In the systems approach you work on the component as best you can to get the best out of the whole. Recall the statement of Deming from Module 1.1.11.5. on defining a system: "If the parts are optimized, the system will not be. If the system is optimized, the parts will not be." That quote is worth repeating any number of times. The quote negates the notion that if all the departments in an organization are the best they can be, then the organization is the best it can be. One or more departments must suboptimize for the benefit of the other departments and the whole. For example, the purchasing department may have to spend more money to get something besides the cheapest part so the engineering department can put a dependable part in the product the organization makes.

Many students don't read (study) their midterm questions carefully and do a beautiful answer to something I didn't ask for. I'm torn between giving a good grade for a good job and a bad grade for the wrong job. In business, you fail. This usually happens to the brilliant students.

Part of understanding the problem is the concept of ownership. In discussing ownership, Max DePree says, "Good readers take possession of what they are learning by underlining and commenting and questioning." (Max DePree, *Leadership is an Art*, Dell Publications, 1989, p. 4.) Once you own the problem, you'll solve the right one. When I discuss a quality culture (Module 3.3.1.), I'll show the importance of the value of learning to continual improvement and to management systems engineering.

In summary, you can do analysis within the systems approach—if you keep the whole and its aim in mind as you scrutinize its parts. Most people lose the forest for the trees and scrutinize the part for its own sake.

1.1.14.5. Define a Management System

If you consider your domain of responsibility as a system, you have a management system.

A system is defined as something that changes inputs into outputs, resulting in throughput, all to meet a common aim, with measures of performance to ensure you're meeting that aim. Your domain of responsibility, or your management system, meets this definition. The domain of responsibility takes many types of inputs from its environment and converts them to outputs. To be successful, your management system must work toward a common aim. I discuss in some detail later the need to define and measure the performance of the management system in meeting its aim.

I think viewing an organization as a management system is fundamental to industrial engineering. So, let's look at the definition of industrial engineering as adopted by the Institute of Industrial Engineering and quoted in its publications: "Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment, and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems."

Figure 1.1.14.5.1. is a simplistic representation of an integrated system including the elements in the definition of industrial engineering. I've put the resources inside a boundary to delimit the domain of responsibility for these particular capital, people, equipment, materials (CLEM), energy, and information. (I've added capital to the list of subsystems the industrial engineer is concerned with integrating.) These resources come into, go out of, and get transformed in an organization. After putting the resources in Figure 1.1.14.5.1. in place, they have to be managed as a system. That is, they need a manager within the system to get the system to do anything.

Figure 1.1.14.5.2. shows the elements required to perform any managerial activity now separated into three components. These components must be included in our study of how to engineer integrated management systems. By placing the manager in an integrated system context, I've defined a domain of responsibility, the domain of that manager. That is, if we look inside a domain of responsibility, or a management system, we'll see the components in Figure 1.1.14.5.2.

The manager is one component of a management system. The manager makes decisions for the components in the management system; but, as we learned from Forrester, the manager needs information to make decisions. We must recognize the importance of the mechanisms that provide the information. If decision making is converting information to action, we must also recognize the converting of data into information—the data indicating the results of the actions the manager takes. These information-providing mechanisms are a component of the system. I call the component management tools. Collectively, the resources are the physical responsibilities of the manager and are a component of the system, which I call the operation. The operation embodies the work process. From the perspective of the management systems engineer, the three components are functionally independent, but interconnected, within the domain, as seen in Figure 1.1.14.5.3.

In Figure 1.1.14.5.3., I've shown the three components as functionally different, separate but overlapping. One of the dangers in analyzing a system is taking components that are intertwined and separating them apart for convenience of study, observation, or explanation. For convenience and simplicity, I'll separate the components further later. Please always remember their oneness within the context of a management system.

The description represented by these figures doesn't mean the domain is completely described. Other perspectives exist that require focusing on different components; for example, the human factors engineer may be concerned with the amounts of light and noise in the workplace, or the sociologist may be concerned with interpersonal communication patterns or office arrangements.

In Figure 1.1.14.5.4., I've not only dropped the details of the components by giving them functional names, I've changed the overlaps among the components into interfaces between pairs of components. The interfaces will serve us well as we engineer the management system and especially as we study the building and use of management tools, which convert data from what is managed into information for who manages to use in making decisions. Our study of management systems engineering will focus on the interfaces within the context of the systems approach. Your management system is connected to other management systems, just as domains of responsibility are connected, which I discussed at the end of Module 1.1.14.3.

The management systems engineer studies the relationships between the components of the management system and their interfaces as shown in Figure 1.1.14.5.4. Despite my showing a functional separation between the components, they're still integrated together within the system.

Note that I'm defining a system, not a process. I'll define a process, which is related to a system, later in Module 1.1.16.5. I'm also not including the systems approach, which I'll define in Module 1.1.16.2. In defining a system, I must define components, attributes, and relationships. I focus on components in Figure 1.1.14.5.4. By stressing interfaces I imply relationships, which I'll fully describe in Module 1.1.18.1. I'll describe the attributes of components in a management system in Modules 1.4.2.6.1. through 1.4.2.6.3. I'll review processes for building and using management tools within the context of the management process in Modules 1.1.21.2. and 1.1.21.4. The management systems engineer applies the engineering process to the management process under the purview of the systems approach.

The what is managed component represents the work process of the management system—the core application system (See Module 1.1.11.6.3. on the engineering process.) to which management systems engineers apply the engineering process. This component lists capital, labor (people), equipment, and materials (CLEM) and energy.

Behind the model in Figure 1.1.14.5.4. is a more basic model that says anything can only be 1) matter, 2) energy, and 3) information. Matter includes CLEM. However, we often use capital as a surrogate or a yardstick for anything.

Consider a classroom a domain of responsibility as described in Module 1.1.14.3. The who manages is the professor. The what is managed includes students, the room, books, and other physical responsibilities. The what is used to manage is the data and information in the grades, homework, rolls, and other information-oriented tools.

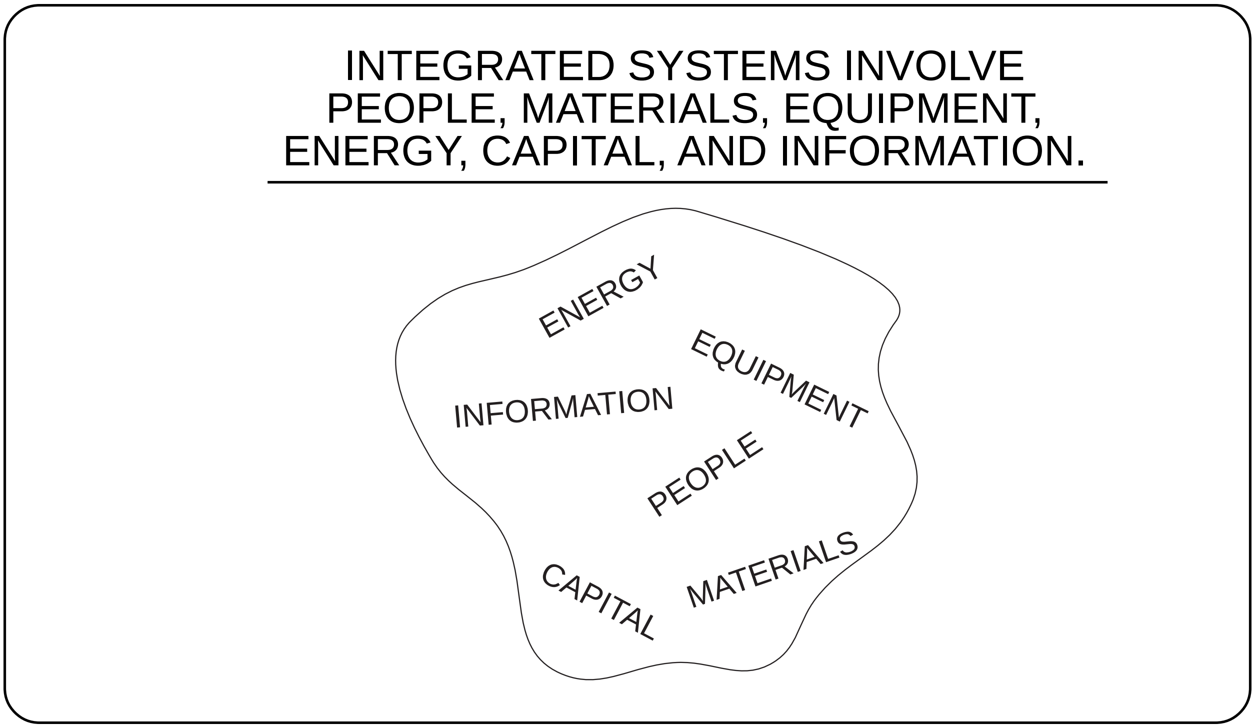

Figure 1.1.14.5.1. *An integrated industrial engineering system involves people, materials, equipment, energy, capital, and information.*

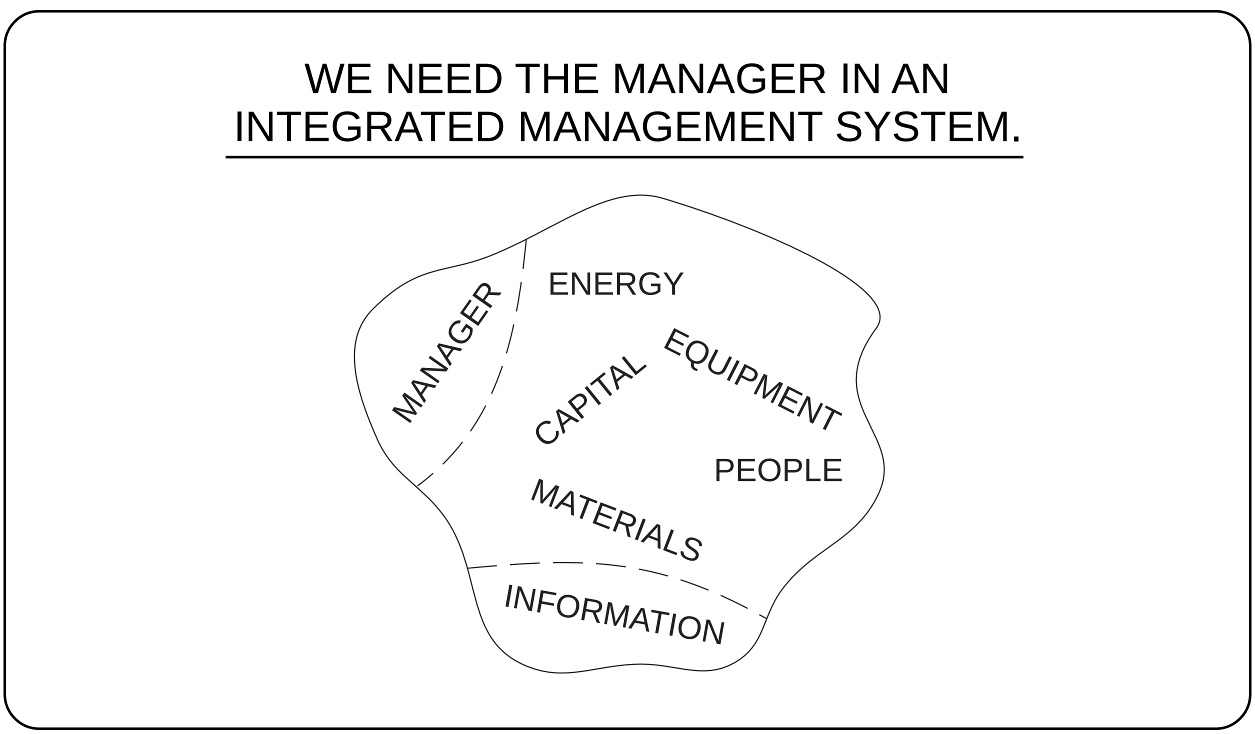

Figure 1.1.14.5.2. *The manager is a mandatory component in an integrated management system.*

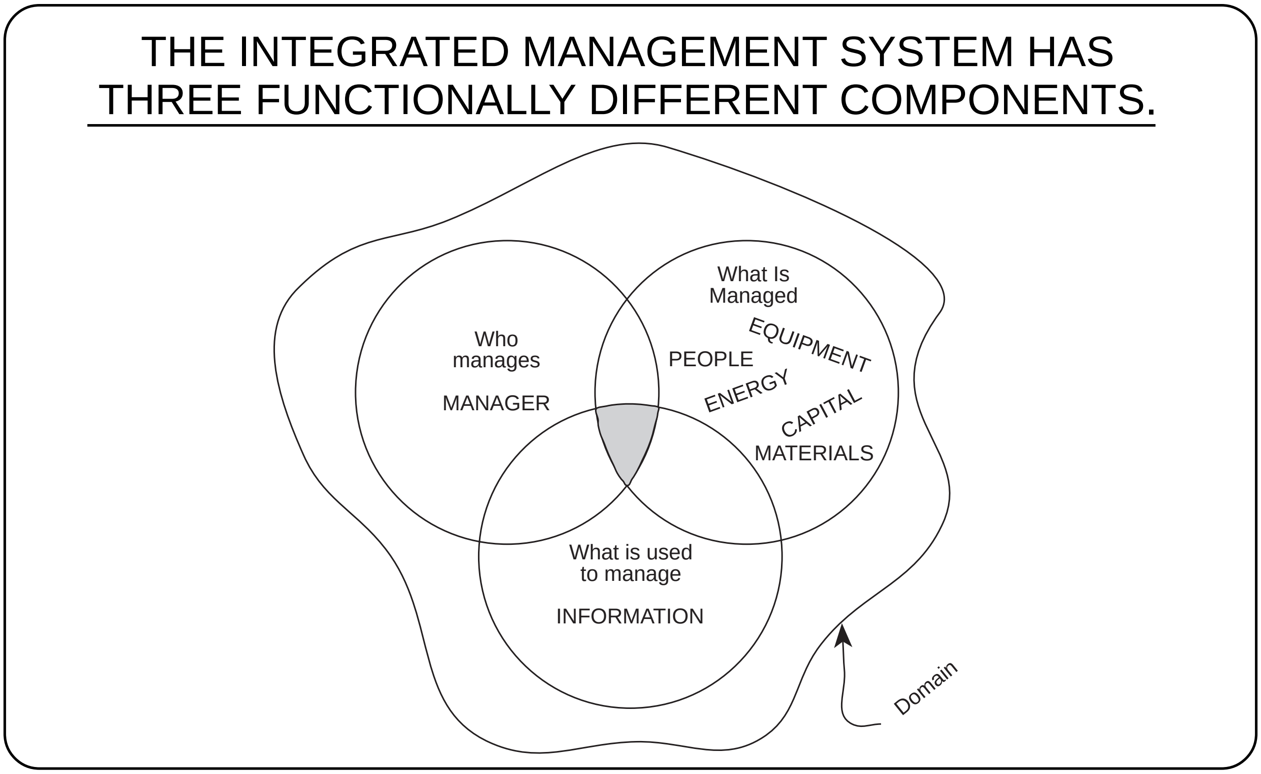

Figure 1.1.14.5.3. *The integrated management system has three functionally different components.*

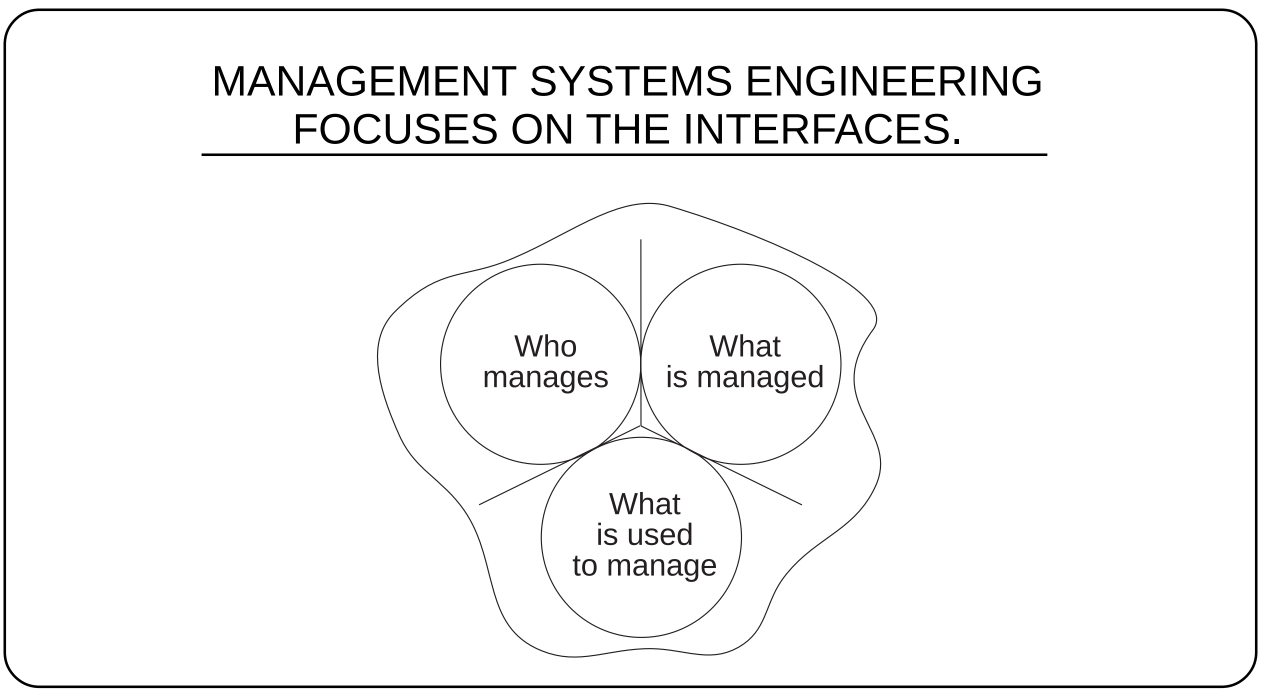

Figure 1.1.14.5.4. *Management systems engineering focuses on the interfaces between three components: who manages for the decision maker, what is managed for the collection of resources working together in a work process called the operation, and what is used to manage for the management tools that convert data about the operation into information for the decision maker.*

1.1.14.6. Exercise on Domains of Responsibility

When you work together with other people, you must know what your responsibilities are and are not or you'll be stepping on the toes of others by either duplicating, and probably contradicting, decisions and actions or by overlooking and neglecting decisions and actions.

Situation Description
Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They bought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. They perceive that there might be gaps or overlaps in their responsibilities. They've recently had a situation where they each gave John assignments that competed for the same time. They don't want conflicts and errors resulting from confused or undefined responsibility.

You've been hired as a management consultant to advise them. Your first task is to delimit the necessary domains of responsibility.

Exercise
Consider the hierarchical domains of responsibility in the situation description. Think about who is responsible for what inside the domain of the shoe store. Make sure all needed responsibilities are covered. Write a memo to the right person delimiting the domain(s) of responsibility.

Make sure you indicate similarities and differences among the domain and the relationships among the domains. For example, is Sally or Bob responsible for John or are all three independent? In what way is someone responsible for someone else?

Comment
Most of the time on my exercises, midterms, and exams and in real life, you'll have to make some assumptions to be able to solve a problem or answer a question. Make assumptions and indicate what they are. Your success usually hinges on how good your assumptions are. Don't assume away something that is given but you don't like. If you do, you're sure to work up a wonderful solution to the wrong problem.

1.1.15. The Systems Perspective—Auguste Rodin (*Eternal Springtime*)

In the system perspective, you must recognize the significance of every system component in its relationship to the whole or you'll have the wrong components or too many or too few components.

Simply put, you'll not understand and be successful at either the engineering process or the management process until you understand and internalize the systems approach. Both processes (and probably all processes) operate under the purview of the systems approach. From Taylor to Deming, we learn about and evolve our understanding of the systems approach. Because the systems approach is conceptual rather than tangible, many people never understand the systems approach. The systems approach is more than a mind issue; it's a heart and a gut issue. Artists tend to be in touch with their heart and gut as well as their mind. Therefore, I believe we can learn a lot from those artists who understood and tried to capture the systems approach through images or their creative process.

I don't believe you learn the systems approach progressively, like you do math or science. Also, I can't give you a pill that you can take today and tomorrow you'll be cured of non-systems thinking. You have to immerse yourself in thinking about the whole and what that means and about everything around you being a system with its associated processes; and then one day the systems approach will reveal itself to you. I suggest that considering the paintings or sculptures of the artists who came to know the systems approach is a good place to start your immersion.

I'll try to give you a feel for the systems approach by taking the dangerous path of analyzing the systems approach. I'll describe the systems approach through three perspectives: the system, holistic, and generalist perspectives. I'll use Rodin's sculptures to highlight the system perspective. I'll use Monet's paintings to highlight the holistic perspective. I'll use Magritte's paintings to highlight the generalist perspective. The danger in showing three perspectives for the systems approach is that the perspectives aren't truly separable. It's like looking at an elephant. If you look at the rear, you see a tail. If you look at the front, you see a trunk. If you look at the side, you see a large mass. But none of those views or the sum of the views is a true understanding of an elephant. Somehow, you have to see enough of the elephant that the views, or perspectives, blend into the whole and you lose the individual views but gain a total understanding.

Among others, Rodin, Monet, and Magritte help me come to grips with the systems approach. Rodin's sculpture clearly embodies the systems approach (and the engineering process) and blends the three perspectives. Yet, I'll use his sculpture to highlight the system perspective. His sculpture couldn't highlight the system perspective if the sculpture didn't embody all three perspectives.

I'm fascinated by the fact that I discovered Rodin's *Eternal Springtime* and Monet's *O Degelo* (*Breaking up of Ice on the Seine near Vertheuil*) in adjoining rooms in the Gulbenkien Museum in Lisbon and saw how clearly each highlighted one of the perspectives within the context of blending the three perspectives. Rodin and Monet knew each other, exhibited together, and were born two days apart. The influence they had on each other and the result of having the same historical environment influence them is hard to measure.

As we look at Rodin's sculpture, consider the balance in each work. Rodin strove for dynamicism and movement from within the piece. Not surface movement, but movement rising out from inside the moment he captures in the sculpture. A person couldn't hold some of his poses for long; the work shows a snapshot of movement. Ingrained in the snapshot is extreme balance. The sculpture shows motion and feeling but they are solid and stable. Biographers of Rodin say, "He loves life: ' Sculpture does not need to be original, what it needs is life', [Rodin] says. And to him life means movement, action. .... [Rodin said] 'I used to think that movement was the chief thing in sculpture and in all I did it was what I tried to attain. My Gates of Hell is the record of these strivings... There I have made movement yield all it can.' .... But [Rodin] does not think of movement simply as the transition from one attitude to another, a gesture or the shifting of an object in space. Movement is a way of expressing inner life, it is the emotional impulse that causes his sculptures to thrill and surge from within. .... 'Grief, joy, thoughts— in our art all becomes action', [Rodin] said. .... Movement foments and exalts matter: it is the subjective drive that animates objective form. All feeling is expressed by an inner movement. Movement also signifies becoming. The concept of time joins that of space, giving a new dimension to the work of art." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 14.)

Rodin said, "Intelligence designs but the heart does the modelling." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 7.) Design is central to the engineering process and comes from the head. The engineering process I've described goes beyond design and intelligence into meaning and feeling. To model the organization well with people in it, you must go beyond intelligence into the heart. Review the fundamentals of the engineering process in Module 1.1.11.6.4. and discover how significant role modelling and models (equations or algorithms) are for understanding the laws of nature and interacting with people. To do the management process, you'll need to use your head and your heart and gut.

In the system perspective, we emphasize the necessity of each of the components of the system and its importance in moving toward the system's aim. When Blanchard and Fabrycky talk about a system comprising components and their attributes and relationships, we don't know if they mean relationships among the components, relationships between each component and the whole, or both. Rodin clearly means relationships between each component and the whole. By exhibiting this preference, Rodin ties the system perspective to the holistic perspective and brings forth the systems approach.

Rodin said, "Great artists proceed as Nature *composes*, not as anatomy describes. They do not carve a particular muscle or nerve or bone for its own sake. They see and express the whole and by broad planes their work throbs with light or sinks into shade... The expression of life, to preserve the infinite suppleness of reality, must never be frozen and fixed."

His biographer continues, "This concept of composition is best explained by contrast with construction. Composition leads to a balance of forces, construction to a balance of masses. One is like music in orchestration of harmonies and concordances, the other like architecture in disposition of volumes. In composition a plane is seen in relation to the whole, in construction in relation to other planes. Composition suggests motion and 'the infinite suppleness of reality', while construction achieves the solid structure of finite static forms." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, pp. 15-16.)

Value analysis, or value engineering, is an important activity in continual improvement. Value analysis focuses on the value of each component of a system relative to the purpose of the whole.

"'An artist is Nature's confidant', said Rodin. 'Trees and plants talk to him like friends.' ...

'Everything in Nature has character,' Rodin said. 'Character is the vital truth of any spectacle, ugly or beautiful. In art, only that which has character has beauty. What is ugly in art is that which is false, artificial, trying to be pretty or handsome instead of being expressive, that which is genteel and affected, which smiles for no reason, is mannered without cause, all that is show of beauty or grace, all that lies.'

This is the most outright rejection of the theories of the academic school, who saw art as an illusion designed to make life more bearable by showing the image of an ideal world that would make us forget the miseries of everyday existence." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, pp. 20-21.)

To do the systems approach, you have to be in tune with nature and the laws of nature. Rodin said the trees and plants talk to the artist. Here, he's referring to the life sciences. As a management systems engineer, you have to be in tune with the physical sciences, the life sciences, and the social sciences so you can feel the cause and effect situations in the workplace.

"Rodin said: ' The artist is the seer. He is the man whose eyes are open and to whose spirit the inner essence of things is made known, at any rate, as a fact of existence... I reproduce only what I have seen and what anyone else could see if they would take the trouble; but then I am always looking and I know there remains to be found out infinitely more than I shall ever have time to discover.'" (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 13.)

We'll learn an important rule governing the management process: Practice inquisitiveness with everything you touch. To comply with this rule, you have to be observant, you have to care about what you do and whom you do it with, and you have to search out the laws and principles governing your work. Like the artist, you have to be a knowledgeable seer, open to the inner essence of things.

When Deming talks about the important things in an organization being unknown and unknowable, he isn't saying that measurable things are good and unknowable things are bad. He's simply addressing the relative importance of the things we can measure versus the things we can't measure. How do you feel about having some things unknown in your workplace? How do you feel about having the most important things unknown?

Rodin addresses the unknowable. His biographer says, "By [his] union of becoming and duration [motion], art 'advances to the preserve of the Unknowable.'"

"To express in sculpture the new balance between duration and becoming, substance and mobility, Rodin used three processes which shocked his contemporaries: composition, *unfinished form* and modelling from within." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 15.)

'Great works of art say all that can be said about man and the world, and then convey that there is something more that cannot be known. Every masterpiece has this quality of mystery.'

Rodin's sculpture approaches the Unknowable and make us realize its existence. There is no art without mystery or without poetry.

The 'leaving unfinished' technique helps to express better the mystery of form awakening in the stone." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 17.)

His biographer further says, "By extending the realm of art to the confines of the Unknowable, [Rodin] restored the mystery of things and the search for their inner truth. Thus the artist became a true creator, instead of remaining a mere imitator.

Rodin helped his contemporaries and successors to understand that art is an unrelenting battle that leads to the very heart of things where the being finds his essential truth.

In our day, when man aspires to explore the galaxies, Rodin's art reminds us that an immeasurable vaster universe still remains to be discovered in the human soul and its yearning for the absolute and eternal." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 120.)

The unknowable in our work gives our work a sense of mystery. That mystery makes life worth living. We must continually search for, discover, and learn about the mysteries in our work processes and in the people we work with. A system is more than components. The systems approach contains the mystery of an immeasurable vaster universe yet to be discovered. When we understand our responsibilities as a system, we find the mystery together with the tangible.

Rodin said, "Force creates charm. I have charmed force." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 30.)

His biographer said, "The names of Cezanne and Rodin will live for ever in the glory of eternal light as two geniuses to whom we owe our completely renewed vision." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 29.)

Look at *Eternal Springtime* in Figure 1.1.15.1. Is this a system? Does this system have components? Are the people components? How about a foot or an arm? What happens if you change one of the components? Move a foot or a hand. Change a position. Then does the sculpture meet its aim? Have we disturbed the exquisite balance of the sculpture?

I can show you another sculpture by Rodin called *Illusions Received by the Earth* (or *The Fall of Angels*). The woman in this sculpture is essentially the same woman in Eternal Springtime. Now, I've implied the components are interchangable. That is, a component can play one role in one system and another role in another system. Each role is necessary for each of the systems to reach its aim.

What is the aim of *Eternal Springtime*? Rodin's biographer says, "Eternal Springtime is the image of love in all its fervor. The purity of the sculpture is assured by the exaltation of the forms. By the force of generalization and the intensity of plastic expression, Rodin rises above sensuality and the particularly case." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 61.)

Is Rodin portraying passion, ecstasy, or rapture? Is the woman in the sculpture showing exhaustion, submission, or rapture? The answers to these questions address the movement Rodin is bringing from within the sculpture. He is modelling from within. Is the sculpture aimed toward intimacy? Rodin integrates the components to achieve his aim.

What about a different system? Include the observer with the sculpture in a system. Now what's the aim of the system? Does the feeling or thought of the observer affect the new system? This sculpture comes from *The Gates of Hell*. Within *The Gates of Hell*, the sculpture in Figure 1.1.15.1. is a component. Now, what role does the sculpture play toward a system's aim? Do you see the sculpture in a different light?

I saw *Eternal Springtime* in one setting, or environment. As part of a system including me, the observer, the environment had dramatic effects on the system. In another place and another time, I might not have had the same relationship with the sculpture. (That's why the frame on a painting is important.) The business environment has the greatest effect on an organization.

When we discuss organizational culture and the organization as a system, we'll find that the business environment and the organization's role in a larger system affect how we see the organization.

Figure 1.1.15.2. is another component of *The Gates of Hell*. *The Thinker* is usually seen as its own system. As the significant top part of *The Gates of Hell*, *The Thinker* contemplates the plight of the human race. Now *The Thinker* has something to think about.

A fascinating aspect of Rodin's life was his relationship with his fellow sculptress and his mistress, Camille Claudel. No doubt, Claudel influenced Rodin and his insight. When we consider the artist as seer and the person with his or her eyes open, we search for the insight of the artist. While Claudel contributed to Rodin's understanding of the systems approach, we can see from Figure 1.1.5.3. that Claudel forfeits balance and stability for movement and emotion. Much of Claudel's emotion included despair and pain. *The Imploring* in Figure 1.1.5.3. shows clearly the movement of despair from within the sculpture.

Rodin's sculptures have balance. Rodin's sculptures show not only motion and passion but, unlike the sculpture of Claudel, are solid and stable.

The movie Camille Claudel with Gerard Depardieu and Isabelle Adjani presents many questions about Claudel's influence on Rodin. We'll never know how much of Rodin's work was influenced by Claudel and, in fact, how much of his work is hers.

We'll never know how much Rodin contributed to Claudel's eventual lunacy. The lunatic mind isn't too far from the mind of the genius. Consider Van Gogh, Edvard Munch, and Camille Claudel. They were able to get in touch with the deep pain and imploring and other struggles of us all. Rodin was not a kind person and treated everyone badly, especially his fellow sculptors and his mistresses.

"Anatole France wrote in 1900: 'Insult and outrage are the wages of genius and Rodin after all only got his fair share.'" (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, p. 7.)

One of the contributions of the impressionist movement was the surfacing of women artists known in their own right, artists like Camille Claudel, Mary Cassatt, Lila Cabot Perry, and Berthe Morrisott. These women all influenced and were influenced by male impressionists like Degas, Monet, and Rodin.

"The liberal middle classes, who had opposed the despotism of Napoleon III, came to power after the disastrous war of 1870 and the tragedy of the Commune. Enriched by the industrial revolution, economic expansion and financial speculation, these middle-class liberals were not bound by tradition. ..... The mythological and historical subjects of the academics were ill attuned to the tastes and aspirations of this rapidly rising new class. Realists in their enterprises and speculations, they expected art to be true and draw its inspiration from contemporary life. ..... Rodin and the impressionists nourished [the ideas of independence, sincerity and individualism]. To apply them, they sought the most appropriate means and thus came to invent a new language of art completely opposed to that of the academic school." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, pp. 12-13.)

Rodin said, "'I have come to realize that geometry is at the bottom of sentiment or rather that each expression of sentiment is made by a movement governed by geometry. Geometry is everywhere present in Nature. A woman combing her hair goes through a series of rhythmic movements which constitute a beautiful harmony. The entire rhythm of the body is governed by law... Nature is the supreme architect. Everything is built in the finest equilibrium; and everything too is enclosed in a triangle or a cube or some modification of them. I have adopted this principle in building up my statuary, simplifying and restraining always in the organization of the parts so as to give the whole a greater unity... Cubic reason is the mistress of things, not appearance.'" (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, pp. 23-24.)

"Much has been made of the sensuality of some of Rodin's sculptures. Indubitably, he did know how to render tactile values in marble, the thrill of a caress and the frenzy of desire. But his sculpture is never vulgar, for the soul is always present: he so exalts form that it is transfigured; he rises above mere sensuality and the particular case by the power of generalization and the intensity of plastic expression.

Concern for truth in Rodin is always coupled with the urge to approach the essence of things. How can this be attained if not by passion?" (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, pp. 22-23.)

"To Rose Beuret [Rodin's mistress, whom he married at the end of her life—less than three weeks before her death] he wrote, ... You will not be surprised to hear that from the minute I reached Florence I have been studying Michelangelo and I believe the great magician is letting me into some of his secrets... In my room, at night, I make sketches, not of his works, but of what I imagine as his framework and the various systems I invent to try to understand his methods; well, I think I succeed in giving them that look, that indefinable something which he alone could give.'

The encounter with Michelangelo's work was decisive to Rodin's evolution, as he confessed in a letter to Bourdelle, in 1906: 'I owe my liberation from academism to Michelangelo.'

He refused to copy or imitate Michelangelo's sculptures for he was seeking a much more fruitful lesson, striving to discover the great master's secret and understand how he created." (Ionel Jianou, *Rodin*, Editions du Musee Rodin, Paris, 1990, pp.40-41.)

The artist and the management systems engineer must not only look for the inner essence in nature but also the inner essence of the processes with which we produce things. Not until we understand the secrets of the processes (not just the steps but the meaning of it all) can we produce better results.

The concepts I intend for you to remember and will reinforce during the book are:

- To be a successful management systems engineer, you must understand and internalize the systems approach.
- The system perspective highlights the necessity of each system component and its importance to achieving the system's aim.
- Systems show internal movement, always changing; and a balanced system has both motion and stability.
- Good models include what we know in our heart and gut as well as in our mind.

- Artists and management systems engineers want to emulate nature by balancing forces in composition, which relates each component to the whole instead of just to other components.

- The laws of nature drive everything.

- The thrill and joy of mystery in the workplace come from the unknown and unknowable, which are the important things in an organization.

- A system not only has components but is always a component of a larger system with a larger aim.

- The role a component plays depends on the system the component is part of.

- As an observer, we become part of and, therefore, change the system.

- In our work, we influence and are influenced by other people and distinguishing who did what refutes the systems nature of things.

- In the late 1800's and early 1900's, we made a step function advancement in being able to see beyond our eyesight to the inner meaning of nature—in physics, in psychology, in art, and in management.

- To get better results, dig into the heart of the process.

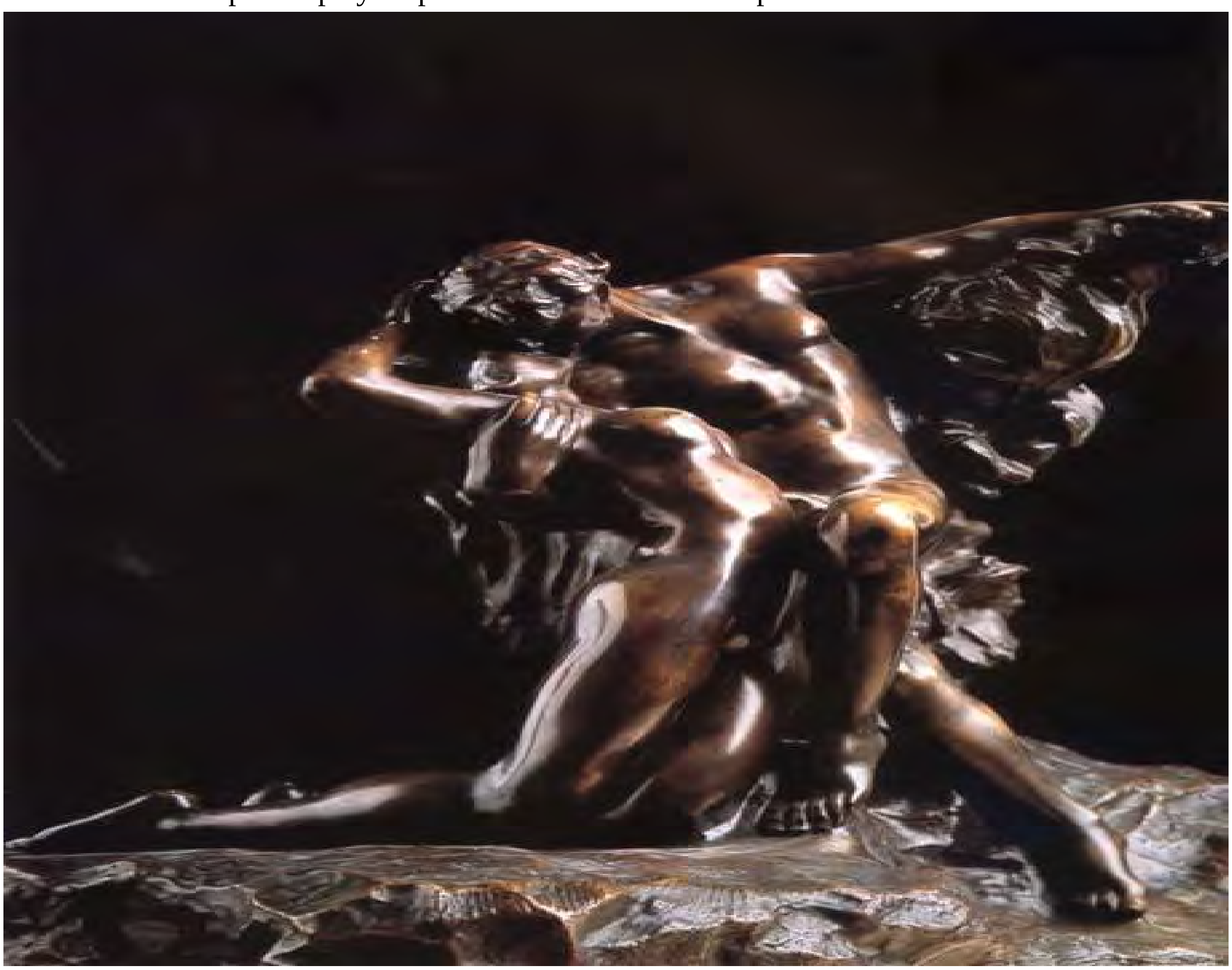

Figure 1.1.15.1. *Rodin's* Eternal Springtime *highlights the necessity of each component of the system and the important role each plays in achieving the aim of the system.*

Figure 1.1.15.2. *Rodin's* Illusions Received by the Earth *shows the woman as an interchangable component with* Eternal Springtime.

Figure 1.1.15.3. *Claudel's* The Imploring *shows how out of balance the pain of imploring can be.*

1. BACKGROUND

1.1. INTRODUCTION

1.1.16. FOUNDATION CONCEPTS II

1.1.16.1. More General Concepts Defined Quickly

To help communicate ideas and models for management systems engineering, discussions of fundamental concepts need to show definitions of terms, relationships to other terms, and meaning of the terms for a) analysis/synthesis, b) synergy, c) balance, and d) functions.

The concepts in the next several modules following this one take relatively more discussion. The concepts in this module take relatively less discussion, and I've grouped them in this general heading. As before, the concepts are cumulative and you'll have to carry a concept throughout the rest of the book.

Analysis/Synthesis

In management systems engineering, you'll be doing both analysis and synthesis activities, and frequently and regularly switching from one to the other. Analysis is defined as: "separation of a whole into its component parts." (*Webster's Ninth New Collegiate Dictionary*) Blanchard and Fabrycky talk about analysis of systems. "The analysis of systems to be brought into being (or already in being) may take one of two forms, process analysis or outcome analysis. *Process analysis* subjects the system to study as a number of related subsystems and components. The intermediate outputs of the system are studied to find the means whereby they comprise serially related processes. ..... *Outcome analysis*, on the other hand, is usually applied to systems not yet in being. It is a macroscopic approach, which treats the system as a whole. Focus is placed on the end result rather than upon intermediate results and means." (p. 24.)

We often practice analysis for tractability. We divide a problem up into parts because each part can be handled. In nuclear engineering, we analyze the neutrons in the reactor core by separating the Boltzmann equation (the equation containing time, space, energy, and angle functions of the neutrons) into diffusion equations for space, kinetics equations for time, group equations for energy, and transport equations for space. We can solve each equation type if we ignore the interplay of all the other types. We can't solve the Boltzmann equation. We assume that when we get each type solved we can somehow assemble the solutions together in such a way that we understand what neutrons do in a reactor. When we solve diffusion equations, we lose the forest for the trees. That's because the forest for neutrons is intractable for our tools and techniques.

If we practice analysis under the umbrella of the systems approach, we never lose sight of the forest. Each step of an analysis, whether of the process or the outcome is aimed at the objective of the whole. In the systems approach, analysis of the process is the heart of the matter because the process begets the outcome. Analysis of the outcome is after-the-fact and is useful to get a window into the process. In short, you can separate the whole into its component parts and either focus on the aim of the whole or focus on the aim and functioning of the part. In the systems approach, you do the former.

In analysis, we run the risk of losing sight of the whole and the role the part plays in the mission of the whole. Figure 1.1.16.1.1. illustrates analysis in a work-breakdown-structure format. The arrows show the direction of focus away from the whole. The figure also looks like the typical organization chart, which Deming argues is dysfunctional.

Synthesis is defined as: "the composition or combination of parts or elements so as to form a whole." (*Webster's Ninth New Collegiate Dictionary*) Blanchard and Fabrycky say, "Synthesis refers to the combination and structuring of parts and elements in such a manner so as to form a functional entity. System synthesis has been achieved when sufficient trade-offs and preliminary design have been accomplished to confirm and assure the completeness of system performance and design requirements allocated for detail design." (p. 272.)

Figure 1.1.16.1.2. illustrates synthesis in a work-breakdown-structure format. The problem with Figure 1.1.16.1.2. is that the figure is an analytical look at synthesis. The figure does show the direction of focus toward the whole. In synthesis, the parts don't add up to the whole. Assembling the whole isn't simple addition or multiplication. The parts interact and intermingle to ensure the whole reaches its aim. Synthesis mirrors the systems approach.

I believe both analysis and synthesis can be microscopic and macroscopic. The difference between analysis and synthesis is the difference between separating and melding. Separation includes intervening space. Melding includes blending and losing distinction among the parts. You can do that at broad or at specific levels of scrutinization. You can do analysis and synthesis activities together. As you analyze the unit of interest, you can do synthesis steps, and vice versa. You can say you're doing mainly analyzing or synthesizing, but you can't say you're exclusively only doing one or the other.

Whether as a child when you're responsible for your pet or as an adult when you're responsible for a business or your family, you're responsible for something. You're a manager because you're responsible for something. You actually manage when you use information to make decisions affecting your responsibilities. Management system analysis helps you figure out exactly what you're responsible for and what's different in what you manage from what others are responsible for. Based on a clear understanding and characterization of your responsibilities, management system analysis helps identify, design, and build all the different management tools you need to help you convert data into information so you can make good decisions and to identify, design, and build productivity and performance evaluation, maintenance, and improvement systems to get the most out of your responsibilities. Management system synthesis helps you use your management tools and performance systems to be successful in doing what you want to do with your responsibilities.

Synergy

Synergy is defined as: "combined action or operation." (*Webster's Ninth New Collegiate Dictionary*) This term is popularly used today to mean the ability of a system to total more than the sum of its parts. The implication is that you can get more out of something than you put into it. We know that notion violates the First Law of Thermodynamics.

A graphic example of what popularly is meant by synergy is the situation where a basketball team with no superstars outperforms another basketball team with all or mostly superstars. We know this phenomenon exists—especially when it's the other team who wins without stars. The phenomenon is important in management systems engineering because we want to manage or help someone manage a winning organization. What we're looking at is suboptimization as opposed to optimization. Remember Deming's words, "If the system is optimized, the parts will not be." When all the parts of a system are there and working at peak performance toward the aim of the system, we see a step-function improvement in the performance of the system. That's synergy—if the unit of interest is the system.

Balance

When we first think of balance or being in balance we think of a beam freely supported in the center that has two pans of equal weight suspended from its ends. We also think of equilibrium or steady state. I don't mean those. By balance, I mean for a system to be so constituted such that when perturbed the system can and will come back to a level of equal or improved performance. The system is stable. Balance applies to everything. When a gymnast is on the balance beam and something goes awry, if they're in balance they'll come back to the same or better position on the beam.

A system has subsystems and components. The balance of the system depends not on the components, rather on the interactions and interfaces among the components. For the system to succeed under pressure or crisis, the components or subsystems have to work together synergistically through their relationships. In Figure 1.1.14.5.3., I showed a management system with three functionally different components and, in Figure 1.1.14.5.4., I transformed the overlap or intermingling of the components into interfaces. I've manufactured the interfaces to represent the interactions between pairs of components. Then, the balance of the management system depends on the interfaces and how well they work.

A marble in a trough is stable, or type I, balance. A marble on top of a culvert is unstable, or type II, balance. Neither is desirable for the organization. Type I is a deadlock and no improvement is possible. Type II is a fake—you think you're in balance and you are, but the slightest disturbance will cause a catastrophe. My definition addresses neither of these. In balance, the organization in balance can and will come back to a better state after a disturbance. We call this kind of organization a learning system, or a learning organization. In imbalance, the organization can or will come back to an equal or worse state after a disturbance. This leads to my analogy of organizational acupuncture. A complex system stays in a "flow balance" even if there's a disturbance from outside. You can't do this in a simple system. This is homeostasis and is used in chaos theory.

Organizational acupuncture is a catchy notion implying that we can cure an organization if we know where to stick the needle. In the Chinese culture, yin yang means that the human's organs must be in balance for a healthy system. Once out of balance one organ can affect another and the body can get progressively worse in a vicious cycle. However, if we can slightly perturb the system in exactly the right way, we can break the vicious cycle and start the system back to good health. In the organizational analogy, a sick organization gets progressively worse with all organs interacting negatively. Our challenge is to know what little perturbation we can make to break the vicious cycle and start the organization to recover progressively getting better as the organs interact in positive ways to bring the system to good health.

Function

I'll describe a number of engineering and management process functions in this book. A function is part of a process. Together, the functions done correctly constitute the accomplishment of the system's aim. The function has the potential to serve a purpose in playing a part in the process. You make the function real (more than potential) by skillfully using tools and their guides.

In a process, you do steps, each of which serves a function. In mowing the lawn with a gasoline-powered lawn mower, you start the mower. The purpose or function is to energize the mechanics of the machine. The system includes you, the lawn mower, and the lawn. If your responsibility is maintenance on the lawn mower, your unit of interest doesn't include the lawn and the aim of the system is different from mowing the lawn. The step of starting the lawn mower and the function of energizing the mechanics of the machine are essentially the same thing. Either statement tells you where you are in the process. The function is realized through the process. In Figure 1.1.11.4., for our intervention, we exercise the tools and guides and techniques through one or more functions in the organizational model to get the performance or success criteria we want. We can look at the function from the perspective of the user of the tool. The user interprets what he or she wants the tool to do and why. For example, a user can choose to use a salt shaker to distribute salt or to pound a nail. From the perspective of the user, a function is "the action for which a person or thing is specially fitted or used or for which a thing exists." (*Webster's Ninth New Collegiate Dictionary*) If we operationalize the definition by substituting the tool for the person or thing, we get: A function is the action for which a tool is specially fitted or used, or for which a tool exists. The idea of the function carries the action and the purpose of the action—if you will, the step and the purpose.

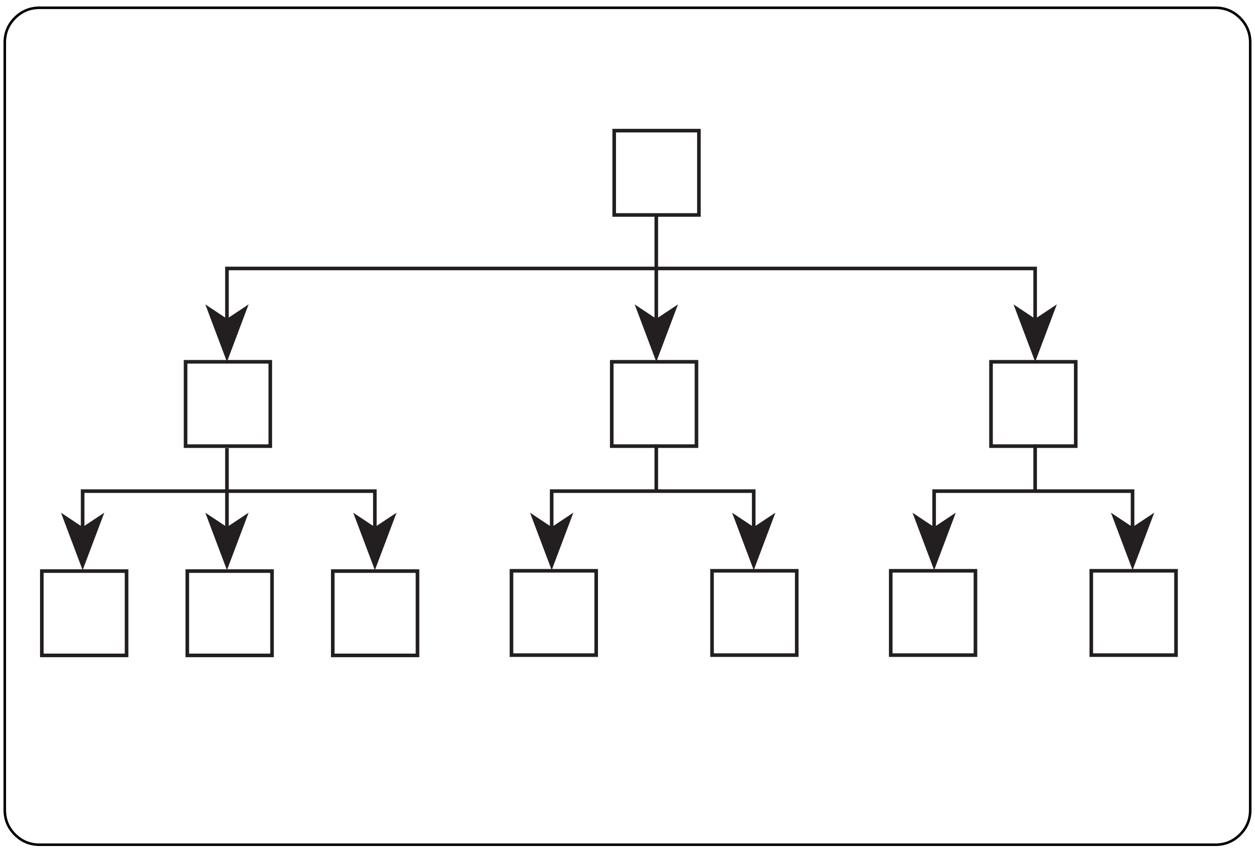

Figure 1.1.16.1.1. *In analysis, we look toward the parts of the whole so we can better deal with each part.*

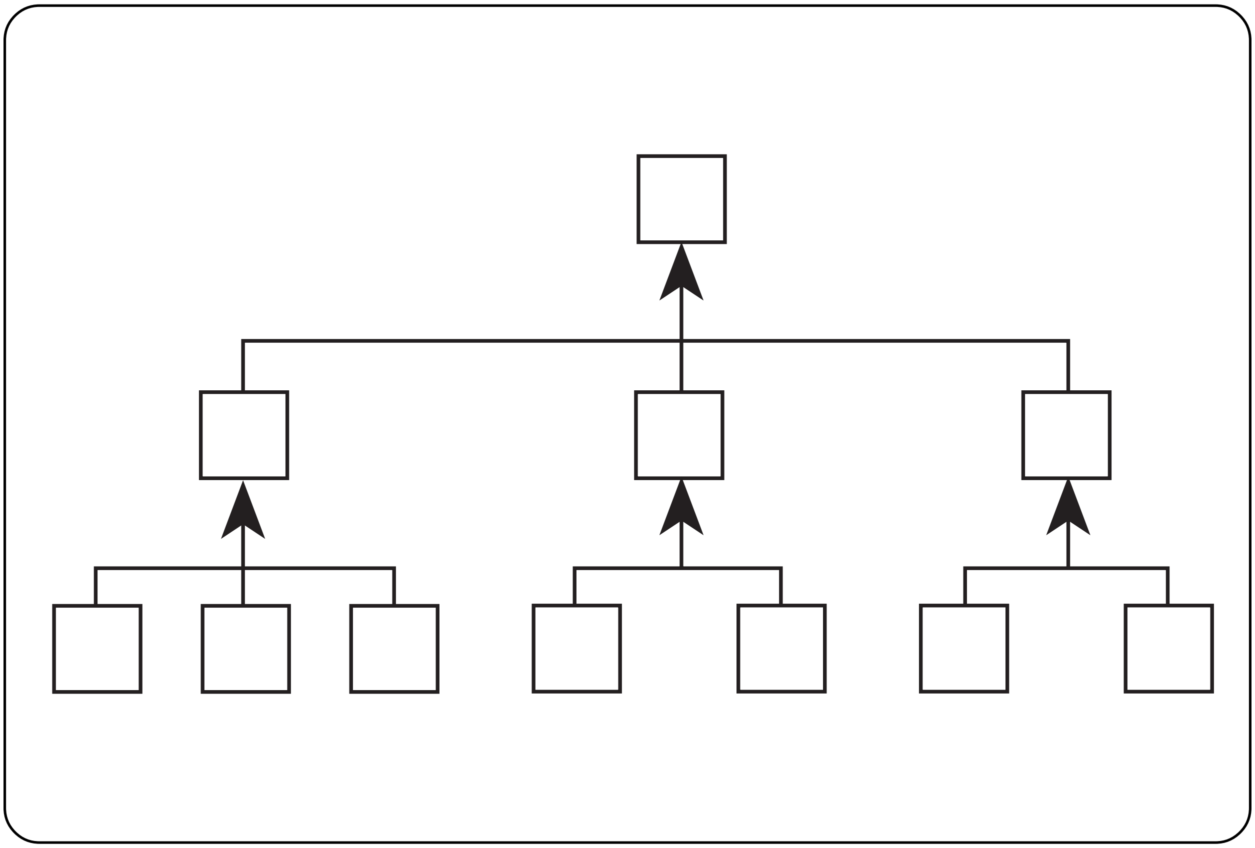

Figure 1.1.16.1.2. *In synthesis, we look toward the whole so each part can contribute to the aim of the whole.*

1.1.16.2. Define the Systems Approach

The systems approach is a way of looking at the world and seeing consistency, meaning, and relationships among all things. In this way, the organization is like a living system, a mechanical system, an electrical system, a system of language, or any other system; and the lessons learned from experience with any system are transferrable to organizations in the ways the system and the organization are similar.

To distinguish the subtle, but important difference between a system and the systems approach, I'll start with another definition of a system. (We defined system earlier in Module 1.1.11.5.) Weinberg, in his book *An Introduction to General Systems Thinking*, also defines a system. "What is a system? As any poet knows, *a system is a way of looking at the world*. The system is a point of view—natural for a poet, yet terrifying for a scientist! (p. 52)

"With 'man-made' systems, we talk about 'purpose,' whereas such language is forbidden for 'natural' systems. Yet much of the dissatisfaction with our man-made systems stems precisely from disagreement about what the 'purpose' of the system is: that is, what the system 'really' is. The answer, of course, is that the system has no 'purpose,' for *'purpose' is a relation*, not a thing to 'have.' To the junk dealers, General Motors *does* exist to put out scrap metal, yet the stockholders probably couldn't care less whether General Motors is producing cars or string beans, as long as it is producing profits." (p. 57.)

"The role of observer is usually ignored in systems writing. The most popular way of ignoring the observer is to move right into a *mathematical representation* of a system—a so-called 'mathematical system'—without saying anything about how that particular representation was chosen. For example, Hall and Fagen (Arthur D. Hall and R.E. Fagan, 'Definition of system.' In *Modern Systems Research for the Behavioral Scientist*, Walter Buckley, Ed. Chicago: Aldine, 1968.) give this definition: A system is a set of objects together with relationships between the objects and between their attributes. Where did these objects come from? Hall and Fagen give no clue. They might have dropped from the sky, except *we* happen to know they came from the mind of some observer.

Hall and Fagen rightly emphasize 'relationships' as an essential part of the system concept, but fail to give the slightest hint that the system itself is relative to the viewpoint of some observer." (p. 63.)

Weinberg uses the term quality instead of the term property used by Blanchard and Fabrycky discussed in Module 1.1.11.5. Weinberg says, "Scientists sometimes speak of two kinds of qualities—*extensive* and *intensive*—according to what happens to the quality when the system is divided into parts. If we break a chocolate bar in two pieces, each piece has a different mass than the original: thus mass would be called an *extensive* quality, since it depends on maintaining the full extent of the system. On the other hand, when we break the chocolate bar in half, each piece retains the same 'chocolateness'; which is therefore said to be an *intensive* quality. Or, to take a more physical example, each half has the same density, so density is said to be an intensive quality." (p. 152.)

When we look at the organization as a system, we'll deal with its states and qualities, or properties. Since organizations have subunits, we'll need to characterize both the system and the subsystems. When we consider cultural strength of General Motors in relation to the cultural strength of the engineering department, are we talking about an extensive or an intensive quality? If cultural strength is extensive, how do we determine the cultural strength of General Motors by surveying its people?

Recall the definition of a system in Module 1.1.11.5. and compare the classical definition of system by Blanchard and Fabrycky to the definition of Weinberg.

I don't accept the apparent contradiction in the two definitions of a system. In fact, I see the two as mutually supporting the idea of systems. The Blanchard and Fabrycky classical definition of a system for systems engineering sees a system as something with components or parts working together toward the benefit of the whole. This system is a thing. The Weinberg definition of a system is a way of looking at the world. This system is a meaning. I believe the first is a system and the second is the systems approach. They go together, but are different in subtle but important ways. Most people don't differentiate between a system and the systems approach and their preference for definition reflects what they're trying to do with the definition. To resolve the apparent difference, we must look below (or perhaps above) the surface to find deeper understanding.

First, I accept the classical definition with components, attributes, and relationships as a system. The systems approach is subtly different. The systems approach includes at least three perspectives, or viewpoints: 1) the system perspective, 2) the holistic perspective, and 3) the generalist perspective. In the system perspective, each of the parts of the system plays a specific and necessary role in the working of the whole. If one of the parts changes its function, the system isn't the same. The combination changes and the meaning is different. In the holistic perspective, we get a gestalt. Changing one of the parts doesn't change the system. If there are a lot of parts, changing several of the parts doesn't affect the meaning. In the generalist perspective, mother nature is consistent. The principles and lessons learned from one system transfer to another system. I'll discuss the system, holistic, and generalist perspectives in more detail in Modules 1.1.16.6., 1.1.27.3., and 1.1.27.6. respectively.

The issue of changing parts affecting the system contrasted between the system and holistic perspectives may seem contradictory. The problem is I'm discussing the systems approach analytically. I'm dividing up something that shouldn't be divided up. Each part of the system is necessary for the system's aim but each part only contributes to the meaning of the system. If we look at the system from one perspective, like seeing an elephant from one side, we can better understand that perspective but don't get the whole picture. I believe the important subtlety of each part of a system (e.g., person in an organization) being necessary and important from the system perspective and the meaning of the system being bigger than the system or its parts from the holistic perspective will be clearer when I discuss the perspectives in more detail.

Let's apply the three perspectives to the situation of the Blanchard and Fabrycky and Weinberg definitions for system. The generalist will accept two agreed-upon, apparently-contradictory definitions as mutually supportive. The generalist wants to see the supporting contributions and transfer the lessons learned reciprocally between the definitions. The holistic perspective steps back to get the broader view and lose the individual definitions in the true meaning of the concept. For a holistic perspective, the two definitions describe the same concept, only with different intent. The systems perspective recognizes the important specific contributions of each to work toward a common understanding and seeks the right roles of each to get the best result.

The three perspectives work together to support the systems approach—a way of looking at the system in question, with its parts, its input, output, and process, and its aim or objective. The systems approach contains more of the aim of the system and the system contains more of the objective. I'll discuss the three perspectives and the differences between aim and objective later.

I'll define a management system with its components, attributes, and relationships. I'll argue that the management process requires functions and rules within the system but also requires the systems approach with its three perspectives. So does the engineering process. To be successful at the management process or at the engineering process, you'll need profound knowledge of systems.

The definition of a system and of the systems approach isn't all there is to understanding systems. I'll round out (add to) our understanding of systems later when I discuss the complementary notion of a process. The notion of a process is important in management systems engineering because of the centrality of the engineering and management processes.

The systems approach is a way of looking at the world that affects your behavior. That is, you do the systems approach, or better stated, you do things a certain way because of the systems approach. When you do the systems approach, you 1) clearly define and scope the unit of interest; 2) exercise the system, holistic, and generalist perspectives; 3) apply system models like input/output models, feedback loops, and influence diagrams; 4) understand and focus on the process; 5) understand and exercise the power of the iterative, recursive, and reversing nature of the system life cycle; 6) establish or distinguish the aim of the system; and 7) exercise analysis and synthesis within the aim of the system. Each of these practices are important to management systems engineering and I'll discuss each in some detail later.

1.1.16.3. Static and Dynamic Systems

Organizations are dynamic systems; but we can model the organization as either a static or dynamic system depending on the purpose of the model.

Blanchard and Fabrycky define static and dynamic systems. "A *static system* is one having structure without activity, as exemplified by a bridge. A *dynamic system* combines structural components with activity. An example is a school, combining a building, students, teachers, books, and curricula. ..... It is recognized that a system is static only in a limited frame of reference. A bridge is constructed over a period of time, and this is a dynamic process. It is then maintained and perhaps altered to serve its intended purpose more fully." (p. 8.)

Notice the implication of the bridge as a system within the larger highway system within the even larger transportation system. Notice the implication of construction as a process and the interchangeability of the terms. We'll distinguish between the two.

The idea of static is relative. There's no such thing as a 100% static system in tangible systems. If something is tangible, it deteriorates. The first basic law of reliability theory is that the reliability of the system is zero at time equal to infinity. Consider an abstract system, such as the system of chemical elements, to be 100% static. Abstractly, the system exists and we just discover a new element from time to time. The potential of the element always exists.

For tangible systems, static depends on time constraints. When we look at a Rodin sculpture, we say the object, or system, doesn't change. But what the object does to people does change over time.

An organization is clearly a dynamic system, although we'll first model the organization as a static system. Of course, we have to make approximations to do so. The results are good in those areas where the approximations are valid. We model mechanical systems first as static then as dynamic. The environment and the decision maker are the forcing functions that cause the organizational system to be dynamic.

We model an automobile using both statics and dynamics. In statics, we're interested in equilibrium, stability, or steady state. I'll use the word balance. Also, in statics we're interested in the strength of the components and the relationships among the components. When we're interested in the change in the automobile over time, we use dynamics. When we think of dynamics and an automobile we think of the velocity and acceleration of the automobile as it changes position during a time period. We can also think of the velocity and acceleration of the deterioration of the car over time. Each model teaches us something about how automobiles work and how well a particular automobile is performing. In management systems engineering, we'll have our versions of statics and dynamics for the same purposes. We'll use statics for balance and strength of components. We'll use dynamics for change and the influence of the environment in causing change.

Organizations change position and they deteriorate during a time period. Often, we have to rebuild an organization. The organization can change market position, product position, and staffing position. Organizations have life cycles, just like automobiles do. Marketing and sales are crucial functions for organizations, because these functions are forcing functions. They beget change.

Organizations have time constants, as do all systems. The time constant is a function of the business environment, the leadership, and the staff. In the limit, as we consider the time period of interest as approaching zero, systems, such as organizations, look static and closed. I'll discuss closed and open systems in the next module.

1.1.16.4. Closed and Open Systems

Organizations are open systems, but we can model organizations as closed or open systems, depending on what we want to learn about the organization, taking into account the approximations we make when modelling an organization as a closed system.

Blanchard and Fabrycky define closed and open systems. "A *closed system* is one that does not interact significantly with its environment. The environment only provides a context for the system. *Closed systems* exhibit the characteristic of equilibrium resulting from internal rigidity that maintains the system in spite of influences from the environment. An example is the chemical equilibrium eventually reached in a closed vessel when various reactants are mixed together. The reaction can be predicted from a set of initial conditions. Closed systems involve deterministic interactions, with a one-to-one correspondence between initial and final states.

An *open system* allows information, energy, and matter to cross its boundaries. *Open systems* interact with their environment, examples being plants, ecological systems, and business organizations. They exhibit the characteristics of *steady state*, wherein a dynamic interaction of system elements adjusts to changes in the environment. Because of this steady state, open systems are self-regulatory and often self-adaptive.

It is not always easy to classify a system as either open or closed. Open systems are typical of those which have come into being by natural processes. Man-made systems have characteristics of open and closed systems. They may reproduce natural conditions not manageable in the natural world. They are closed when designed for invariant input and statistically predictable output, as in the case of an aircraft in flight.

Both closed and open systems exhibit the property of entropy. *Entropy* is defined here as the degree of disorganization in a system, and is analogous to the use of the term in thermodynamics. In the second law of thermodynamics, entropy is the energy unavailable for work resulting from energy transformation from one form to another.

In systems, increased entropy means increased disorganization. A decrease in entropy takes place as order occurs. Life represents a transition from disorder to order. Atoms of carbon, hydrogen, oxygen, and other elements become arranged in a complex and orderly fashion to produce a living organism. A conscious decrease in entropy must occur to create a man-made system. All man-made systems, from the most primitive to the most complex, consume entropy: the creation of more orderly states from less orderly states." (p. 9.)

Being open or closed, like static or dynamic, is also a relative term. In the definition of a closed system, Blanchard and Fabrycky show the relativity through the words "does not interact *significantly* with its environment." [Italics added] Closed systems are only closed in relation to energy and matter. They aren't closed in relation to information, because information doesn't consume time or space. The Rodin sculpture may look like a closed system because it doesn't trade materials, people, or energy with the environment. However, the sculpture must interact with the environment for the work of art to achieve its aim. (In the classical sense, we'd say no energy is transferred to the viewer, information is.)

An organization is clearly an open system. However, we can consider the organization as a closed system for some analyses. In trying to regain control of a floundering organization, sometimes we circle the wagons, look inward, and get the system working for itself before we build bridges to the environment. At best this practice is an approximation in that we can never forget the customer, who is a key element in the environment. However, in certain circumstances our focus causes the system to look like a closed system. Closed system models help in static studies and in situations where the organization needs to get a grip on its internal strength.

I'm not searching for closed systems. I'm using the closed system as a useful approximation (a useful step in thinking). There aren't any truly closed systems. When we talk about the organization's stakeholders, we include the staff and owners as inside the organization and the customers, neighbors, and vendors as outside the system. Depending on the size of the frame you draw, or the unit of interest, you would consider at least parts of the customers, neighbors, and vendors as receiving interaction from the system. As we focus on the importance of customers, for example, we tend to draw them inside the system. However, customers have more in their lives than our organization, and, therefore, are part of the organization's environment. Customers yield the standards or reference inputs into the organizational system. Therefore, marketing, sales, and customer service are crucial forcing functions in the organization. Forcing functions come from the environment when considering the organization as an open system and from the manager when considering the organization as a closed system.

When we look at the components of the organization, we can distribute the inputs to the organization (capital, labor, equipment, materials, energy, data, and information) to these components. Capital, labor, equipment, materials, and energy come into and out of the work processes of the organization. Data comes into the management tools, which convert data to information. Information comes into the decision maker.

The difference between open and closed systems is important as we work toward quality and good management. "An open system may 'actively' tend toward a state of higher organization; that is, it may pass from a lower to a higher state of order, as a result of conditions in or actions upon the system. *The notion of continuing quality improvement is based on this principle*." (Gabriel A. Pall, *Quality Process Management*, Prentice-Hall, Inc., 1987, p. 160.)

1.1.16.5. Define Process

A process is a collection of well-defined, repeatedly-used functions and rules carried out under an overarching approach.

Just as guides tell us how to use tools (e.g., the user's manual in the box for the radial arm saw), rules tell us how to perform functions in a process. The rules include directives (specific), norms (unwritten), and principles (broad). The process acts under the umbrella of a philosophy or approach. A manufacturing process could act under the philosophy of maximizing throughput, for example. The overarching philosophy I'll espouse for the engineering process and for the management process is the systems approach.

Webster defines process as: "a series of actions or operations conducing to an end; especially a continuous operation or treatment. (Webster defines conduce as: to lead or tend to a particular and usually desirable result.) (*Websters Ninth New Collegiate Dictionary*) I'll operationalize the definition for process by substituting the words functions and rules for actions or operations. My view of the dictionary definition is: A process is a series of functions and rules conducing to an end; especially a continuous operation or treatment. The end we're conducing to is the aim of the system (at least for a system made by people) as dictated by the systems approach. We especially want a continuous operation or a cyclic arrangement.

A process is conceptual. When we add people, materials, or mechanisms to the concept we have in mind, we restrict the operationalization of the concept. Remember the process you want and be open to mechanizing the process in different ways as you learn what restrictions affect the aim of your process or associated system differently. When we define the functions of the management process, we'll use concepts like setting expectations and surveying work. When we choose the tools and skills for setting expectations (e.g., priority lists or scoping agreements) or surveying work (e.g., flow charting or input-output analysis), we constrain the management process to a particular organization and lose the generality or ultimate power of the management process. However, we focus and implement the management process to a particular situation.

Figure 1.1.16.5.1. is taken from *Chemical Engineering* edited by J.M. Coulson and J.F. Richardson, Volume 6: *An Introduction to Chemical Engineering Design* by R.K. Sinnott, Pergamon Press, 1983, p. 5. Sinnott describes the figure as "the basic components of a typical chemical process, [in which] each block represents a stage in the overall process for producing a product from the raw materials. Figure [1.1.16.5.1.] represents a generalized process; not all the stages will be needed for any particular process, and the complexity of each stage will depend on the nature of the process. Chemical engineering design is concerned with the selection and arrangement of the stages, and the selection, specification and design of the equipment required to perform the stage functions." Sinnott uses the word stage where I've used step. Sinnott uses the word equipment where I've used tools and guides. Sinnott describes components as blocks or components of the diagram and stages as containing tools required to perform functions of the stages.

Figure 1.1.16.5.1. shows sequential functions or steps with a start (stage 1), an end (sales),

feedback (recycle), and outputs (product, by-products, and wastes). Figure 1.1.16.5.2. shows a cyclic process within a system. This figure implies we can enter and leave the process at any step or function. In practice, the management process and the engineering process are very much like Figure 1.1.16.5.2. James A. Kowal, in *Analyzing Systems* says, "A PROCESS is a defined activity or task that can be accomplished completely in a finite period of time. It is used to transform input data flows into output data flows." (p. 5, Prentice Hall, 1988.) Kowal sees a process more like Figure 1.1.16.5.1. than like Figure 1.1.16.5.2. We'll think in terms of Figure 1.1.16.5.2.

Many people see process and system as one and the same thing. From Figure 1.1.16.5.2., you can see that I see process and system as different. The process goes on in association with the system. Since there's a one-to-one relationship between process and system, if you identify one you identify the other. I say that processes are associated with a system. A system has subsystems, and processes have subprocesses. Systems have components we usually identify in diagrams as nouns. Processes have functions, or steps, we usually identify in diagrams as verbs. Nouns give us subject and object. Verbs give us action. For example, the design process and decision making process are subprocesses of the engineering process and the management process, respectively. Whether a process is within a system or vice versa is unimportant. However, since we're going to get into the details of two processes less tangible than say a manufacturing process, I need to distinguish between system and process. I'll give two examples of related systems and processes to help make the distinction between system and process.

My first example is for the system of language we use for communication. The system of components, attributes, and relationships (for example, language system) aims at transferring information (the systems approach) through the communication process, which includes steps, functions, and rules. We learn tools and guides to help us communicate. Then, system, process, and systems approach aren't exactly the same. But one can't get along without the other two. This subtle difference is important to be successful at the management and engineering processes. I'll recapitulate the distinction between system and process later when I compare these terms with function, systems approach, and tools and guides.

Is the process of communication within the system of language? I don't know. But I do know the difference is subtle and important and that one is already associated with the other. Is there more than one communication process within the language system? Or do we have subsystems?

My second example is for the school system we use for teaching (or better yet, learning). The school system aims at education (or learning) through the teaching process. The school system has components, including buildings, students, teachers, books, and so on. A county-wide school system has subsystems in each school and is part of the state school system. If we practice the system, holistic, and generalist perspectives, we address education through the systems approach. The teaching process includes a series of steps, or functions, and involves a number of tools and guides to support the steps. A good teaching process is iterative, recursive, and reversible.

The importance and confusion of the concept of process is described by William W. Scherkenbach in his book, *Deming's Road to Continual Improvement*. "One of my biggest frustrations, as I help others improve, is the difficulty I have in getting them to recognize that everything they do can be described in terms of a process. This is not a trivial matter because if one does not believe that everything he does is a process, then he might not be compelled to learn more about how to better manage that process. Every expert and 'guru' on Quality are in agreement that processes are everywhere. ..... Processes apply not only to manufacturing, but in the management of every size and shape of organization. In fact, *most* of the opportunities for improvement are in non-manufacturing processes. ..... In the early 1980's, at Ford, I argued with financial and purchasing and computer people who categorically stated that they managed 'systems' not 'processes.' No amount of logic could convince them otherwise. So we compromised: we used both words. Even today, I believe, Ford does not use the word 'process' by itself, but rather the term 'process/system,'" (pp. 5-6.)

Scherkenbach then defines process: "What is this process that many people find so difficult to understand? It is virtually everything you do and everything you think. Whether you manage a company or manage to get by, plan an attack or plan a party, do a pilot study or do lunch, check a mistake or check out, act on impulse or act your age, write a check or write a book, drive to work or drive a golf ball, conduct a meeting or conduct an orchestra, make a decision or make a sandwich, assemble a satellite or assemble a crowd, you do it through a process." (p. 7.)

Scherkenbach further says, "The outputs of any organization are the result of an interdependent network of processes. If you took away all of the organizational, geographical, and functional boundaries that management has created, you would be left with a process flow which I call the 'micro-transactions' of an organization (see Figure [1.1.16.5.3.]).

This is the 'informal organization,' or the way the work gets done. There could be any and every combination of vertical, horizontal, and diagonal customer and supplier transactions, as seen in Figure [1.1.16.5.3.]. Real organizations cannot, and should not, be described by the neat and orderly columns and rows, as graphically described by many of the organization charts that are seen in companies everywhere." (pp. 10-11.) Although Scherkenbach chooses not to recognize the difference between system and process, I believe he reflects the difference between a system and a process when he recognizes that the organization (the system) produces outputs resulting from the processes (the work and management processes).

"A management system can be defined as the method by which an enterprise, making use of available resources, directs and controls its business processes to meet established goals." (Gabriel A. Pall, *Quality Process Management*, Prentice-Hall, Inc., 1987, p. 171.). I argue that Pall is addressing the process associated with the system. This distinction is an important one for you to address and resolve for yourself as you learn to do the systems approach.

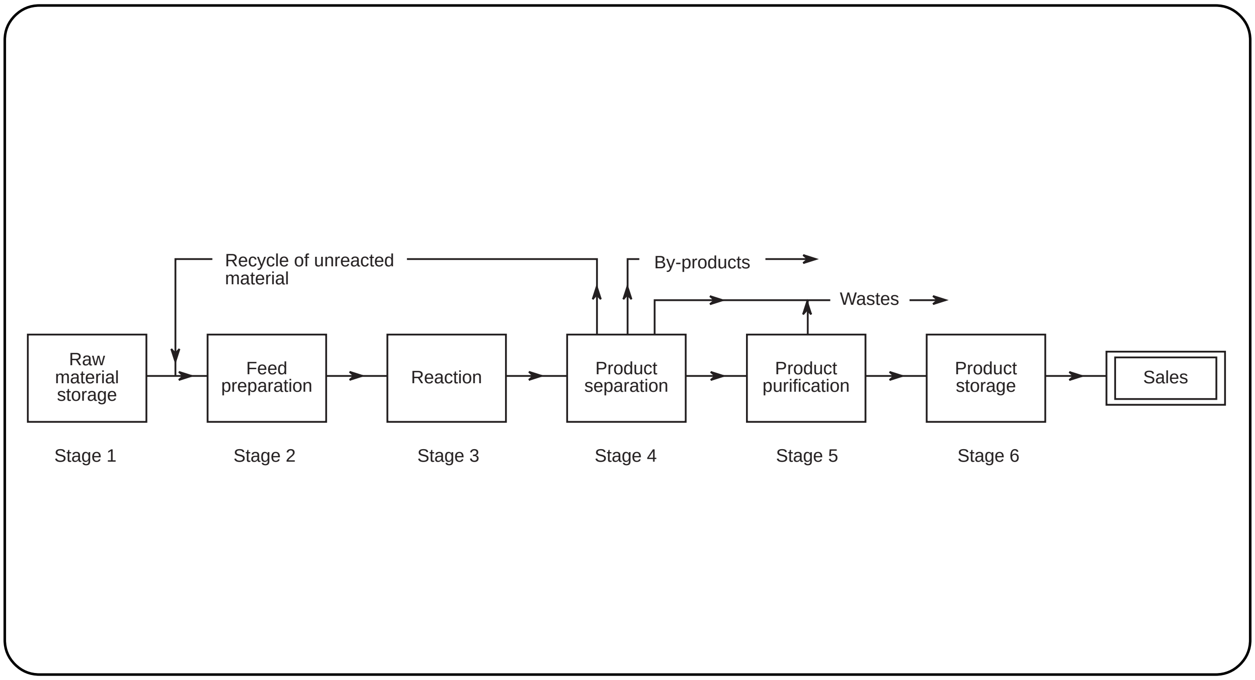

Figure 1.1.16.5.1. *The anatomy of a chemical process shows a sequential process with feed-back. (taken from Sinnott, p. 5)*

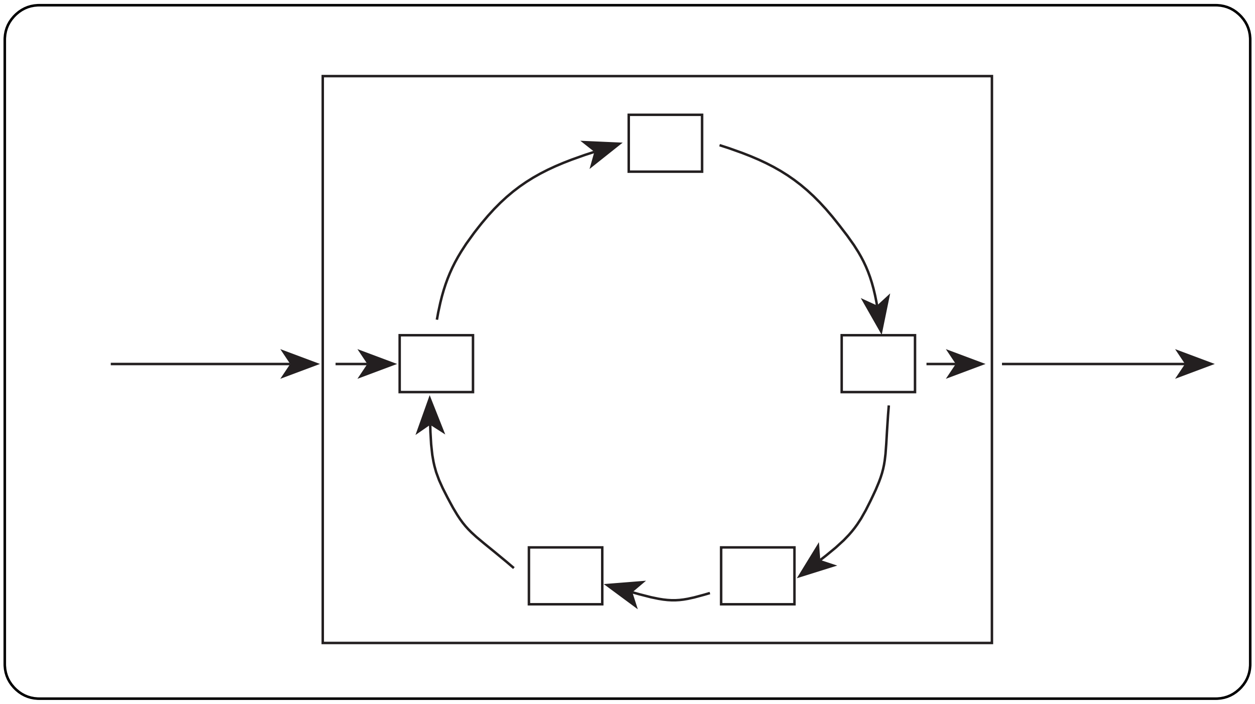

Figure 1.1.16.5.2. *A cyclic process is associated with a system.*

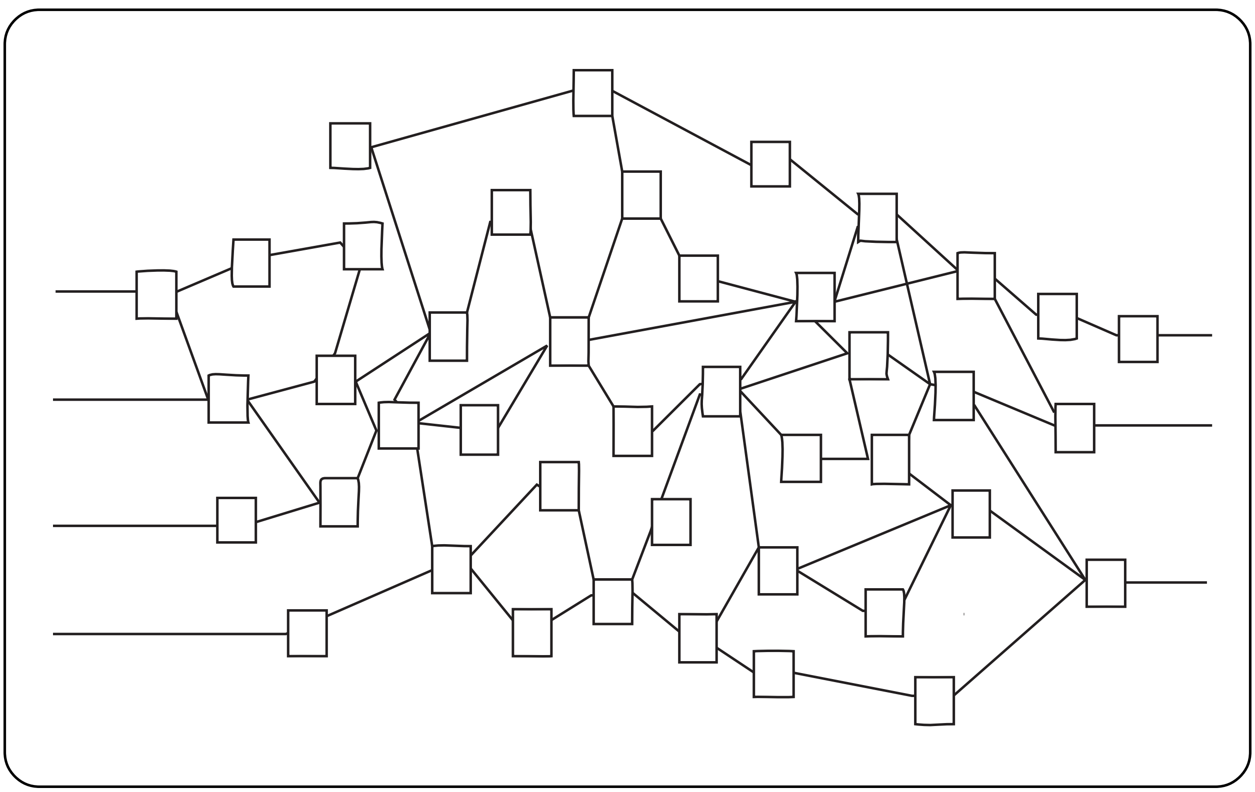

Figure 1.1.16.5.3. *If we put an arrowhead on the line connecting any two elements of the process, we then know what the relationship between the elements is. (taken from Scherkenbach, p. 10)*

1.1.16.6. Define System Perspective

In the system perspective, for the whole to meet its aim every component of the whole has a well-defined and necessary role to play in relationship with other components.

A system includes components, attributes, and relationships. In the system perspective, we recognize the importance—actually necessity—of each component (For reliability we can have more than just the necessary components, called redundancy. However, one of the redundant components is necessary.) If we change a component or the relationship of a component to other components, we run the risk of changing the system and its aim.

We say if we touch a system anywhere, we touch it everywhere. This statement is more true for tightly-coupled systems. In a tightly-coupled system, the relationships are stronger. A loosely-coupled system may not act as a system. Consider an object with a temperature distribution throughout the object. In a tightly-coupled system, if you change the temperature at one corner of the object, the entire distribution changes proportionally with a short time constant across the entire object. In a loosely-coupled system, a temperature change at one corner takes so long to be felt at the farthest corner of the object, some other temperature change at the original corner could have started in the meantime. In the loosely-coupled system, one corner of the object hardly knows what the other corner is doing.

Relationships among components of a system are most important in the system perspective. Strong relationships make tightly-coupled systems. Well-defined relationships ensure each component plays its role in causing the system to carry out its mission to meet its aim.

The implications for organizations are important. In a tightly-coupled organization, a change in one person or group or department affects everybody right away. The communication channels and dependencies among people, materials and so on are so strong, nothing acts by itself. This kind of system can react immediately to a change in its environment. This kind of system also absorbs perturbations throughout the domain so the effect of the perturbation isn't pinpointed in one place. When a perturbation is pinpointed at a single place in the organization, the potential for damage before the organization can recover is greater. The chances for balance in the organization are fewer.

In the system perspective, we look at each component to make sure it can play its role as well as possible. However, that role is a role within the whole and not a role for the benefit of the component. In this way, we recognize the importance of the individual and the individual's need for recognition. People need both to stick out and to be part of a team. Peters and Waterman, in their book *In Search of Excellence* found that excellent companies recognized the importance of each person. "In short, we found the obvious, that the individual human being still counts. Building up organizations that take note of his or her limits (e.g., information-processing ability) and strengths (e.g., the power flowing from commitment and enthusiasm) was their bread and butter." (p. 8.)

The system perspective works together with the holistic perspective and the generalist perspective to make up the systems approach. The system perspective emphasizes the components of the system and the role each plays in meeting the system aim. The holistic perspective emphasizes the gestalt in the system and its aim. The generalist perspective emphasizes consistency among the systems and the transferability of lessons learned from one to the other. I'll discuss the holistic and generalist perspectives in more detail in Modules 1.1.27.3. through 1.1.27.7.

1.1.16.7. INFORMATION BIASING—ANNE-LOUIS GIRODET DE ROUCY TRIOSON

1.1.16.8. Define Tools and Guides

Tools are a means to an end. You want them to work together, not at odds with one another and to work for you, not against you.

We use tools every day. We brush our teeth with tools; we hang a picture with tools; we communicate with tools; we get to work with tools; we type a letter with tools. We manage our domain of responsibility with tools.

Behind each of our tools is a guide, such as a procedure or set of instructions telling us how to use the tool. A tool is fine; but, if we don't use the tool right, we'll probably fail and hurt ourselves. We don't think about a written set of instructions for using a tooth brush and tooth paste. We probably never looked for the instructions on the box the tooth brush came in or on the tooth paste tube. Our parents or dentist told us the instructions and we keep them in our head.

The tooth brush and tooth paste tube are tools. The instructions are a tool also. Even though we keep the instructions in our head, we could make them physical by putting them on a piece of paper or on the tooth paste tube. The tooth brush is a physical tool we can't keep in our head. I call that tool an operations tool because the tooth brush is part of the what is managed component of a management system. Yes, brushing your teeth is a process. The guide, or list of instructions, is also a tool, which you can keep in your head—but don't have to. I call that tool a management tool because we use it to convert data to information. The management tool is part of the what is used to manage component of a management system.

What happens if we write down the instructions? Then the piece of paper is an operations tool and the information on the paper is the result of a management tool. In your head you have a guide for using the piece of paper to get the instructions from. So, you have a guide for using the piece of paper embodying the guide. Guides are management tools that play the special role of helping us use other tools, our resources, and our processes well.

Materials flow through a process. Tools don't. Unless, of course, you're manufacturing tools.

Webster defines a tool as: "an instrument used or worked by hand; something (as an instrument or apparatus) used in performing an operation, or necessary in the practice of a vocation or profession; a means to an end." (*Webster's Ninth New Collegiate Dictionary*) The instrument used by hand fits for an operations tool as part of the what is used to manage component. If I operationalize vocation or profession into management, and management is decision making, I substitute management and decision making into the definition and get: A management tool is something used in decision making or necessary in management. I especially like the idea of a tool being a "means to an end."

We must distinguish between our means and our ends. Let's look at the management system. Our ends are the operation, what we manage. Our ends are physical and measurable. Our means are the management tools, what we use to manage with. Our means are conceptual. To get all our management tools to work together for us, we must focus on our ends. The user of our management tools includes both the manager and the operation being managed. To be successful, the tools must fit both. Einstein has warned us against confusing our means and our ends.

If you manage a construction project, you're responsible for ladders, hammers, and trucks, as shown in Figure 1.1.16.8. These are the operations tools. They are some of your ends. In your head, you keep a plan for the project, a budget for the cost, and information on progress I'll call an MIS. They are some of your means. You use the plan, budget, and progress information to manage the ladder, truck, and hammer. If you manage an office, you're responsible for word processors, copy machines, and pencils. These also are operations tools. You'll use a plan, budget, and progress information to manage the word processors, copy machines, and pencils.

I'll illustrate the difference between means and ends through a story. Some years ago, I regularly drove from Blacksburg to Maryland to work on a research project for the Department of Energy. I always left Blacksburg after work and stayed at the same hotel. My secretary always made reservations and guaranteed late arrival using my credit card. Often arriving at the hotel in the wee hours of the morning, I soon learned what guaranteed late arrival meant. If I fail to arrive, they charge my credit card. If they fail to have a room, they have to find another in the vicinity. Since I arrived so late, the hotel felt they could get double the return on the room by renting the room to a weary traveller at their desk late at night. When I finally arrived, there was no room at the inn and they would find me another room 50 miles away. Since I had a job to do early the next morning, the 100 mile round trip meant I lost about two of my three hours sleep. I wasn't a happy camper.

The problem was that my secretary was confusing means with ends. She figured that her job was to do the paperwork—make the reservation, get a confirmation number, and put the information on my itinerary. Those are the means. Her job really was to get my weary body into a bed near the Department of Energy building for as long as possible, given my driving schedule. Those are the ends. The ends are physical. The means are conceptual—even though we might claim the paper itinerary is physical. When we focused on the ends, we found the answer. Call the hotel before quitting time, when we know for sure I'm leaving that night, and preregister me in a room. The room is then mine. As far as the front desk is concerned I'm in the room. The not-so-bad part of the solution is that if someone called for me at the hotel, the clerk would say I had checked in. The moral of the story is that paperwork is a management tool. If paperwork is used as an end, you'll have big problems and hate paperwork. (We all do, don't we?) If paperwork is used as a means to an end, you'll solve problems. Some people become convinced paperwork is the end and their job is to do paperwork. Isn't that sad. With a slight change in orientation we can change a demeaning job into a focused, stimulating one.

One of the interesting mind games you can play with many of these systems concepts is when you work the concept against itself. For example, what about the person responsible for the company's budget having a budget for his or her responsibility? Then the company's budget is the ends and the person's budget is the means. Some companies use management information systems to help produce management information systems. We can have processes for processes and systems of systems. Be careful to sort out your thinking before you get into an infinite do loop on one of these concepts. One of the keys to being able to sort out your thinking is to clearly define your unit of interest.

The bottom line on tools, and especially management tools, is that they should work together and not at odds with each other and they should work for us and not against us. If tools aren't working right, then we must fix them. There's no good reason for living with that frustration and waste. Most management tools don't work right. Plans sit on shelves. The management information system is ignored. And we all know the organization chart really isn't how things work around here. The management systems engineer's job is a big one.

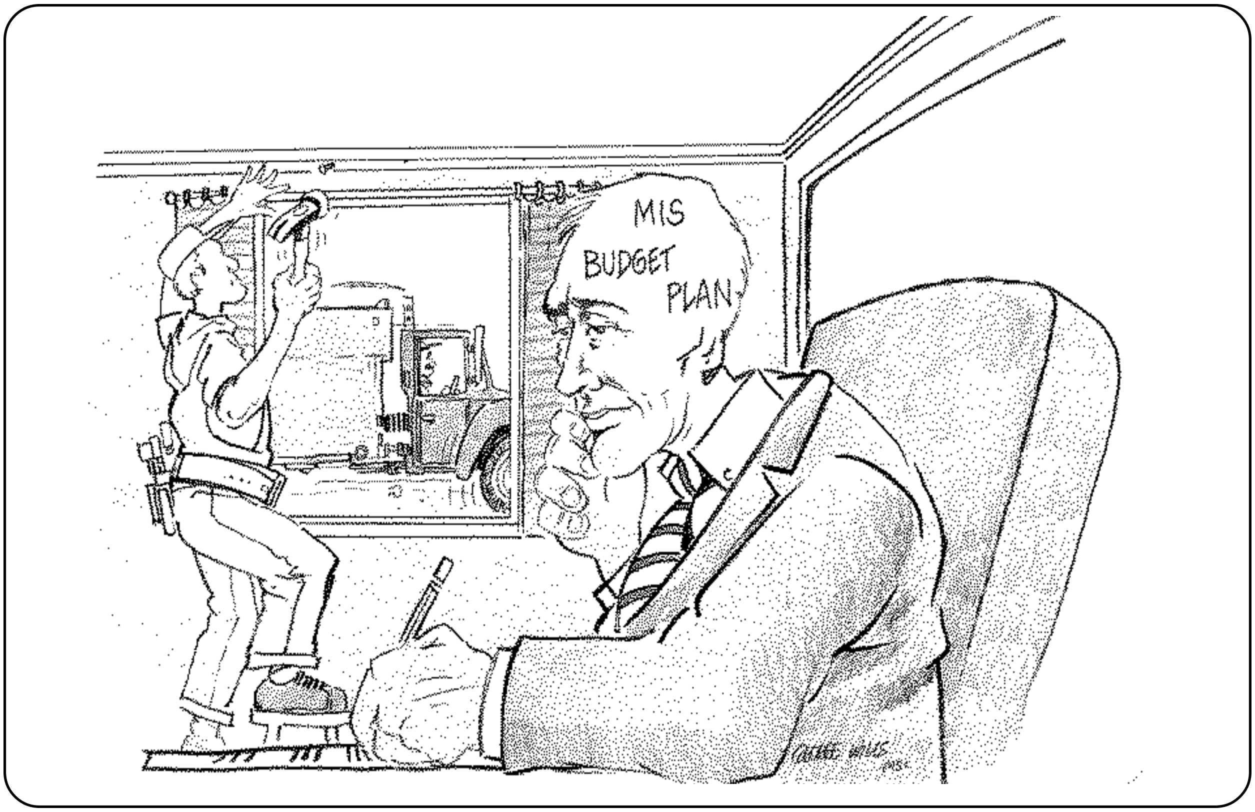

Figure 1.1.16.8. *The person in the illustration is dealing with physical operations tools and conceptual management tools.*

1.1.16.9. Comparing Systems-Oriented Concepts

Systems-oriented concepts center around a system designed and operated to meet an aim. Management systems engineers follow the systems approach and focus on the tools and the management and work processes of the management system.

Let's first sort out the concepts of systems approach, system, and process. Then we'll fit in the concepts of component, function, tool and guide, and data and information. For management systems engineers, the objective of all this is to use the engineering process with its functions to get tools to provide the right information to managers for making decisions within their management process with its functions so their management system, or domain of responsibility, will meet its aim.

I list systems approach, system, and process in that order because there's sort of an hierarchy involved. Look at Figure 1.1.16.9. I show the systems approach as a cloud because the systems approach, with its three perspectives, is conceptual. As you approach your responsibilities, you look or work through three lenses I call perspectives. The systems approach is a way of looking at your world, a way of thinking, a way of being. The systems approach is almost religious. The systems approach is global and can apply to anything.

The system tends to be physical, or at least tangible. In Figure 1.1.16.9., I show the system as a box with arrows for its input and output. A specific system is easier to describe because you can sense a system; that is, you can touch, see, hear, smell, and/or taste a system. Even for a system of measurement, you can sense an inch and can relate an inch to a foot or even a meter. For a system of government, you can sense the system either directly or indirectly, through its components.

The process is also tangible in that a process is something you do. You do steps or stages or activities of a process. In Figure 1.1.16.9., I show a process within the system box. I mean for the process to be shown as associated with the system. I show the process as a cyclic series of steps, or functions, connected by arrows showing sequence. Since system and process are like different understandings of the same thing, be careful. But I only have two dimensions on a piece of paper and we may be talking four dimensions here.

A system has parts, or components. A system is something that is. The more physical the system is, the more we can separate the system into its parts and lay them out in front of us. I don't show components of the system in Figure 1.1.16.9.

A process has steps or functions. A process is something we do. The more physical the process is, the easier it is to see us doing one function followed by the next. I do show functions of the process in Figure 1.1.16.9.

A component is a part, like a carburetor in an automobile engine. In the system concept, the part can have parts, and a carburetor does. One part may do or participate in one or more functions. One component may play more than one role. For example, the CV (constant velocity) joint is part of the steering subsystem in the automobile and is also part of the suspension subsystem in the automobile. These two subsystems have separate aims and involve different processes. A function is an action, like mixing gas with air. A tool is used to help build or do the function, like a carburetor or a wrench. A tool can be applied to any number of functions or components. A component is integral to the process. In terms of means and ends, a component contributes to the ends. A tool is brought in to apply to the process. A tool contributes to the means to the ends.

The system has an aim. The system's aim relates to the meaning, purpose, and results (output and outcome) of the system. The process is the system's way of accomplishing its aim. Therefore, the process is more important than the results of the system because it's through the process that the system begets its results, not vice versa.

In Figure 1.1.16.9., I show the tool and guide as within one of the functions of the process. In reality, the tool is applied to the function; and the tool could be applied to other functions too. The tool could be an operations tool or a management tool, depending on whether the tool could be in your head and yields information or not. The guide is always a management tool.

Depending on the unit of interest, a tool can be a system or a subsystem, a component can be a system or a subsystem, and a function can be a process or subprocess.

To stress the importance of understanding systems, subsystems, and components in organizations, consider this analogy of automobile manufacturing. If someone works on manufacturing steering wheels and only knows steering wheels, they're in the steering wheel business. From the perspective of the automobile as the system of interest, they're suboptimizing. However, if someone works on manufacturing steering wheels and knows about the linkages and drive train and the rest of the automobile, they're in the automobile business. The latter people will manufacture steering wheels that make a better automobile. However, the first group may make the best steering wheels that end up in the worst automobiles. As always, you must know your world, your domain of responsibility, your unit of interest; and you must know your unit of interest in context with its place in a hierarchy of systems. (The automobile manufacturing analogy was suggested to me by Brian Kleiner one day over lunch.)

Let's compare the analytic approach with the systems approach. We want to do analysis and synthesis on systems and their processes. (See Module 1.1.6.2.) We can do both within the systems approach if we focus on the aim of the system in doing each. However, we can contrast the analytic and systems approach by looking at the perspectives of each. The analytic approach emphasizes analyst and specialist perspectives. The systems approach emphasizes the system, holistic, and generalist perspectives.

Consider also the integrative and differentiative perspectives—perspectives I see as part of the system perspective. In the integrative perspective, we emphasize the importance of finding, designing, and working linkages among components. We look for connections, or bridges. In painting, for example, we carry, or connect color, an idea, or a theme from one part of the painting to other parts. This practice gets all parts to work together as a system. In the differentiative perspective, we distinguish key connections or attributes to work with. In sensitivity analysis, we distinguish which parameter is sensitive to change in other parameters, the system, or its environment. In painting, for example, we show little details that carry great significance to the meaning of the painting or make other parts or details of the painting more meaningful.

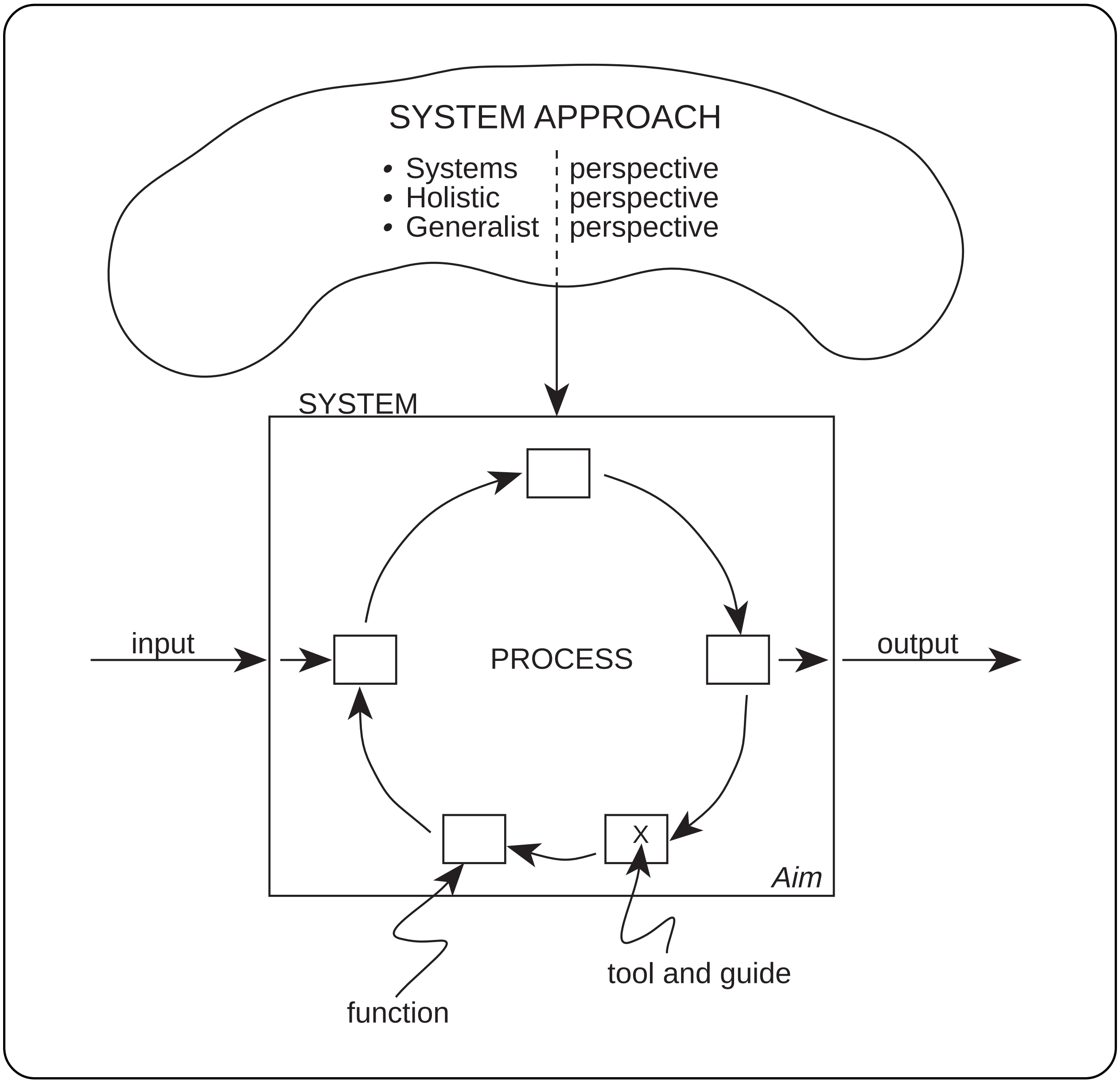

Figure 1.1.16.9. *The systems approach is an overarching philosophy for the system that contains one or more processes. The tools and guides help us do the functions making up the process.*

1.1.16.10. Define Data and Information

If you don't distinguish between data and information, you're sure to suffer from a bad case of DRIP: Data Rich, Information Poor.

With computers today, you can be inundated with data. The only data you need are those that yield the information related to the decisions you make.

Management tools convert data to information. For management tool design to move from an art to a science, we need a detailed understanding of data, information, and the conversion process for making information from data. The what is used to manage component of the management system includes all management tools. Each tool can be a system, for example, a management information system. These systems include processes for converting data to information. We need a clear understanding of the difference between data and information; and most people use the terms interchangeably. They confuse data with information.

Boland says, "Data becoming information is what information systems are. Data becomes information in the consciousness of a human subject, and that is where we must look if we are able to understand information systems." (Richard J. Boland, Jr., *Phenomenology: A Preferred Approach to Research or Information Systems*, Research Methods in Information Systems, 1985.) Note from Boland's brief statement that 1) data and information are different, 2) we have to do something to data to make them information, 3) information is input to human decision makers, and 4) management tools like information systems must take into account the conversion of data to information and the delivery of information to decision makers.

Others have started to define the distinction between data and information. I'll need to carry the distinction even further here so we can study the conversion processes in management tools. Sherman C. Blumenthal in his book, *Management Information Systems: A Framework for Planning and Development* (p. 30.), says, "A *datum* is an uninterpreted raw statement of fact. *Information* is *data* recorded, classified, organized, related, or interpreted within context to convey meaning." Daniel S. Appleton, in his article *Organizing and Managing Information Resources in the Data-Driven Enterprise* (Industrial Engineering, June 1986, pp. 62-72.) says, "'Just give me the facts,' said Inspector Poirot, interviewing yet another suspect on the Orient Express. This one query was intended to provide him with some information, which, when combined with some other information, would help him to validate his facts, analyze them and finally discover the truth.

But how would Poirot know the truth when he finally found it? Especially when he could not tell whether the information he was collecting—some of it from the bad guy—was true or false.

The answer is simple. He did not evaluate each piece of information he had received to determine whether it was intrinsically true. Instead, he sorted through the responses to find the facts presented in those pieces of information. He knew that within each piece of information, the facts would be consistent, but that the truth would be discovered when the facts were consistent among all of the various pieces of information he had collected.

Today's knowledge worker is not unlike Inspector Poirot. He is constantly bombarded with pieces of information, each one contributing its own set of facts, and yet many of them inconsistent. He knows that the truth lies in the fundamental consistency among the facts—not in what any one piece of information presents to him. He also knows that if the facts are fundamentally consistent, all of the various pieces of information containing them will be consistent as well, and that if his various pieces of information are inconsistent, he does not have the real facts. .....The relationship of facts, data, and information is very complex. Information can be defined as 'an aggregation of data needed for a specific purpose.' This implies three important ideas. First, information cannot exist if there is no purpose (demand) for it. Second, information and a datum are different ideas. Third, one information, if you will, is made up of at least one datum, but probably several data. This means that from 400 data we could create 10^{869} informations. Thus, by managing a few data directly, we indirectly manage a bunch of informations.

But what is a datum? This question is even more difficult than the first. Some people believe that 12345 is a datum. It is not. It is a fact. Also, M is a fact, and so is 10.

The problem with these facts is that we do not know what they mean. The numeral combination 12345 is a part number. It is also the zip code of Schenectady, New York. M stands for male; it is also a letter of the alphabet. The symbol 10 could be an age, or it could be a pseudonym for Bo Derek.

To have a datum, then, we must have two things: a fact and a meaning. A fact alone is nonsense. But, [for] each meaning we can have zero, one, or many facts.

Therefore, the problem for data management is not managing the facts. It is managing meanings. This is because for each meaning, we can have many facts. The meanings (not the facts) define an organization's (or a person's) concept of reality."

Recall the first of Appleton's three important ideas. We know what Appleton means for the purpose for information: decision making. His thought of demand in that idea has important consequences for us. The demand for information comes before the information, setting up a sequence for something—we'll learn that something to be building management tools. You don't need information unless you have a decision to make. Then, information is purposeful even though the purpose may be a potential purpose. Since one person may have a purpose for a given set of information and another person may not, the "information" is data or noise for one and information for the other.

To carry the difference between data and information further, I'll quote from a paper summarizing Steve Berube's thesis work at Virginia Tech (D. Steven Berube, Harold A. Kurstedt, Jr., and R. Martin Jones, *A Framework for Data and Information,* Proceedings of SETIMS, 1989, pp. 266-268.).

Data and data components

"Data are what are commonly referred to as facts. They serve as a surrogate for the things we manage by identifying the attributes of the things we manage. Bender defines data as symbolic representations of reality. These symbolic representations, or facts, describe reality through its attributes. If we want to know the performance of a machine, we measure attributes of the machine, such as its operating speed, its throughput, its downtime, or others. Each attribute is a symbolic representation of the machine, and each is a datum. There are two components of each datum: a kernel, and a set of specifiers. The kernel is the actual value of the attribute. The kernel is called a 'fact' by Appleton and Ijiri. A kernel has the potential to mean something to a manager, but by itself, a kernel is meaningless. We have to add ingredients, called specifiers, to get meaning. Specifiers are called 'meaning' by Appleton. Appleton's 'meaning' can apply to zero, one, or many 'facts', but my set of specifiers uniquely defines one kernel. Recording data kernels removes them from context. Specifiers are used to carry the context of the kernel to the manager who uses the data. When I measure the throughput of a machine as 23 units, it's easy for me to see that the units are widgets, and the measurement was taken at 3:00 PM on July 22. When I record the number 23 on the data collection sheet, all the specifiers are lost and the kernel has no context. Specifiers must be included with the kernel to convey the context of the data to the manager. Specifiers fulfill the requirement of data by Ijiri, who says data must be well-specified.

Two data types make information

Peterson says data acquire meaning when compared to other data. Peterson uses the word 'meaning' to denote something managers can use to make decisions. Comparison is the way data become information. The comparison of any two data produce information. Each datum plays a special role in producing information. One datum is selected to provide information to the manager. This datum I call an indicator. To use this indicator to produce information, a benchmark must be selected to compare the indicator against. This benchmark I call a reference. Kurstedt shows data being compared to setpoints or references to generate information. Together, one indicator datum and one reference datum make an information packet. In this information packet are all the ingredients to produce information. [Peterson's "meaning" is different from Appleton's. Appleton's "meaning" puts the datum into context. Peterson's meaning relates to the idea of bias, or what makes information.]

The information packet is evaluated in two steps to produce information. Recall that the indicator and the reference are both data, and each has a kernel and a set of specifiers. In the first step, the indicator kernel is compared to the reference kernel to determine the difference. This comparison may be expressed as a percentage or as the numeric difference between kernels. The second step is to compare indicator specifiers with the reference specifiers. [Some reference specifiers are implicit, others are explicit.] The specifier differences describe what the kernel differences can be attributed to. To evaluate the production of a machine this week, I might compare it to the production of the same machine last week. The difference in the number of units produced each week is the kernel difference. The specifier difference is last week as opposed to this week.

Quantitative information is produced by evaluating the information packet. Quantitative information describes the differences between the indicator and the reference datum. Quantitative information might be 'widget production for machine A is up 12% this week from last week'. The comparison of the indicator and reference data through evaluation of the information packet is evident in the quantitative information. The difference in specifiers is the week during which each datum was collected. The kernel difference is 12%, so the indicator kernel was 12% greater than the reference kernel.

Qualitative information supports a manager's decisions

The manager now has quantitative information that widget production for machine A is up 12% from last week. Is this good or bad? It would be good if the manager needed more widgets, but what if the manager is overstocked with widgets? Quantitative information will not support managers' decisions without further processing. The quantitative information must be converted to qualitative information to be used for decisions. Qualitative information are the triggers to action for managers. Qualitative information is the subjective interpretation of quantitative information, and is expressed in terms of good, bad, too much, too little, go, no go, etc.

The process of going from quantitative to qualitative information is complex. The amount of quantitative information required to produce qualitative information varies according to the type of decision being made. Gorry and Scott Morton use Thompson's two decision dimensions to describe unstructured and structured decisions. Decisions are either certain or uncertain in two dimensions: beliefs about cause/effect relations, and preferences regarding possible outcomes. Structured decisions have certainty in both causation and preferences regarding possible outcomes, while unstructured decisions have uncertainty in both dimensions. Semistructured decisions have uncertainty in either the causation dimension or preferences regarding possible outcomes. For a structured problem, a manager needs only a few pieces of quantitative information to make logical qualitative extrapolations with confidence. If the manager faces unstructured problems, where uncertainty exists in causation and preferences regarding possible outcomes, more pieces of quantitative information are needed to make logical qualitative extrapolations with confidence. These qualitative extrapolations from quantitative information are qualitative information, which can be used in decision-making.

Summary of the data-to-information process

Data are representations of reality. They represent reality by describing attributes of reality. A datum consists of a kernel and a set of specifiers. The kernel is the actual value of the attribute, and specifiers uniquely define the kernel and provide context. When a manager needs information, two data types are needed: an indicator and a reference. The indicator datum represents what the manager wants information about. The reference datum is selected as a benchmark to evaluate the indicator. An indicator datum and reference datum make up an information packet, which can be evaluated to produce quantitative information. The evaluation is two steps: the indicator and reference kernels are compared, and the indicator and reference specifiers are compared. Quantitative information is generated by evaluating an information packet, and expresses the indicator datum in terms of the reference datum. Qualitative information is the subjective evaluation of quantitative information. As the problem becomes more unstructured, more quantitative information is needed before qualitative information can be produced. Qualitative information are triggers to action, and can be used in decision-making."

Another Data-Information Illustration

Consider a tradition still carried on in the middle east today. Shepherds keep track of their flocks with stones. When a sheep leaves the pen each morning, the shepherd reaches down, picks up a small stone, and puts it in a sack. When a sheep returns to the pen each night, the shepherd tosses a stone out of the sack. When the shepherd thinks the sheep are home, he or she looks in the sack. What's the datum and what's the information? What information is missing? Why?

DRIP

Figure 1.1.16.10. illustrates a bad case of DRIP: Data Rich, Information Poor. (See Module 1.1.25.6. for the origin of DRIP.) I'll bet the illustration looks familiar. You have more data than you know what to do with, and you still can't answer the question. You may have great amounts of the wrong data or may have unrefined data you can't work with. To reduce the DRIP syndrome, you must distinguish between data and information and have management tools that give you the information you need for your decisions. Superfluous data and information cause an expensive waste of time, energy, and resources. We must concen-

trate on what is really information and what is just data. Even though automation generally leads to a data-rich, information-poor situation, the manager still receives copious quantities of both and truly suffers from information overload. Admiral Rickover, the father of the nuclear navy, once said to Marjorie Holt, a congresswoman from Maryland, "The paperwork for an aircraft carrier weighs more than the carrier itself."

Figure 1.1.16.10. *"I've got the answer to your question here—somewhere—boss."*

1.1.16.11. All Information Is Biased

If you believe all information is biased, the crucial question then becomes: Whose bias should be in the information a manager uses to make decisions with?

Data are valuable resources of the domain of responsibility. They're the ore from which we refine information. But what happens to the information due to our choice of reference point?

Data Are Assets

Data are like all resources; they're assets of the organization. Data are like ore. Until they're refined, they're potentially valuable. Appleton talks about data as assets. "However, resources cannot be reused unless they have been designed expressly for that purpose; i.e., unless they are assets. ..... The most reusable information resource is data." (p. 72.) In fact, data are a key corporate resource because without data on other resources, there can be no effective control.

When people diagram the inputs to and outputs from (resources) an organizational system they include capital, labor, equipment, and materials (CLEM) and energy and data/ information. Later, I'll distinguish among CLEM and energy as input to the operation, data as input to management tools, and information as input to the decision maker. Together, the operator, the tools, and the decision maker constitute an organizational system.

Data are some of your most important assets. When you manage data as a resource, like other resources, you gather, verify, store, retrieve, update, and process data efficiently and effectively and convert those data into information to make decisions and take action. In module 1.1.16.12., I'll show the processing of data to be similar to processing materials in a refinery and later I'll show that storing data is similar to storing groceries in an inventory management problem. Decision makers at all levels in the organization and working at tasks of differing complexity and significance need the best possible data. Data are perishable and have a shelf life. You have to watch data in storage to make sure you replace bad or old data. Since data often are combined to make information, rotten data will affect good data. Data are not only valuable assets, but they're perishable.

All Information Is Biased

Consider Figure 1.1.16.11. The temperature in the room is 72 degrees Fahrenheit. What's the kernel? Fact? Specifier? Reference point? Datum? Information? You can't yet answer all these questions. The number 72 is the kernel, or fact. Degrees Fahrenheit is a specifier. The datum is 72 degrees Fahrenheit. I'm the man in the illustration. I prefer the room to be 68 degrees Fahrenheit. Now can you answer the other questions? My preference is the reference point. The quantitative information is that the room is four degrees too hot for me. The qualitative information is that I'm uncomfortably hot. With this information, I can make a number of decisions leading to actions. I can decide to turn on the air conditioner. I can decide to open a window since it's cold outside. I can't make a decision on the datum, but I can on the information. With the qualitative information, anyone can decide to open the window. But, you'd need the quantitative information to decide how long to keep the window open.

The woman in Figure 1.1.16.11. is my mother. She prefers the room to be 78 degrees Fahrenheit. You can answer all the questions above; but, you get different answers—because you have different information. The datum is the same—72 degrees Fahrenheit. The reference point is my mother's preference. The quantitative information is that the room is six degrees too cold for her. The qualitative information is that she's uncomfortably cold. Your decision is the opposite. Close the window or turn up the furnace.

Based on the information we each have, I'm opening the window and my mother is turning up the heat. The reason is that our respective information is biased differently. My information is biased by my preference and her information is biased by her preference. The bias comes in through the reference points. We'll learn that the reference points in an organization are the preferences of the customer or the user. We'll also learn that information comes from comparing the voice of the process (72 degrees Fahrenheit) to the voice of the customer.

Assume you're a supervisor and need to make decisions on allocating resources to activities in a project. You ask a subordinate to find out which activities are in trouble or need additional resources to keep on schedule. Your subordinate prepares a spreadsheet listing all activities whose end points are within five days of overrunning the schedule. Do you have data or information? The datum is the date of the end point of an activity. The reference is not only the due date but whether the due date is within five days of the end point. The information is the activity within five days of overrunning the schedule. What's the bias? The five days. Who set the bias? The subordinate. Who should set the bias? You, of course. Otherwise, who's really making the decision on resource allocation? The subordinate. Did you delegate that responsibility? You might feel that allocating resources to activities within ten days of the end point is the right move.

The supervisor must establish and communicate his or her bias. The bias is usually based on the customer. The relative value of data and information depends on whether you know the bias (reference point) and whether or not it's the bias you want. Data (indicators) aren't worth much without knowing the reference point—but at least you have the indicator to compare to some reference point. With the wrong reference point and not knowing the indicator, information is even less valuable. Bias in information isn't necessarily bad. It's just the choice of reference point.

Information Is Power

People say information is power. They mean, if you know what's going on, you're in control of the situation. Which is more important to know in an organization, data or information? Remember, while data may have measurement bias (yet another discussion), information has interpretation bias. Which is more important to know if you're going to second guess a decision, data or bias? This concern is what causes some people to hoard data and information. As a valuable resource, we can't afford for people to hoard data. Do we care if they hoard information? Is sharing data frightening?

Walter Wristen, past CEO of Citicorp said, "Information about money is almost as important as money itself." We'll all agree that information is powerful either in doing good or doing harm. Some will say that information allows for potential control. For this reason many people hoard data, especially in big organizations or between organizations. Data provide control only if the bias is known; for, without knowledge of the bias, the conclusions and resulting decisions cannot be predicted. Therefore, there is no need to hoard data if the bias isn't known. Then, the database can be opened to anyone with a "need to know." Of course, once someone has the data, acquiring knowledge of the bias (or guessing it correctly) unlocks the door.

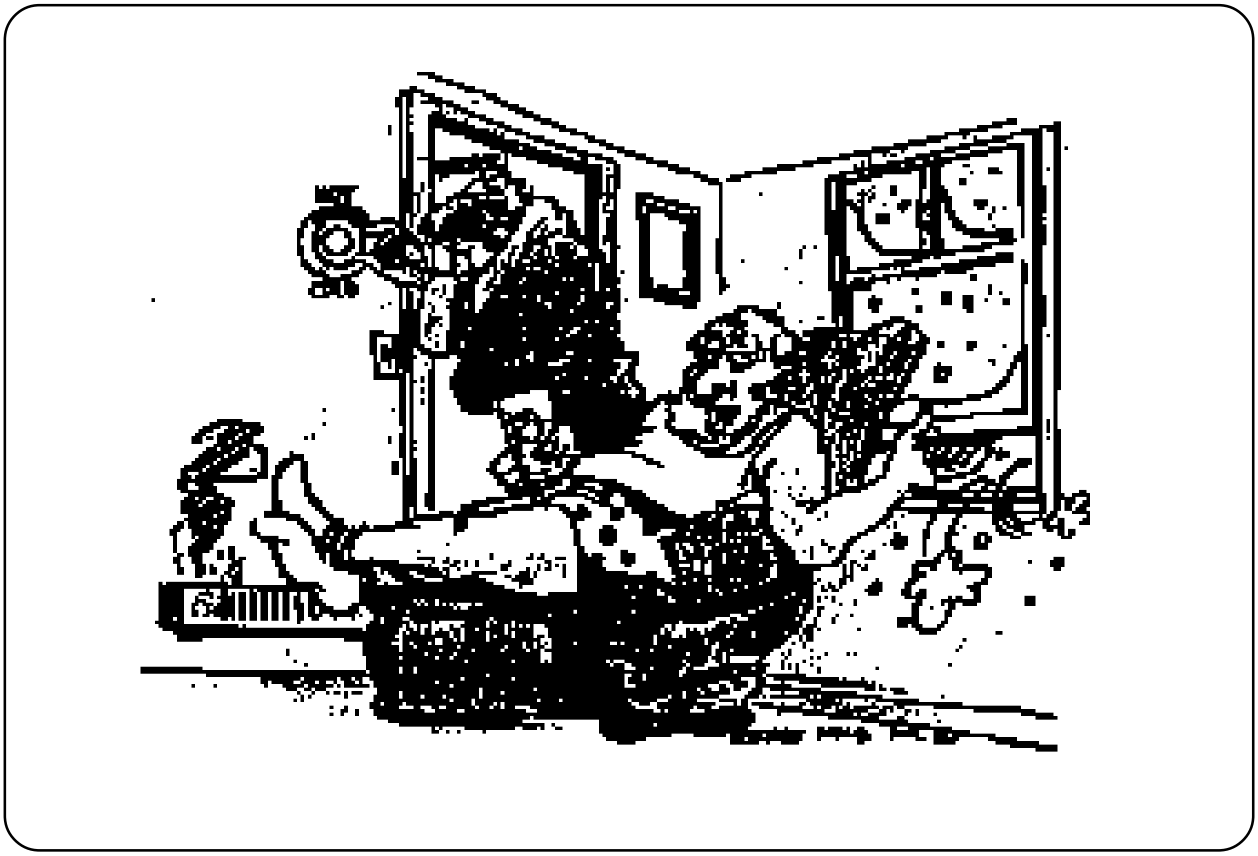

Figure 1.1.16.11. *"Your bias is a hot one."*

1.1.16.12. The Process for Converting Data into Information

One person's information can be the next person's data.

Let's extend the idea of the room temperature from Module 1.1.16.11. This time we're in a conference room listening to a boring speaker and the temperature is 72 degrees Fahrenheit. The consensus is that the temperature should be 68 degrees Fahrenheit. If I were responsible for the room and/or the meeting, I can take the indicator datum and the reference datum and make information to make the decision to turn on the air conditioner. But, this room doesn't have its own thermostat. My boss is responsible for the department and the people in the offices on the floor believe the temperature should be at 74 degrees Fahrenheit. My boss determines the reference to be 74 degrees Fahrenheit and my four-degree, too-hot situation becomes a datum to use with other data from the offices to compare to the reference datum to make information. My boss's boss is responsible for the whole building and isn't only concerned about comfort but energy savings. The information on the temperature change for the floor becomes data for my boss's boss.

You can see the multi-stage process occurring in this example. Consider Figure 1.1.16.12.1. This figure illustrates a multi-stage conversion process like for a chemical plant. Each conversion process would include the stages from Figure 1.1.16.5.1. The product stream from one conversion process can be tapped for product or passed as feed material to the next conversion process for additional refinement. Now consider Figure 1.1.16.12.2. This figure illustrates the example of passing the information from one data-to-information conversion process on as data to the next data-to-information conversion process. You can see why we want source-point data capture. But, how can we be sure we're at the initial source.

In the flows in Figure 1.1.16.12.2., data and information, unlike other types of feed and product streams, aren't used up. Sharing information isn't like sharing cookies. The same information can be used by many people. I'll discuss this concept more in modules about information sharing.

I've mentioned measurement bias in getting original data and the problem in finding the initial source of data. I've stressed interpretation bias and the importance of the reference point in making information from data and the fact that such information can be the data for the next conversion process. Clearly, information is not only crucial for decision making but it's perishable stuff with a limited shelf life. How many people accept data and information as gospel, especially if they come from a computer? But more about that later.

Bryce says, "The organizations that will [excel] will be those that manage information as a major resource...Managing the information resource essentially means gathering, storing, and processing data so efficiently and effectively that organizations produce the best information with which to make decisions and take actions—both on operational and corporate levels." (Milton Bryce, "Information Resource Mismanagement", *Infosystems Magazine*, February 1983, p. 88.) I'll consider the decision maker using information to make decisions and take actions later when I look more closely at the interfaces between pairs of components in the management system in Figure 1.1.14.5.4.

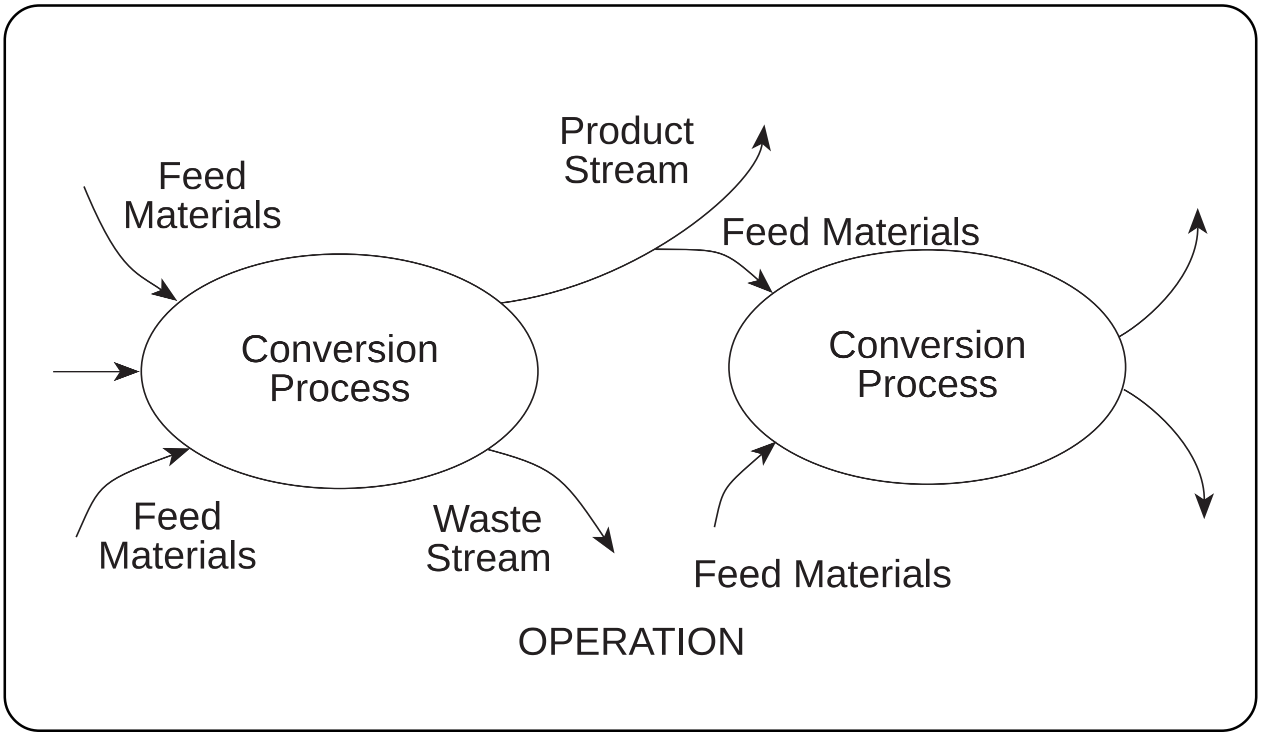

Figure 1.1.16.12.1. *We can refine materials to add value at many stages.*

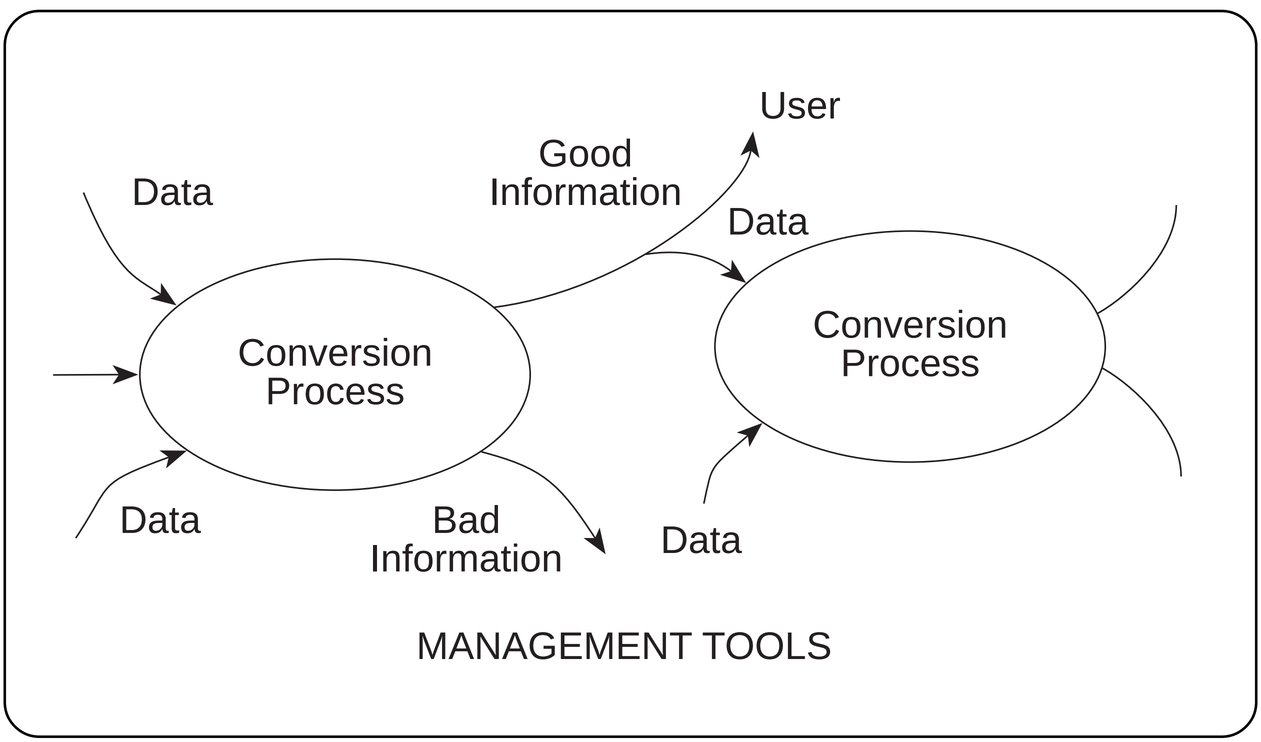

Figure 1.1.16.12.2. *We refine information in a multi-stage conversion process.*

1.1.16.13. A Management System Isn't an Information System.

A management system is a domain of responsibility, converting capital, labor, equipment, materials, energy, and data and information inputs into outputs. An information system regularly and frequently converts data and information inputs into outputs.

People often confuse the terms management systems, management information systems, information systems, and computer-based information systems. I see a management system as a domain of responsibility, where the what is used to manage component is management tools, which includes management information systems. I see management information systems and information systems as the same thing, since the purpose of information is for management, or decision making. I see computer-based information systems as an information system involving a computer rather than, or in addition to, another mechanism, such as a magnetic board, a rolodex, a file cabinet, or a notebook. That is, magnetic boards and the like play similar roles to the computer. The computer has certain handy advantages when the amount of data and information or the rate of change of the data and information is great. In cases where these conditions aren't met, I find the computer often does more harm than good. The notebook, for example, continues to be a handy mechanization for managing information. We often make our lives harder and sometimes unreasonably so by using a computer just to be part of a fad.

A management system is a domain of responsibility, which is a system that includes a management process for converting interventions into performance. An information system is a system for producing information that involves a process for converting data into information.

Milton Bryce states the problem well. (*Information Resource Mismanagement,* Infosystems Magazine, February 1983, pp. 88-92.) "To put it bluntly, most corporate executives and managers do not really understand information and information systems...or how to build them. And frankly, neither do most people in computing. If companies built bridges the way they have built information systems for the past two decades, this would be a nation dependent on ferryboats.

There are exceptions: good systems have been built, enlightened management can be found. But generally, organizations continue to be plagued with complaints of information systems that do not meet the needs of users and are not easily adaptable to ever-changing requirements. As if that weren't enough, add severe cost overruns (100 percent is not uncommon), incessant delays, lack of standards, terrible or nonexistent documentation, and modifications and maintenance that consume 85 percent of staff time."

The fact that Bryce's words are as true today as they were in 1983 attests to the notion that technology isn't the answer to these problems. Bryce implies that the cause of the problems rests on two misconceptions: 1) people equate information and data and 2) they equate information systems and computer systems. No more profound causes of these problems were ever made. As we deal with domains of responsibility and building and using management tools for providing good information for decision making, we must address and correct these misconceptions. Not correcting them has led managers to failure for decades. Because of these misconceptions, information specialists don't ask the right questions and they look to hardware and software as the centerpiece of solving an organization's problems. Managers, on the other hand, don't express what they need and why they need it.

Information systems don't have to be computer-based, and most aren't. In my management information systems classes, my cardinal rule is that we won't use the word computer or use the computer for more than a word processor. I've found that including the computer in the classes distracts the students from the important issues—the value and use of data and information. They want to deal with the more tangible subject of the workings of hardware and software, which are no more important to management information systems than are the workings of notebooks, file cabinets, and rolodexes. Hardware and software may be more exotic, but they're not more important to understanding systems of information to help manage with. Including the computer in information systems design classes focuses the students on the solution before they even understand or have defined the problem. They want to discuss and integrate computers before they know what to integrate them in to. I'm afraid students aren't the only kinds of people easily distracted by computers in this way.

To illustrate information systems without computers, I like to use the information system in Figure 1.1.16.13. When I was young and went to a baseball game, I received a scorecard. I recorded the lineup by player's name and position, in batting sequence. I tracked the game's events using detailed symbols for base hit, strike out, fly to the center fielder, and so on. I could store and retrieve data for tallying batting averages, fielding percentages, wins, losses, and much more. I used source-point data capture. My data came from direct observation, biased only by my eyes and ability to use the scorecard. I got quite good at it at a very early age. That manual system was a management information system. The person who used it for real, as we see in the illustration, wore the word "manager" on the back of his jacket.

Today, with computers, we can tell you what percentage of the time a batter swings at the second pitch or a runner tries to steal on left-handed pitchers and blond catchers on the first pitch, and so on. I wonder if the computer has made things worse or better. In my day, Bob Gibson or Don Drysdale could pitch nine, ten, or eleven innings (whatever it took) every fourth day, month after month. Today the computer tells us what to do with pitchers and we can't seem to get a pitcher to complete a nine inning game once a month.

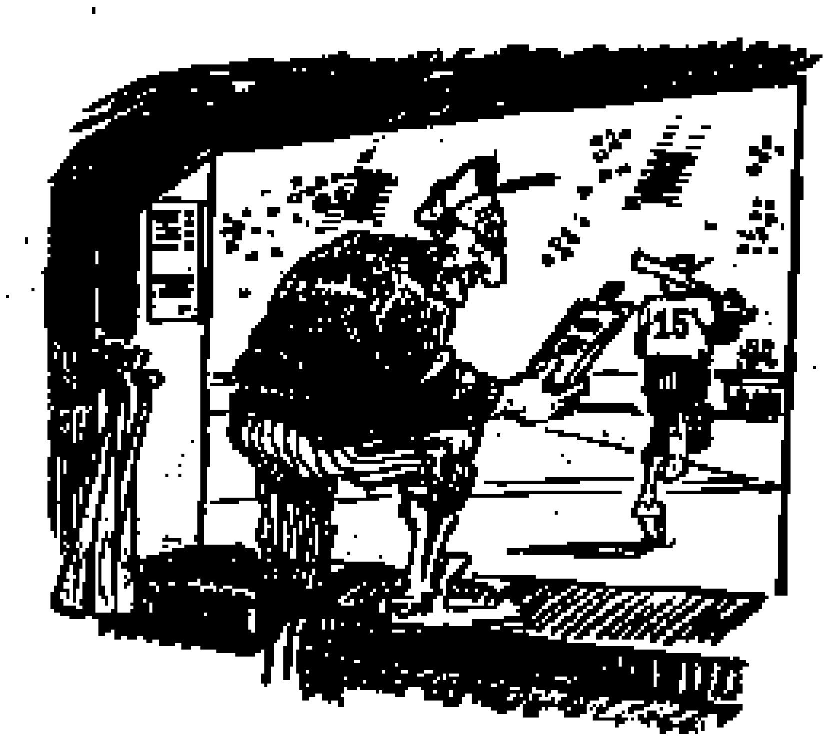

Figure 1.1.16.13. *"Who's on first?"*

1.1.16.14. Exercise on Systems-Oriented Concepts

We distinguish between subtly different concepts to gain sufficient depth of understanding to diagnose, explain, design, implement, and upgrade the building and use of management tools and the management process.

Situation Description
As you think about baking a birthday cake for your roommate in your kitchen, you decide to treat the project as a domain of responsibility. Being in a management systems engineering class, you distinguish concepts for a deeper understanding of the effort you're about to start.

Your father gave you his mother's recipe that you have on a three-by-five card in a metal box on a shelf. You have a modern stove and all the necessary utensils. You've bought all the ingredients and they're in the refrigerator and in the pantry. You're going to decorate the cake with Virginia Tech colors and turkeys. You have some artistic talent and expect to do a realistic representation.

You expect a number of people to eat the cake and will prepare the cake a day ahead of time because you have classes most of the day of your roommate's birthday.

Exercise
Identify in whatever portrayal format you like the various systems-oriented concepts we've discussed. Include concepts like system, process, systems approach, functions, rules, management and operations tools and guides, data and information, information systems, and bias.

1.1.17. Knowing the Laws of Nature underneath the Picture—Michelangelo, the Sculptor *(David, the Pieta)*

1. Background

1.1. Introduction

1.1.18. The Management System Model

1.1.18.1. DESCRIPTION OF THE MANAGEMENT SYSTEM MODEL

The Management System Model describes the components and relationships in the management system and highlights the need for balance obtained by matching the interfaces between pairs of components for the domain of responsibility to perform well.

I'll describe the Management System Model as a simple but robust framework for showing the interplay among the concepts I defined in Sections 1.1.14. and 1.1.16. within the context of the management system defined in Module 1.1.14.5. I'll extrapolate from Figure 1.1.14.5.4. The Management System Model represents a structured approach for understanding, building, and using management tools. The Management System Model gives us a simple framework for describing a management system defined in Module 1.1.14.5., its components, and their relationships. I'll discuss the attributes, or characteristics, of a management system as a series of frameworks in later modules in Section 1.4.5. I'll describe the attributes of the components of the Management System Model in Modules 1.4.2.6.1. through 1.4.2.6.3.

Figure 1.1.18.1.1. repeats the three essential components of a management system shown in Figure 1.1.14.5.4. but separates the three components and uses arrows to show that one component affects the others. Don't confuse the arrows in this model with flow. The arrows show sequence, or relationships. The who manages component, or the manager, is anyone who uses information to make decisions resulting in actions affecting what is managed. The what is managed component, or the operation, includes the tangible things the manager is responsible for. The what is used to manage component, or the management tools, comprises tools we could keep in our head, like organizational structures, plans, and information systems. The Management System Model explicitly separates the means of the manager, or what is used to manage, from the ends of the manager, or what is managed. A common source of management tool failure is emphasizing what is used to manage as the ends rather than the means. The Management System Model implies the focus of management attention is the tangible operation, or work process, that constitutes what is managed. The arrows in Figure 1.1.18.1.1. show that 1) the manager makes decisions resulting in actions affecting the operation, 2) by measuring indicators in the operation we get data to feed into our management tools, and 3) the management tools portray information to be perceived by the manager to support decision making.

A successful domain of responsibility balances the three components in Figure 1.1.18.1.1. Without balance, you and your domain fail. I've found that management tools fail when they're not in balance with who manages and with what is managed. Conversely, those tools that succeed do achieve the required balance. If a management tool is too sophisticated for a manager, the balance is lost. If a management tool doesn't reflect the operation, the balance is lost. If the manager doesn't provide the right intervention to the work process, the balance is lost. A system out of balance is out of control. The question is: How do we identify, achieve, and maintain balance among the components of a management system? The answer is to focus on the interfaces between pairs of components identified in Figure 1.1.18.1.2.

Figure 1.1.18.1.2. distinguishes and emphasizes the interfaces between pairs of components by dividing the arrows in Figure 1.1.18.1.1. into pairs separated by an interface

screen. You get balance among the components by paying close attention to the interfaces between the pairs of components. Each interface matches what one component yields with what the following component requires. You want to match the *information portrayal* from your management tools, what is used to manage, with your, who manages, preferred *information perception*. Your characteristics (attributes) for cognitive style affect how you like to see or hear information and are important in making the match.

You also want to match the *decisions* you, who manages, make with the *actions* you take affecting your operation, what is managed. I show this match in Figure 1.1.18.1.2. as the interface between you and your operation. Likewise, I show a needed match between *measurement* of your operation, what is managed, and the *data* you feed into your management tools, what is used to manage. You should be able to see Forrester's model from Figure 1.1.11.2. in Figure 1.1.18.1.2.

If you consider the framework for the management process in Figure 1.1.11.4. from the perspective of the center box being the operation, or what is managed, (one of the dual personalities) and Forrester's model from Figure 1.1.11.2., you'll see an overlap with the Management System Model (MSM). Forrester focuses on who manages in terms of information in and decisions and actions out. The interventions-organization (operation)-performance of the management process framework shown in Figure 1.1.11.4. focuses on the actions into the what is managed component, the work process of what is managed, and the performance of what is managed in terms of what is measured to become data about performance.

Figure 1.1.18.1.3. illustrates the Management System Model, which describes any domain of responsibility as a management system. As in all aspects of life, balance is vital for the components in the MSM. For management systems engineering, we need a structure to model the domain of responsibility as a system to make the domain work well—or more likely, to make it work better—so we can see with comprehensive clarity what the system components are and how they relate to one another.

The MSM illustrates many important management principles, including: 1) management is decision making; 2) the decision maker converts information into decisions; 3) decisions are valueless unless they result in appropriate actions; 4) actions cause your operation to change; 5) you must know what to measure before you get useful data; 6) all management tools convert data into information; and 7) when you portray information, you must consider how the information will be perceived; and many more.

Each component of the MSM is a subsystem and contains one or more processes. The manager, or who manages, is a subsystem that converts information into action through a decision making process. The operation, or what is managed, is a subsystem that converts action into performance through the work process. The management tools, or what is used to manage, is a subsystem that converts data into information through a comparison and interpretation process. One of the types of management tools is called a management information system, emphasizing the hierarchical nature of systems and subsystems.

The MSM *does not* include a representation of the environment around the domain of responsibility. Therefore, the MSM is a closed system look at an open system. That is, a management system is an open system; the MSM is a closed-system model. I'll discuss strengths and weaknesses of the MSM later. You can't model reality completely; all models are approximations. The trick to using a model is knowing where the model works well and where it doesn't.

Recognize that the MSM doesn't include the environment of the domain. Recognize also that the model doesn't include the inputs from and the outputs to the environment. The MSM deals only with internal inputs and outputs between the components. I'll use other models later to deal specifically with environmental inputs and outputs. However, think about the operation, or what is managed component, for a moment. The operation not only converts managerial action into performance in the form of measurements and data, the operation also converts capital, labor, equipment, materials, (CLEM) and energy inputs into similar outputs in the form of products and services from the work process. Beware that data, information, authority, and other inputs from the environment and outputs to the environment come into and go out of the management system *but not* the operation. The other components, the manager and the management tools, also have environmental inputs and outputs separate from the operation. Of course, the environmental inputs and outputs of any component are also inputs and outputs of the management system.

Since the MSM and the management process center on decision making, the conversion processes in the MSM and the management process center on the inputs and outputs of decision making.

The MSM represents an application system for the engineering process, as described in Module 1.1.9.2. The core application system (as described in Module 1.1.11.6.3.) is the what is managed component.

Always remember that I formed the MSM by sorting the entities in Figure 1.1.14.5.1. into three groups and evolving the three components from overlapping first to touching and then to separated with interfaces. I've found great advantages in defining components, getting separations, and showing relationships. However, inputs don't go to one component or another; they go into the domain where the components are totally intermingled. But, as I've designed the MSM, data and information aren't input to the operation, they're input to the management tools and to the manager, respectively.

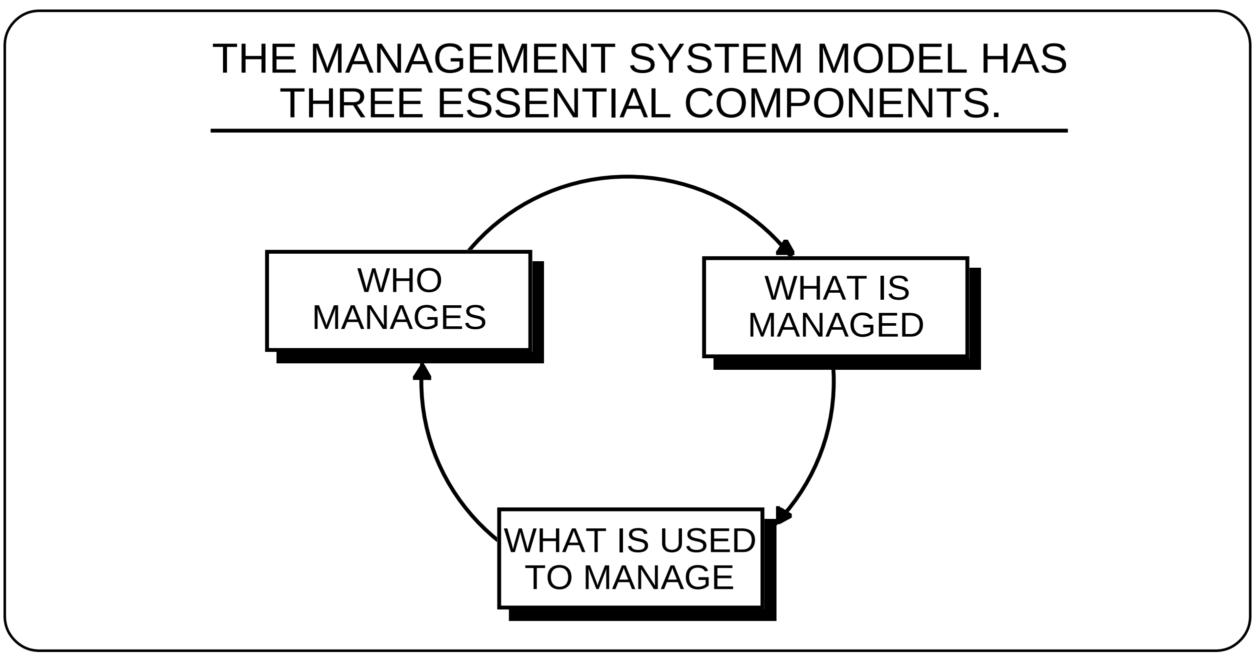

Figure 1.1.18.1.1. *A management system has three essential components.*

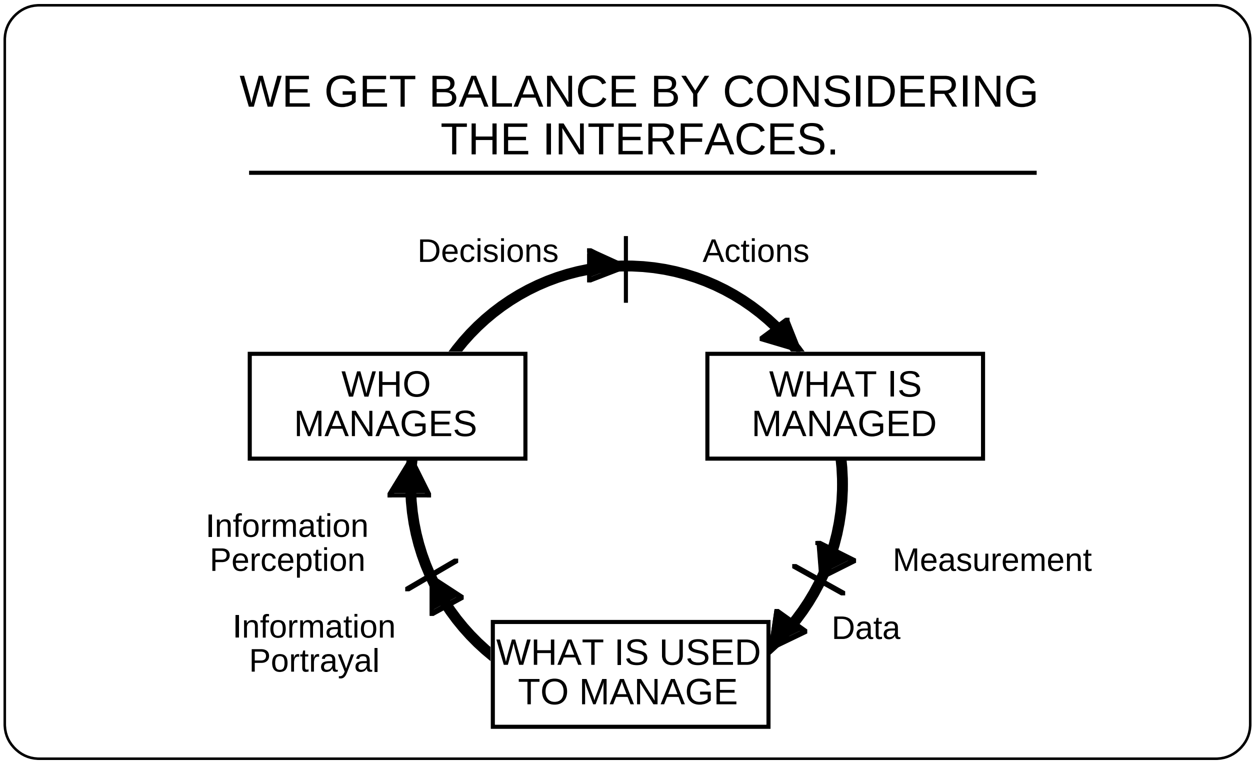

Figure 1.1.18.1.2. *We get balance by considering the interfaces.*

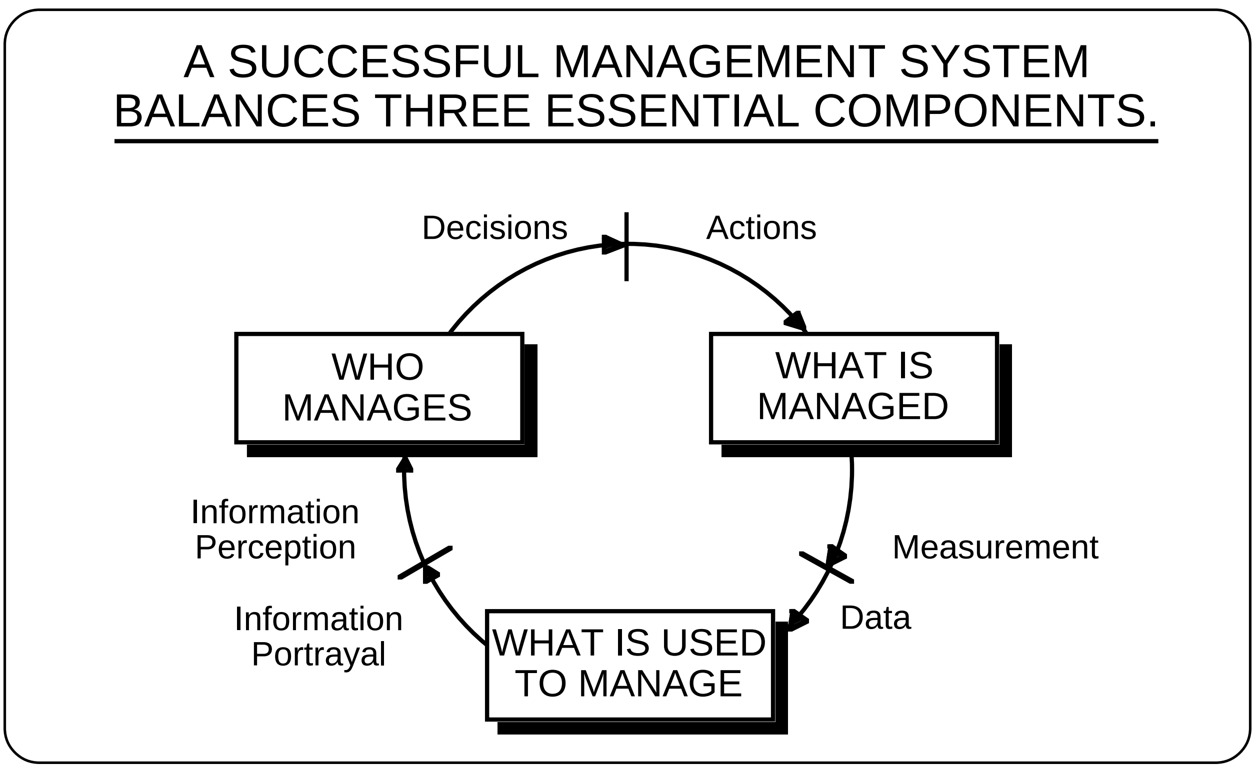

Figure 1.1.18.1.3. *A successful management system balances three essential components.*

1.1.18.2. Origins of the Management System Model

The Management System Model began as a structure to identify impediments to the building and use of management information systems.

Because of my decades-long concern for the many failures in management tools, in the winter and spring of 1984, I was particularly intrigued with an important booklet by Henry Mintzberg called *Impediments to the Use of Management Information*. (copyright by National Association of Accountants, 1975) Mintzberg says, “In recent years, those specialists concerned with the design of the formal management information system (MIS)—notably accountants, MIS specialists and management scientists—have shown considerable interest in how the manager makes use of the information such systems provide. More to the point, these specialists are concerned that the manager does not use their information as they believe he should, and they would like to know why. ..... This paper reviews the literature in the search for answers to the question, ‘Why do managers not use information as they apparently should?’ Ten answers are proposed which fall into three domains—the information, the organization and the brain. In effect, this paper suggests that the ‘blame’ lies in three areas: inappropriate information, problems in the functioning of organizations, and design features of the human brain. The basic premise of this paper is that the use of management information is determined by the complex relationships between the information made available to the manager, the pressures imposed upon him by the organization in which he works, and the ways in which his brain receives and processes the information available.

The first section of the paper contrasts the formal with the informal information system in order to explain why managers often favor the latter. Four basic weaknesses of the MIS are highlighted:

1. *The formal information system is too limited.*

2. *Formal information systems tend to aggregate data; as a result much of the information produced is too general for the manager.*

3. *Much formal information is too late.*

4. *Some formal information is unreliable.*

There is a tendency on the part of specialists to lay all the blame for misuse of information on the manager. Thus, the faults in the formal information system are discussed first to emphasize that problems exist on both sides of the issue—the way information is provided as well as the way it is used.

In the second section, the organization is treated as the problem. Specifically noted are:

5. *Organization objectives are often rigid and dysfunctional and encourage the manager to use inappropriate information.*

6. *The power and political situation within the organization may cause the manager to ignore or distort information related to overall effectiveness.*

7. *The nature of his work drives the manager to favor verbal channels and neglect documented sources for information.*

In the third section, we delve briefly into cognitive and personality psychology and treat the brain as the difficulty. The three conclusions are:

8. *The manager suffers from cognitive limitations that restrict the amount of information he can consider in complex decision processes.*

9. *The brain systematically filters information in line with predetermined patterns of experience.*

10. *Psychological failures and threats further impede the brain's openness to information.*

The body of this report discusses these ten points in some detail. Two final sections then present a summary review of the impediments to the use of management information and some implications for the design of MIS. Before proceeding with this description, we must clarify the use of the term *formal* information. As is evident above, a clear (perhaps overly sharp) distinction is made between the information provided by formal systems and the rest of the information to which the manager has access. Such formal information includes accounting, manufacturing, marketing and other reports, is typically presented on a regularly scheduled basis, and is largely quantitative in nature. This information normally is produced by an in-house MIS and is designed and operated by specialists who often rely extensively on computer processing. The manager's other information may include a vast array of inputs—gossip, ideas, news and so on, provided through less formal (and irregularly reporting) channels. These may include personal contacts, trade organizations and informal subordinate contacts." (pp. 1-2)

The impediments I've just listed are shown in Mintzberg's figure, which I've repeated here as Figure 1.1.18.2.1.

Mintzberg discusses each of the impediments under three major headings he calls 1) the formal information at fault, 2) the organization at fault, and 3) the brain at fault. He then lists eight implications for the design of the MIS: 1) Managers need broad-based formal information systems, in large part independent of the computer; 2) In an ideal MIS, the rate of information bombarding the manager would be carefully controlled; 3) Concentration on intelligent filtering of information is a key responsibility of the MIS; 4) Careful determination of channels is necessary in MIS design; 5) The formal information system should encourage the use of alternative and in-depth sources of information; 6) Stored information must be conveniently available to the manager; 7) The information specialist must be sensitive to the manager's personal and organizational needs; and 8) The MIS should be designed to minimize some of its disruptive behavioral effects.

Not only did Mintzberg's three major headings become information, organization, and brain leading to management tools, operation, and manager, but the impediments and implications affected the thinking of many of the concepts later evolved from the MSM.

Several years before reading Mintzberg's booklet, I read Peter Drucker's *The Effective Executive*. Drucker insists that decisions must have actions tied to them. I had always been interested in the problem of perceiving information depending on how the information was portrayed. As a result I drew the Management System Model (MSM) with its components and relationships. The only difference then was that the model was arranged with a counterclockwise sequence rather than the clockwise sequence shown in Figure 1.1.18.1.3. My students argued that the who manages component should take a more prominent position in the MSM and I seemed to satisfy them by changing the arrangement and putting who manages in the upper left part of the diagram. Immediately, I found an added benefit when I had the what is used to manage component at the bottom of the diagram where I could expand the management tools component for discussion because I had room on a vertical sheet of paper.

After reading Simon and Forrester, I confirmed the interfaces surrounding who manages. Blumenthal's (Sherman C. Blumenthal, *Management Information Systems: A Framework for Planning and Development*, Prentice Hall) torturously detailed diagram confirmed all the pieces of the MSM in his definition of a management information system. I've reproduced Blumenthal's diagram (p. 34.) as Figure 1.1.18.2.2. Can you find the components and interfaces of the MSM in the figure?

Others confirm the MSM. Harry Snyder showed me Alphonse Chapanis' book *Man-Machine Engineering* with an MSM-like diagram on page 20 of the book. *Principles of Information Systems for Management* by Niv Ahituv and Seev Neumann shows or implies the components and interfaces in a diagram on page 100 of their book.

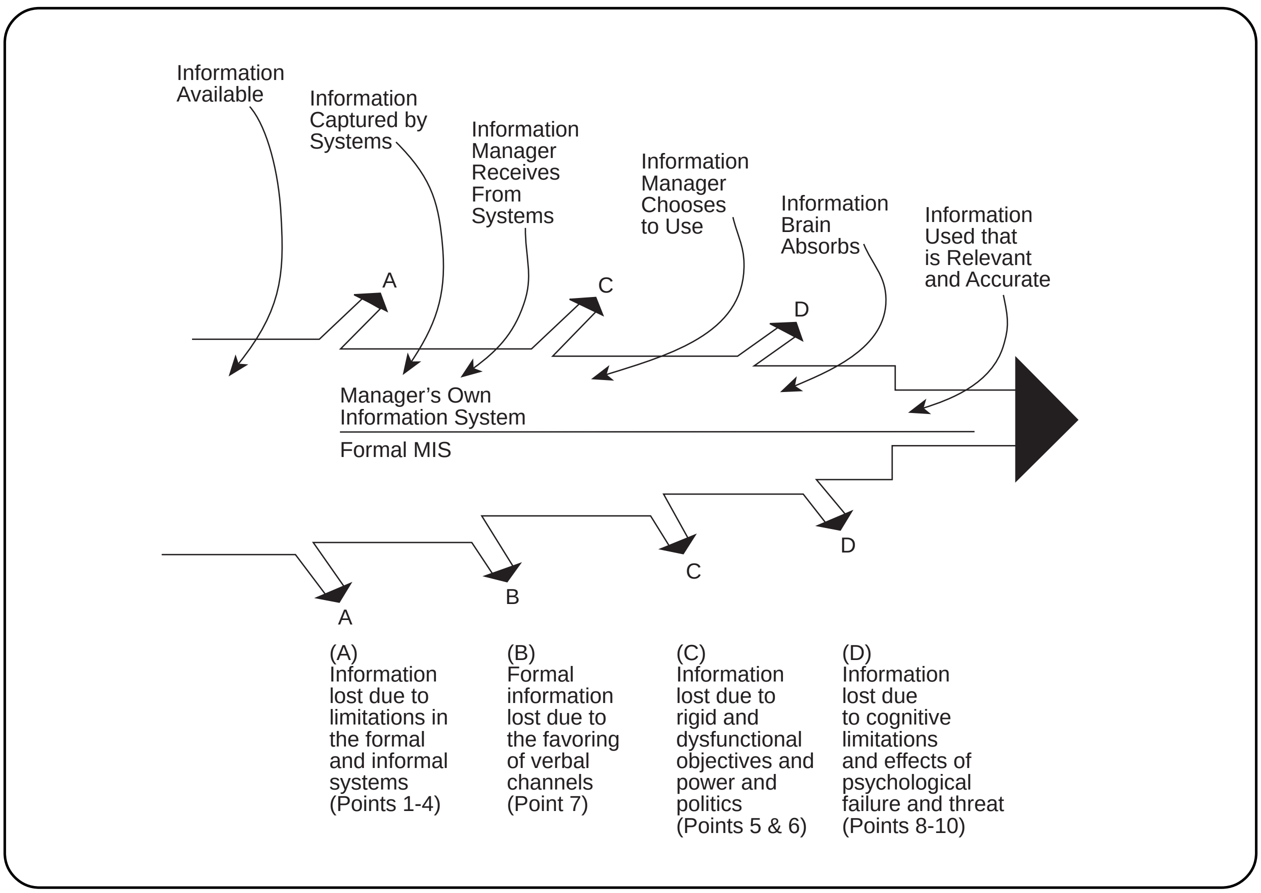

Figure 1.1.18.2.1. *A general view of impediments to the use of management information (adapted from Mintzberg, p. 18)*

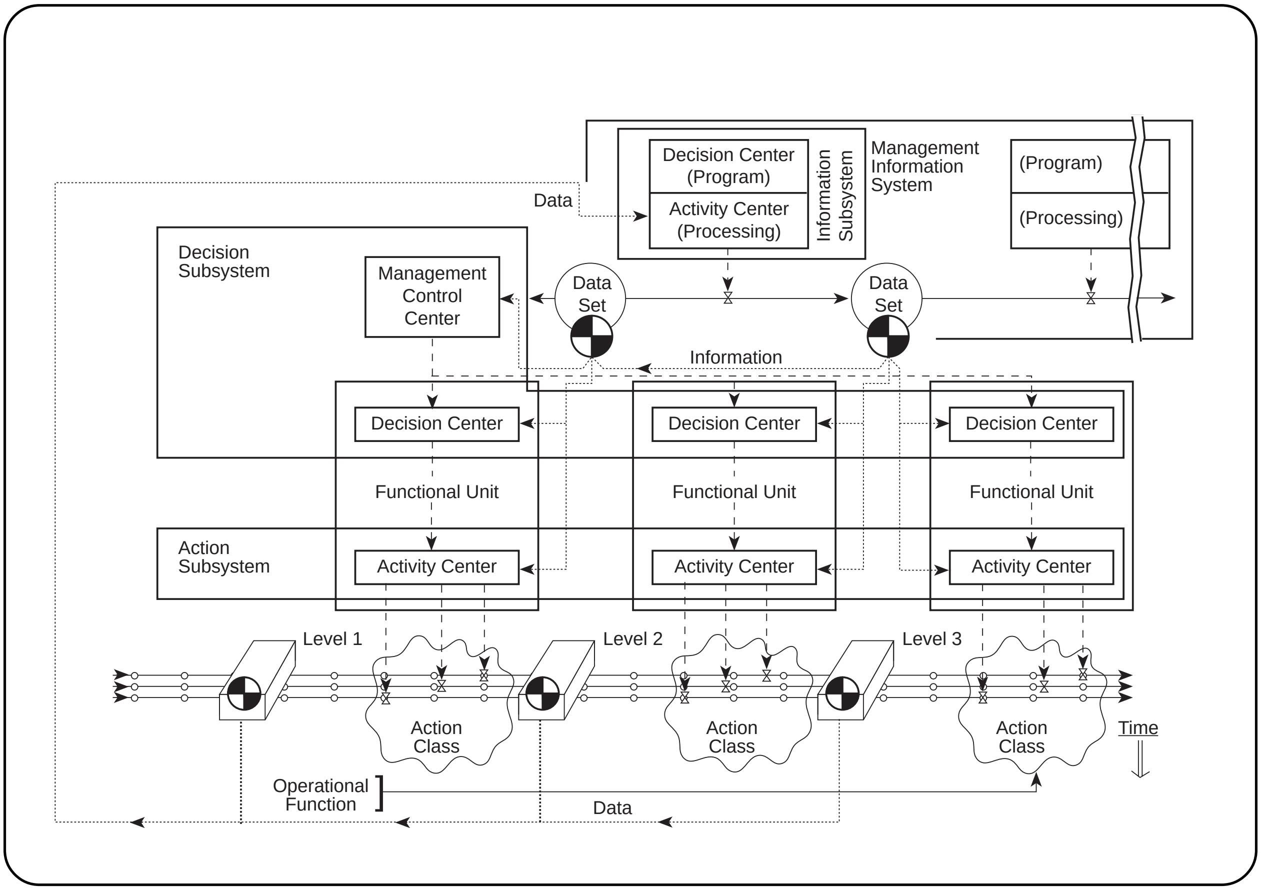

Figure 1.1.18.2.2. *Schematic representation of [management information system]. (taken from Blumenthal, p. 34*)

1.1.18.3. The Cyclic Nature of an Effective Management System

By changing our view of a management system from a closed loop to a sine wave, we can get a view of changes in task performance, management performance, and organizational learning as a function of time.

The Management System Model

The Management System Model is a closed-loop cycle representation of an organization's three components: the decision maker, the work process, and the information-converting management tools. The closed-loop representation emphasizes the importance of the interfaces: decision to action, measurement to data, and information portrayal to information perception.

The Management System Model is a closed-system look at an open system. The Management System Model is a closed-loop, closed-system model. The strength of the Management System Model is that it can describe and explain the management principles listed in Module 1.1.18.1. The weakness of the Management System Model is that it doesn't include a representation of the environment around the domain of responsibility.

By showing the cyclic nature of the Management System Model in a different representation, we can see the effects of the environment on the domain, even though we don't include the environment in the model. This other representation shows the cycle not as a closed loop but as a sine wave.

The Sine-Wave Representation of the Organization

Within our domain of responsibility, we solve problems resulting from sequences of related decisions. By participating in problem-solving experiences, we learn lessons. Each person involved in the problem-solving experience learns his or her set of lessons. Depending on how well we observe and remember what we see in our work process, we learn from the problem-solving experience differently. Depending on how well we access, interpret, and act on what we learn, we go into the next problem-solving experience differently.

When we take our lessons learned into the next problem-solving experience, we change our task performance. When we decide and act differently based on what we learned from the previous problem-solving experiences, we change our management performance. When we store and refine our lessons learned from our previous problem-solving experiences, we change the content of our organizational memory. The change in organizational memory constitutes organizational learning.

I represent the influence of learning on subsequent problem-solving experiences as a sine wave shown in Figure 1.1.18.3. First, notice the changes in task performance, management (decision-making) performance, and organizational memory in moving from problem-solving experience to problem-solving experience, from decision to decision, and from information storage content to information storage content, respectively. Second, trace through the sine-wave representation to pick up the what is managed, what is used to manage, and who manages components of the management system. Third, identify the measurement to data, information portrayal to information perception, and decision to action interfaces between pairs of components.

The sine-wave representation of the organization emphasizes the continual repetitive nature of the learning cycle and process. When we consider a single person's learning from a particular problem-solving experience, we have a representation of individual learning. When we consider the collective lessons learned by people in the organization, we have a representation of organizational learning.

If I represent the components and interfaces of the Management System Model as a sine wave, I emphasize the place of the components in the organizational learning cycle and the effects of the environment on the components and on the learning cycle. The work process, or what is managed, contains the actualization of the problem-solving experiences. Since each person observes or experiences something different in the problem-solving experience, each person learns a different lesson. Each observer has a different learning experience.

The information-converting management tools yield information from a process of storing and refining data into memory. In Figure 1.1.18.3., I show the continual change in learning experiences and update to the contents of organizational memory in subsequent crests and valleys of the wave.

The decision maker retrieves information from memory and interprets the information for decision and action. The action adjusts the next problem-solving experience and yields an updated learning experience.

The sine-wave representation emphasizes the importance of the components. The sine-wave representation gives us the advantage of digging into the organizational learning characteristics of the management system.

The sine-wave representation doesn't show the environment acting on the organization. Instead, the sine-wave representation shows the effects of the environment on the organization. The sine-wave representation includes the effects of the environment by showing the difference in problem-solving experiences at times t_1, t_2, t_3, etc. These times represent snapshots of the organization at the time the organizational memory is updated.

Including the effects of the environment on the organization is a model representation problem not a problem in seeing the change in the organization resulting from the effects of the environment. The change will happen due to the environment acting on the organization. The sine-wave representation includes the results of the interaction. But the sine-wave representation doesn't include a representation of the interaction.

The implied axes of Figure 1.1.18.3. are time and knowledge or performance. For learning, the dimensions are best interpreted as time and knowledge. For improvement, the dimensions are best interpreted as time and performance of the operation or of the manager. Performance and knowledge are related.

In Figure 1.1.18.3., the what is managed component of the Management System Model is also labeled source or object. The physical responsibilities, or operation, or work process is the source of data and the object of action. As we discuss management tools (what is used to manage) more, we'll partition the data-to-information convertion process into functions, including storage and refinement of data. The storage of data represents memory of the management tool.

As a conceptual entity, rather than a physical entity, the management tool is the place where we store data in our memory. Any decision maker in the organization can retrieve and interpret the organizational memory to support his or her decision making. The source that feeds the organizational memory is the problem-solving experience in the work process. The object that receives the action of the decision making is the work process, which becomes the next problem-solving experience.

I discovered the sine-wave representation of the Management System Model when working with Tim Kotnour on his dissertation (Timothy G. Kotnour, *The Effect of Lessons-learned Sharing Processes for Organizational Learning on Decision-making Performance*, unpublished PhD dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 1995). Kotnour says, "The four functions of organizational learning, as I define organizational learning, are shown as (1) problem-solving or learning experience, (2) storage and refinement, (3) retrieval, and (4) interpretation."

Using the Sine-wave Representation

By comparing successive similar positions in the peaks and valleys of the sine-wave representation in Figure 1.1.18.3., we can focus on learning, performance improvement, or management improvement. In this way, we see change in the organization as a function of time. Learning is the change over time shown as the valleys of the sine-wave representation. Task, or performance, improvement is the change over time shown as the crests of the sine-wave representation. Management improvement is the change over time in the decisions shown in the ascending part of the sine-wave representation.

For organizational learning, we do the updating of memory with the purpose of improving management (decision making) which, in turn, improves performance (the work process and thereby the products and services of the organization). This sequence from memory to management to performance helps explain the link between knowledge and performance that I mentioned when characterizing implied axes for Figure 1.1.18.3.

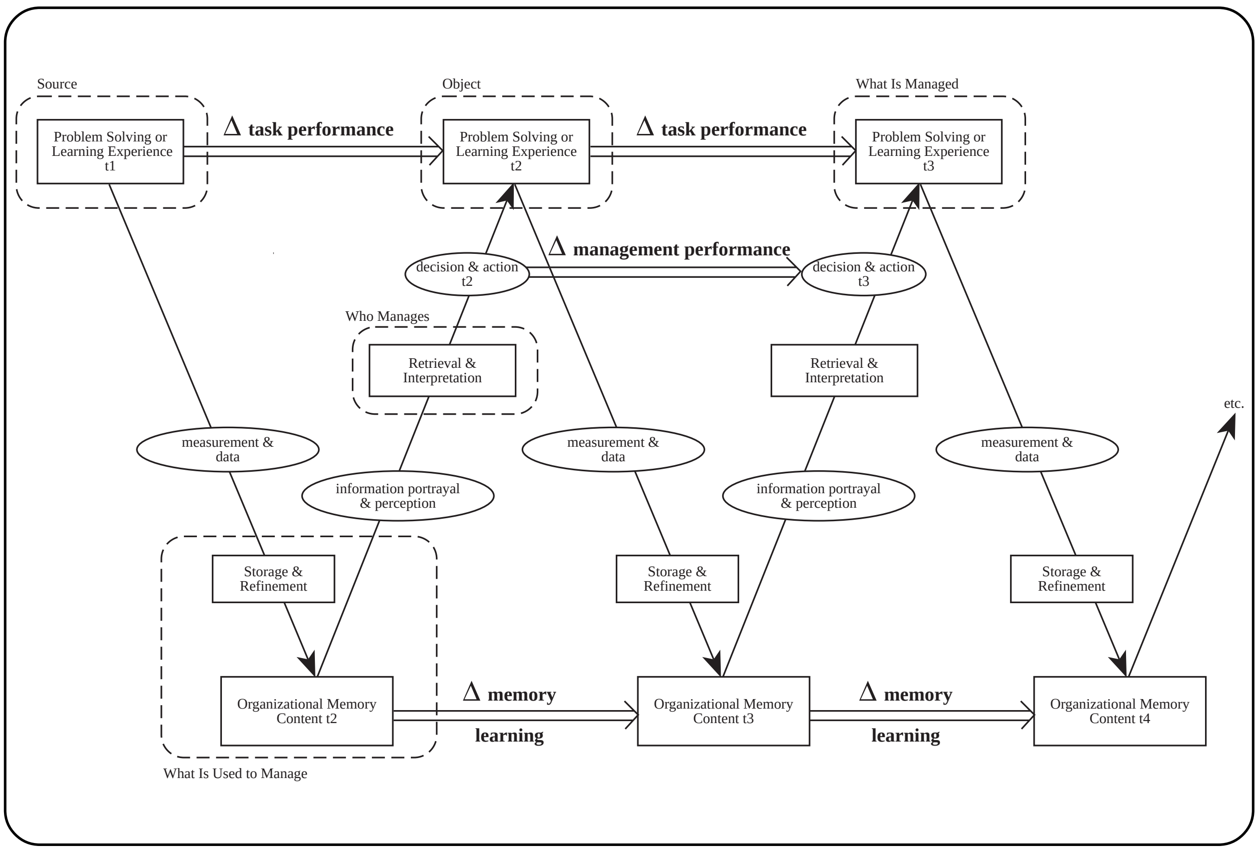

Figure 1.1.18.3. *The sine-wave representation of the organization shows learning, performance improvement, and management improvement resulting from lessons learned about problem solving or learning experiences.*

1.1.18.4. Balance Is the Answer for the Management System Model.

The Management System Model helps us understand a management system like statics helps us understand a mechanical system.

When we model any system, we design the model based on our objectives in understanding the system. For a complex system, no one model will serve all purposes. So, we make assumptions about the system we're modeling to get the form of the model and then we apply boundary and initial conditions to apply the model to a specific type of system. The most important assumption in the Management System Model (MSM) is the assumption of no external forces on the system.

In the MSM, we look for balance in the domain of responsibility. We focus on the components of the domain and the relationships among them. We don't look at changes over time. The MSM is like snapshots of the domain at points in time. (You need more than one snapshot to investigate balance.)

In Figure 1.1.18.4., I show the three components of the management system as three blocks (masses) connected by springs and dash pots. The springs and dash pots represent the interfaces between pairs of components. I show no connections to anything outside of the three-component system. If we perturb one of the blocks, the system will respond and either go out of control or return to steady state. My concept of balance not only requires a return to steady state but a return to at least as good a steady state. In a management system, perturbing a block would include changing the manager of the domain (who manages), changing the work process (what is managed), or adding a new management tool (what is used to manage). In this book, I'm most interested in the effects of changing a management tool or adding a new one. This is one perspective for approaching the management system to improve performance. Other perspectives include improving the work process and improving the decision making process.

For balance in a management system, we'll concentrate on the attributes of the system and of its components and on the relationships among the components and their attributes. I'll use an information system example to illustrate balance. Today, in every magazine or journal for management, people espouse the importance of color graphics for portraying information. Color graphics is an attribute of some mechanisms of management tools—a way of portraying information. Color graphics is also an attribute of some people's preference for perceiving information. Given the same information content in a spreadsheet and in a color graphic, not everyone prefers the color graphic. If a decision maker is sold on color graphics by the magazine and really prefers a simple spreadsheet, the who manages and what is used to manage components of the management system won't be in balance. Researchers argue that intuitive people prefer pictures and color in perceiving information and sensing people prefer numbers and structure. Intuitive people prefer color graphics and sensing people prefer spreadsheets. Since 75% of the people in the United States are considered to be sensing (by the Myers-Briggs Type Indicator studies), most people won't like color graphics for information perception. They may like color graphics to keep up with the fad or to look high-tech. Of course, we hope they'll prefer the portrayal with the best information. But, if the information content is the same, you most likely will perceive the information better in spreadsheet form. My experience in industry and government settings supports this result.

One of the frightening issues in the relationship between success of the organization and balance in the MSM is that if you dramatically change a component, you threaten the balance and, hence, threaten success. For example, if we design and build management tools that promote balance in the MSM and the manager is changed, the whole system can go out of balance. The first place we usually see the balance problems for a new manager is his or her dislike and immediate refusal to use the management tools of his or her predecessor. Until we build adaptive management tools, able to immediately and inherently adapt to a new user or manager, we'll find problems with some management tools each time the manager changes.

Some years ago I built a milestone tracking system for a Department of Energy office director. He, the decision maker, influenced the design of the system. He, his deputy, and other direct reports used the system monthly to ensure all projects were on track. The system was successful. When he left for a new job, his deputy replaced him and, based on his previous involvement with the system, continued to use the system successfully. Later, a new person appeared on the scene. The original deputy was promoted and the new office director had never dealt with the milestone tracking system. The system died on the spot. The new person didn't like the system. The balance between the tool that was used to manage and the decision maker was lost. Either he couldn't feel ownership, he was uncomfortable with the guiding process, he didn't like the portrayal format, or he had other mismatches at the information portrayal, information perception interface. The management system components fell out of balance when the decision maker was changed. Obviously, the tool could be successful and was with two different managers. But the tool failed because the management system components disconnected when the new manager arrived.

For the overlap of the management system components in Figure 1.1.14.5.3. and for the interfaces between the components in Figure 1.1.18.1.3., the meshing or matching of the components' attributes spells balance and success. One way to characterize a successful domain of responsibility is for the system to be in balance.

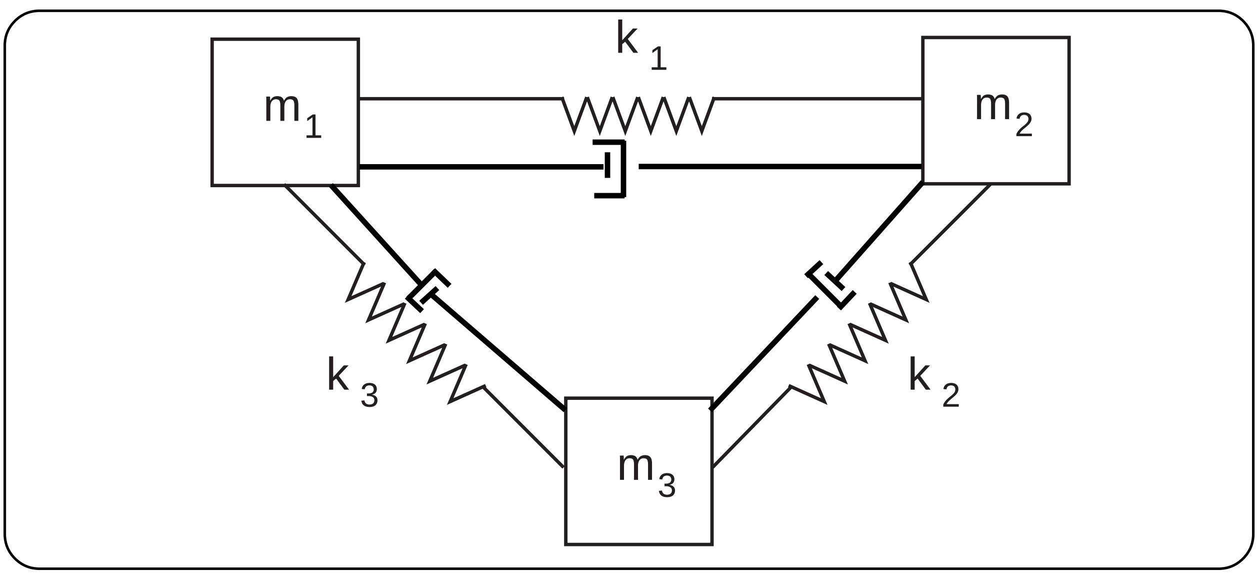

Figure 1.1.18.4. *Three blocks connected by springs and dash pots form a system analogous to the Management System Model. (This analogy was developed during my interaction with Larry Mallak during his Master's degree work at Virginia Tech.)*

1.1.18.5. Uses of the Management System Model

The Management System Model is a simple, robust, closed-system descriptive model for looking at an open system—a domain of responsibility—most useful for learning about the relationships between the essential components of a management system.

The Management System Model (MSM) is a descriptive model and to some extent an explanating model, but the MSM doesn't help for prescriptive or predictive purposes. Later, I'll describe similar models we can use for prescription or prediction. As a descriptive model, the MSM shows components and relationships in the system so we can discuss and learn about how the components and relationships work.

Starting with description and explanation isn't near to us. To begin learning how an automobile works, we first need to know the subsystems and components, how they work, and how the components affect each other. Much later, we need to know how to build or drive an automobile. Later yet, we can predict how a change in the automobile will affect its performance or prescribe what to do to the automobile to get desired performance.

I'll use the MSM to single out a component or a relationship to discuss. The MSM not only helps single out (analyze) a component but the MSM also helps tie the component (synthesize) back together with other components in how the component contributes to the larger system.

The MSM brings us back to the big picture and puts us in touch with the fundamental components of our domain of responsibility. We've been distracted from the big picture—first since the 1950's and 60's by operations research models, and second since the 1970's and 80's by the computer. We must concentrate on the big picture and manage all our tools so that they will work for us.

Strengths and Weaknesses of the Management System Model

Simplicity is the greatest strength of the Management System Model. The greatest weakness of the MSM is that the MSM is in a vacuum—there are no interactions with the environment. This strength and this weakness give us the age-old dilemma of simplicity versus accuracy. All models are approximations. Where the assumptions fit, the MSM works well. When we look at the domain by itself and we want internal relationships and the strength of the components, we won't be affected by the MSM's weakness.

I use the MSM to understand the inside world of the domain first. I want to figure out how the organization works within itself before worrying how it interacts best with the outside. I'll use other models to understand the outside world and the relationship of the MSM to the outside world.

I believe you shouldn't try to modify the MSM to include the effects of other domains or of the environment. You then complicate the MSM and lose its strength. And you only patch over its weakness. If you want to show interactions with other domains, use another model designed for that purpose. I'll describe several later.

The second greatest strength of the MSM is its robustness. The simple model includes the concepts of Sections 1.1.14. and 1.1.16. and the teachings of Simon, Forrester, Taylor, Drucker, Mintzberg, and others. We can use the MSM as a foundation model to build other important concepts.

The Management System Model doesn't work well to show teamwork, participative management, and interactions among decision makers. Some people like to include more than one decision maker in the who manages component. An important point made with the MSM is that even though a number of decision makers may work together, each has his or her own responsibilities with corresponding authority and accountability. Responsibility can be delegated. Responsibilities can overlap. Responsibilities can change. But, one person ultimately must be accountable for each task at any given point in time. (Unfortunately, sometimes a task is forgotten or not delegated to someone.) Cooperation and teamwork (implied in multiple decision makers) are crucial. But, so are coordination and knowing expectations (implied in a single decision maker).

The Power of Simple Models

I learned the power of simple models when I was responsible for the kinetics (time-dependent) analysis of a small, solid-metal nuclear reactor for the United States Army. When I arrived on the scene, the scientists using the reactor to study radiation effects on equipment were using a relatively sophisticated space, time, and energy dependent computer model. The problem was that the model wasn't predicting the results of their experiments. The computer package was a standard in the industry and the scientists had confidence in the package's reliability. The direction to me was to increase the number of space nodes and/or energy groups, because surely we didn't have enough detail in the model. Instead, I tried a simple, back-of-the-envelope model that included no spatial or energy variation. This model treated the reactor as a point in space (or essentially a volume with constant energy and spatial distribution of neutrons, where any point could be normalized to represent the entire reactor).

To make a long story short, my simple model worked beautifully. In hindsight, a more sophisticated model would have been worse than what they started with. The reasons my model worked so well were: 1) the tightly-coupled, fast-neutron reactor core, in fact, acted like a point and the assumptions of the simple model fit, and 2) I didn't need accurate measurements of many input parameters or coupling coefficients because the model didn't include the variables or the coupling equations; so I could concentrate on the accuracy of the few parameters I did need.

This convincing experience turned me on to simple models. I like the idea of doing something easier and better at the same time. A simple model is usually easier, but is only better when the assumptions behind the model fit the application.

1.1.18.6. Expanding and Modifying the Management System Model

When you change a model designed to meet certain needs, you risk failing the original needs while trying to be new needs with a model designed for something else.

Should we include other components of a system in the MSM? Is there a component between the decision and action? For example, are there decision making tools, like actuators, that convert decisions into actions? How do we show interfaces with other domains of responsibility?

We're always tempted to add just one or two items to a simple model to make the model better. A better model would be one that suits your specific application more closely. We try to adjust the model to compensate its weaknesses or to enhance its strengths. Most of the time, however, we do the opposite.

I've seen a number of different types of extensions and modifications made to or argued for the MSM. A few I believe capture yet another piece of understanding of a management system. Most, however, lose more than they gain. Some of the types of changes I've seen are:

1) more than one decision maker in who manages,

2) various connections with other domains or the environment of the domain,

3) additional components and/or subcomponents

4) a distinction between physical and conceptual interfaces.

These are all worthy thought exercises. I hope the MSM stimulates that type of thinking. My experience is that to show any of these, you're better served to develop another model. Putting a bandaid on a model doesn't often work. Use the MSM to do what the MSM does best. Use another model to make other or additional contributions. Then integrate the understandings of the two models.

1.1.18.7. Three Different Management System Model Perspectives

The perspective you take to the Management System Model directs the type of performance you see.

Figure 1.1.18.7. shows three different views from which we can view the Management System Model. Each of the views centers on one of the components. In fact, if we view the MSM globally, we could include a fourth perspective.

I've labeled each view in terms of the type of performance motivating my looking from a perspective in the first place. The perspective of primary concern in this book is the view from the bottom, toward the what is used to manage component. This is the management tool perspective and the one suited to engineering the engines of the management process. This view gives us information-oriented performance. Information-oriented performance includes issues like the timeliness, accuracy, and relevance of data and information. Management tools can be measured in terms of productivity, quality, efficiency, effectiveness, and other measures. In a later module, I'll expand on these measures for information-oriented performance. The Management Systems Laboratories (MSL) focuses on the info-oriented performance perspective within the context of the MSM and the other perspectives.

Another equally important perspective is looking from the right in the figure, toward the what is managed component. This is the perspective of most students of productivity and quality. This view gives us operation-oriented performance. The what is managed component converts interventions into performance data. In converting capital, labor, equipment, materials, and energy inputs into product and service performance, the operation yields productivity, quality, efficiency, effectiveness, quality of work life, and other measures. Be careful to note that when you look strictly at the work process, or the operation, your productivity and other measures don't measure the performance of management tools.

At Virginia Tech, we have the Virginia Productivity Center (VPC). Like other productivity centers in other states, VPC looks at improving the performance of organizations. VPC focuses on operation-oriented performance within the context of the MSM and the other perspectives.

The third equally important perspective is looking from the left in the figure, toward the who manages component. This is the perspective of management schools teaching people to be managers. This view gives us personal performance—a crucial function in the management process. We measure our decision making effectiveness and quality so we can improve.

Business colleges look at developing managers and improving individual and organizational effectiveness. A business college focuses on personal performance within the context of the MSM and the other perspectives.

Finally, the global perspective looks at the entire figure. This is the perspective management schools, engineering management programs, and management systems engineering programs need to understand better. This view gives us organization performance, which represents a holistic combination of the other three perspectives. In management systems engineering, we want to work toward organizational performance.

I've found that you can quantify measures for management tool performance. When building and using management tools, you improve by measuring different performance factors and implementing lessons learned in the management tools.

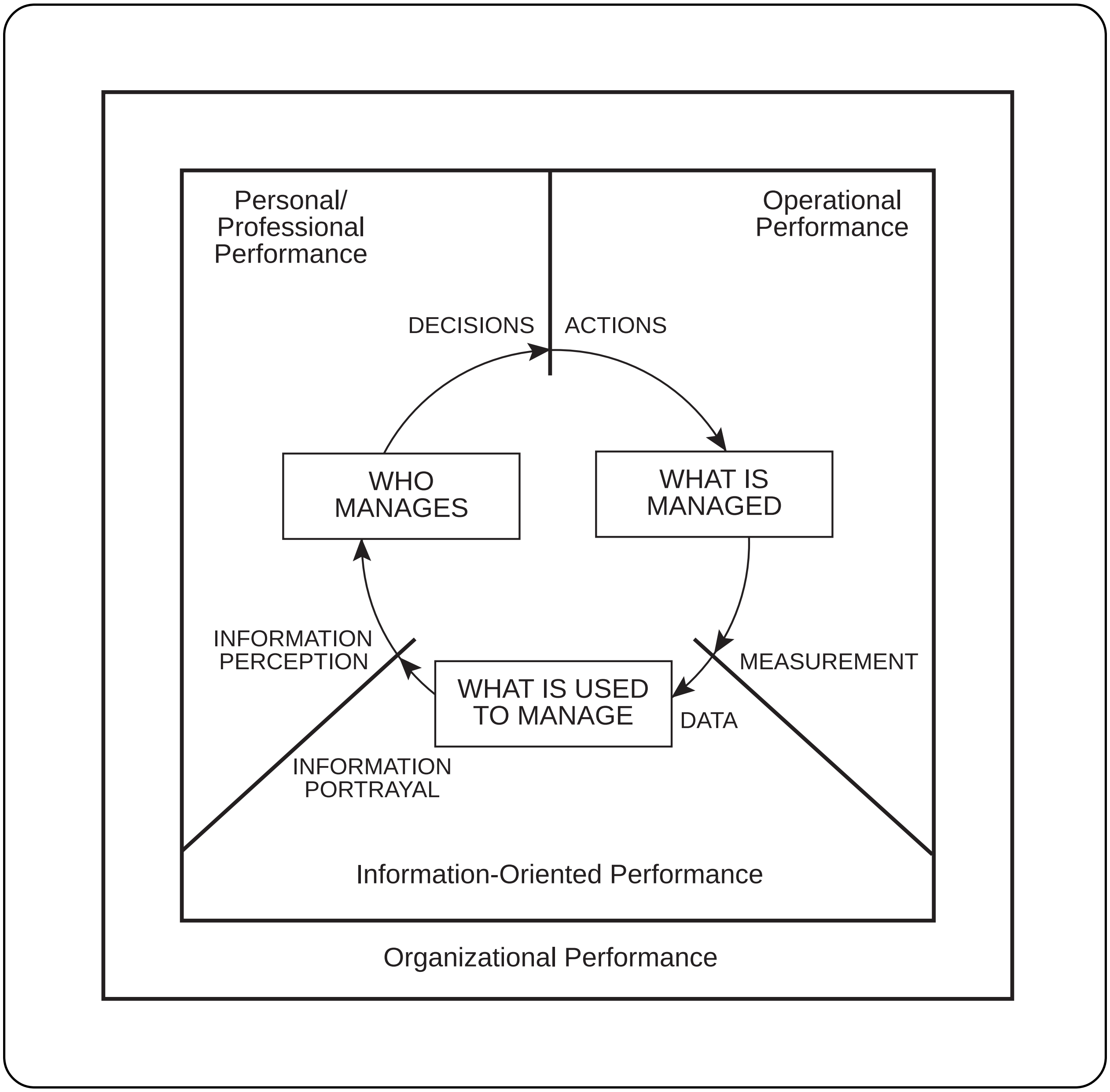

Figure 1.1.18.7. *The Management System Model can be viewed from a global and three directed perspectives. (This diagram was developed during my interaction with David Hill during his master's degree work at Virginia Tech.)*

1.1.18.8. *OBJECTIVE* OF THE APPROACH

The objective of the approach is to build and use management tools in such a way the tools can be the means for adjustment in the management system to balance the Management System Model and gain success for the organization. The objective of this book is to give the reader the understanding to meet the approach's objective.

Our goal is to improve the organization's performance. The Management System Model (MSM) says we can choose among three components to affect the organization in such a way we improve its performance. We can focus on the manager, the work process, or the management tools. We can determine success in the organization as good and improving performance. I've spelled success as balance in the MSM. If the MSM is out of balance for an organization, to bring the organization back into balance for success, we can adjust one of three components: who manages, what is managed, and what is used to manage.

Situational leadership theory (Kenneth Blanchard and Paul Hersey, *Management of Organizational Behavior*, Prentice Hall, 1982) says managers need to use different leadership styles based on the maturity of their followers. Follower maturity is defined in terms of their ability and willingness in regard to various tasks. The idea here is to get the manager to adjust—in my terms, to bring the MSM into balance.

Fred Fiedler (*The Contingency Model: A Theory of Leadership Effectiveness*, Problems in Social Psychology, McGraw-Hill, 1970) says, "The model also points to a variety of administrative and supervisory strategies which the organization can adopt to fit the group-task situation to the needs of the leader." Fiedler, other researchers, and practical experience suggest that a way to get balance in the MSM is to adjust the organization or the operation to the needs of the manager.

These two adjustments—change the manager or the work process—seem to be ways we try to fix organizations. Changing the operation seems to be the easy way out. If things aren't working, change the staff or adjust a part of the work process so the manager fits the situation. The next easy way out is to change the manager, either by training or reassignment. You know which is easier. Each of these two adjustments is worth considering; and in some cases, is the way to improve performance.

The MSM suggests a third adjustment—a third way to keep the organization in balance for success. Adjust the management tools.

I've learned in industry and government that you can't easily jerk around someone's work process, and certainly not without justification. I see us streamlining the work process to reduce waste and frustration and to save time, steps, and paperwork; but I don't see us changing the operation to make a better match with the manager or the management tools.

I believe you want to take advantage of a person's strengths in interest and ability. So, I don't like to cause people unnecessarily to do something in a way they aren't good at or don't like to do. I would be careful in changing a person's style. Training in skills is one thing, changing style is another. Certainly, inflexible decision makers or work processes ultimately are problematical. But, I think we have another good, yet neglected, alternative.

The component we can adjust with the greatest promise of bringing balance to the MSM is the what is used to manage component. People are reluctant to adjust management tools today because they're afraid of the information specialist who wants to save a nanosecond of computing time regardless of the cost in human time. I believe improved performance of the organization is more important than the elegance of the mechanization of the management tool.

Information-oriented performance as discussed in Module 1.1.18.7. is important when linking management tools use to organizational performance. One way to directly link tools to performance is to build adaptive tools—tools that inherently adjust to the user and to the operation. I'll describe adaptive tools later. In short, all ways of improving balance in the MSM and of improving performance are important. I believe focusing on adjusting the tools and on improving information-oriented productivity needs to be emphasized because, relatively speaking, that perspective has been neglected.

My objective in this book is to use the management tools as the significant influence on bringing the MSM into balance.

1.1.18.9. Scoping Your Domain Clarifies Your Responsibilities

If you haven't scoped your domain of responsibility, you don't know what you're doing and will probably work up a wonderful solution to the wrong problem.

Throughout the previous discussions, I've used the term domain of responsibility in a way to make its meaning implicitly clear. Now, in light of what has come before, I can define it explicitly. Your domain is a system, a system fully represented by the Management System Model (MSM). It has extent; it has boundaries. Shifting the boundaries in your mind every time you consider another tool or application will cause those tools or applications to reflect slightly different domains and not work together as well as they should.

If you add another person to your domain of responsibility, everything you use to manage that reflects numbers and types of people, locations, and arrangements has changed. Many more changes and the tools won't work together.

Your Domain Has Boundaries

In your mind or on paper you should be able to draw a circle around your domain to isolate it both horizontally (functionally) from other systems with which it interacts and vertically or hierarchically (structurally) from a larger system of which it is a constituent element. Although I have come many paragraphs from our opening, I am, with the concept of the domain of responsibility, conceptually as well as practically at my starting point, the heart of the matter. The systems approach to management must begin with a clear look at a manager's domain.

Through the boundaries of your imaginary circle (your domain of responsibility) consider the information flows in and out which tie your domain to the rest of the world. These are your information inputs and outputs. And everything outside your domain of responsibility, from a systems perspective, is the environment of your management system. Your circle with inputs and outputs is Ed Yourdon's context diagram. (Tom deMarco, *Structured Analysis and System Specification*, Prentice-Hall, Inc., 1978, pp.75-76.) You'll practice a context diagram in the next module.

The person for whom the management tools are to be built and what is managed in terms of physical extent, mission, and objectives must be clearly identified at the outset, or there is considerable risk that the wrong management tool will be built for the wrong person.

To be able to manage well, you must know your role and responsibilities. Consider the predicament shown in Figure 1.1.18.9. of the construction foreman who was out on the job one day. He asked a man sawing boards what he was doing. The man said, "I'm a carpenter and I'm sawing boards." He asked a man laying bricks what he was doing. The response was, "I'm a brick-layer and I'm laying bricks." Then he asked the pipe fitter, shown in the illustration, what he was doing. The pipe fitter said, "I'm toiling with my fellow workers to build a cathedral to the glory of God. All the peoples of the earth can come as one to worship the Lord." The foreman fired him—because they were building a gas station.

Your System Is Tightly Coupled

What is a system? A system converts inputs into outputs resulting in throughput to meet some objective(s) and incorporates measures of performance to determine how well the objectives are being met. A measurable change in any one of a system's parts will cause a measurable change in all the other parts.

Now we can see why the MSM is such a powerful tool—for, whether we like it or not, to touch a system anywhere is to touch it everywhere, especially for a tightly-coupled system. Within a system, it is impossible to do just one thing. This has always been true, but it is especially critical now.

Today, information technology advances so rapidly, providing such a vast array of products and services, that most become outdated before the ink dries on the user's guides. Now as never before, a manager must be able to understand how his or her domain of responsibility behaves as a system, converting inputs into outputs, without thinking in terms of computers or other electronic wizardry at all.

Information technology is a fast track, which most managers are already on. If you are not, you will have to get on soon, because the changes released by microprocessors are now part of the woodwork, entrenched and irreversible. When the automation specialist, in-house or out, comes to the door of your domain, you need to know how to help him or her help you—and how to prevent him or her from inadvertently doing serious damage. Getting the right equipment to provide the right services to the right people at the right time—and being able to use the equipment for even two years—is, given the bewildering selection, partly a matter of luck. But luck, as Pasteur said, favors the prepared mind.

The systems approach taken here is different from that suggested by Ed Yourdon. Yourdon advises the system designer, or the manager who must help the system designer, to begin at the smallest partitions of a domain and to create, bottom-up and step-by-step, a context diagram for the whole system. I suggest that, though the bottom-up approach is valuable, even necessary, it should come second, after the domain has been seen as a functioning whole through a top-down application of the MSM and in the light of the four external or contextual frameworks I'll discuss later in Section 1.4.5. In other words, I favor a dual-path approach, which incorporates the strengths of both classical approaches.

The Systems Approach Helps Management Transition toward a Science.
I'll extend slightly the quote in module 1.1.8. from the first page of Jay Forrester's landmark book, *Industrial Dynamics*. Forrester says "Any worthwhile human endeavor emerges first as an art. We succeed before we understand why. The practice of medicine or of engineering began as an empirical art representing only the exercise of judgment based on experience. The development of the underlying sciences was motivated by the need to understand better the foundation on which the art rested... Management is in transition from an art, based only on experience, to a profession, based on an underlying structure of principles and science." (p. 1.)

Here we are, decades later. Certainly at strategic levels, management remains an art focused on unstructured decisions involving "judgment based on experience." We have no real experts upon which to base an expert system. The developing science is working at operational and clerical levels. "Art" re-enters the picture as a guide to proper use of the tools of science.

You can find anybody who is good at the science of making or adjusting tools. You can't find many who know the art of what to make or what to adjust them to—that requires an understanding of what is managed and who manages and how they relate. The MSM is valid at strategic levels because it is still qualitative, it hasn't yet been restricted through quantification.

For the MSM and the contextual frameworks described in later modules, conceptual qualitative models are presented based on qualitative observation and experience. The approach to these conceptual models is adapted from Glasner's constant comparative method for systematizing qualitative data. I consider a need of or a perspective for a tangible management situation. The nine steps to the model are: 1) list everything that applies, 2) identify categories and define their properties, 3) compare items within categories, 4) integrate categories and their properties, 5) test the categories by fitting new items, 6) delimit the theory, 7) iterate often, 8) write or structure the theory that relates the categories to one another, and 9) test the theory through experimentation. Thus, the resulting theory behind the qualitative model is grounded in the data originating from the management situation.

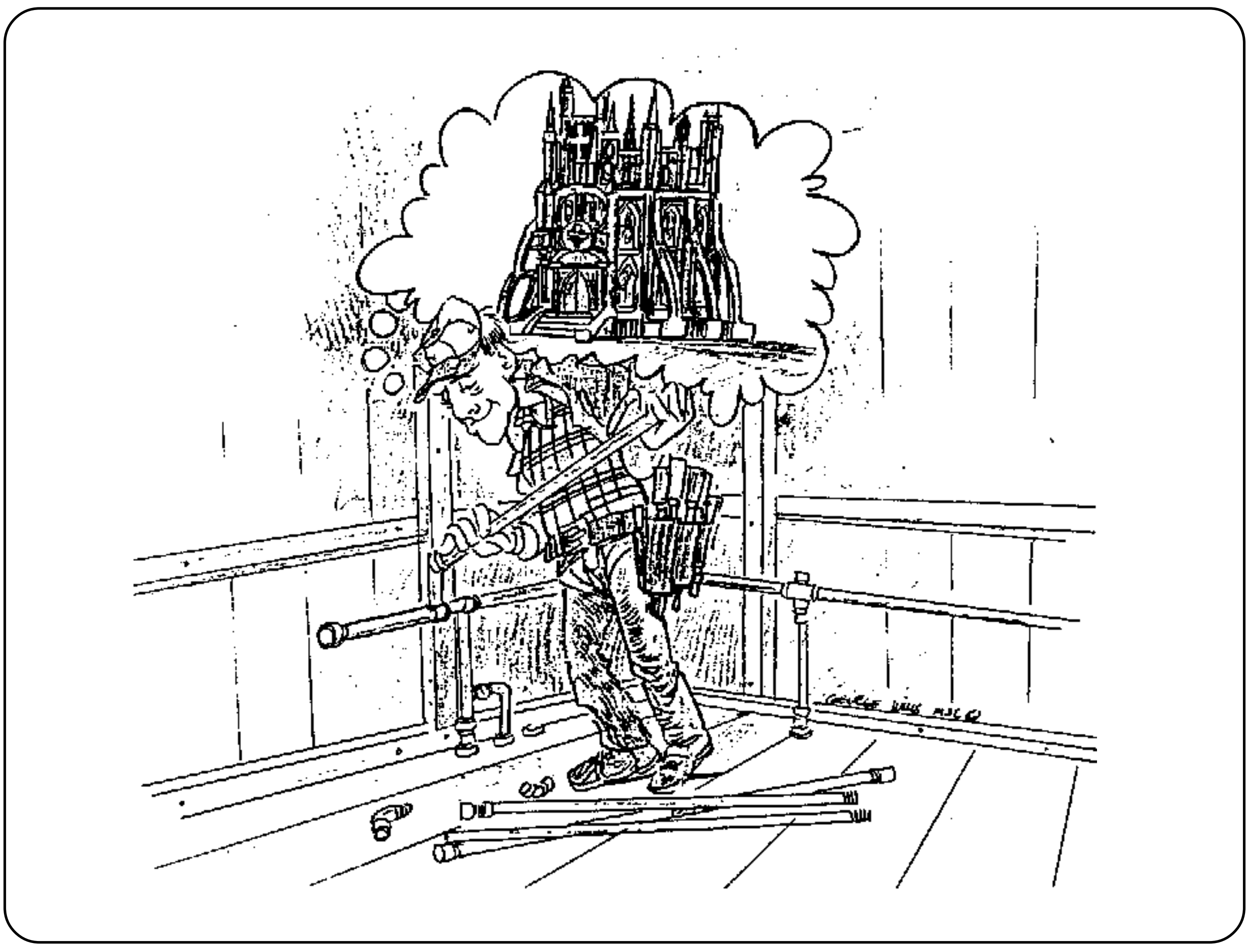

Figure 1.1.18.9. *"Next, I work on the baptismal font."*

1.1.18.10. Exercise on Scoping a Domain of Responsibility

A context diagram is a handy way of scoping a domain of responsibility.

Explanation
For this exercise you'll do a context diagram. The idea is to place the domain in question into context with its environment. Probably the most significant issue in managing, and in building management tools, is to make sure you know what's inside and what's outside your domain of responsibility. One way is to do an input/output analysis on the management system. There are a number of other ways. Since information into and out of the system, or domain, overlays the other inputs and outputs, a simple way to get a first look at boundaries around the domain is the context diagram. The objective of the context diagram is to show all information flows into the domain from outside domains and all information flows out of the domain to outside domains. These information flows are shown as arrows across the boundaries of the domain. The arrow head shows the direction of the flow. The domain in question is shown as an oval. The domains outside the domain in question are shown as rectangles. (Ovals, arrows and rectangles are convention for convenience and consistency. There's no special significance in the symbology.)

Situation Description
Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They bought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. You've been hired as a management consultant to advise them.

Exercise
Start with the domain of responsibility representing the shoe store. Who's the who manages? Never forget the human decision maker. Draw an oval representing the shoe store. Iterate between imagining the information flows and the outside domains. Information flows help you think of outside domains and vice versa. Draw and label the rectangles for the outside agencies and lines for the information flows. Now you'll have trouble with some of the information flow's directions. You don't have to have them correct, but the arrowheads help visualize what's going on in the system. Here's the lesson on information flows and direction: Each arrow is a pipeline through which information can flow in both directions, and information usually does. If you send an order out to Acme Shoe Manufacturers, Inc., you'll get an invoice back (and probably a packing list) and you'll send payment in return. In your information transfer

back and forth with Acme, you'll identify the linkage with Acme and establish that you don't produce at least the type of shoe you buy from Acme. That fact that there is such a flow is pretty obvious. Since you're reaching out to Acme to buy shoes, I'd show the direction as out of your domain. But, what about preparing ads for the newspaper? Do you do that in house or do you contract ad preparation out to a graphic arts firm? I'll know the answer to that when I see your context diagram. Then I'll know whether that responsibility is inside or outside the domain.

Since the situation description doesn't tell you about who does graphic arts, or shoe manufacturing for that matter, you'll have to make up what you put on the diagram. In a real situation, you can ask or assume. If you assume, you can show the store management a draft and get quick feedback on what you assumed wrong. If you ask, "What are your information flows across the boundaries of your domain?", you probably won't get a good answer. You might lose your consulting job, because if the management could quickly complete the context diagram, they wouldn't need you. You're paid for your ability to think of things not obvious to management, even though they're up to their ears in shoe store stuff. You're the management and information counselor. I've started the context diagram for you in Figure 1.1.18.10. Don't be limited by the number of arrows and rectangles. Do be limited by one oval.

Thought Question

What would the context diagram look like for one of the subdomains within the shoe store? One of your jobs as consultant would be to produce context diagrams for each and all of the domains (systems) involved.

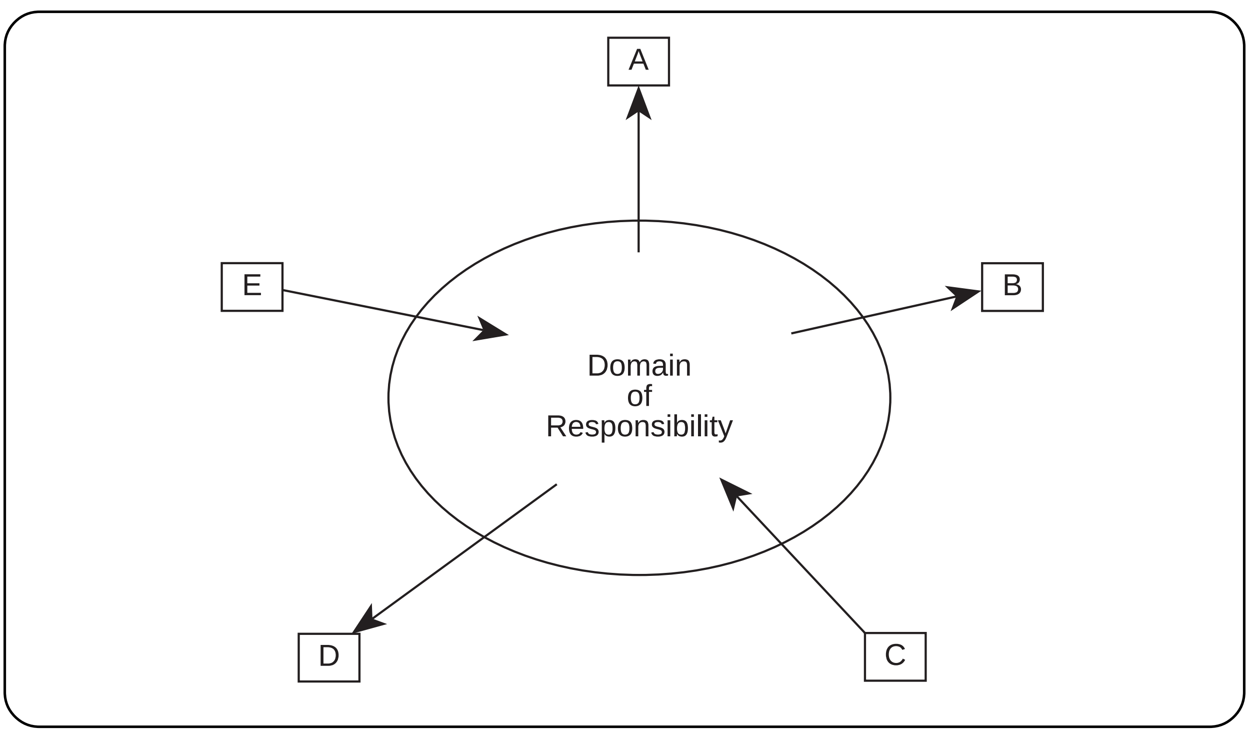

Figure 1.1.18.10. *This generic illustration of a context diagram shows the form and symbology, but doesn't show the large number of information flows into and out of even the simplest organization.*

1.1.19. PERSPECTIVE AND BALANCE—BERNARDO BELLOTTO

1. Background

1.1. Introduction

1.1.20. The Structure of the Engineering Process

1.1.20.1. Overview of the System Life Cycle

The system life cycle represents the framework of the engineering process, including the 22 functions and their results.

The engineering process is framework and philosophy underpinned by fundamentals of teamwork, communication, and application. The systems approach and the scientific method are the heart of the philosophy of the engineering process. In engineering we apply the engineering process to an application system. The framework of the process fits within the five categories of functions of Module 1.1.11.7. as shown in Figure 1.1.11.7. The complete framework includes the functions and steps for using the tools and guides. This well-known framework reflects the scientific method and has been shown in any number of forms.

A system life cycle is a means of organizing the thousands of individual, interrelated tasks to be completed in the building and implementing of any management tool. Also, the life cycle provides a means for control—to make sure tool development remains within cost and time constraints, that the tool is of high quality, and most important, that the resulting tool meet the user's needs.

Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. show a detailed diagram of the framework of the engineering process, known as the system life cycle. To be consistent with the literature, I might call the system life cycle the system development life cycle. I choose system life cycle to emphasize the need to include the non-development functions. However, you could argue that, generally speaking, development as a broad term includes even disposal. These figures provide a process-oriented view of the engineering process. The diagram is long enough to require two figures to hold the entire cycle of functions. The system life cycle and the engineering process are cyclic and recursive, centering on the design function(s), which in itself is a process as we saw in Figure 1.1.11.6.

The categories of functions from the framework shown in Figure 1.1.11.7. are carried over into Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. through the dotted lines. The 22 engineering-process functions are shown as rounded rectangles. These functions are generic, applicable to any engineering activity. The results of conducting the engineering process functions *for building and using a management tool* are shown in the figure on the arrows leaving each function.

To show the engineering process framework comprehensively, I've shown more formal results typical of a large effort and a complex management tool. For smaller efforts and simpler tools, some results could be informal communications. I've also shown several players in the user role. These players could be the same person for a simple situation. The manager plays the decision-making role.

Figures 1.1.20.1.2.a. and 1.1.20.1.2.b. provide the legend for the players shown as rectangles in the management process structure and for the destinations (shown in the diagram as numbers in circles) of the results of conducting some of the functions. The numbers in circles show connections. Some of the connections are user and builder input. Some results of functions flow directly to other functions and don't need connections. The results are identified as information documents. Many of the functions in the engineering process will yield hardware, software, and other more-equipment-oriented results. However, the information documents overlay whatever type of result comes from the functions and therefore make consistent surrogates for results of all the functions.

I'll dedicate a significant portion of this book to the 22 engineering process functions as I will the five building-tool functions and the nine using-tool functions of the management process. I'll orient my discussions of all functions toward management tools in the context of the other two components in the management system. I'm looking at the Management System Model from the perspective I called information-oriented performance in Module 1.1.18.7.

Figure 1.1.20.1.3. shows a control-oriented view of the framework for the engineering process. The control-oriented view focuses on the manager shown as the left-hand rectangle at the top of the process-oriented view diagram in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. I've shown each of the functions in the flow of the engineering process framework; and I've identified each information input to the manager in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. as the same circled numbers from those figures. The diamonds represent decisions. The flow of the figure doesn't include the negative side of the decisions. I only want to show the information and decision linkages.

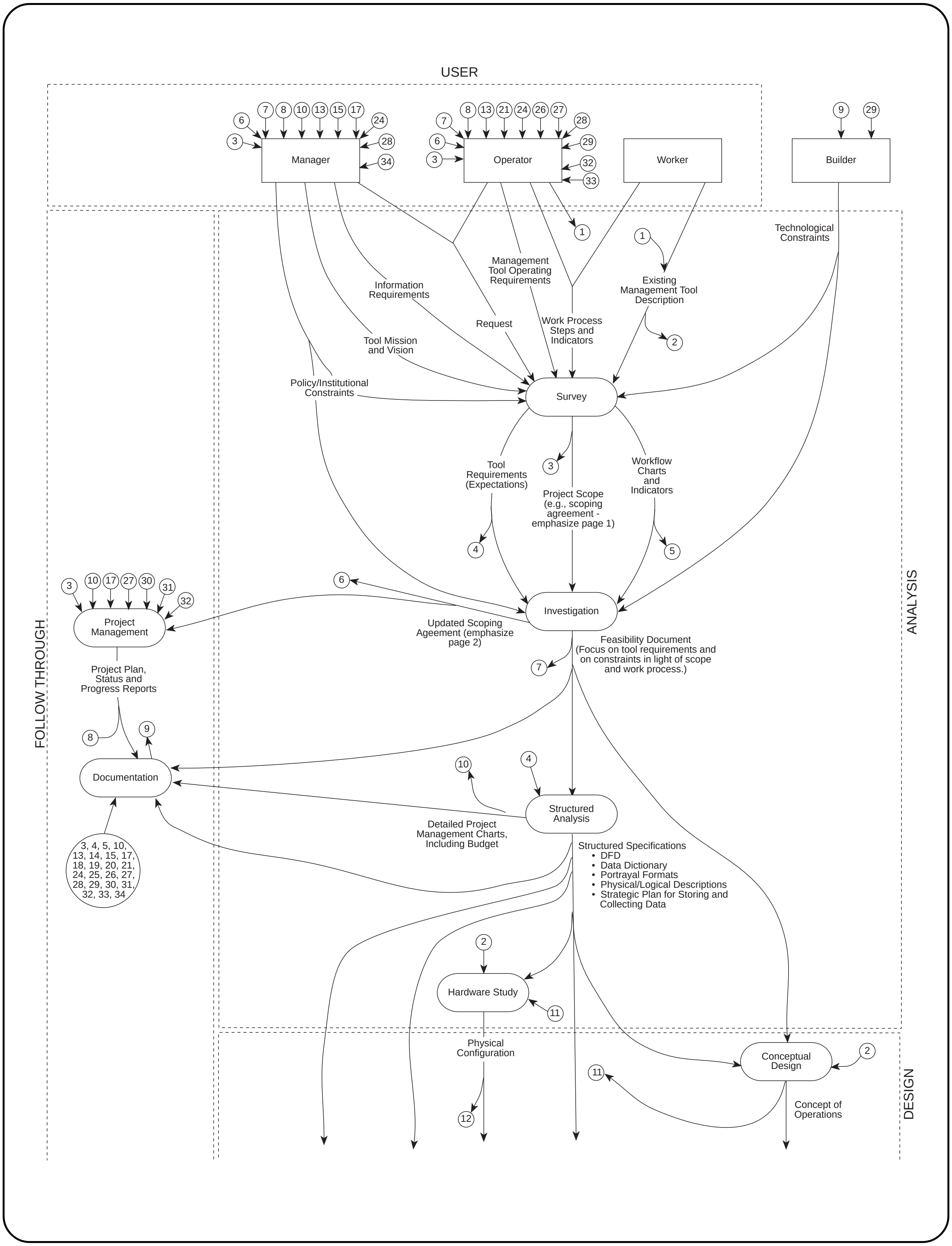

Figure 1.1.20.1.1.a. *In a process-oriented view of the system life cycle applied to building and using a management tool, we emphasize the information outputs from the functions. (Part 1)*

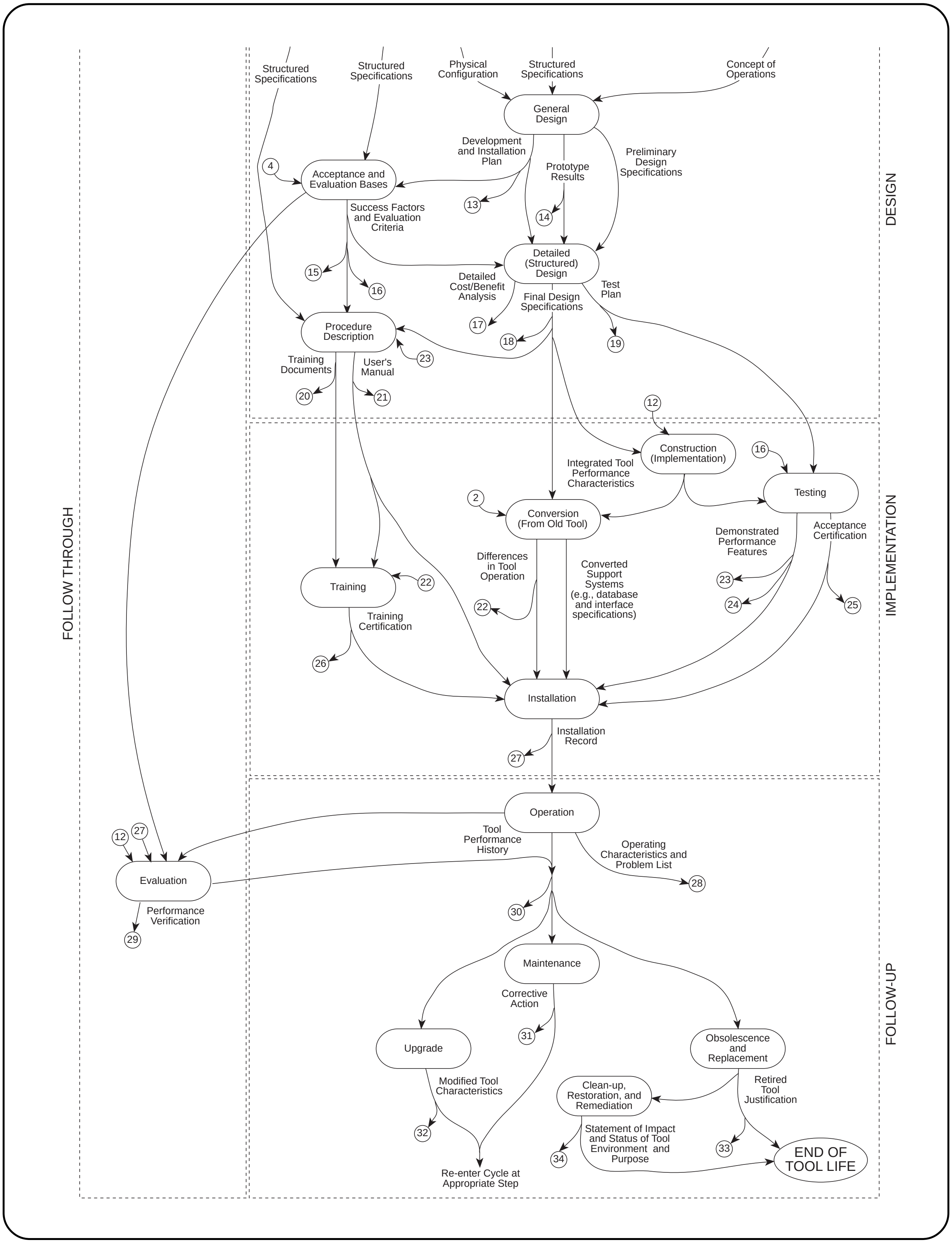

Figure 1.1.20.1.1.b. *In a process-oriented view of the system life cycle applied to building and using a management tool, we emphasize the information outputs from the functions. (Part 2)*

LEGEND

Manager: The person who needs the information from the management tool to make decisions (who manages)

Operator: The people who convert data to information using the management tool (They operate the tool and bridge data and information.)

Worker: The people who produce the product or service that generates the indicators to be measured to yield data for input to the management tool (These people are a key part of what is managed.)

User: All those who depend on the management tool to convert data to information in a given domain of responsibility—the manager, the operator, and the worker, collectively

Builder: The people who design, develop, and install the management tool (responsible for what is used to manage)

Note: Sometimes, the worker and the operator are the same person. Sometimes, the operator and the manager are the same person. Sometimes, the operator and the builder are the same person. The builder must suit the operator and the manager. If the tool isn't workable for the operator, the tool will fail. If the tool doesn't generate the right information for the manager, the tool will fail.

1. Operator and Worker together determine existing management tool description
2. Existing management tool description from Worker and from Operator to Hardware Study, to Conceptual Design, and to Conversion
3. Project scope from Survey to Manager, to Operator, to Documentation, and to Project Management
4. Tool requirements from Survey to Structured Analysis, to Acceptance and Evaluation Bases, and to Documentation
5. Workflow charts and indicators from Survey to Documentation
6. Updated scoping agreement from Investigation to Manager
7. Feasibility document from Investigation to Manager and to Operator
8. Status and Progress Reports from Project Management to Manager and to Operator
9. All documents in Documentation from Documentation to Builder
10. Detailed project management charts, including budget from Structured Analysis to Project Management, to Documentation, and to Manager
11. Concept of Operations from Conceptual Design to Hardware Study
12. Physical Configuration from Hardware Study to Construction and to Evaluation

Figure 1.1.20.1.2.a. *A legend for information outputs helps us easily follow the connections in the process-oriented view of the system life cycle. (Part 1)*

13. Development and installation plan from General Design to Documentation, to Manager, and to Operator

14 Prototype results from General Design to Documentation

15. Success factors and evaluation criteria from Acceptance and Evaluation Bases to Documentation and to Manager

16. Success factors and evaluation criteria from Acceptance and Evaluation Bases to Testing

17. Detailed cost/benefit analysis from Detailed Design to Project Management, to Documentation, and to Manager

18. Final design specifications from Detailed Design to Documentation

19. Test plan from Detailed Design to Documentation

20. Training documents from Procedure Description to Documentation

21. User's manual from Procedure Description to Documentation and to Operator

22. Differences in tool operation from Conversion to Training

23. Demonstrated performance features from Testing to Procedure Description

24. Demonstrated performance features from Testing to Documentation, to Manager, and to Operator

25. Acceptance certification from Testing to Documentation

26. Training certification from Training to Documentation and to Operator

27. Installation record from Installation to Documentation, to Operator, to Project Management, and to Evaluation

28. Operating characteristics and problem list from Operation to Documentation, to Manager, and to Operator

29. Performance verification from Evaluation to Documentation, to Operator, and to Builder

30. Tool performance history from Operation to Documentation and to Project Management

31. Corrective action from Maintenance to Documentation, to Operator, and to Project Management

32. Modified tool characteristics from Upgrade to Documentation, to Operator, and to Project Management

33. Retired tool justification from Obsolescence and Replacement to Documentation and to Operator

34. Statement of impact and status of tool environment and purpose from Obsolescence and Replacement to Documentation and to Manager

Figure 1.1.20.1.2.b. *A legend for information outputs helps us easily follow the connections in the process-oriented view of the system life cycle. (Part 2)*

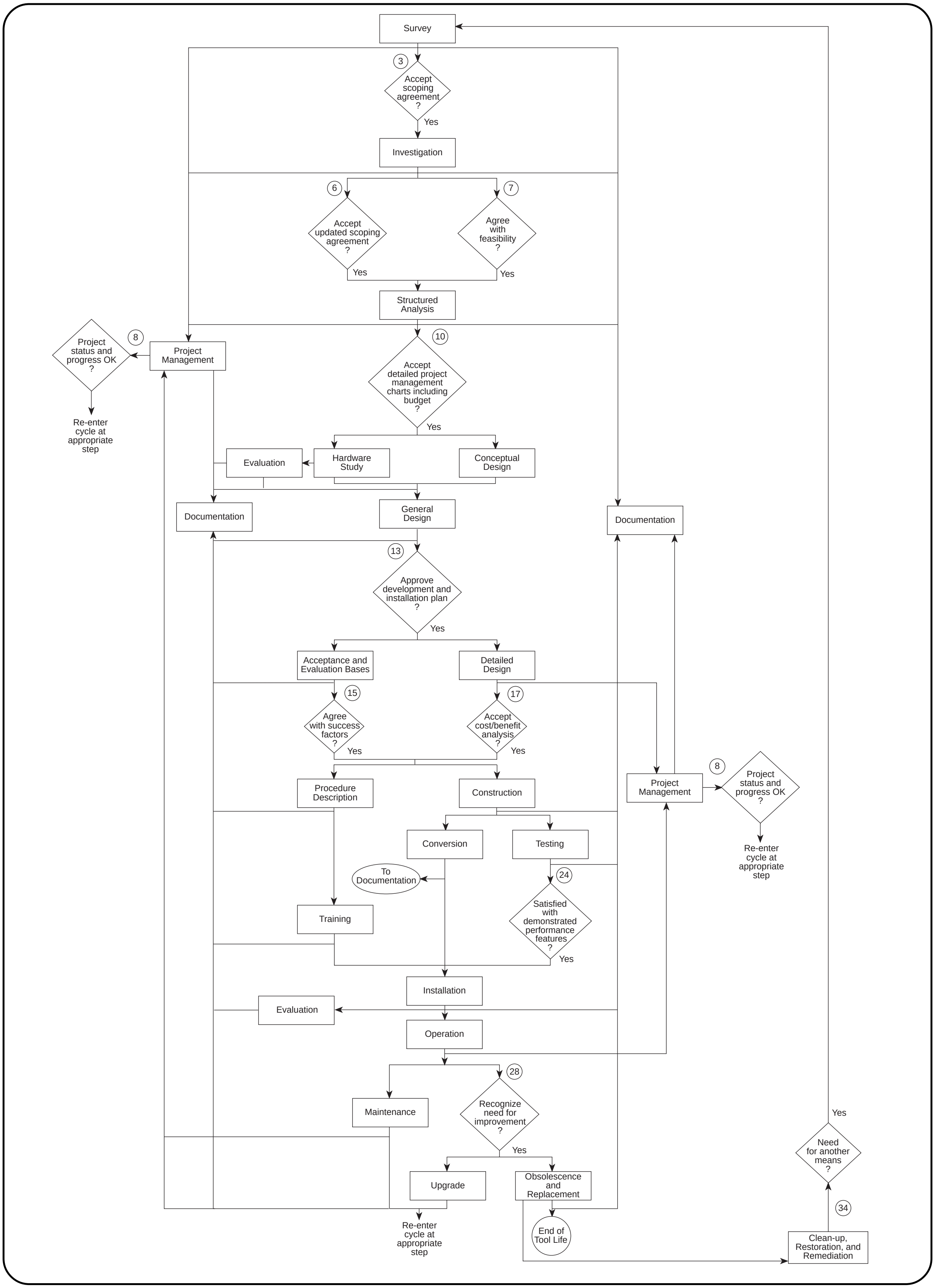

Figure 1.1.20.1.3. *In a control-oriented view of the system life cycle, we emphasize the decisions the manager makes in building and using a management tool.*

1.1.20.2. Applying the System Life Cycle Functions within the Engineering Process

The system life cycle integrates with the laws of nature, the application, and the systems approach to bring the engineering process to life.

Typically, engineers learn those laws of nature that apply to a particular type of machine; e.g., mechanical machines, electrical machines, chemical machines, machines for mining, machines for aerospace, and so on. I use the word machine in a general sense. A machine can be a chemical processing plant, an evaporator, or a wrench.

For management systems engineering, our machines look less like machines yet they act according to the laws of nature like their more tangible counterparts. The machines of management systems engineering are organizations, management tools in a closed set, an individual management tool like a management information system or an organization chart, the work process, a stage in the work process, and many more. We can even analyze the who manages component of the Management System Model like a controller in an electrical or mechanical servomechanism.

Each of these machines are systems and subsystems, depending on our unit of interest, or in management system terms, domain of responsibility. We apply the functions of the system life cycle to any of these machines, or systems. We apply the functions to the processing plant, the evaporator, the wrench, the organization, the management information system, the work process, and more—even the manager. In the engineering process, when we apply the functions, we must use the systems approach by understanding the system, the laws of nature behind that system, and the aim of the system.

The structure of the system life cycle is the body, or skeleton and muscles, of the process; applicable laws of nature are the brain; the application is the heart; and the systems approach is the soul. They work together to give the engineering process intelligent life. How's that for practicing the generalist perspective and transferring concepts from one discipline to another?

The structure of the engineering process, the system life cycle, is the easiest part of the engineering process to lay out, pull apart, and study in detail. We can and will study the functions of the engineering process and the tools and skills you need to do the engineering process functions well.

Shortly, I'll describe the management process with its structure and philosophy. We can and will study the functions of the management process and the tools and skills you need to do the management process functions well.

We can't combine the engineering process and the management process functions into a grand structure like we can't combine the engineering process and the chemical process functions into a grand structure to diagram in a figure. However, we do blend the processes together with their structures and philosophies like we blend yellow and blue to get green. The result of blending the engineering and management processes together gives different shades of the blend depending on our objective.

1.1.20.3. ORIGINS OF THE SYSTEM LIFE CYCLE FUNCTIONS

The system life cycle functions come primarily from the project management life cycle and, more specifically, the computer information system life cycle, thus aiming the functions toward the building of management tools.

When I came to Virginia Tech in the summer of 1974, I discovered the almost-deliberate ignoring of the nuclear-fuel life cycle by the nuclear engineering community. The words fuel cycle meant how to shuffle fuel in a nuclear reactor during periodic refuelings. I had never been taught in school or industry, and the discipline had been put on the back burner, the cradle-to-grave fuel cycle starting from the raw uranium ore in the ground to the ultimate disposal of nuclear waste and the remediation and restoration of the environment affected by converting the fuel into waste. Joel Nachlas (of the Industrial Engineering Department) and I (of the Nuclear Engineering Program) found we could combine understandings of nuclear and industrial engineering in better management of the nuclear fuel cycle. We team-taught a course on the subject. By May 1977, we had a research contract to study management of the nuclear fuel cycle. That research contract evolved over the years into what was to become in 1981 the Management Systems Laboratories.

I wasn't taught about life cycles in civil engineering or in nuclear engineering. I was never taught the framework for the engineering process. Engineers must learn and practice the life cycle whether they're building (analysis, design, implementation, etc.) automobiles, bridges, computers, nuclear reactors, or organizations. When we talk about green engineering today, we're invoking the system development life cycle. Green engineering requires a cyclic, recursive, reversible process. Green engineering requires the rudiments of management systems engineering.

I first recognized the system life cycle for what it was in the spring and summer of 1984 when I worked on the two-day workshop on office automation for information systems designers and manager-users in the United States Department of Energy Senior Executive Service. I had to speak to managing the life cycle for information systems. Hardware and software typically had very short (and ever shortening) life spans. Organizations were looking at replacing or upgrading their hardware and software on an 18-month cycle. Now, there's a life cycle we can get our arms around—quite different from a 50-year life cycle for a bridge or a nuclear facility. We couldn't practice NIMPL (Not In My Professional Lifetime—taken from NIMBY and NIMTO, popularly known as Not In My Back Yard and Not In My Term of Office) on computer projects.

I discovered a book by Edward Yourdon called *Managing the System Life Cycle* (Yourdon Press, 1982). He says, "Recently, however, the approach taken to systems development has begun to change. More and more large *and* small organizations are adopting a single, uniform project life cycle—otherwise known as a project plan or systems development methodology, or simply, 'the way we do things.' Usually contained in a notebook as ponderous as the standards manual that sits (unread) on every programmer's desk, the documented project life cycle provides a common way for everyone in the EDP [Electronic Data Processing] organization to go about the business of developing a computer system. ..... Three obvious objectives may be discerned from the comments above: One purpose of the project life cycle is to define the activities that must be carried out in an EDP project. A second is to introduce consistency among the many EDP projects in an organization. A third objective is to provide checkpoints for management control and checkpoints for go/no-go decisions." (p. 36.)

Yourdon describes weaknesses in what he calls the classical project life cycle and offers his version of a structured life cycle.

He says, "The use of bottom-up implementation is, in my opinion, one of the major weaknesses in the classical project life cycle. [The] project manager is expected to carry out all of his module testing *first*, then subsystem testing, and finally system testing. I'm not quite sure where this approach originally came from, but I wouldn't be surprised if it was borrowed from assembly-line industries. The bottom-up implementation approach is a good one for assembling automobiles on an assembly line—*but only after the prototype model has been thoroughly debugged!* Unfortunately, most of us in the computer field are still producing one-of-a-kind systems, for which the bottom-up approach has a number of serious difficulties ..... The second major weakness with the classical project life cycle is its insistence that the phases proceed sequentially from one to the next. There is a natural, human tendency to want this to be so: We want to be able to say that we have *finished* the analysis phase and that we'll never have to worry about that phase again. Indeed, many organizations formalize this notion with a ritual known as 'freezing the specification' or 'freezing the design document.'" (pp. 39-40.)

I've reproduced Yourdon's figure for the structured project life cycle as Figure 1.1.20.3.1. You can see the heavy branching among his activities implying recursive, reversible sequencing. The cyclic nature of the process is implied in its title—life cycle.

Perhaps computer systems people were the right ones to introduce me to the system development life cycle because they seem to elevate the idea of a system, and for some of those people (like Weinberg), the idea of general systems thinking to a prominent level.

Yourdon's comments clue us into the idea that life cycles are things project managers know about. Harold Kerzner addresses life cycles in his book *Project Management: A Systems Approach to Planning, Scheduling, and Controlling* (Van Nostrand Reinhold, 1984). "Every program, project, or product has certain phases of development. A clear understanding of these phases permits managers and executives to better control total corporate resources in the achievement of desired goals. The phases of development are known as life-cycle phases. However, the breakdown and terminology of these phases differ, depending upon whether we are discussing products or projects.

During the past few years, there has been at least partial agreement about the life-cycle phases of a product. They include:

- Research and development
- Market introduction
- Growth
- Maturity
- Deterioration
- Death

Today, there is no agreement among industries, or even companies within the same industry, about the life-cycle phases of a project. This is understandable because of the complex nature and diversity of projects." (p. 71.)

I'll address the difference in programs, projects, and products later in a framework I call pursuits, which includes perplexities, problems, programs, projects, and processes. I'll argue that the system life cycle fits in whole or in part to each of these pursuits. Kerzner reaffirms at least the last three pursuits and the life cycle.

To me, the life-cycle phases, or steps, or functions are consistent from project to project or from projects to processes to programs when you step back far enough to see the functions generically. Then the functions fit the industry or pursuit as they are specified to address the unique characteristics of their application.

I've reproduced Kerzner's table of project life cycle phase definitions for different industries as Figure 1.1.20.3.2. To me, each industry group exhibits the same life cycle flow for the project, except each group reflects the terminology or emphasis of that industry.

The theoretical definitions of the life-cycle phases of a system development are applied to projects by Cleland and King in their *Project Management Handbook*. They say, "New products, services, or roles for the organization have their genesis in ideas evolving within the organization. Typically, such 'systems' ideas go through a distinct life cycle, i.e., a natural and pervasive order of thought and action. In each phase of this cycle, different levels and varieties of specific thought and action are required within the organization to assess the efficacy of the system. The 'phases' of this cycle serve to illustrate the systems development life-cycle concept and importance." (pp. 210-211.)

Cleland and King list and describe the life-cycle phases as the conceptual, definition, production or acquisition, operational, and divestment phases. They continue, "Taken together [the details of the phases] provide a detailed outline of the overall systems development life cycle. Of course, the terminology [used] is not applicable to every system which might be under development, since the terminology generally applied to the development of consumer product systems is often different from that applied to weapons systems. Both, in turn, are different from that used in the development of a financial system for a business firm. However, whatever the terminology used, the concepts are applicable to all such systems. ..... Life cycle management refers to the management of systems, products or projects throughout their life cycle. In the context of the sales life cycle, life cycle management is usually called 'product management.' In the development life cycle, it is usually called 'project management.' In all cases, life cycle management is needed because the *life cycle reflects very different management requirements at its various stages*." (p. 214.)

Starting in 1986, I used the book *Computer Information Systems Development: Analysis and Design* by Powers, Adams, and Mills (South-Western Publishing Co, 1984) in my undergraduate class on information systems. The authors emphasize the life cycle and say, "A systems development life cycle provides a methodology, or an organized process, that can be followed in developing any CIS [Computer Information System]. Emphasis is on organization. In developing a CIS, thousands of separate, individual tasks must be completed. Some of these must be performed in a certain given order. Many people are involved. Their efforts must be coordinated. By organizing all of these efforts, the systems development life cycle fulfills its main purpose: It provides a basis for control.

Any systems development effort will be too large to proceed without control. The controls needed are in the areas of:

- Functions
- Budgets
- Schedules
- Quality

To make sure that a system is being developed with the proper and necessary functions, within budget, on schedule, and up to quality expectations, a number of checkpoints are needed. These checkpoints are important for assuring that work is reviewed and decisions are made on a timely, organized basis. In other words, checkpoints hold the key to control in systems development." (pp. 40-41.)

The functions of Powers, Adams, and Mills are functions of the system, while my functions are functions of the system life cycle. The idea of checkpoints in the system life cycle stimulated the idea of the control-oriented life cycle diagram in Figure 1.1.20.1.3. and the decision points shown in that diagram.

Finally, recall the discussion of Blanchard and Fabrycky's life cycle functions in Module 1.1.11.7. Those functions included system planning, system research, system design, production and/or construction, system evaluation, and system use and logistic support.

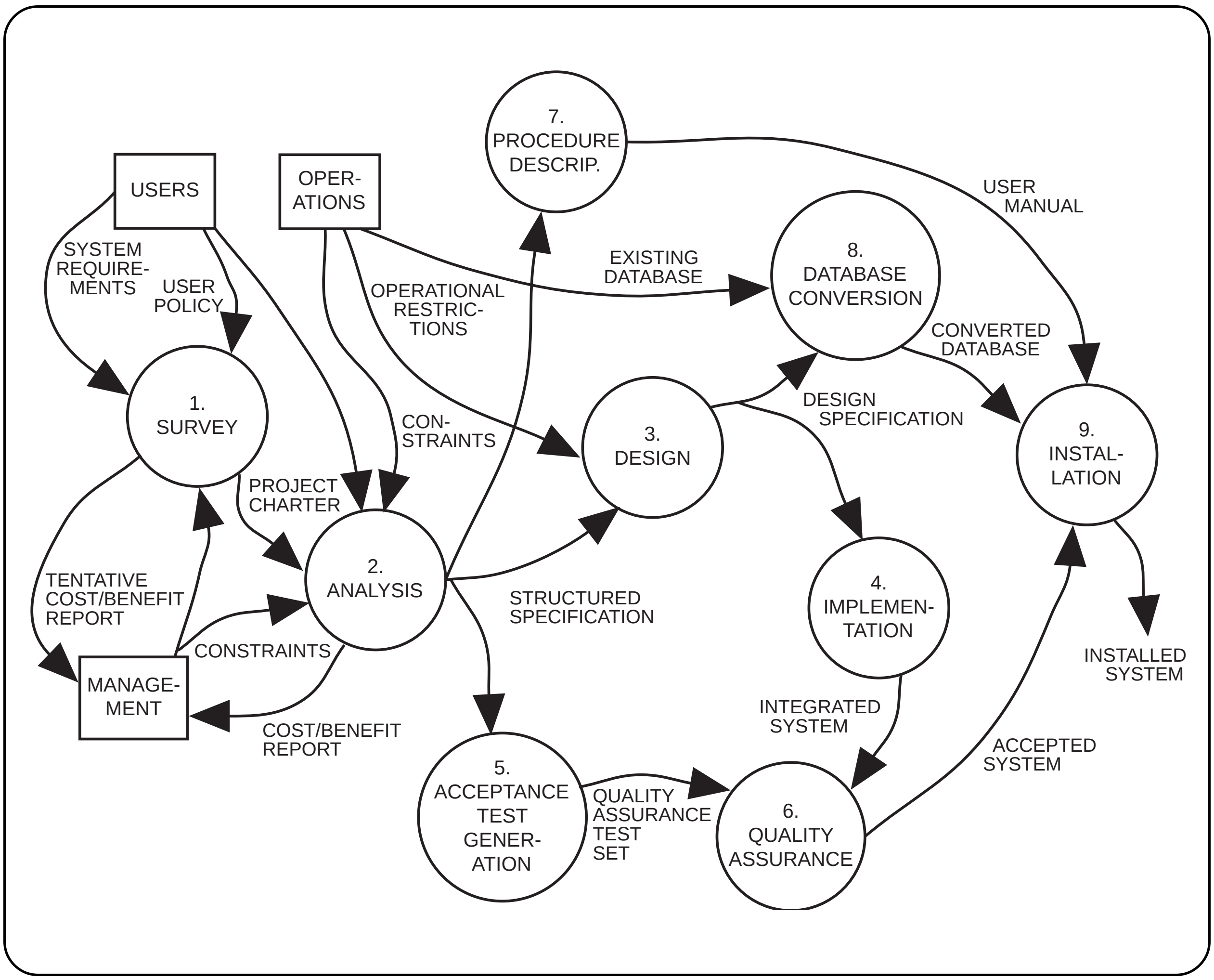

Figure 1.1.20.3.1. *The structured project life cycle reflects some computer system terminology but can be applied generally to all systems. (taken from Yourdon)*

ENGINEERING	MANUFACTURING	COMPUTER PROGRAMMING	CONSTRUCTION
• Startup • Definition • Main • Termination	• Formation • Buildup • Production • Phase-out • Final audit	• Conceptual • Planning • Definition and design • Implementation • Conversion	• Planning, data gathering and procedures • Studies and basic engineering • Major review • Detail engineering • Detail engineering/ construction overlap • Construction • Testing and commissioning

Figure 1.1.20.3.2. *The project life cycle phase definitions for several industries show a consistent flow among the phases and reflect the functions of the system development life cycle in Module 1.1.20.1. (taken from Kerzner)*

1.1.20.4. Organizational Life Cycles

Organizations go through life cycles too, and we can use our understanding of the organizational life cycle to determine the right intervention to use during a particular stage of the organization's growth and aging stages.

We've looked at the system life cycle, which is discussed most in terms of information technology or project management. But, we know products have life cycles too. (Consider buggy whips.) If we consider the Studebaker car (or the Packard or many others), we realize companies have life cycles. Some corporate life cycles are short (80% of new companies last less than two years—either due to undercapitalization or to lack of commitment on the part of the founder.) and other life cycles are long. Within corporations, groups (domains of responsibility) are forever being reorganized or terminated, having life cycles of their own.

The problem with some of the life cycles I've just described is that they're once-through. The corporation is born, grows, ages, and dies. Sometimes the corporation doesn't do much growing and aging, just birthing and dying. Where's the iteration that makes life cycles so powerful? That's the point. Successful corporations, or organizations, do iterate through the life cycle. When they reach their prime, they find ways for rebirth and continue through another cycle. (This stage is where you want to do business process re-engineering, not when the organization is in its death-throes.) Since we don't know exactly when we've reached our prime and when exactly to confuse the success with renewal and rebirth, we often undershoot or overshoot a bit.

How many organizations last in their original form (not merged or otherwise significantly changed) more than a decade—at least those not mandated (as in some government organizations). We each can identify a government organization that has outlived its usefulness and would be dead in an open marketplace. Not many organizations last long, and we need to know what happens to shorten their life cycle and what to do the lengthen the life cycle in healthy ways (not by mandate).

Adizes has made his career out of understanding and intervening in organizational life cycles. When he discusses the life cycles of organizations, he looks at the life cycles of building an airplane (a project) and a marriage in parallel with the life cycle of the organization. He talks of growth and aging in the corporation just as we would in describing the life cycle of a person. One of his most interesting parallels between people and organizations is his discussion of the idea that size and time aren't causes of growth and aging. He says, "Growing means the ability to deal with bigger, more complex problems. The function of leadership, then, is to manage the organization in such a way that it is able to move to the next, more demanding stage of the Lifecycle. .... You can tell the 'size' of a person by the 'size' of the problems that preoccupy him. *Small* people spend their lives worrying about small problems: what the neighbor did or did not do, who wears what makeup or drives what car. *Big* people worry about big problems, those which are more complex to analyze and difficult to resolve. They seek insight about their own lives—about the nature of the environment, the quality of life, the political system, the education of their children, and the next generation. A person must grow out of small problems to free up the energy to deal with bigger problems. That is the process of growing and maturing. The same applies to organizations. .... Aging means there is a decreasing ability to deal with problems. .... The purpose of management is to provide for balanced growth or rejuvenation and to bring the organization to Prime [one of his stages of the life cycle] and keep it there." (pp. 3 - 4.)

In Module 1.1.20.1., I've implied that a cycle is a circle, which is correct. However, a cycle can also look like a sine wave. That's the form Adizes chooses in his book, *Corporate Lifecycles: How and Why Corporations Grow and Die and What to Do about It*. (Prentice Hall, 1988). Figure 1.1.20.4. is from Adizes' book. (p. 84.) This figure and Adizes' analysis of the stages is another good diagnostic tool for understanding your domain of responsibility. Like the pursuits framework or the endeavors framework, we can use Adizes' life cycle diagram to understand what interventions, like management tools, need to be used to be successful.

Consider Figure 1.1.20.4. The courtship stage occurs before birth and is the first stage of the organizational lifecycle. The organization exists only as an idea in the courtship stage. In the courtship stage, we find the process of building commitment to the idea, which is accompanied by excitement, enthusiasm, and emotion resulting in "'heat,' as if energy is coalescing to one point to be released." (p. 12.) Between courtship and infancy is birth. Birth occurs when the commitment is successfully tested and risk is overridden. If the test of commitment fails, the idea was only an affair and the lifecycle is over. In infancy, management is often by crisis and when the infant dies, the causes are usually undercapitalization and failure of the founder's commitment. The third stage, the go-go stage, is euphoric. The organization can do no wrong, and the founder is always in charge and usually right.

In going to the adolescence stage, the organization is reborn apart from its founder. The jagged lines in Figure 1.1.20.4. are for painful, intense, transition stages. Notice how on the growth side a painful transition is needed to get to the good times. If the organization survives the adolescence stage, it gets to the prime stage, the optimum point on the life cycle where the organization is able to balance flexibility and controllability.

The stable stage is the first of the aging stages of the life cycle. The organization is strong but is starting to lose its flexibility. When at this stage, we have the greatest chance for a successful renewal and rejuvenation. The organization is strong and can support the needed inward scrutiny for renewal. If the organization can't or won't change and renew itself, the stages of aristocracy, early bureaucracy, bureaucracy, and finally death follow. As the organization moves into the later stages of aging, an interesting dilemma occurs. First, the organization faces clearer and more significant threats. To be motivated to go through the great pain and effort of change in culture, you need to face a threat to your survival or you need very strong leadership, preferably both. Second, the organization isn't as strong as it once was and has trouble devoting the resources to the inward effort of changing culture.

Compare Adizes' life cycle to the stages of the system life cycle. After all, the organization is a system. We do analysis during the courtship and infant stages. We do design during the infant and go-go stages. We do implementation during the go-go, adolescence, and prime stages. After those stages, we're into follow-up. We do follow-through throughout the stages. Just as a project can be terminated (early death) in early stages of the system life cycle, an organization can die during the early stages of the organizational life cycle. Those projects that don't get beyond the early stages of the system life cycle and those companies that don't get beyond the early stages of the organizational life cycle fail. Those that work the increasingly complex and interesting problems of the progressive stages of the life cycle succeed. Those that do reappraisal and renewal to iterate through the stages of the life cycle find prolonged and progressive success.

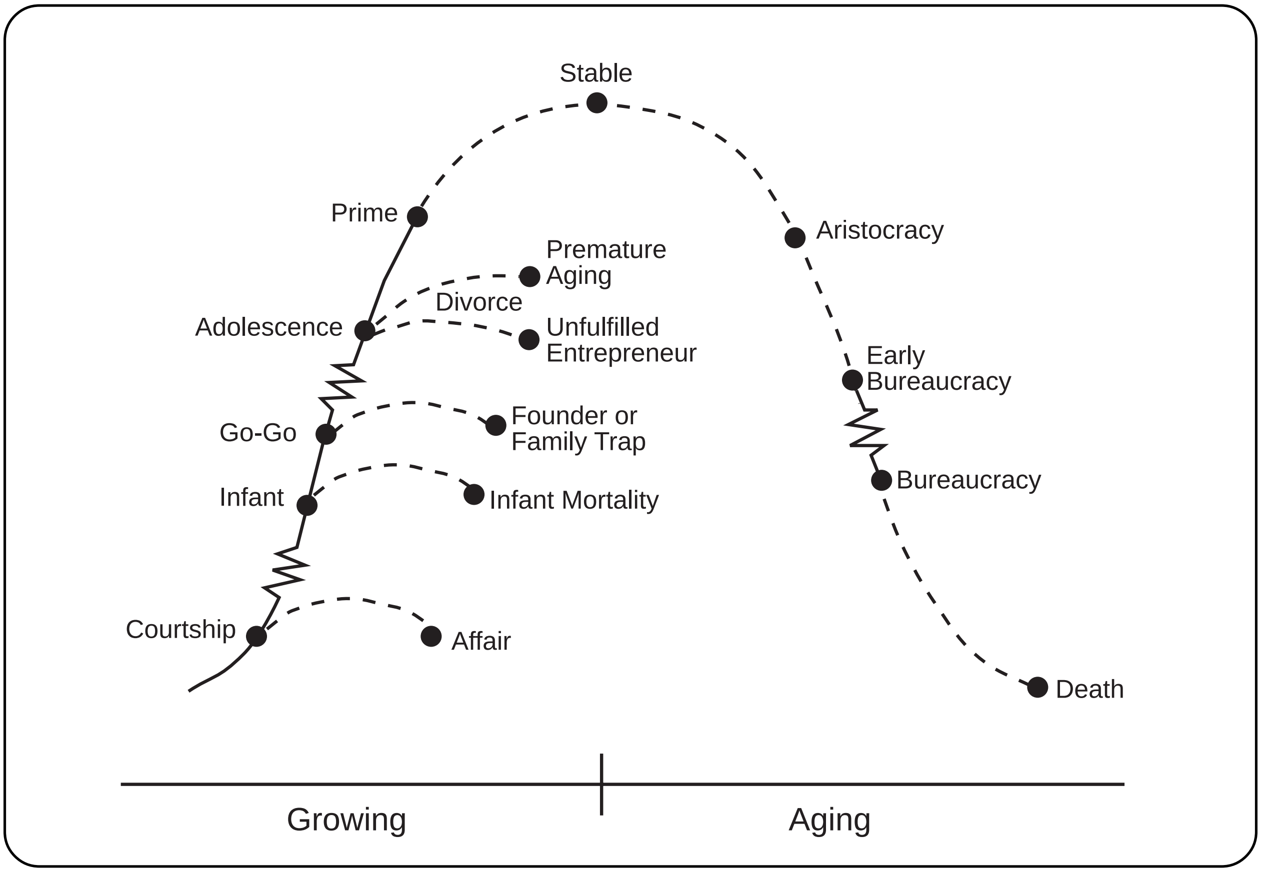

Figure 1.1.20.4. *The organization grows and ages through early stages of high flexibility and late stages of high controllability. At the prime stage the flexibility and controllability are balanced. (taken from Adizes, p. 84)*

1.1.20.5. A World of Life Cycles

1. Background

1.1. Introduction

1.1.21. Building and Using Management Tools

1.1.21.1. Analogies—Rene Magritte

1.1.21.2. Analysis and Synthesis Orientations to Management Tools

We use an analysis orientation for building management tools and a synthesis orientation for using management tools all within the systems approach.

What do you use to manage? Information from a sophisticated computer system or a file cabinet and a rolodex? Information from an automated manufacturing process line or a word processor? Corporate policy or operating procedures? Optimization models or rules of thumb? Expansive and fashionable appointments and offices for people or a simple office layout? You need to get the most from these management tools or you seem to get further behind in meeting the objectives of your responsibility. You had hoped your tools would work better, didn't you?

Our jobs are faster moving, more complex, always changing, requiring more and more knowledgeable decisions. In such a dynamic environment we have to make sense of what we do and have our tools work for us and not against us. In this day of modern computing tools, we can empathize with the sad situation in Figure 1.1.16.9.—the data-rich, information-poor (DRIP) situation wherein the computer produces so much and helps so little.

The 1912 publication of Taylor's *The Principles of Scientific Management* introduced a new approach to decision-making based on structure. He was known for ideas founded on quantitative measurement, such as time and motion studies and standardized industrial tools and procedures. Moreover, Taylor wanted managers to know not just that a practice does or does not work, but why and how the practice works.

What does structure mean to us in our work? A science. A frame of reference. A handle to hold onto to keep all our tools in order and to choose the right one at the right time and have it work because that tool, the operator (us), and the operation to which we apply the tool all match and work well together.

Through a series of simple and integrated qualitative models, I structure what you manage, your objectives for developing your management tools (through automation, for example), procedures for developing your tools, and evaluation methods to gauge your success with your tools. As a group, the models provide an integrated method from beginning to end—from analyzing your situation to resolving your needs.

Most of our tools don't work well. I claim that 70% of all management information systems fail and the little argument I get with the claim is that the number may be low. When our tools fail, we fail. The failure is largely due to a confusion of ends and means—a confusion between what is managed and what is used to manage—and due to a lack of understanding the significance of the preferences of who manages (our preferences)—a tendency to bend our needs to fit the tools rather than vice versa.

Focus on management tools and start with the Management System Model (MSM). What do we want the tools for? Ultimately to help in decision making—in management. So, the starting point for building a tool is to know what type of decision the tool will support within the context of the domain of responsibility. Is the domain of responsibility a management systems engineering course with

Harold the who manages and the decision how to grade midterms? Is the decision which classroom to use? Is the domain of responsibility Management Systems Laboratories? The answers to these kinds of questions about domain and decision making starts the tool-building process. For goodness sake, don't start that process by saying, "Here's a nifty hardware or software package; we ought to be able to work this in somewhere."

By starting and focusing on the end use of the tool, we're embarking on an analysis effort within the context of the systems approach. I'll start with a function for scoping the domain and another function for identifying decisions and related actions and use the MSM to direct me through an analysis process for the building-management-tool part of the management process—a process I call management system analysis (discussed in Module 1.1.21.3.). Clearly, the functions of the building-management-tool part of the management process structure and the functions of the engineering process structure shown in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. work hand-in-hand. But they aren't the same. The engineering functions are analysis, design, and implementation oriented. The management functions are decision, information, and data oriented. Both start with scoping the situation.

When using management tools we start where the action is—in the work process by making measurements to get data for the management tools to convert into information. I'll start with functions for setting expectations and surveying the work process and use the MSM to direct me through a synthesis process for the using-management-tool part of the management process—a process I call management system synthesis (discussed in Module 1.1.21.5.). The measurements and data are the most rudimentary components of the management system, and we synthesize them into information for decision making.

The MSM directs and gives a sense to the completeness of the sets of functions and their sequence. I use the MSM in a symbolic way so I can tie together the building-management-tool part of the management process structure and the using-management-tool part of the management process structure and the engineering process structure. The MSM has great power in directing the three sets of functions, but the MSM isn't detailed enough and it reflects its closed-system nature. So I use the MSM as a rallying point or an icon when sorting out management system analysis and management system synthesis functions.

We use management system analysis to get a proper analysis of the *problem*; and we use management system synthesis to get a proper synthesis of the *solution*. However, the target for both management system analysis and management system synthesis is data. When we build a management tool, we want to find out the necessary data and only the necessary data to provide information for decision making. When we use the management tool, we must collect the right data or the tool will fail.

The bottom line for management system analysis and management system synthesis and for the engineering process is building and using the right tool for the right application. Figure 1.1.21.2. illustrates a much-too-common situation. The wrench in the figure may be a visual example of tool failure. However, we try to do the same sorts of things with management tools. The job of the management systems engineer is to make sure the manager has the right tool for the right job.

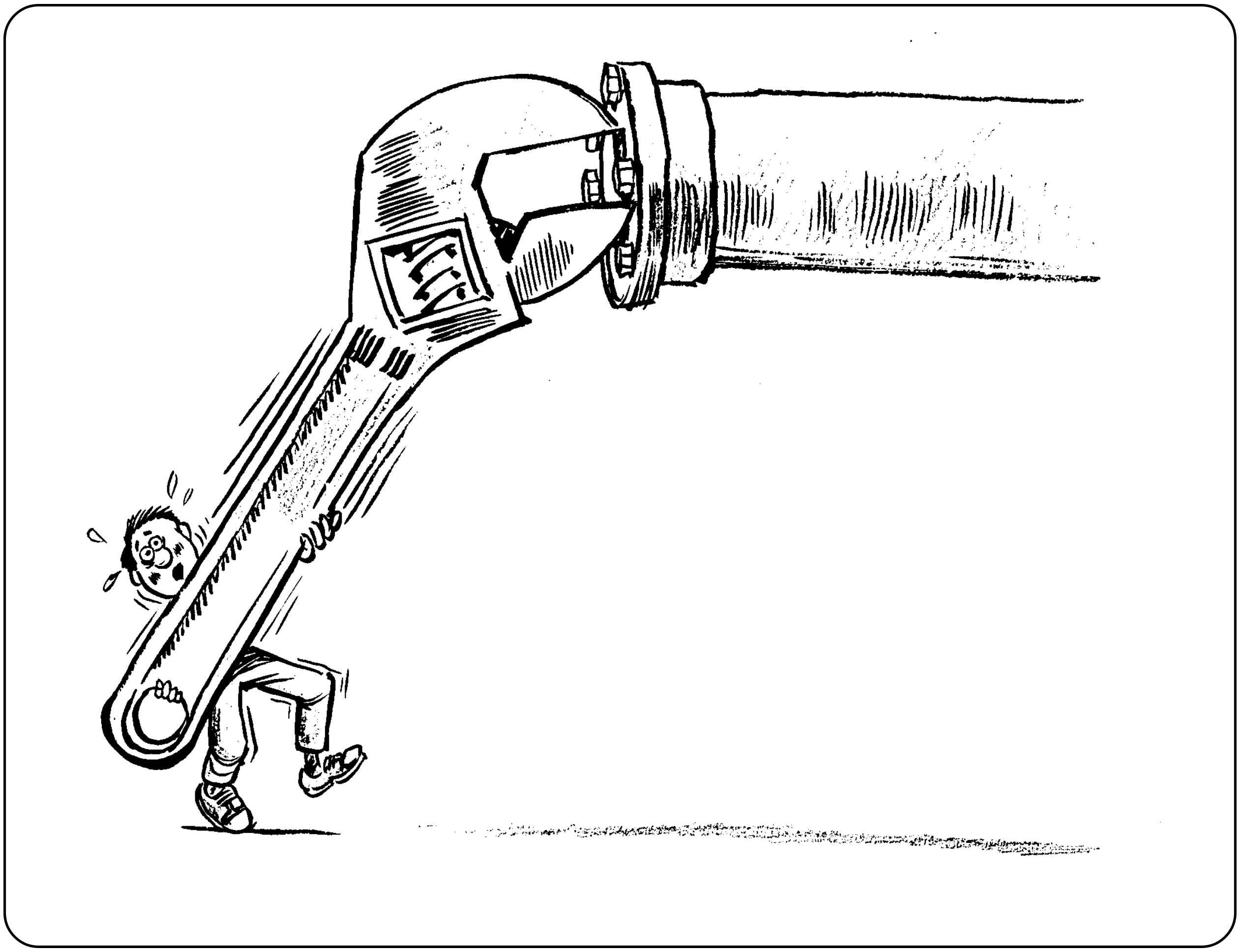

Figure 1.1.21.2. *"This seems like an awfully hard way to do a simple thing."*

1.1.21.3. The Five Functions of Management System Analysis

The Management System Model points us to five functions for building management tools, together making up management system analysis—the building-tool part of the management process.

Management Systems Laboratories (MSL) of Virginia Tech evolved management system analysis through the years 1982 to 1984 during their work with government and industry research sponsors. MSL designed the analysis to help managers determine which management tools work best for them. The analysis is unique because of the role the human manager plays in the heavily structured approach. The analysis is based on the Management System Model (MSM).

People who study productivity and performance call the combination of decision and action in the MSM an intervention. (See the decision-to-action interface of the MSM in Figure 1.1.18.1.3.) An intervention includes both a decision based on information about the productivity or performance indicators and the resulting action the manager takes to affect what he or she manages. Productivity and performance people design interventions to improve productivity and performance. Because the analysis is oriented toward helping the manager, productivity and performance people have found MSL's management system analysis equally valuable in finding the right interventions as MSL does in finding the right management tools. (Recall information-oriented performance and operational performance as two of the three perspectives for the MSM in Module 1.1.18.7.)

The manager can find the right management tools either by selecting one already available or building a new tool to suit the needs of the domain of responsibility. This make-or-buy decision is crucial and evolves from management system analysis. The manager, of course, is the user of the management tools and is responsible for the interventions for productivity improvement.

In its simplest form, management system analysis includes five steps:

1. Delimit the domain of responsibility and understand the operation, or work process, to ensure you know the problem before starting on a solution.

2. Determine the interventions (decision-action pair) needed to improve the operation or carry out the work process and the manager's role in making the needed decisions.

3. Figure out what information best supports the decisions and which management-tool features you need to get that information.

4. Deduce what data make up the needed information and what measurement means are required to collect the data.

5. Determine the indicators highlighting the operation's working and outputs that the measurements measure and the relationships among the identified indicators.

Figure 1.1.21.3. uses the MSM for direction and as a rallying point for the five management system analysis functions. In the figure, I include the MSM more as an icon than as the framework for management system analysis. You can see that the five functions of management system analysis fit comfortably around the MSM. The MSM tells us we have a closed

set of functions for analysis by showing no gaps and overlaps in considering the components and interfaces of the MSM. Through the MSM, we have confidence that the foundation concepts leading to the MSM are carried into management system analysis. Just as the components and interfaces of the MSM are really intermingled and have been pulled apart for ease of discussion, the management system analysis functions must work together within the systems approach. The cycle of the functions includes sequence but allows the necessary cyclic, recursive, reversible nature of the management system.

Figure 1.1.21.3. labels the five functions as CCW1, CCW2, and so on. CCW1 stands for the first counter-clockwise function. The management system synthesis functions go in the other direction; so the labels distinguish between analysis and synthesis and indicate sequence.

The success of management system analysis is in taking the functions in the proper sequence. Notice how the functions of the analysis move counter-clockwise sequentially around the components and interfaces of the MSM. We want to get to functions 3 and 4. But if we don't do functions 1 and 2 well and define decisions and actions needed for the domain, our information efforts won't work well. We must tightly relate functions 2 and 3. That is, we have to key information to the decision the information serves. Function 5 completes the loop. We can't measure the effect of interventions without function 5. In fact, we have a loop we must iteratively work to design, cause, and measure performance improvement.

After we use management system analysis to analyze management tool selection or productivity or performance improvement interventions, we use the management process to implement what we've learned from the analysis. We use the measurements and log data for the indicators. We prepare the data for the management information system and organize and present information. Then we review status and progress toward productivity or performance goals and appraise the results. In implementing what we learn from management system analysis, I've just worked my way back clockwise around the MSM. Now, I'm doing management system synthesis.

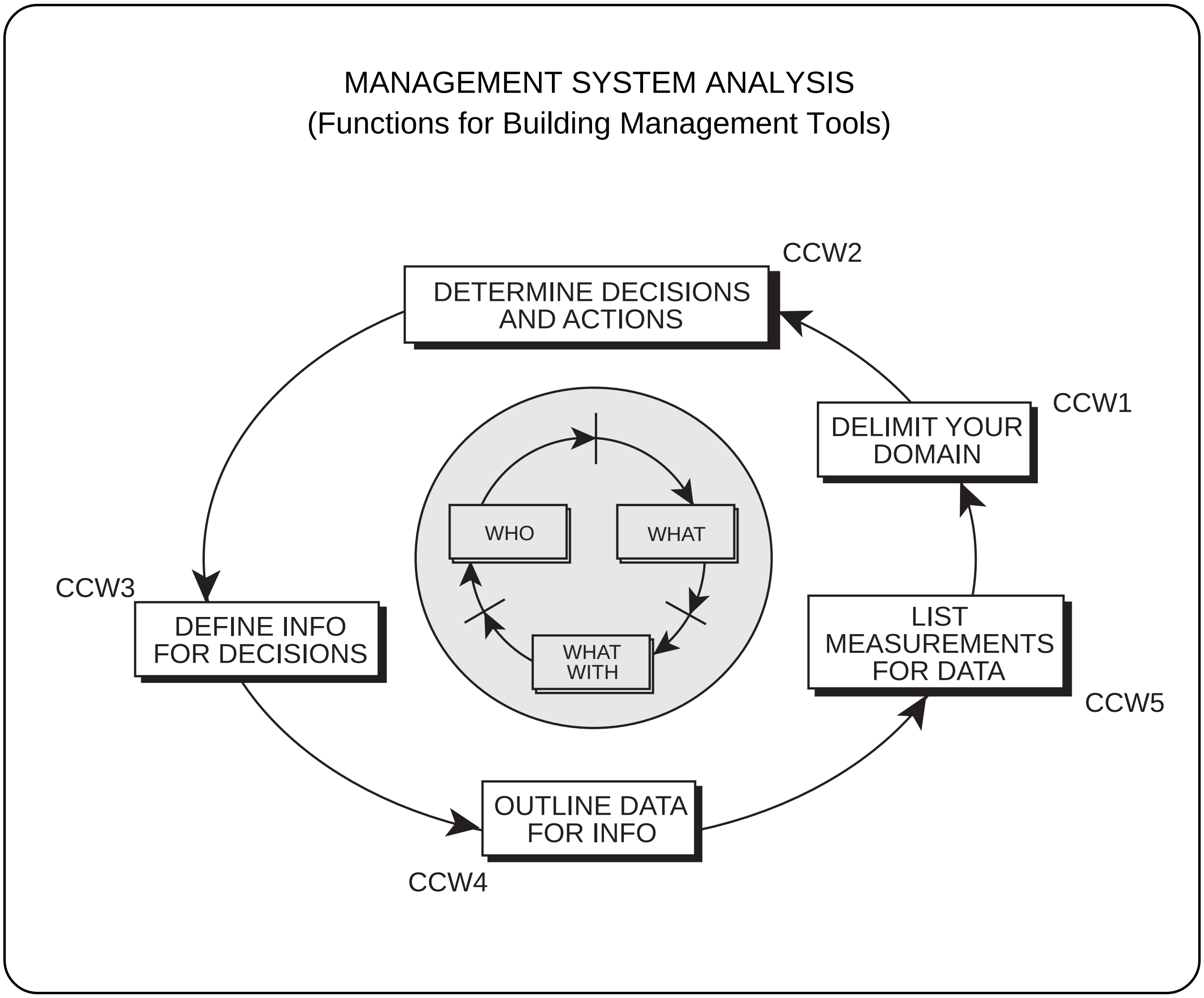

Figure 1.1.21.3. *The five management system analysis functions for building management tools work counter-clockwise around the Management System Model.*

1.1.21.4. Origins of Management System Analysis

Through their intimate knowledge of the first several steps of management system analysis, managers play an instrumental initiating role in providing input to information specialists when building management tools.

For most of a decade, Management Systems Laboratories built management tools knowing you had to start with the application and work your way toward data—the nitty-gritty issue in any management tool. During the period 1982 to 1984, the sequence of management system analysis surfaced as an informal procedure for building tools.

In the spring and summer of 1984, we were asked to present a two-day workshop on office automation for information systems designers and manager-users in the United States Department of Energy Senior Executive Service. We knew the needs of these managers weren't how to use a spreadsheet package or a word processing package. Rather the managers needed to know what tools they needed and how to make decisions to ensure they got the right tools. The managers were used to going to a contractor and asking the contractor to build a tool for them. The tools they got were useless because they didn't fit the operation or weren't comfortable for the users.

In discussing information processing as an integrating concept in organizational design, Tushman and Nadler say that their model's central hypothesis is that "...organizational effectiveness is indeed associated with the fit or match between the information processing requirements facing an organization (and its subunits) and the information processing capacity of its structure." They define fit as "Effectiveness is a function of matching information processing capabilities with information processing requirements." (Michael L. Tushman and David A. Nadler, "Information Processing as an Integrating Concept in Organizational Design," *Academy of Management Review*, July 1978, p. 622.)

In producing large information systems for wholesalers in 1973-1974, I discovered the key to success was fit. We implemented the same system in a large number of companies. When the fit of the system to the operation and the decision makers was good, the system helped the company succeed. When the fit was bad, the system helped the company fail. My experience, then, supports the Tushman and Nadler hypothesis.

In the Senior Executive Service Workshop, we discovered two important issues. First, the managers could use management system analysis to start with what they knew best—their operation—and work to what they knew next best—the decision makers involved—and then be able to specify to the contractors exactly what they needed. Second, the contractors could never know the operation of the domain as well as the managers did. Through the MSM and management system analysis, we could show that without the manager making a crucial contribution through functions 1, 2 and 3 to building the management tool, the tool was destined to fail. However, the manager's contribution required only familiarity with management, information, data, and systems approach concepts, not technical or specialist expertise in hardware or software issues of any kind. They felt so relieved! They didn't have to become expert in this strange technology to stay up with a changing world. But, they did need to know more about their domain of responsibility and associated decisions than before. They had to understand what they managed well enough to work through the first few management system analysis functions and to tell someone else what they knew. This job was harder than you might expect, but a job they needed to do to be successful in their responsibilities.

We used Figure 1.1.21.4. to demonstrate the crucial role the manager plays in building management tools and the interface the manager has with the information specialist. The manager contributes the management system analysis functions around the upper part of the MSM and the information specialist contributes the functions around the lower part. The manager's functions come first. Figure 1.1.21.4. shows the interfaces or the overlap between the manager and the information specialist. One overlap is at the information portrayal/information perception interface of the MSM. The other overlap is at the measurement, data interface. These overlaps were the two places where the manager and the information specialist needed to understand each other and communicate.

The two overlaps in Figure 1.1.21.4. highlight the two classical ways of analyzing the need for management tools. The first way is to start with what data is available and figure out how to store, retrieve, and manipulate those data and then how to make information out of them. Most people do management tools this way. That's why you have so many notebooks, file cabinets, and computer data bases with worthless stuff in them. The second way is to start with the decisions the management tools are to support and strive for only the information needed for the decisions and the data needed for the information. The first way started at the measurement, data overlap between manager and information specialist and the second started at the information portrayal, information perception overlap. Management system analysis clearly says that the best way is the second. The managers learned that lesson and they're glad they did.

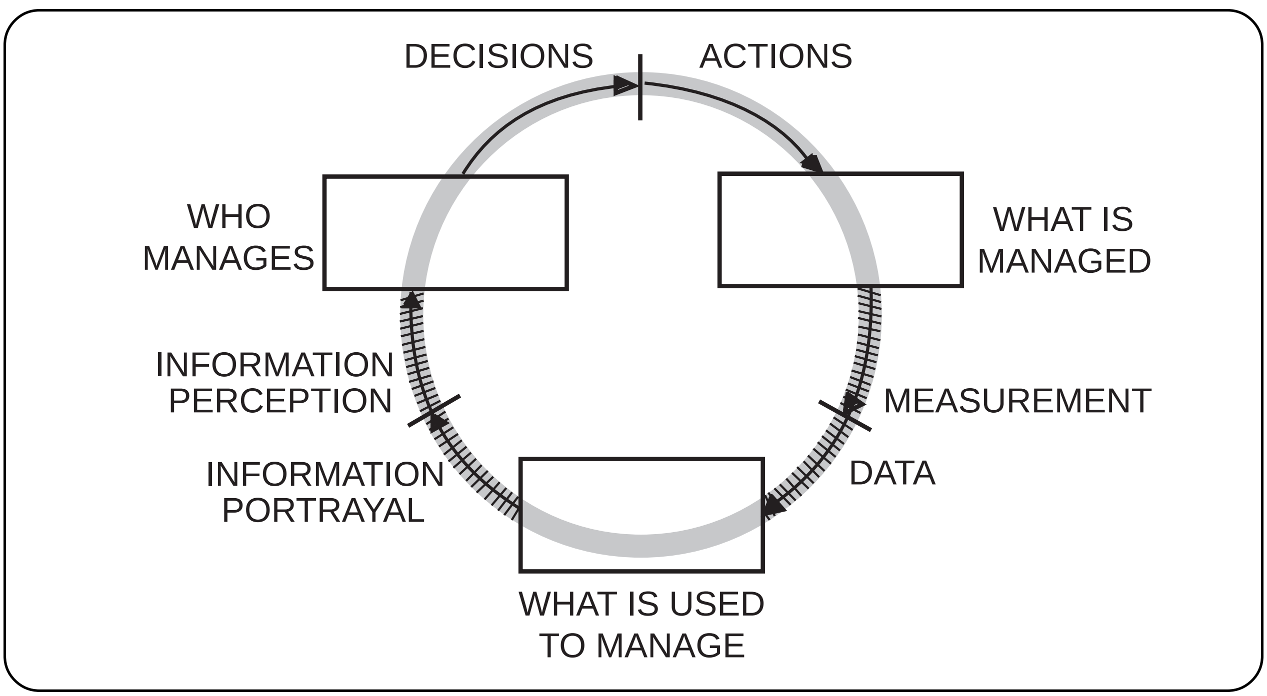

Figure 1.1.21.4. *The manager and the information specialist overlap contributions toward building management tools at two Management System Model interfaces. Management system analysis says the interface starting the interaction should be the information portrayal/information perception interface.*

1.1.21.5. THE NINE FUNCTIONS OF MANAGEMENT SYSTEM SYNTHESIS

To use management tools within the management process, we use nine management system synthesis functions, best described in terms of the Management System Model.

The nine functions of management system synthesis serve two purposes. First, they provide a map for continuous performance improvement. The map is an embellishment of Deming's Plan-Do-Study-Act (PDSA) Cycle, which is an embellishment of Shewhart's Specification-Production-Inspection Cycle, which is an embellishment of the scientific method. Second, they tell us how to use management tools. Since the five functions of management system analysis tell us how to build management tools, the nine functions of management system synthesis work together with the five functions to provide a closed set for directing us how to build the right tool and then how to use that tool correctly. The building and the using of the tools then aren't separated conceptually.

One group of people may build the tool and another group may use the tool, but the map of the management process structure, through the 15 functions, ties everything together. If we do the functions correctly, the manager (decision maker) is the consistent player through the building and using directions of the management process.

In its simplest form, management system synthesis includes three groups of steps:

1. Three steps, or functions, for planning what the manager will do with his or her operation using the management tools (Decide what to do. These functions relate to the *Plan* part of the PDSA Cycle.)

2. Three steps, or functions, for executing the plan using the management tools (Do what you decided to do. These functions relate to the *Do* part of the PDSA Cycle.)

3. Three steps, or functions, for comparing the plan with the execution to determine status and progress (See how well you did what you decided to do. These functions relate to the *Study* part of the PDSA Cycle.)

The groups of functions, and therefore the functions, are cyclic. So, after seeing how well you did what you decided to do, you start all over again by planning what to do to improve based on what you learned in the preceding cycle. (The closing of the cycle and the implications for recycle relate to the *Act* part of the PDSA Cycle.) In this way you execute the cycle and improvement spiral shown in Figure 1.1.9.1. in the module called Define Management Systems Engineering.

Figure 1.1.21.5. uses the Management System Model (MSM) for direction and as a rallying point for the nine management system synthesis functions. In the figure, I include the MSM more as an icon than as the framework for management system synthesis. You can see that the nine functions of management system synthesis fit comfortably around the MSM. The MSM tells us we have a closed set of functions for synthesis by showing no gaps and overlaps in considering the components and interfaces of the MSM. Through the MSM, we have confidence that the foundation concepts leading to the MSM are carried into management system synthesis. Just as the components and interfaces of the MSM are really intermingled and have been pulled apart for ease of discussion, the management system

synthesis functions must work together within the systems approach. The cycle of the functions includes sequence but allows the necessary cyclic, recursive, reversible nature of the management system.

Figure 1.1.21.5. labels the nine functions as CW1, CW2, and so on. CW1 stands for the first clockwise function. The management system analysis functions go in the other direction, so the labels distinguish between analysis and synthesis and indicate sequence.

In analysis, we separate the whole into its parts so we can better deal with each part. Under the systems approach we analyze with the whole and its aim always in mind. In management system analysis for management tools, we start with the whole—an understanding of the domain for which we intend to improve its performance. Then we separate the intervention into the decisions needed in the process of building and applying the intervention, the information needed to support the decisions, the data needed to make up the information, and the measurements to collect the needed data—a process continually moving us into greater detail and specificity, an analysis.

In synthesis, we combine the parts to make up the whole so we can make sure everything works toward a common aim. In management system synthesis for management tools, we start with the parts—the expectations of the domain and its parts, the details of the work process, and the indicators to be measured to see the workings of the operation. Then we convert the data from the measurements into information for the manager to compare to expectation to determine new or better interventions for continuously improving performance.

The success of management system synthesis is in taking the functions in the proper sequence. Notice how the functions of the synthesis move clockwise sequentially around the components and interfaces of the MSM. We want to get to the comparing functions. But if we don't do the planning and executing functions well, our comparisons will be worthless. The verifying performance function completes the loop. We can't determine how good our expectations, work process, and measurements are until we know what they yield in terms of the aim of the management system. In fact, we have a loop we must work iteratively to design, cause, and measure performance improvement.

Management system analysis and management system synthesis work together. I'll show how you can jump from analysis to synthesis or vice versa. For example, if you're working the synthesis loop (using management tools) and converting data to information, you may find that you need an improved management tool to do what you want. You can continue the clockwise loop and simultaneously work counter-clockwise to improve the tools you need to get the data. Soon, I'll describe the inter-workings of management system analysis and management system synthesis within the management process.

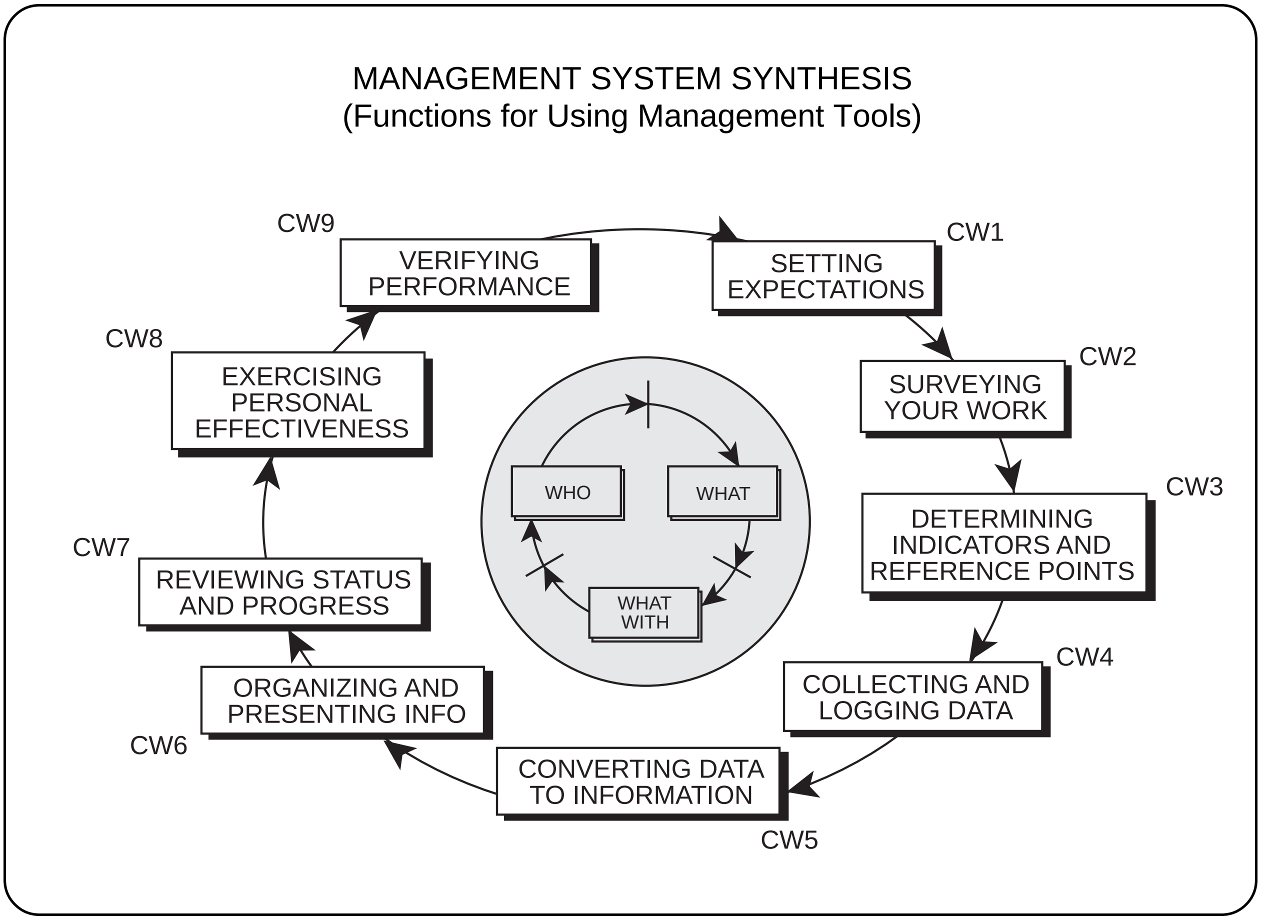

Figure 1.1.21.5. *The nine management system synthesis functions for using management tools work clockwise around the Management System Model.*

1.1.21.6. Origins of Management System Synthesis

Management system synthesis originated in successful management practices for continuous performance improvement.

During the period 1972 to 1974, Pamela Kurstedt and I worked with Management Horizons Data Systems, a company that provided management, data, and information services to wholesale warehousing companies. Citicorp had just assumed majority ownership and control of the company. They applied the successful Citicorp management techniques of the 1970's and turned a failing company into a successful one. We didn't know it then, but we were part of management system synthesis.

In 1986, one of the Citibank executives who participated in the informal, evolutionary development of what was the successful Citicorp management process of the 1970's asked Pamela and me to capture the management style still practiced by some people in Citibank and write an internal training manual. His objective was to recover and promulgate the management process, what he called methods for management.

The most exciting part of the management process was a series of rules that had become ingrained in Citibank's culture during that successful time period. The less exciting, but most important, part of the process was a number of methods (That's what Citibank called them.) that were guided by the rules. In hindsight, Citibank's methods included functions and methods and other management tools. For example, one method was work flow charting, which in this book is a tool to help do the surveying your work function. While work flow charting is a superb tool, we can use other good tools to help do that function.

The management process reflected the ideas of the quality movement but neglected the human flavor of willing workers doing their best. However, the parts of the process promoted cooperation and continuous performance improvement.

When the internal training manual was published in 1988, we had defined eight of Citibank's methods. The manual generated much excitement and many thousands of copies were used throughout Citibank's offices all over the world. Pamela and I helped install the methods for management with the methods and rules in a number of Citibank's divisions where the process had been forgotten or neglected.

Later, we generalized the rules and methods and helped government agencies and various industries learn and practice the process. During this time, we rewrote the rules so they had broad application and less Citibank jargon. We also discovered the inconsistency among the function, tool, and method category of the methods. So, we deciphered the functions behind the eight methods.

When we saw the functions, we discovered the connections to the Management System Model. As a result, we added the ninth function; and one of the difficulties we had in the original training manual was resolved. Immediately, we saw the reflection of Deming's Plan-Do-Study-Act Cycle in the functions. We carefully adjusted the present labels for and implementation of the functions and the rules that guide them so they center on the human aspects of continuous performance improvement. Studying the management systems synthesis, or using management tools, part of the management process is essentially studying total quality management.

I argue that from Taylor's time until today we've been evolving total quality management and continuous performance improvement to properly answer the time-honored, fundamental management questions in Module 1.1.4. Management systems engineers are well equipped to lead the answers to the questions.

The nine functions were always used to implement management with existing management tools. Clearly, they were using-management-tool functions. When people used the functions well, they discovered ways to improve their management tools. So, we now see the connection between the building-management-tool and using-management-tool functions.

The origin of management system synthesis was inductive. Based on observations in organizations trying to use management tools and trying to install and implement the functions for using management tools, we developed the closed set of nine functions and a set of eight rules (described in Section 3.0 of this book) for management system synthesis. Management system synthesis is empirically derived and not derived from management theory. In evaluating management system synthesis, we see the management theory at work.

1.1.21.7. Management System Model, Management System Analysis, Management System Synthesis

Management system analysis and management system synthesis work their functions around the Management System Model and their functions interplay to help managers convert interventions into improved performance.

If we look at an organization from the perspective of building and using management tools, we can construct an organizational model based on the five management system analysis functions and the nine management system synthesis functions as shown in Figure 1.1.21.7. The fourteen functions work around the Management System Model (MSM). The MSM acts as an icon or rallying point for the two cycles of functions. The MSM made its contribution in integrating the foundation concepts and stimulating the creation of the two cycles. The MSM plays primarily a symbolic role in the practice of the functions.

The direction of the sequencing of functions in Figure 1.1.21.7. reflects the way the MSM is drawn in Figure 1.1.18.1.3. The clockwise direction in the MSM goes from who to what to what with. You can find the starting points for both management system analysis and management system synthesis in Figure 1.1.21.7. To build a tool well, you start by understanding your domain and proceed counter clockwise to the decisions you need to make by working toward measuring indicators to get data to convert into information to support the decisions. To use a tool well, you start by surveying your work and proceed clockwise to the indicators you must set to get the data you need and work toward making and communicating decisions to improve the organization. The starting point is always profound knowledge of the workplace by understanding your domain, or surveying your work. Proceeding either counter clockwise or clockwise through the functions requires profound knowledge of the management process and of what Deming calls profound knowledge: the theories of variation, systems, knowledge, and psychology.

If you look back at Figures 1.1.21.3. and 1.1.21.5., you'll be able to interpret connections between the clockwise and counter-clockwise functions. In Figure 1.1.21.7., I've shown these connections as two-headed arrows between the cycles. The arrows in the figure aren't all there are. The few I show represent the crosswalk between management system analysis and management system synthesis. These arrows emphasize the idea that we can be following one cycle in sequence, move to the other cycle and proceed in the opposite direction. The combination of the cycles shown in the figure emphasizes the reversible nature of the management process. Figure 1.1.21.7. shows the complete structure for the management process. This structure, together with the management process rules and the systems approach helps us convert interventions into performance improvement.

Here's an example of what I mean by switching directions in the two cycles of functions by moving from one cycle to the other. As you work on using a management tool through management system synthesis and are figuring out how to portray information in CW6, you may realize you need to improve the management tool and its data gathering ability. Then, you switch from using the tool into building a better tool by moving from the clockwise direction to the counter clockwise direction.

Here's another example. As you work on building a management tool and finding out the information you need in CCW3 for the decisions you make, you may want to look at charts of the work flow to determine the possibility of operationalizing the measurements of data to get that information. Then you switch from building the tool into using the tool better by moving from the counter clockwise direction to the clockwise direction.

I've emphasized the management-tool (what is used to manage), or information-oriented, perspective from Figure 1.1.18.7. in developing and discussing the functions of the management process shown in Figure 1.1.21.7. I've emphasized the engineer's interest in the machines of management. The management process and this figure apply equally well to the perspectives emphasizing the operation (what is managed) and the manager (who manages). Since who manages uses the management tools, the functions help the manager determine how to build and use the management tools. Since the management tools are used on what is managed, the functions tell us how to apply the management tools to the work process.

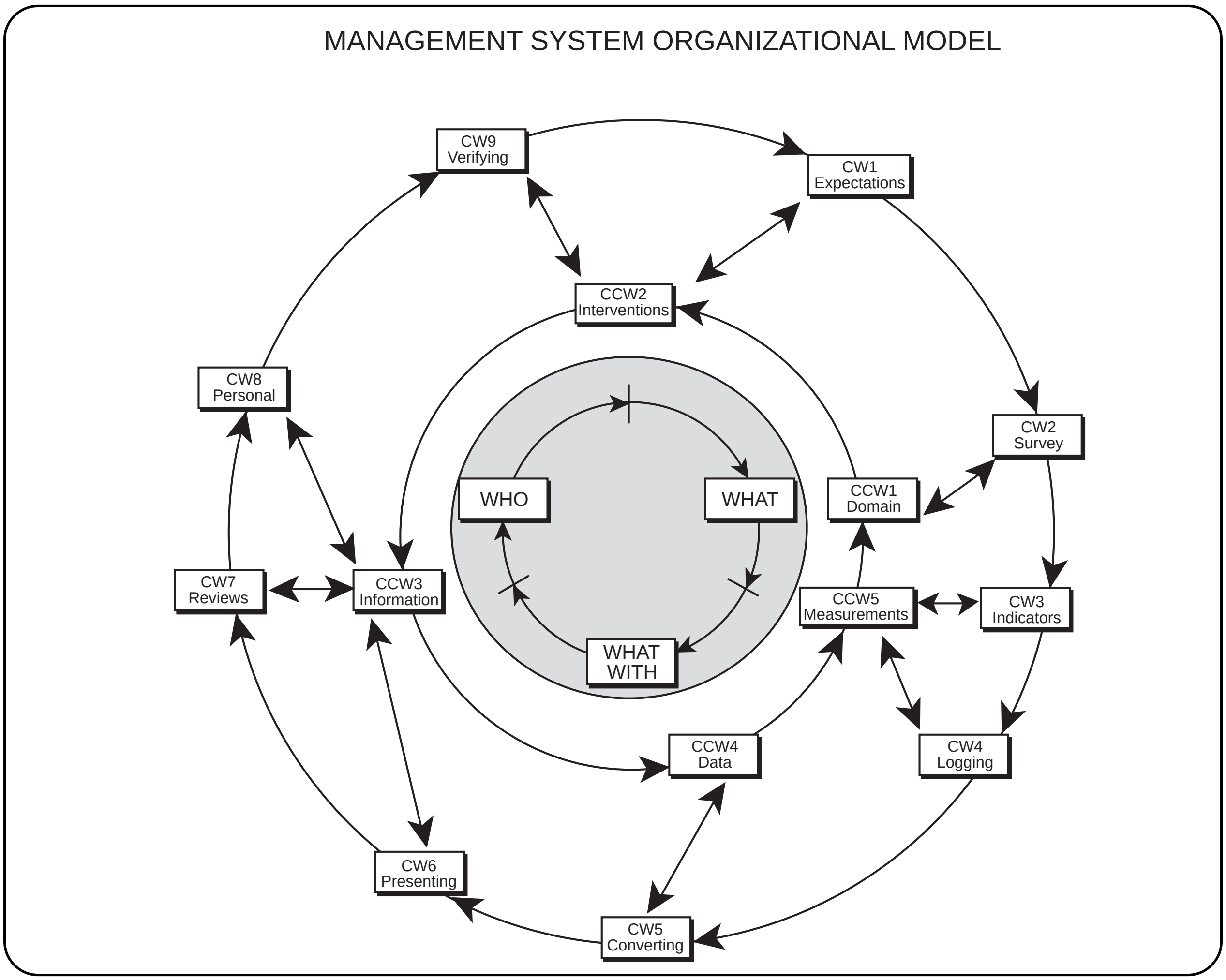

Figure 1.1.21.7. *When we put the management system analysis and the management system synthesis functions together around the Management System Model, we see the cyclic, recursive, and reversible nature of the management system.*

1.1.21.8. Beyond the Management System Model

We can use the Management System Model to develop new models, compatible with the Management System Model, that emphasize management parameters the Management System Model doesn't.

In management systems engineering, we must bridge our engineering and management thinking. Management system analysis and management system synthesis form the structure of the management process and represent management thinking. When we make physical science analogies, we put management issues in physical science terms. Applying the engineering process is even more direct when the object of the application is in physical science, or engineering, terms. We then generate solutions to management questions or problems in an engineering context. If our analogies are solid, we can transfer back the engineering solutions to contribute to management solutions.

To extend our thinking beyond the Management System Model (MSM), we want other simple models, each emphasizing and displaying management issues different from those best addressed using the MSM. A good example of such an extension and one that illustrates the value of finding an analogous engineering model is the control loop. Recall that the MSM is a descriptive model. A major contribution of the control loop is that it is predictive.

To discuss the control loop analogy, I'll quote from *Engineering Analogs in Management* by Kurstedt, Mendes, and Lee (Proceedings of the Ninth Annual Conference, American Society for Engineering Management, October, 1988, pp. 197-202.). "Inspired by the MSM's circular loop (suggesting a feedback control diagram), I decided to use an analytical framework based on automatic control theory. I was trying to model the interfaces in the MSM by looking at the relationships between the components, and this is what control theory does. (Control theory studies the dynamics of a given 'plant,' and decides what is the best way to make it track some desired behavior. The desired behavior corresponds to the engineering criteria. In a management situation, these criteria result from a (participative or not) decision-making process.) Control-based management models are supported by the literature, either explicitly (e.g., Forrester, 1961) or implicitly (e.g., Argyris and Schon, 1978). As a point of interest, the MSM-based control framework complements classical industrial engineering (Herzog, 1985) and managerial control theories (Amey, 1986).

My objectives are: (1) to get a generalized model from the analysis of common classes of variables and types of elementary components found in different physical environments, and (2) to use the meaning of variables and relationships in the general model to understand and specify the meaning of variables and components in the MSM (See Mendes, Kurstedt, and Lee, *An Information Strategy is Fundamental for Sustained Competitive Advantage*, Proceedings of the Ninth Annual Conference, American Society for Engineering Management, October, 1988 for an application of these concepts.) According to the preceding definition of Industrial Engineering [See Module 1.1.14.4.], predicting the behavior of engineered systems is a major objective, attainable through the formal application of scientific knowledge. Analogies between physical systems reflect general laws. For example, the continuity law is the basis of Forrester's rate equations, useful in modeling the operation (the 'What is managed' component in the MSM):

(Flow into system) - (Flow out of system) =
(Time rate of change inside system).

To model each person's management system I use a control systems perspective. Tosi (1983) defines 'the control structure [as] the set of factors, and the relationships between them, which elicit predictable performance from individuals and groups in organizations.' He sees control as influencing people to minimize problems and insure compliance with norms and goals. Without going this far, the more traditional control systems theory I subscribe to supports the three stage maturity concept of control: to maintain the values of an output variable close to a preset value, and absorb disturbances.

I use the MSM to understand the 'inside world' first, and the 'outside world' after, i.e., to figure out how the organization works within itself before worrying how it interacts best with the outside. I deal with shared information processing (information for both the inside and outside world) through different information portrayals. Now, to physically model a management system, I represent the MSM as a control loop in the lower part of Figure 1.1.21.8. The MSM and the control loop are placed together to show their analogous components and relationships. The controller in the control loop is the 'who manages' in the MSM, the plant is 'what is managed,' and the sensors are 'what is used to manage'; the interfaces are intact. The analog is complete because the control loop shows the interactions with the environment as inputs (set points), disturbances, and outputs. At this time I don't consider the interfaces. Those are only required during implementation.

The analogy can be further explored. When something goes wrong and a manager is unable to control the operation as desired, either the manager is replaced, the organization changes, or both. That corresponds to either replacing the controller or facing an unstable system. Another alternative is to change goals, but that corresponds to changing the inputs, the desired system behavior. Similarly, changing a manager's attitudes is equivalent to tuning the controller, and improving the tools is like calibrating the sensors.

The control theory loop is general. I use the control theory representation of the MSM to study the response of a management system to changes in the reference input. The comparator [the little circle where the reference input and results meet] shows the manager's bias relative to the incoming information, such that managers in different positions in the organization will respond differently to the same changes (See also Kurstedt, Berube, and Mendes, *We Bias Information Differently for Managers at Different Organizational Levels*, Proceedings of the Ninth Annual Conference, American Society for Engineering Management, October, 1988.) In physical systems, sensors also have reference inputs, used for calibration purposes. Continuing with the analogy, I say the management tools are also biased relative to the incoming data."

The interfaces of the MSM aren't emphasized in the control loop in Figure 1.1.21.8. The inputs and outputs to the environment are. I find that the functions of management system synthesis lay on top of the control loop quite well—better than they do the MSM. We can also find the ABC Model in the control loop analogy. The disturbance input represents C, cater to crises. Administer the work process, A, is the action of the controller on the plant based on the reference input. When we extend A to include administer the management process, we include the feedback through the sensors. Build the business, B, occurs when we set the reference to a new level and adjust the plant accordingly.

I argue that the control loop analogy is a good way to extend the MSM. Obviously, the control loop stands on its own in modelling the organization. The MSM served its purpose in giving us confidence that the analogy works. Now we have two different models, each with its strengths.

I prefer two different models rather than Rube Goldberg type attachments or extensions to either model. I intuitively know we'll find more models, each serving a valuable purpose in understanding the complex system we call an organization.

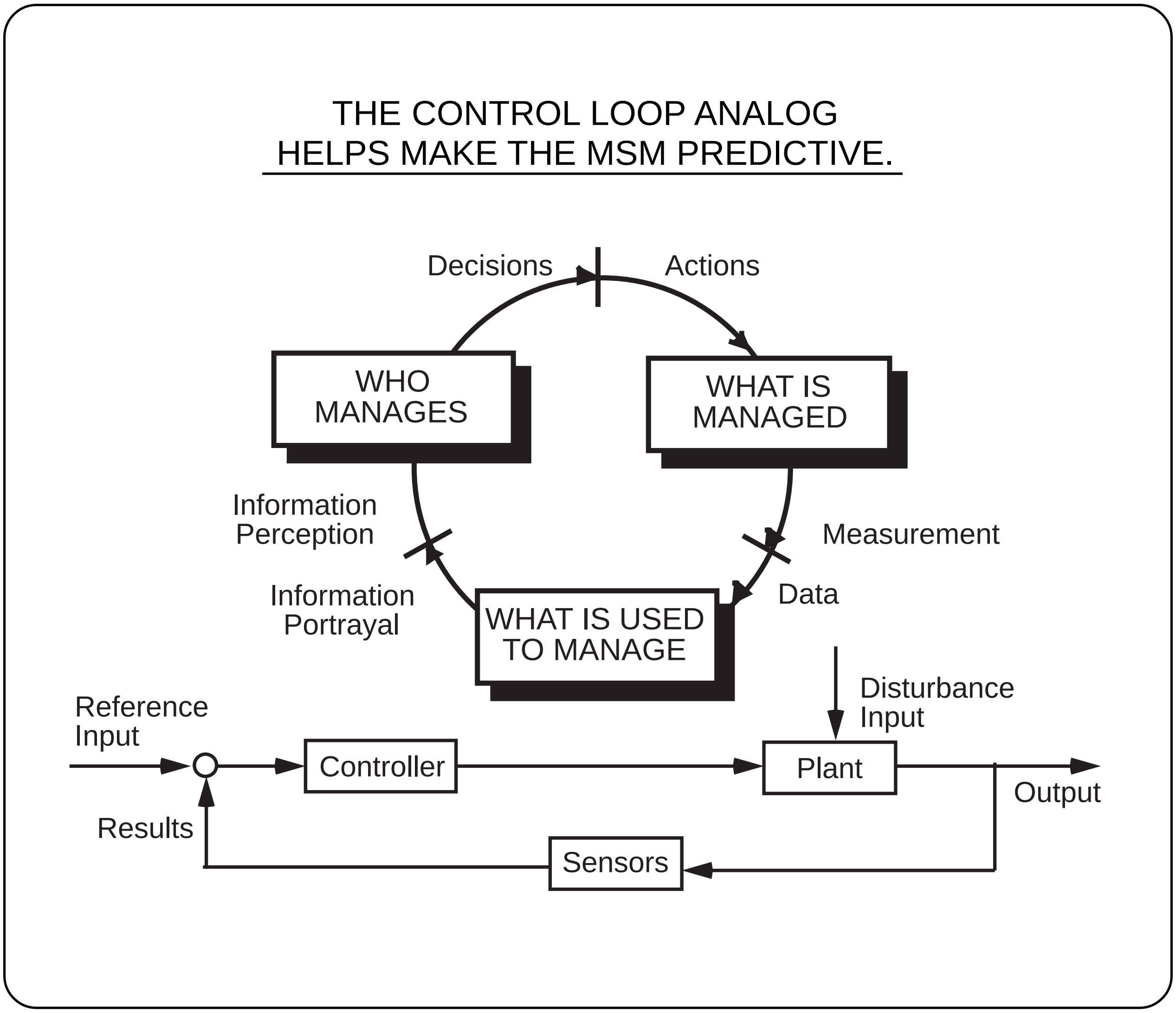

Figure 1.1.21.8. *The control loop analog helps make the Management System Model predictive and extends the Management System Model to a new form emphasizing the interaction of the system with the environment and the resulting dynamics of the system. (The control loop analogy was contributed by Pedro Mendes during our work together on his PhD dissertation. Pedro has the best understanding of anyone I know on how to extend the MSM. In his dissertation, Pedro applied the control loop analogy to an emergency management problem. Later, I'll use Pedro's dissertation to render the control loop into terms directly related to management questions.)*

1.1.21.9. The Statics View Versus the Dynamics View

Management system analysis and management system synthesis are equally good for looking at balance—the statics view—and for looking at change—the dynamics view—in an organization.

When engineering a mechanical system, we find value in taking both a statics view and a dynamics view. We use each view to learn something about the mechanical system. Each view contributes something different to our understanding, based on what that particular view is best equipped to do. Recall this discussion from Module 1.1.16.3.

I'll transfer the perspectives we've learned in statics and dynamics to understanding how organizations work. Statics looks at balance in organizations. (Don't imagine a scale—as in the scale of justice—when I say balance. Balance here is more like fit and adjustment to a match or compatible and productive arrangement. I discussed the idea of fit in Module 1.1.21.4.) Dynamics looks at change in organizations. Since the organization is an open system, the forces for change must include external forces. For a dynamics view of the organization, we have to include external forces on the organization. The resistance to change in an organization is internal. In terms of statics and dynamics, resistance to change caused by an external force is friction. Clearly, we can use mechanics analogies to represent organizations. But, what can we learn from the analogies?

The Management System Model (MSM) is a closed system model and is most directly useful for balance. The MSM is an internal look at the organization and includes the operation as a subsystem acted on by interventions and yielding measurements and data for management tools. Figure 1.1.21.9.a. shows the part of the MSM where the operation is influenced by actions internal to the organization. In Module 1.1.21.8., I showed another model for the organization, a control loop analogy, to help us look at dynamics of the management system so we can study change. The control loop model looks at the organization under the influence of the environment. Figure 1.1.21.9.b. shows the part of the control loop where the organization is influenced by the vendors and the customers of the organization.

The control loop model incorporates all the parts of the MSM, but can't be called an extension or modification of the MSM. The control loop is its own model. The control loop has been used in electrical engineering, mechanical engineering, psychology, and other disciplines for many years to study the time-dependent performance of a system under external forces.

Even though the MSM directed the development of management system analysis and management system synthesis, the MSM didn't carry into management system analysis and synthesis its exclusion of the connections of the management system to the environment. As a result, management system analysis and management system synthesis apply both to balance and change.

I'll illustrate how management system analysis and synthesis have the ability to deal with the organization's environment. My first illustration is for using management tools—management system synthesis . If the surveying your work, collecting and logging data, and reviewing status and progress functions shown in Figure 1.1.21.5. are internal, we deal with internally stimulated change and resistance to change. (To continue the mechanics analogy, we do so in terms of force, weight, and friction.) We're considering the work process as shown in Figure 1.1.21.9.a. By including the vendors on the input side of the management system in Figure 1.1.21.9.b. and the customers on the output side within the three management system synthesis functions I just listed, we include external forces for change.

In working with management tools, we first understand the tools we need by looking at the organization internally—a statics view—and focusing on the work process as shown in Figure 1.1.21.9.a., where the tools directly experience the data from the operation. Then, we refine our management tools by looking at the organization externally—a dynamics view—and adjusting our view of tools to include the environment as shown in Figure 1.1.21.9.b., where the tools indirectly reflect measurements related to vendors and customers. In the dynamics view, the tools include both input effects of the environment and output effects on the environment in relation to the work process as used by the manager and his or her understanding of data and information not only coming from the operation but coming from and going to the environment.

My second illustration of how management system analysis and management system synthesis include effects of the environment is for building management tools—management system analysis. We can build management tools based on decisions for actions on the operation from the feedback within the MSM on the operation's performance. However, we can build management tools based on decisions including external as well as internal information, data, measurements, and indicators. Therefore, management system analysis is just as valuable for change as for balance. The same is true for management system synthesis.

The MSM and statics lead to management system analysis. In building management tools, we look for balance and strength of the MSM components. These activities relate more to A activities (administer the work and management processes) in the ABC Model shown in Figure 1.1.7.

The control loop and dynamics lead to management system synthesis. In using management tools, we look for change in the MSM components. These activities relate more to B activities (build the business) in the ABC Model shown in Figure 1.1.7. Soon, I'll extend my discussions of the ABC Model and how to use the model.

In summary, the MSM provides a statics-type view of the organization. We need the control loop model for a dynamics-type view. Management system analysis and management system synthesis 1) overlay both the MSM and the control loop model, providing both statics and dynamics views; 2) can be confined internally for a view as a closed system, MSM, or statics; and 3) can be extended externally for a view as an open system, control loop model, or dynamics.

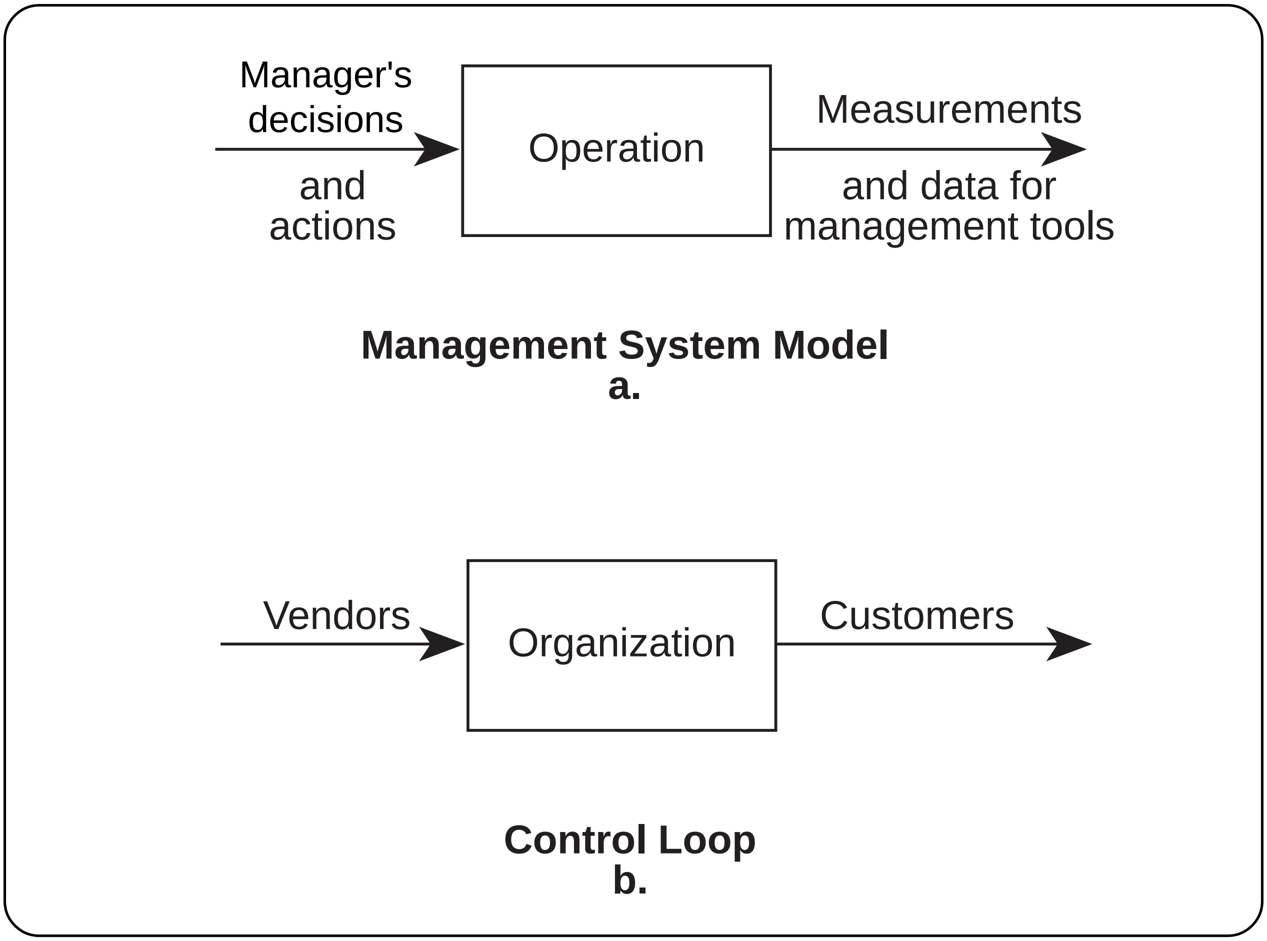

Figure 1.1.21.9. *The Management System Model focuses on the inner workings of the management system for balance and strength of components, whereas a control loop model focuses on the external effects on the management system for change.*

1.1.21.10. Forces, Energy, and Friction in the Workplace

Analogous parameters from the physical sciences, so familiar and useful to engineers, like forces, energy, and friction help us generate relationships for answering fundamental management questions.

Recall two of the time-honored, fundamental management questions from Module 1.1.4. How do I get useful information (the right, high-quality information on time) about my work to support the decisions I make? How do I improve morale and reduce fear in the workplace? When you're responsible for the work several people do and need to make decisions on reliable, often-detailed data, you must interact with people in non-threatening but penetrating ways.

In trying to solve a problem, you must get to the root cause of the problem. One technique is a Japanese technique called the five-whys technique, where you ask why five times to dig deeper and deeper into the problem to find the root cause. In this technique you depend on information from the person you're asking why. They must cooperate or you'll never get the information you need. If they feel threatened, they won't cooperate. So, you must penetrate to the root cause without being threatening. In short, to be successful, you often need a potentially-threatened person's help.

Penetration requires specifics, not a broad approach. To penetrate to the specifics, you must understand the technology of the work process and of the management process.

Success in penetrating for information requires 1) understanding of the technology and 2) the help of a potentially-threatened person. For success in penetrating into the specifics, you must enhance driving forces in your penetrating skill and reduce restraining forces by reducing barriers and resistance to penetrating.

Consider Lewin's force field analysis described in Chapter Three of Weisbord's *Productive Workplaces*. I've set up a simplified force field analysis diagram for the problem of interacting in non-threatening but penetrating ways in Figure 1.1.21.10. The diagram is simplified since I'm sure you can add both driving forces and restraining forces to the diagram. A valuable group activity in an organization would be to complete the set of forces in the diagram, determine the length of the arrows to represent relative sizes of the forces, and discuss ways to increase forces in the direction of desired movement and ways to reduce forces opposite to the direction of desired movement. Remember that you get better results from reducing restraining forces because increasing driving forces begets increased restraining forces.

Our objective is to move the problem from the status quo by increasing the drives or reducing the restraints. My point in all this is that in raising the fundamental management question and finding the answer we have developed a diagram of forces on or within an organization. As engineers, we feel comfortable analyzing forces.

Our diagram looks a little like a free-body diagram in mechanics for studying statics and dynamics. If the sum of the forces in the x direction is zero, the system is in equilibrium and the status quo is maintained. If the sum of the forces in the x direction is different than zero, the system is going to move (change) in the direction of the prevailing forces. But the forces aren't like the ones we're used to from mechanics. These forces have to do with human characteristics like abilities and motivation. Yet they're forces just the same.

What about continuing the analogy. If we apply a force through a distance, we get work. What is distance in an organization? I'll argue organizational distance ranges through people or jobs up and down the organizational hierarchy and across people or jobs at a level in the hierarchy.

The more broadly the force is felt, the more positive or negative work done by the force, where positive or negative depends on the direction of the force. Each force does work that accumulates effort regardless of direction. (You accumulate effort in the sense that if you carry a brick up and down a hill to return to the point of origin, you might do no work but you still get tired.) We know the work accomplished is the resultant force acting through the distance moved and occurs only when some of the forces prevail.

If we integrate the force through distance over time, we get energy. In an organization, we find many types of energy, including motivation, joy, and frustration.

We know what time is in an organization. We can even develop an analogy for weight in the organization. Let weight be a function of size and density. Size we can handle, but what's density? Perhaps influence on others and on the work process. If we're moving an organization through or across another medium and the organization has weight, we'll get friction. We know organizations get conflict and loss of energy through friction. Generally, we want to reduce friction because friction results in a dissipation of energy and a loss of work. Sometimes we want to convert energy from one form to another (e.g., mechanical energy to thermal energy) and increasing friction does this. We know that intentionally producing friction is a delicate matter because that energy is usually lost or harmful to the system. One of the fundamentals of the engineering process is knowing how to gather, convert, and conserve energy. This fundamental applies to engineering a management process too. (Perhaps we can find an analogy between friction in pipes and delaying or distorting information flow.)

Through the mechanical analogy, I've set up some relationships by which we can discuss cause and effect in using forces to do work and generate productive energy recognizing we can waste it all through energy dissipated through friction. Eric Mills of my 1993 class suggests that if friction is external resistance to change, then inertia is internal resistance to change. I've set up relationships for dealing with at least some of the fundamental management questions in Module 1.1.4. I discovered these relationships by considering mechanical analogies. If any of the relationships makes sense on the face of it, we can test the relationship through observation and measurement.

We can find many analogies from the physical sciences to develop useful parameters and relationships, like control, force, work, energy, power, strength, and many others. When we have the analogies and have confidence that, through the systems approach (generalist perspective), the analogies apply, we can transfer the relationships among variables and study the sensitivity of one variable to changes in another variable. Today, we seldom are able to plug in numbers and get quantitative results. We can't quantify fear in pounds or pounds per square foot. But we can get qualitative results; and qualitative results aren't only the starting place, they're the most potent results.

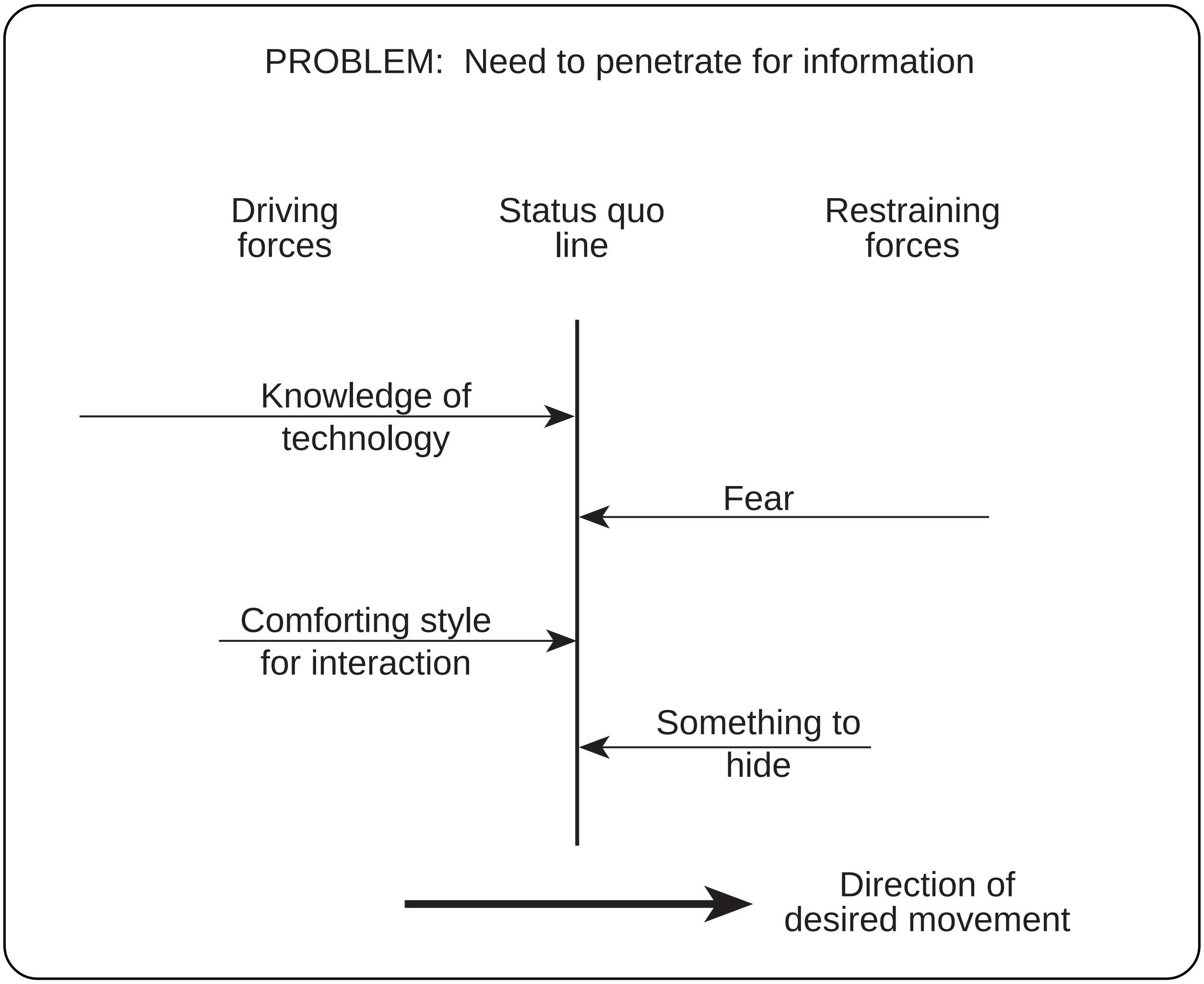

Figure 1.1.21.10. *A force field analysis diagram helps give us a handle on answering the question: How can I interact with people in non-threatening but penetrating ways?*

1.1.21.11. The Care and Feeding of Analogies

Morris indicates that analogies are good starting points for new models. (William T. Morris, "On the Art of Modeling," *Management Science,* 13 (12), August 1967, p. B-709.) He says that analogies between the problem at hand and some previously well-developed logical structure help us make intuitive leaps. Analogies are effective when dealing with an emerging science in that they stimulate premises to be proven or disproven through further study. Engineering analogies help us with management systems engineering and management, which are emerging sciences.

1.1.22. The Feeling of Energy—Theodore Géricault *(Raft of the Medusa)*

1. Background

1.1. Introduction

1.1.23. Other Useful Organizational Models for Using Management Tools

1.1.23.1. Alternative Models for the Organization in the Management Process Framework

As we implement our strategy to address changes due to our organization's environment, we'll need useful organizational models in addition to the structured fourteen-functioned management process.

Directed by the Management System Model, management system analysis and management system synthesis when assembled together as the structure for the management process give us one representation of the organizational model called for in Figure 1.1.11.4. We'll use this structure most heavily as we study building and using management tools.

The manager conducts a number of broad, focused activities when making decisions and taking actions. These activities include leadership, culture management, and others and are described in the form of an organizational effectiveness model in Module 1.1.23.3. The manager needs his or her management tools to support these activities. Several ways of looking at the organization consider these activities and the way management tools support them. One such model is Weisbord's people, technical, and reward subsystems for the management system shown in Figure 1.1.4. This model gives us another structure for the organization to help us build and use successful management tools. The structure I'll use as the primary organizational model in the center box of Figure 1.1.11.4. is the dual cycle of the fourteen management process functions shown in Figure 1.1.21.7. However, to help tie the tools together to get synergy among them, we'll look at other models for structure.

Consider Figure 1.1.23.1. Notice the relationship of this figure to Figure 1.1.11.4. What's inside the box called organizational models? It depends on what you want to focus on. Your focus is directed by the environment of the management system, or domain of responsibility. One of the traditional tenets of management is that structure follows strategy, which follows environmental change.

When your domain's environment changes, your strategy for operation and for dealing with the environment should change immediately. Your organizational structure, usually thought of in terms of the wiring diagrams we call organization charts (one of your management tools), should adjust to support the new strategy. However, as we look at a structure of management process functions or a structure of activities like leadership and culture management, your emphasis or connections among the parts of the structure will change to meet the need. For example, a change in your environment may cause you to change your strategy in such a way you need to change your emphasis from leadership-dominated activities to culture-management-dominated activities. However, each of these activities is tightly tied to the other. Deal and Kennedy (*Corporate Cultures*) say the business environment is the most significant element in a corporate culture.

The idea of structure following strategy, which follows environmental change shouldn't be foreign to people who practice the engineering process. A need, or application, begets a plan, which leads to the structure of the solution to the need.

We'll find in Module 1.1.23.3. that the activities-oriented structures for the organizational model in Figure 1.1.23.1. draw heavily on skills of the manager. The management process functions draw on skills to build, use, and integrate the management tools—skills for building tools like system analysis, information gathering, information analysis, and developing data and information stores and skills for using tools like communication, getting consensus, and sharing information. I'll discuss these skills as I detail the functions where you need to use them. The activities-oriented structures for the organizational model draw on skills not so keyed to management tools, like envisioning for leadership and cheerleading for culture management. Activities-oriented structures emphasize the manager and his or her roles. Management-process-oriented structures, like the one in Module 1.1.21.7., emphasize decision making.

Decision making is central to the management process in much the same way as design is central to the engineering process (as described in Module 1.1.11.6.2.). The management process is about decision making and what precedes and follows from decision making. The engineering process is about design and what precedes and follows from design.

As we expand and use Figure 1.1.11.4., we'll need one or more of the alternatives for the organizational model in the center box. In the general sense, all the alternatives are intermingled in the box. If we were to consider each of the alternatives as represented by a different color, their integration in the center box would make it a black box. With all the alternative models working together in the box called organization, that box represents the domain of responsibility not just the operation.

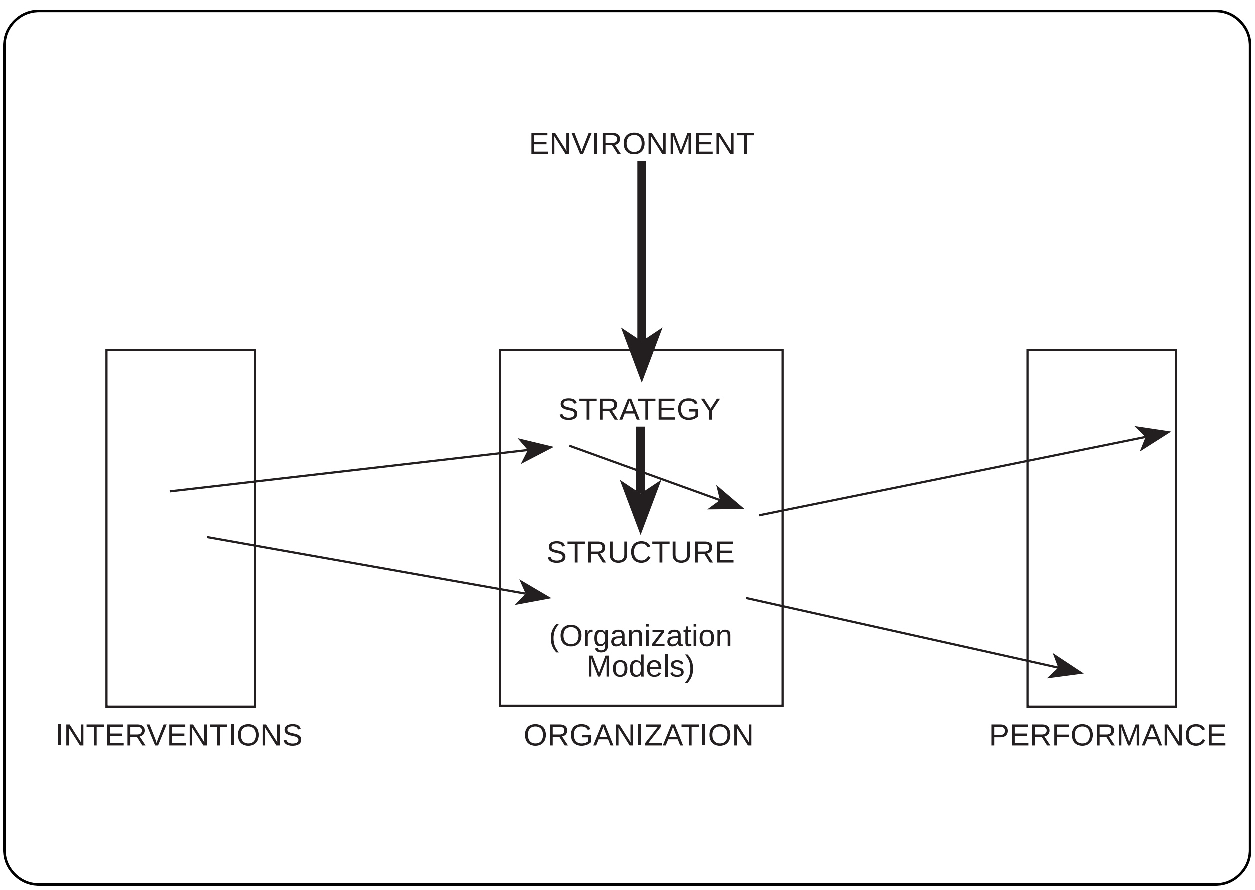

Figure 1.1.23.1. *We can represent the organization by a number of models as the structure influenced by our strategy as we deal with changes in the organization's environment.*

1.1.23.2. Structure Responds to Strategy Reflecting Changes in the Environment.

While structures in an organization, like reporting structures and geographic layout, are visible and immediate, they can't be developed properly until you have a strategy based on your business environment.

Figure 1.1.23.2. contains a planning model reflecting the thought process people in an organization need to go through before they can make effective interventions in the domain of responsibility. The planning process must be a closed loop. Strategy and structure are only of value when they result in actions (interventions) changing the organization and affecting the business environment. The organization affects the business environment through its merchandising (suppliers) and its marketing (customers) strategies and interventions.

The process in Figure 1.1.23.2. is highly recursive and you'll find loops within loops. The environment plays the role of forcing function on the organization.

I'll discuss the steps in Figure 1.1.23.2. in the modules about using management tools. Notice, however, the sequence from environment to strategy to structure. Also, notice the decision/action interface (interventions) of the Management System Model represented in the last step. These decisions and actions become the interventions you make on the organization affecting its structure of relationships among people (organization structure), tasks (work flow), and resources (for money, chart of accounts or budget, and reporting structure).

From Figure 1.1.23.2., notice that between the business environment and the organization's strategy is the organization containing four steps, or sets of characteristics, describing and defining the organization. Again, we find that if you don't have profound knowledge of your domain of responsibility (the organization) you don't have the foundation to proceed intelligently. The organization steps in Figure 1.1.23.2. tell us we must know identity (who we are), mission (what we do), vision (where we're headed), guiding principles (the rules we follow), culture (what we stand for and believe in), and strengths and weakness (internal and external barriers, threats, and constraints) before we can move forward in planning. The box for strengths and weaknesses is often called SWOT for strength/weaknesses/opportunities/threats or SWOC for strengths/weaknesses/opportunities/constraints.

In discussing organizational change, DeLisi describes an experience he had at Digital. As part of their strategic planning intervention, Digital was working on what was essentially a SWOT analysis. They were preparing the background to work on strategic goals. But, they couldn't bridge from SWOT to strategy without dealing with the culture they had and the culture they wanted. In figuring out their culture, they found they were caught in between an entreprenerual culture and a professional management culture. This dilemma was essentially what Adizes describes when he discusses the nature of growing and aging in an organization. (Ichak Adizes, *Corporate Lifecycles*, Prentice Hall, 1988, p. 3, p. 227.) The growing company is long on flexibility and can change relatively easily because it has a low level of control. The aging company is long on controllability and has little propensity for change. The dilemma is appropriate because when an organization is both flexible and controllable, the organization is neither too young or too old. It has the advantages of both growing and aging.

Before Digital could work out their strategy, they had to deal with what kind of company they wanted to be—organizational culture. DeLisi says, "Before this time, key questions masqueraded as structural issues (should we be centralized or decentralized?), strategy issues (should we strive for cost leadership or differentiation?), and control issues (should we control more tightly or continue to give the divisions autonomy?). Now it was clear that the fundamental question facing this company was a cultural one. The company already had a highly entrepreneurial culture, but some managers thought it needed to move toward professional management, now that it had grown very large. The professionally managed culture, however, represented values that contradicted those of most individuals within the organization; they had grown up with entrepreneruial values. Once the executive committee understood that the core issue facing them was about culture, they decided to reaffirm the values that had made their organization successful in the past. *Apparent issues of strategy, structure, process, and information technology suddenly fell into place.*" (Peter S. DeLisi, "Lessons from the Steel Axe: Culture, Technology, and Organizational Change," *Sloan Management Review*, Fall 1990, pp. 83- 93.) [italics added]

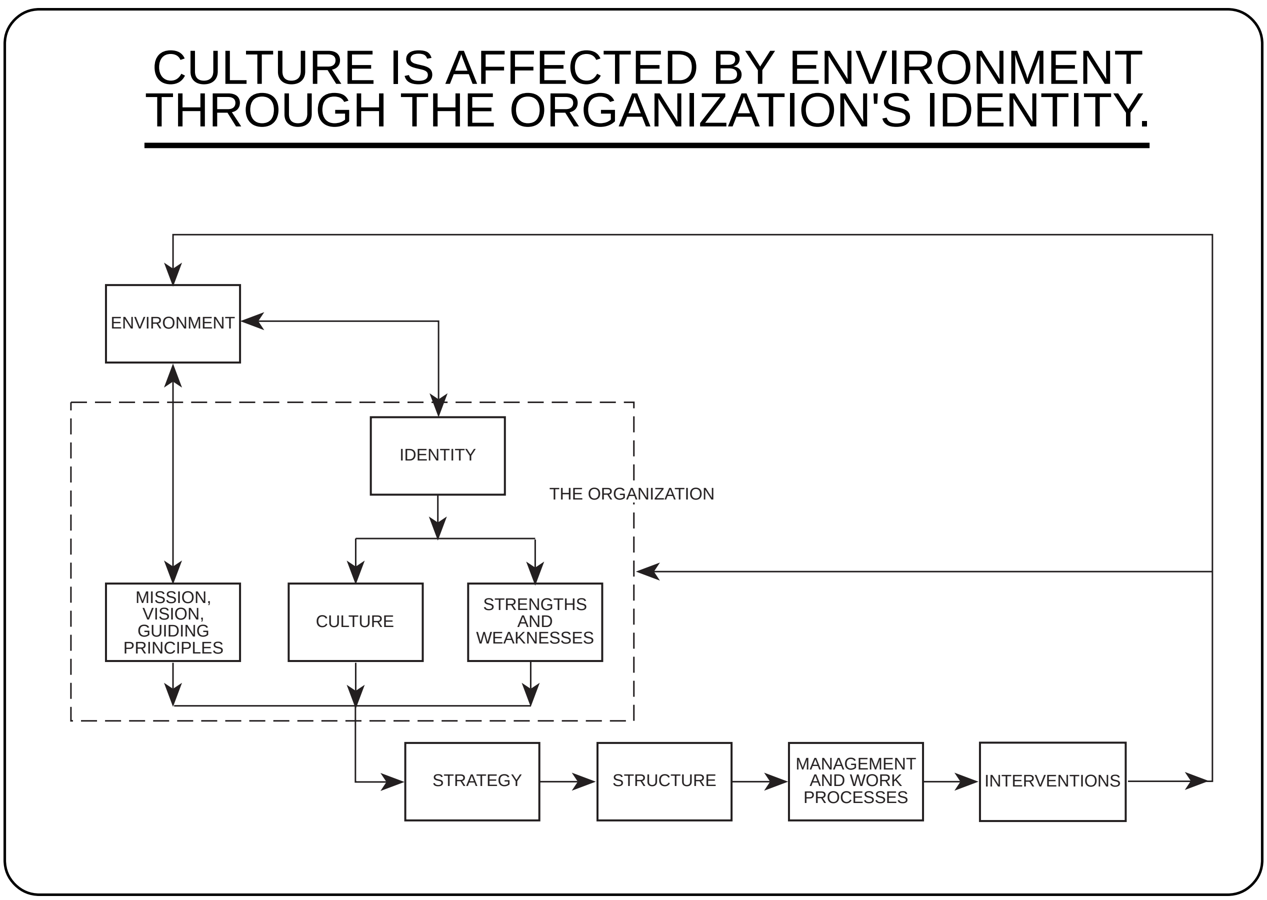

Figure 1.1.23.2. *The planning process represents an organizational model emphasizing the effect the environment has on the organization's strategy, which absolutely must be known before anything can be structured properly.*

1.1.23.3. The Organizational Effectiveness Pyramid

The organizational effectiveness pyramid tells us how to deal with four types of activities the manager must work in balance to move the organization forward.

As managers build and use tools to support their decision making, they have a number of things to do and roles to play. The pyramid in Figure 1.1.23.3. includes a significant set of activities at each apex: comprehensive planning, leadership, continuous performance improvement, and culture management. Together, the four significant sets of activities contain the essence of the organization and what the organization does. What an organization does and believes in is displayed as values, norms, and traditions. Values are long-term beliefs that are hard to change [Atkinson]. Traditions are established or customary patterns of action or behavior [Webster]. Norms are unwritten rules of behavior [Perry Buffington]. Together, the four significant sets of activities represent what the people in the business college call organizational effectiveness.

The organizational models I'll discuss as companions to or alternates for the management process functions all center on activities, tracks, fronts, or pursuits—in short, broad sets of things managers do and make decisions about in dealing with their responsibilities. I like the organizational effectiveness pyramid because of the raw strength, durability, balance, and cohesiveness of it. By its very nature, the pyramid shows strength, durability, and tight connections. In civil engineering, we learn what people have known since the pyramids in Egypt were built. In two dimensions, we gain structural strength through the triangle; and in three dimensions, we use the pyramid.

Peter DeLisi of Digital Equipment Corporation [in the Fall 1990 Sloan Management Review, pp. 83-93] when discussing information technology recalls the MIT framework for the Management in the 90s program as "a model of systemic interactions among organizational elements (information technology, organization and culture, strategy, individuals and their roles, and management processes) with 'management processes' in the center. ..... I would argue that 'organizational culture and leadership' should be separated from organizational structure and granted the central role in the system." The original MIT framework has been modified a number of times, including DeLisi's version, to search for what goes in the center. (DeLisi then discusses two models for an organization: the original MIT framework and DeLisi's own model.) In Figure 1.1.23.3., I show the kind of elements MIT uses in their framework as apexes and see the center as soft, human issues like values, traditions, and norms. The pyramid doesn't choose a central activity or responsibility of management, but does show cultural components as central, agreeing with DeLisi.

I like the pyramid representation because no apex is central. All apexes must be implemented. If one is ignored or not properly addressed, any short-term improvement will fade away. Since a manager can't do everything at once or is usually more capable or interested in one or more apexes over the others, the manager usually leads out with one apex. The pyramid says that if the manager gets one apex too far out ahead of the others, the strength of the pyramid is threatened. I, like Sherkenbach in his latest book [*Deming's Road to Continual Improvement*], see a manager's activities involving physical, logical, and emotional levels in dealing with an organization. I feel the continuous performance improvement apex emphasizes the physical, in that we need to get to specifics and measure something for continuous performance improvement. Customers demand quality rather than an illusion of it. I feel the leadership apex emphasizes the logical or mental, in that we need to logically move from the known toward the unknown in living up to a vision. I feel the culture management apex emphasizes the emotional, in that we need to rally people's emotions around beliefs and symbols to excite them in the mission, vision, and guiding principles of the organization. I feel the comprehensive planning apex emphasizes a fourth level I'll call the clairvoyant level, in that we need to forecast the future in all planning and have the vision to see things that don't exist. (According to Webster, clairvoyance is "the power to perceive matters beyond the range of ordinary perception." In the sense that Deming says management is prediction, perceiving beyond ordinary perception is necessary.)

A critical point in all this is that if you're doing continuous performance improvement, you make progress through physical means and arguments; whereas, if you're doing culture management, you make progress through emotional means and arguments. If the issue is emotional, you address that issue with emotional means. Another critical point is that the physical level has its place; but you must not overdo it. The emotional level has its place; but, you must not overdo it. If you push one level, or apex, too far, the pyramid comes apart.

The manager wants to work his or her organizational effectiveness pyramid to take advantage of its strength. As you work one apex, use the management tools appropriate to that apex and based on the right level of effort. But be ready to bring along the other apexes with the right tools to meet the needs of each apex.

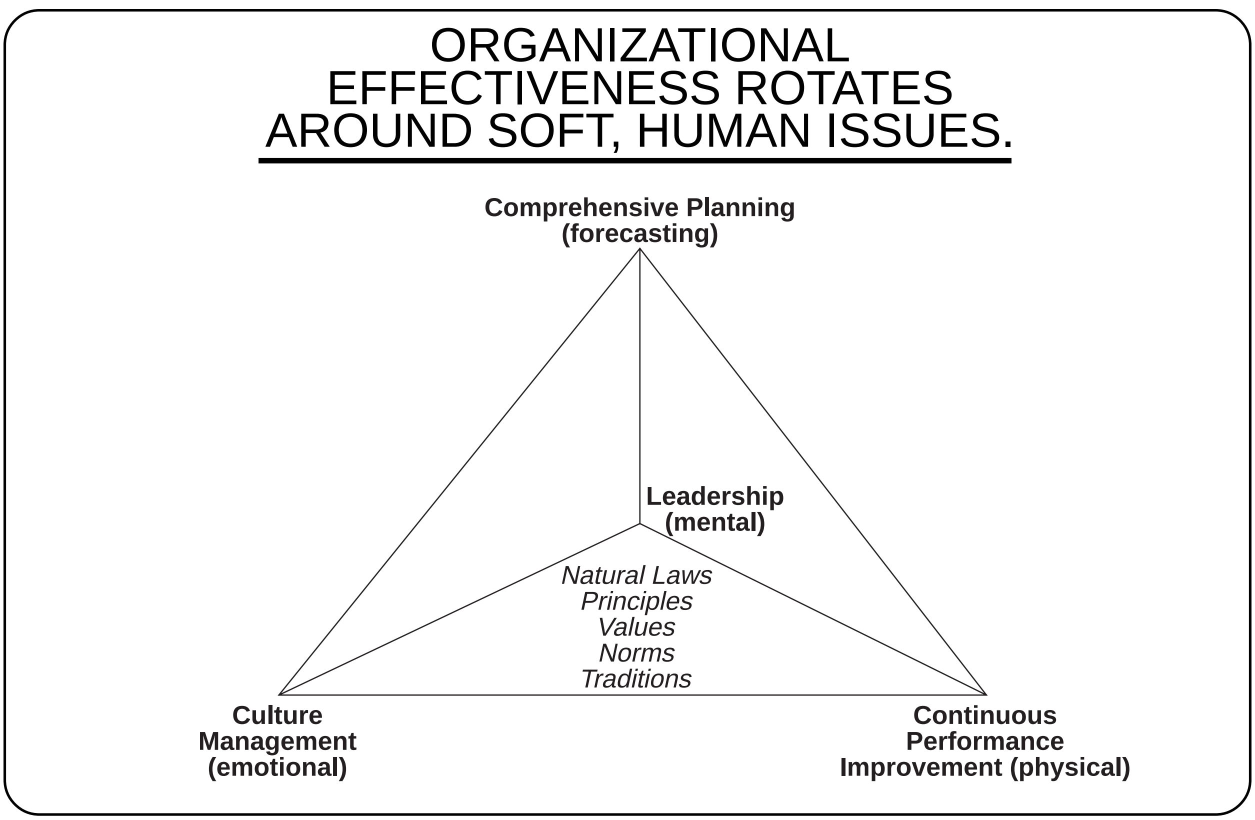

Figure 1.1.23.3. *The organizational effectiveness pyramid shows the strength, durability, balance, and interconnectedness inherent in balancing the activities for meeting a set of responsibilities.*

1.1.23.4. Origins of the Organizational Effectiveness Pyramid

As you work two or more of the apexes of the organizational effectiveness pyramid, you discover strong linkages among them, as in the case of culture management and continuous performance improvement providing connections for learning how to change to a quality culture.

Early in 1990, I was asked by a number of Westinghouse divisions to work with them on culture change. One of the divisions was responsible for operating the Department of Energy facility at the Savannah River Operations Office in South Carolina. At that time, all companies operating DOE sites were working under Secretary Watkins' direction that the DOE complex would change its culture.

I found that Westinghouse at Savannah River wanted to expand their safety culture into a quality culture. This direction spelled the tie-in between continuous performance improvement and culture management. I was also impressed with Edgar Schein's book *Organizational Culture and Leadership*. As an old civil engineer, the triangle of leadership, continuous performance improvement, and culture management displayed the strength that this huge undertaking needed. The graphic representation of the triangle gained favor in its ability to show strength and connections among the several sets of activities.

As I worked with several of the Westinghouse divisions over the next couple of years, our efforts looked a lot like a very comprehensive planning effort. This observation became more pronounced until I had no choice but to make the triangle a pyramid. In April, 1991, I made a teleconference presentation on *How to Change to a Quality Culture* in which I emphasized culture, culture change, quality, and the management process. I used the organizational effectiveness pyramid as the framework and rally point for those discussions.

I'm always concerned about a framework's completeness. I look for indications that the entities in the framework form a closed set, because I believe when you have a closed set and work the set properly you get a step function increase in synergy.

The engineers working with the pyramid were anxious about the emotional issues involved in culture management. The engineers knew very well you couldn't run things on emotion for very long. Emotion seems fleeting. A cheerleader charges you up today. But the realities of tomorrow have a sobering effect. Clearly, facts, direction, and physical evidence couldn't be neglected. But, I argued, neither could the emotional side of the coin. I suggest using emotional means when dealing with culture and its emotional underpinning. I suggest using physical evidence and facts when dealing with continuous performance improvement. Emotion-based tools and guides have their place, just as fact-based tools do. The four levels of physical, emotional, mental, and forecasting (clairvoyant) filled the bill in searching for balance and for confirming a complete set of activities in Figure 1.1.23.3.

Steve Markham of Virginia Tech's college of business was involved in brainstorming a map (flow diagram) for culture change in a discussion including the organizational effectiveness pyramid. He said that the pyramid offered nothing new in that the apexes were what people in the business college call organizational effectiveness. At this point I named the pyramid. I prefer to believe that what's new is the engineer's perspective of the strength and cohesiveness of the pyramidal structure and the emphasis the pyramid places on the interdependency of the activities of the apexes. That way, we don't lose the forest as we investigate the trees. You can study any of the trees (apexes) for years and believe that apex is all there is and that following the apex spells success. Many have tried and failed. I worked with a person on a Citibank project who believed he could ride culture management to ultimate success. As a result, he lost his company. The pyramid says you can't forget the forest (the four sets of activities and how they connect) or you'll fail.

Steve Van Aken reflects on the idea that in materials science a pyramid is a tight, well-bonded (covalent) unit, a diamond. The pyramid is shaped like a diamond, although the unit cell of a diamond is a face-centered cubic. I like the analogy. If we find the fundamental activities of organizational effectiveness bonded like a diamond, we find not only great strength but great beauty.

1.1.23.5. Support for the Organizational Effectiveness Pyramid Linkages

Researchers and practitioners in organizational effectiveness support the strength and cohesiveness of the organizational effectiveness pyramid by demonstrating the importance of each link between apexes.

The pyramid gets its strength through the linkages among the apexes. I'll show support for the linkages shown in Figure 1.1.23.3. by relating how each link is demonstrated by a leading researcher or practitioner.

The advocates of the *culture management/continuous performance improvement linkage* are Philip Crosby who said, "Reaching the desired [result is] a matter of culture change. Keeping it there is a matter of management style." [*Quality without Tears*, p. 13], Kiyoshi Suzaki in his book *The New Manufacturing Challenge: Techniques for Continuous Improvement*, and John P. Kotter in his book *Corporate Culture and Performance* (with James L. Heskett).

An advocate of the *culture management/comprehensive planning linkage* is Ralph H. Kilmann in his book *Managing beyond the Quick Fix* (1989). He says, "A multiple approach to organizational success must include a variety of leverage points in order to control—hence manage—performance and morale. A *leverage point* is anything that a manager can change in the organization, such as rules, procedures, objectives, and the acquisition of skills. The principle of multiple approaches is demonstrated by the five tracks: (1) the culture track, (2) the management skills track, (3) the team-building track, (4) the strategy-structure track, and (5) the reward system track. These tracks are designed to remove the full range of at-the-surface and below-the-surface barriers to organizational success. Each track consists of specific leverage points for use by managers and consultants.

Furthermore, as a result of the interconnectedness of every aspect of the organization, the five tracks must be conducted in sequence—(1) through (5)—as multiple, *integrated* leverage points. The first track develops a culture to foster trust, communication, information sharing, and willingness to change among members—the qualities needed to proceed with all other improvement efforts. During the second track, all managers learn new skills for solving complex problems. In particular, they learn the methods for uncovering and then updating assumptions; without a supportive culture, managers would keep their assumptions under lock and key. The third track enables each work group to make daily use of the new culture and updated skills for solving important business problems; gradually, former cliques become effective teams. The fourth track guides these effective teams to address two of the most important yet most sensitive problems an organization can face: its own strategy and structure. Once the organization and all its members are moving in the right direction, the fifth track designs a reward system to sustain high performance and morale into the future. Naturally, the organization's functioning must be examined periodically to evaluate whether fine tuning is needed in any of the tracks. Any external changes in the organization's setting may require corresponding internal adjustments, and the cycle of planned change continues.

Multiple approaches to organizational success, therefore, mean influencing all the organization's surface aspects and its cultural, assumptional, and psychological aspects. This point is so fundamental that it cannot be overstated. I consider it foolhardy for managers and consultants to try to solve today's interconnected problems with a single approach that uses only one leverage point." (pp. 12-13.) This quote shows the sequencing of tracks from culture management (the culture track) to comprehensive planning (the strategy-structure track).

I'll discuss Kilmann's ideas more when I describe his five tracks in another module.

Advocates of the *leadership/comprehensive planning linkage* are Richard O. Mason and Ian I. Mitroff in their book *Challenging Strategic Planning Assumptions* (1981). They say, "Today, few of the pressing problems policymakers face are truly problems of simplicity or of disorganized complexity. They are more like ... problems of organized complexity. These problems simply cannot be tamed in the same way that other problems can. For this reason Rittle refers to these problems of organized complexity as 'wicked' problems.

Wicked problems are not necessarily wicked in the perverse sense of being evil. Rather, they are wicked like the head of a hydra. They are an ensnarled web of tentacles. The more you attempt to tame them, the more complicated they become. ...Most policy planning and strategy problems are wicked problems of organized complexity." (pp. 9-11.) The authors list six characteristics complex wicked problems exhibit. They are:

"1) Interconnectedness—Strong connections link each problem to other problems. ...

2) Complicatedness—Wicked problems have numerous important elements with relationships among them, including important 'feedback loops' through which a change tends to multiply itself or perhaps even cancel itself out. ...

3) Uncertainty—Wicked problems exist in a dynamic and largely uncertain environment, which creates a need to accept risk, perhaps incalculable risk. ...

4) Ambiguity—The problem can be seen in quite different ways, depending on the viewer's personal characteristics, loyalties, past experiences, and even on accidental circumstances of involvement. ...

5) Conflict—Because of competing claims, there is often a need to trade off 'goods' against 'bads' within the same value system. ...

6) Societal Constraints—Social, organizational, and political constraints and capabilities, as well as technological ones, are central both to the feasibility and the desirability of solutions." (pp. 12-13)

"The wicked problems of organized complexity that policymakers face today have two major implications for designing processes for making policy:

1) There must be a broader participation of affected parties, directly and indirectly, in the policy-making process.

2) Policy making must be based on a wider spectrum of information gathered from a larger number of diverse sources." (p. 13)

I read Mason and Mitroff's suggestion for how to deal with wicked problems as 1) involve the stakeholders (participation—consensus) and 2) use systems thinking. These ideas are two main ideas I'll discuss at length throughout this book. As you look at the characteristics of wicked problems, I believe you'll discover that more and more problems are wicked today. The leadership and comprehensive planning linkage and the complete organizational effectiveness pyramid address the ideas of participation and systems thinking.

The advocate of the *culture management/leadership linkage* is Edgar H. Schein in his book *Organizational Culture and Leadership* (1985).

A advocate of the *comprehensive planning/continuous performance improvement linkage* is J.M. Juran in his book *Juran on Planning for Quality* (1988).

The advocate of the *leadership/continuous performance improvement linkage* is W. Edwards Deming in his book *Out of the Crisis* (1982).

1.1.23.6. Culture, Symbols, and Models—Emanuel Leutze

1.1.23.7. A Strategic Planning Framework Reflecting Organizational Effectiveness

We can determine a process model of the organization to reflect components of organizational effectiveness and to incorporate planned or unplanned interventions affecting performance.

In Figure 1.1.23.2., we saw the importance of the environment and changes in the environment on the organization and its planning. Management Systems Laboratories (MSL) has developed a planning process that reflects the cyclic, iterative nature of Figure 1.1.23.2. I show that process, which MSL calls its change management model, in Figure 1.1.23.7.1. A simpler version of Figure 1.1.23.7.1. is shown in Figure 1.1.23.7.2. Notice from Figure 1.1.23.7.1. that we best manage change through a closed-loop process; to be successful in change we need extensive training; and, to implement change, we need basic skills in project management (box number ten in Figure 1.1.23.7.1.).

MSL's Approach

The planning process is the vehicle by which the organization determines what is *should* be about and how best to do it. Even in the case of public organizations whose missions are dictated by precedent, statute, or regulation, strategic planning is vital to insure all stakeholders are considered in the operational plans and that no part of the organization negatively affects what the organization wants to do. The process in Figure 1.1.23.7.1. is modular and no organization can perform every step completely each planning cycle. However, over a period of time, the organization works through the closed-loop process to improve performance.

Step 1. Prepare the Organization for Planning

We identify a champion to implement the planning process. The champion wants the planning process improved and can obtain the necessary commitment from employees and resources needed to accomplish the change. We then do an organizational survey to determine the current climate and culture. With the survey, we interview key personnel who will be involved in the planning process to provide an overall assessment of where the organization is in terms of knowledge and information needed for an effective implementation process.

Step 2. Review Inputs, Assumptions, and Constraints

We review key organizational documentation related to mission, vision, principles, and organizational functions. We review organizational requirements from higher levels of authority (for public organizations, senior department and offices in government, Congressional legislation, etc.; for private organizations, corporate headquarters, stockholders, etc.) to place organizational planning within the context of a larger system.

Step 3. Define the Organizational System

We define the organizational system by looking at inputs and outputs to the system or by looking at the organization's primary process. We define inputs and outputs, suppliers, consumers, customers, and stakeholders (both internal and external). We want to think beyond the traditional structure and look at the organization as a system.

Step 4. Confirm the Organizational Functions

We review organizational functions based on the results of the previous step. Organizational functions must align with the current inputs, outputs, suppliers, and customers for efficiency and mission effectiveness. We assess organizational teamwork and acceptance of the responsibility for carrying out the functions defined.

Step 5. Conduct a Situational Analysis

We review current performance levels within the context of their internal and external environment. We analyze internal strengths and weaknesses and external opportunities and constraints to set the stage for defining goals and strategies for the organization.

Step 6. Define the Strategic Path
At this point, we have the necessary information to define strategic goals for the organization. Strategic goals state what must be done to accomplish the organization's mission in pursuit of its vision. They represent a desired future state without quantification or time definition. We define strategic goals. We define near-term operational objectives to achieve the strategic goals from the bottom up based on the environmental analysis completed in Step 5.

Step 7. Define Strategies
Now, building on the results of Steps 1-6, we define strategic programs to build on strengths, correct weaknesses, take advantage of opportunities and deal with constraints. We give the programs that are associated with a particular goal identified in Step 6 priority based on availability of resources and importance to the mission.

Step 8. Review the Current Mission
Here, we take a longer view of the strategies being developed and their alignment with the organization's mission. In Step 2, we reviewed the mission as input into the planning process. In this step, we review the mission for content to ensure it aligns with the goals, objectives, and strategies defined in Steps 5-7. If we find little or no alignment, then we either revise the mission statement or develop new strategies that fit the mission. If the mission isn't aligned with the goals, objectives, and strategies and remains unaligned, inefficient work processes and ineffective decision making processes will emerge over time. This emergence will cause the organization to become unstable and adversely affects its ability to react appropriately to changes in the environment.

Step 9. Review Organizational Structure
Prior to implementing strategic planning efforts, we must review the organizational structure and its alignment with the chosen strategies. Does the organizational structure support the successful accomplishment of the goals, objectives, and strategies? If the current structure hinders achievement of strategic goals, we need to consider alternative structures. Occasionally, organizations can't restructure. In such a case, we at least identify structure as a constraint and plan around the constraint.

Step 10. Develop Action Plans
Here we develop the action steps to successfully implement the strategies. The level of the organization doing the planning will determine the specificity of the action steps. For instance, action steps at corporate headquarters are usually broader and more strategic than those at the field level. At this time, we need to define the measures necessary to track progress toward achieving our goals. These action plans form the basic components of the five-year plan.

Step 11. Measure Progress
Assessment of progress toward the implementation of strategies and accomplishment of strategic goals is an ongoing process. We must monitor action plans with measures of merit and then adjust accordingly.

Step 12. Assess the Situation
In today's dynamic environment, we must continually monitor our external conditions and adjust to the changing situation. The strategic plan identifies most likely forces to significantly affect an organization's operations and anticipates how these forces might change over time by the use of structured planning tools. Periodically, we must assess the current situation to ensure changes to the internal and external environment haven't made goals or strategies obsolete.

Step 13. Conduct Annual Review
Annually, we must review Steps 1-5 to revisit our mission in light of the current situation and assess progress toward achieving our goals for the year.

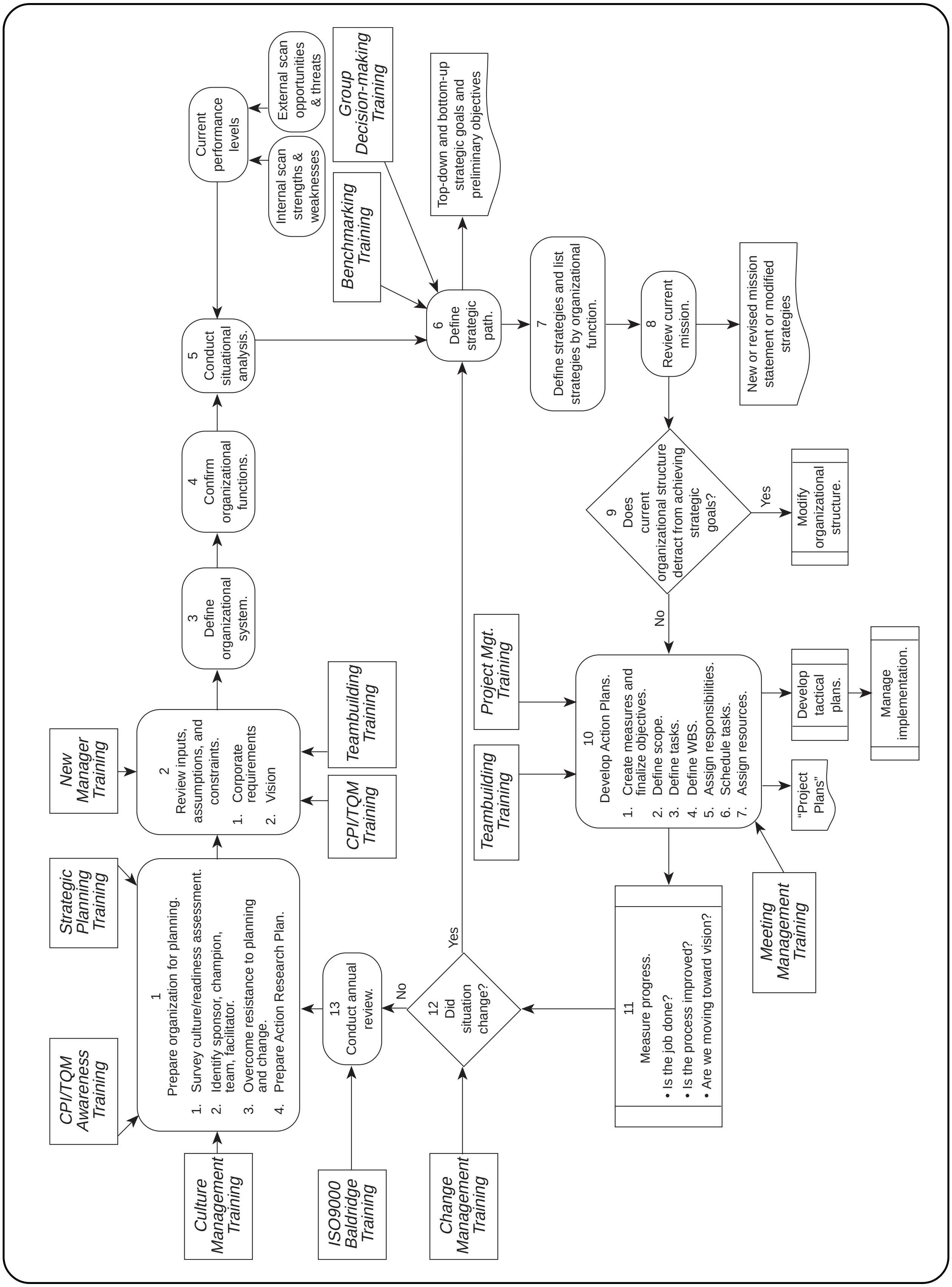

Figure 1.1.23.7.1. *The MSL Change Management Model, largely produced by Will Guerrero, shows the closed-loop process nature of continuous improvement.*

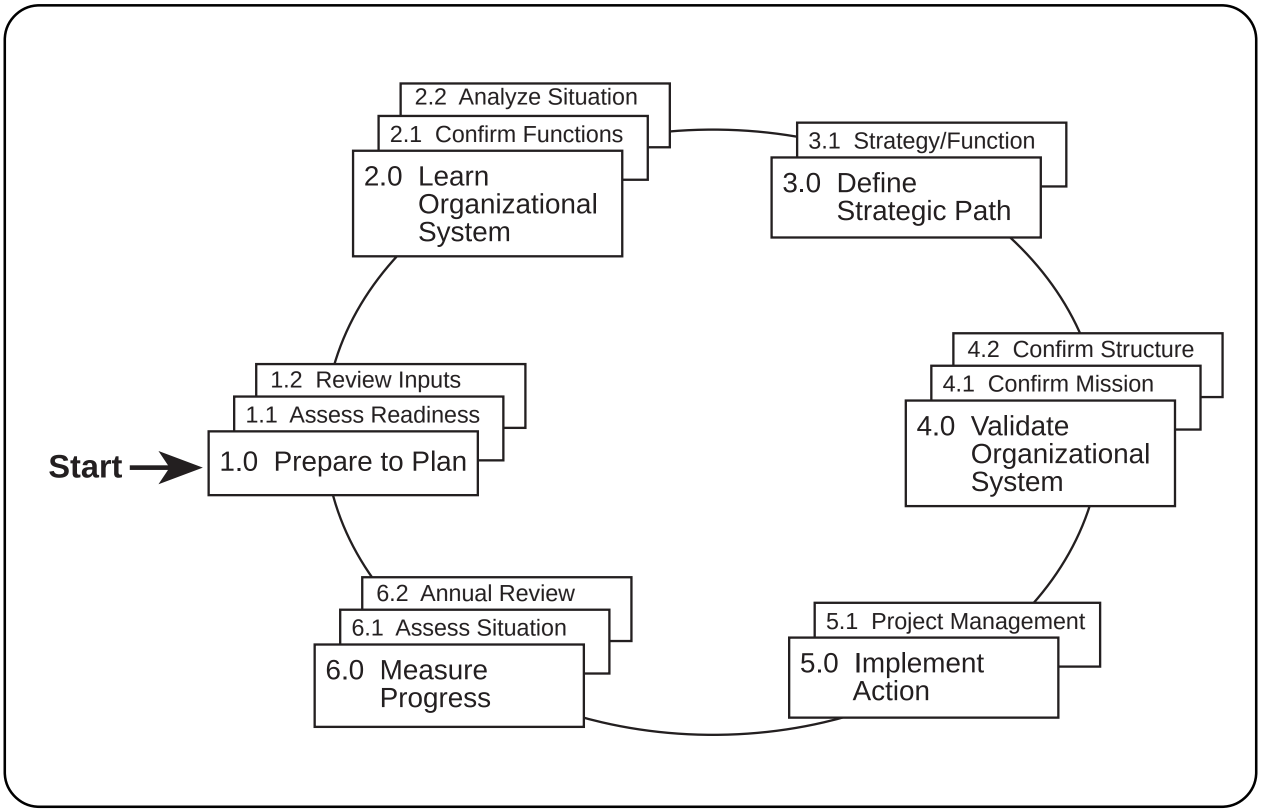

Figure 1.1.23.7.2. *Brian Kleiner's simplification of the change model highlights six major phases of the change process.*

1.1.23.8. Weisbord's People, Technical, and Reward Systems

The domain of responsibility considered as a management system includes three highly-interactive subsystems: people, technical, and reward systems.

I introduced Weisbord's model for people, technical, and reward systems in Module 1.1.4. when asking time-honored, fundamental management questions. Weisbord's model, reproduced in Figure 1.1.4., is especially useful because of its simplicity, robustness, and universal application. You can see these three systems (or I prefer to call them subsystems of the management system) at play everywhere.

Early in Weisbord's career, he was introduced to his model with the suggestion to "stop building long lists of undifferentiated problems and instead think of [himself] as managing three related systems." In reviewing what he calls "'exemplary individuals' in management history," Weisbord links pairs of the subsystems. Frederick Taylor took the engineer's technical approach to management. Kurt Lewin and Douglas McGregor took the social scientist's people approach to management. Fred Emery and Eric Trist took a combination, or sociotechnical, approach to management. Weisbord says, "Trist coined the phrase *sociotechnical system* to underscore his observation that the interaction of people (a social system) with tools and techniques (a technical system) results from choice, not chance. Our choices are dictated by economic, technological, and human values." (p. 143.)

We know that people look at management from the socioeconomic perspective and from perspectives combining the economic (reward) and the technical subsystems. As a matter of fact, Frederick Taylor was also known for combining the economic and technical subsystems. (Weisbord, p. 64.) Everyone asks questions ultimately involving all three subsystems. When they apply their expertise, they tend to focus on the question from one or two of the subsystem perspectives.

Weisbord says, "Trist invented a way of thinking about management more grounded in the way businesses really run. He called it 'finding the best match between social and technical systems.' Emery, perhaps the first to apply open systems thinking to social change, pointed out that optimal results could be achieved only when social systems, which obey the laws of biology, psychology, and sociology, are *designed integratively* with technical systems following the laws of physics, chemistry, and engineering." (p. 23, italics added) As a management systems engineer, you'll need to mix the quantitative sciences (technical systems) with the qualitative sciences (people systems) with great facility.

Weisbord finds Taylor "a perfect projection screen for the dialogue in each of us between social and technological impulses ...." (p. 27.) Throughout Weisbord's book, he presents us with the issue of balance—here the need to balance people and technical aspects of management, later to balance the Theory X and Theory Y impulses in all of us.

In discussing Taylor further, Weisbord says, "His intent was to accumulate the best knowledge available and ensure its quick transfer. ..... That is still our intent. Productive workplaces require it. Yet we know for certain now that optimum productivity and human satisfaction can't be reduced to rules and formulas, whether grounded in economics, engineering, or human relations. Indeed, high-quality work requires a creative interaction of all three perspectives. In successful workplaces workers, managers, and staff specialists achieve a partnership, learning together, bringing skills, expertise, information, and mutual support to economic and technical problems. ..... Moreover, we simply do not know enough about the complex process of working to make a true science of figuring out the right balance among people, economics, and technology. In each place it will be different. ..... The important thing to see is that three realities—social, technical, and economic—must be simultaneously worked with if we wish to achieve productive workplaces. More, none of the three bailiwicks can be left to experts. Information from and about all three must be freely available to everybody, so that an organization develops through mutual influence, knowledge, and commitment, rather than coercion, whimsy, or unilateral action." (pp. 64-66.)

Weisbord considers his people, technical, and reward systems to be the makeup of a productive workplace—if you will, a management system. He illustrates the fundamental nature of the subsystems in a diagram I've reproduced here as Figure 1.1.23.8. He says this about the diagram: "If I have learned anything from my time trip it is this: those who set sail to improve innovation and stability, work and working life, quality and output, always come up short if they focus only on technology, only on costs or profits, only on human resources. Productive workplaces require that people—you, me, everybody—be deeply engaged in understanding and working with economic and technological matters. The only sensible way to make real a commitment to 'our people' is to have our people work together in rethinking their own work—as captured in [Figure 1.1.23.8.]. Figuring out how to do that has been a dominant theme for workplace improvers for two decades now." (p. 180.) In short, balance is the answer.

In his last discussion of economics, technology, and people, Weisbord says, "My major ah-ha after finishing this book is how concepts of improvement evolved over the last century, from experts solving problems piecemeal (Taylorism), to everybody solving problems piecemeal (participative management), to experts improving whole systems (systems thinking), and now everybody improving whole systems (third-wave stuff)." (p. 373.)

Later when I discuss the generalist perspective, I'll argue the importance of drawing connections among seemingly dissimilar things. Bühler, the psychologist, described the ah-ha (or aha) experience. Lou Middleman in his book *In Short* says he defines an "Aha! as a suddenly perceived <u>connection</u> between two or more things you did not previously see as connected." (p. 17) So, when we say we had an aha we mean we understand a new connection.

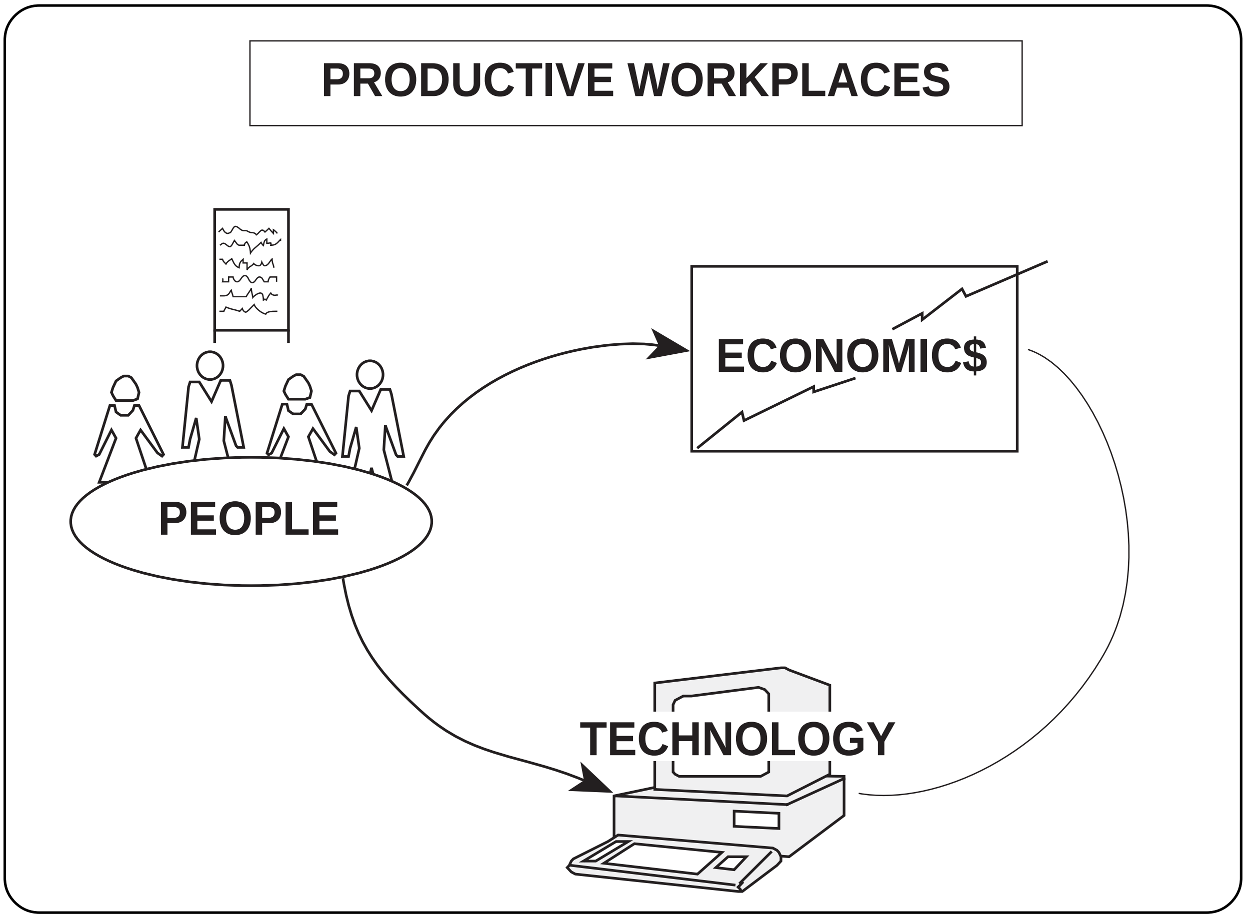

Figure 1.1.23.8. *A productive workplace includes people, economics, and technology subsystems working within a whole system. (taken from Weisbord, p. 180)*

1.1.23.9. Kilmann's Five Tracks

Kilmann designed his five tracks (culture, skills, team-building, strategy-structure, and reward system) to organizational success to act on five leverage points in his Barriers to Success Model to transform all controllable barriers into channels for success.

Kilmann's Barriers to Success Model fits well within the organization box of the management process framework and, according to Kilmann, approaches the world as a complex hologram.

Kilmann describes his five tracks as actions on five leverage points to transform controllable barriers into channels for success in an organization in his book *Beyond the Quick Fix*. (Jossey-Bass, 1984) Kilmann argues that past approaches to organizational success (the right-hand box in the management process framework) have failed because each looked for a single answer in a complex, open system. He indicates the human relations training of the 1940's, management by objectives of the 1950's, decentralization of the 1960's, corporate strategy of the 1970's, and corporate culture of the 1980's (Salmans, 1983) weren't effective because their perspectives we're too narrow. (p. ix.)

Kilmann offers the solution. He says, "Single approaches are discarded because they have not been given a fair test. Essentially, it is not the single approach of culture, strategy, or restructuring that is inherently ineffective. Rather, each is ineffective only if it is applied by itself—as a quick fix. ..... The only alternative is to develop a truly integrated approach." (p. x.) I like this thinking because Kilmann doesn't discard any of the previous approaches as wrong. Instead, he sees each as stepping stones toward an integrated, effective solution. Such a solution brings success defined as achieving both high performance and high morale over an extended period of time. Kilmann lists five tracks within a complete program to get this success.

"The complete program consists of five tracks: (1) the culture track, (2) the management skills track, (3) the team-building track, (4) the strategy-structure track, and (5) the reward system track. If any of these tracks is implemented without the others, any effort at improving performance and morale will be severely hampered. Any benefits derived in the short term may soon disappear. Lasting success can be achieved only by managing the full set of five tracks on a continuing basis." (p. x.)

You can see reflections of the other organizational models in Kilmann's tracks. You see the culture management apex of the organizational effectiveness pyramid, the strategy-structure connection in the model linking structure to strategy to environmental change, and the reward system of Weisbord.

Kilmann further says, "The five tracks—in contrast to a quick fix—are integrated in a carefully designed sequence of action; one by one, each track sets the stage for the next track. ..... To illustrate the integrated nature of the five tracks, consider the following scenario: If I could investigate only one aspect of an organization in order to predict its long-term success, I would choose the reward system. In essence, if members feel that (1) the reward system is fair, (2) they are rewarded for high performance, and (3) the performance appraisal system regularly provides them with specific and useful information so that they know where they stand and can improve their performance, then, in all likelihood, all tracks have been managed properly. The reward system could not motivate members to high performance if all the other barriers to organizational success had not been removed by the preceding four tracks." (pp. x-xi.)

With this comment, Kilmann sets up the need to remove barriers to success. Recall Lewin's force field analysis, where we say the way to move the status quo in the direction we want is to emphasize reducing restraining forces over enhancing driving forces.

Kilmann says, "Behind every approach to organizational success is a theory. This theory proposes how a change in one set of variables will bring about change in a second set. The first set of variables usually includes leverage points that are directly controllable by managers and consultants; the second set is the intended result—organizational success.

The theory that supports a quick fix states that a change in *one* independent variable, such as strategy, is enough to change a desired outcome, such as performance. This type of theory is as simple and machine-like as the quick fix itself. The theory that supports an integrated approach states that changes in *several* interrelated variables, such as strategy, structure, and culture, are necessary to achieve the intended results. The theory behind the five tracks, therefore, must show the complex relationships among many different kinds of variables." (pp. 31-32.)

Recall that the framework for the management process brings out relationships between variables related to the interventions, variables related to the organization, and variables related to performance. When we understand the variables and their relationships we understand the framework for the management process. I agree that high morale must be included in the success criteria in the performance box of the management process framework.

Kilmann introduces his model by saying, "Figure [1.1.23.9.] shows the theory behind the five tracks in the form of a model. The model consists of five broad categories representing the open systems aspects of an organization plus, at center stage, three holographic aspects that add the dimension of depth. ..... The double arrows surrounding the 'holographic diamond' signify the strong reciprocal influence between the three below-the-surface aspects and all the other categories. ..... The purpose of the holographic model is to understand and master all these 'interrelated guesses.'" (p.32-33.)

The arrows in the management process framework of Figure 1.1.11.4. between boxes and within boxes represent hypotheses we need to substantiate for a given domain of responsibility. Kilmann's model fits comfortably within the organization box, except that the "The Results" category belongs in the performance box of Figure 1.1.11.4. Kilmann calls his model the Barriers to Success Model and he identifies uncontrollable barriers and controllable barriers. His five tracks relate to the controllable barriers.

"Regarding the *un*controllable barriers, each organization has three 'facts of life.' The first is the setting in which the organization exists. While dynamic complexity can be monitored, it must be taken as a given. The second uncontrollable barrier is the human psyche—deep-seated, relatively fixed styles to cope with life's problems. The third such barrier is assumptions—the unstated beliefs behind decisions and actions. While assumptions are hidden from view, they can be updated to reflect reality with proper management skills and a supportive culture." (p. 34.)

The setting in Kilmann's model is the environment in some models, the category that allows the model to represent an open system. Notice that the other categories flow from the setting category in Figure 1.1.23.9.

Kilmann further says, "Regarding the controllable barriers, each organization has five leverage points that can affect morale and performance: (1) the firm's culture, (2) the mangers' skills for solving complex problems, (3) group approaches to decision making and action taking, (4) strategic choices and structural arrangements, and (5) the purpose and design of the reward system. There also may be a number of other leverage points whereby the organization can be 'touched' directly, but these other points tend to provide quick fixes (such as replacing personnel or reclassifying jobs) rather than long-term solutions to complex problems.

The five tracks to organizational success were designed to act on these five leverage points—to transform all controllable barriers into channels for success. The culture track is a series of planned action steps to identify an outdated culture, develop the new culture that will move the organization forward, and then implement the new culture into each work unit. The management skills track, as a series of action steps, provides managers with the new skills necessary to address dynamic complexity—skills for surfacing, examining, and then updating assumptions. The team-building track does three things to improve the quality of group decision making in a series of action steps: (1) keeps the troublemakers in check so that they will not disrupt cooperative team efforts, (2) brings the new culture and updated assumptions into the day-to-day decision making of each work group, and (3) enables cooperative decisions to take place across work group boundaries, as in multiple-team efforts. The strategy-structure track goes through a step-by-step process to determine (or confirm) the new strategic directions of the firm, including the organizational structures that would most support the accomplishment of the firm's mission. The reward system track goes through its action steps to design the compensation and performance appraisal system necessary to sustain the benefits from all the other tracks."

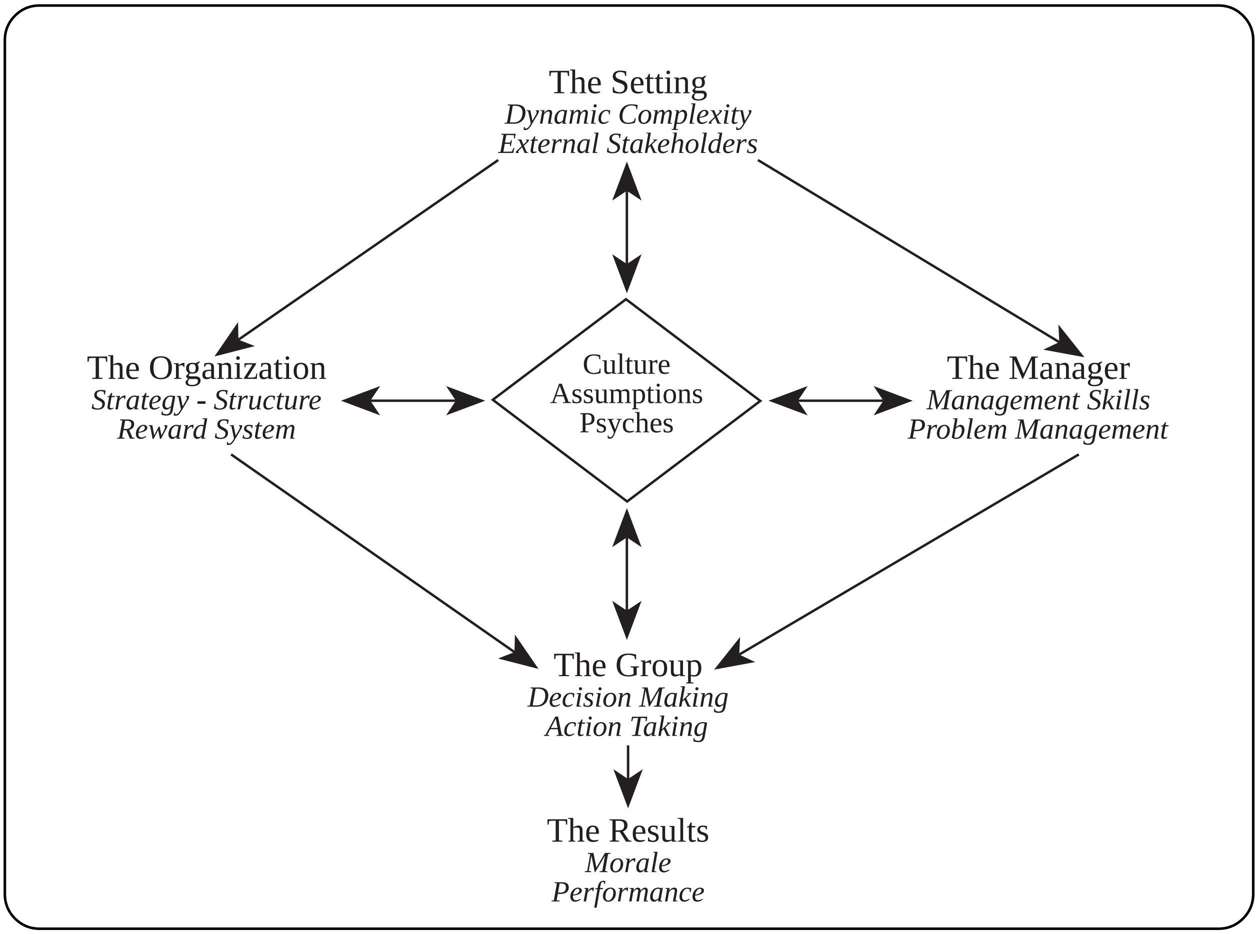

Figure 1.1.23.9. *Kilmann's Barriers to Success Model identifies the leverage points where you can apply the five tracks as channels for success. (taken from Kilmann)*

1.1.23.10. Sink's Seven Fronts

The organization can be viewed as containing seven (or perhaps eight) fronts using tools and guides to translate interventions into success criteria. The eight fronts include planning systems, culture management, infrastructure, education and development, measurement systems, recognition and rewards, politics, and technology.

Scott Sink brought to some mutual work we were doing a concept of seven fronts for improving performance within a grand strategy perspective. Under a grant for the United States Department of Energy, one of the fronts became more specific and another front was added—at least for the grand strategy application of the grant. I'll quote the seven fronts and their use in developing a grand strategy from a paper by Kent E. Williams, Harold Kurstedt, and D. Scott Sink titled *A Grand Strategy System Helps Managers Continuously Improve their Planned Strategies*. (American Society for Engineering Management, October 1991)

"Figure [1.1.23.10.] shows the conceptual model [for] grand strategy [and] includes six elements: past, present, future, fronts, integration within and among fronts, and feedback across time horizons. The systems, tools, and procedures associated with managing performance across the fronts, are implemented in the present to become past strategy to be measured in terms of success or failure, and will lead to future decisions regarding needed interventions. Future strategies for continuous improvement must be influenced by what has been done in the past to ensure constancy of purpose (Deming, 1991). There are seven fronts: culture, measurement, planning, infrastructure, rewards and recognition, education and development, and politics. Interventions of one front may or may not affect other frontal interventions.

Fronts include the systems and tools used to manage and eventually improve the performance of organizational activities. If managers don't manage these fronts synergistically, they won't satisfy four major success criteria: cost, schedule, quality, and satisfaction of critics." (p. 91.)

The seven fronts (or however many) can be tied together hypothetically as an organizational model within the organization box of Figure 1.1.11.4. The success criteria belong in the performance box. Rather than using the term procedures with the tools, I would use guides to be consistent with the concept of tools and guides in Module 1.1.16.8. I'll show later that procedures are one type of guide.

Williams, et al continue, "The seven fronts will be integrated as interventions incorporated into present strategy during the process of formulating planned or future strategy for desired organizational change. These fronts, therefore, are believed to affect the quality of the grand strategy system process shown in Figure [1.1.23.10.]. If the difference between desired outcome of past and present strategy is unacceptable, improvement to the organization can be promoted by the intervention of activities, tools, and systems associated with each front. As an example of implementing a grand strategy system, planned strategy and its implementation must be monitored by the appropriate measurement system. Formulating planned strategy must integrate planning with staffing, budgeting, sales, marketing, production capacity, etc. Likewise, activities associated with other fronts must be considered in formulating planned strategy. The seven fronts defined are:

Planning Systems: Interventions to enhance the way the organization plans, particularly planning for improvement (e.g., Total Quality Management/Leadership implementation and deployment), includes integrating planning activities with other management functions (e.g., budgeting, staffing, reporting).

Culture Management: Interventions to identify, understand, and improve the organization's shared values, beliefs, and norms.

Infrastructure: Parallel structure (outside the formal organization chart) established to support a continuous performance improvement implementation.

Education and Development: A broad spectrum of interventions aimed at continuously improving an organization's base of knowledge and skills.

Measurement Systems: Interventions to enhance the indices the management team uses to determine how the organization is performing (i.e., whether it is improving, and/or if it is in control).

Recognition and Rewards: Interventions to improve the way an organization recognizes/rewards employees on a formal and informal, financial and non-financial, individual and group basis.

Organization-Specific: Areas of strategic importance due to the organization's current internal and external environments." (p. 92.)

The organization-specific front was oriented toward politics, especially for a government agency and defined in grant documents as "The system that focuses on interorganizational linkages, networking, maintaining essential communication within organization and between organizations, upline posturing, influencing decisions and actions within and around the organization, managing the task environment (e.g., quality [checkpoints]), includes the concept of political astuteness, incorporates informal organization theory." The eighth front is technology. The front is defined in grant documents as ".... very generally 'the way things get done'. To include software, hardware, procedures, methods, processes." (From grant reports)

Fronts are called fronts because you don't let one get ahead of the other. The word front is a military analogy. A front is an area of emphasis to move on an objective. If one front gets too far ahead of the others, the front can be cut off and you'll fail the objective.

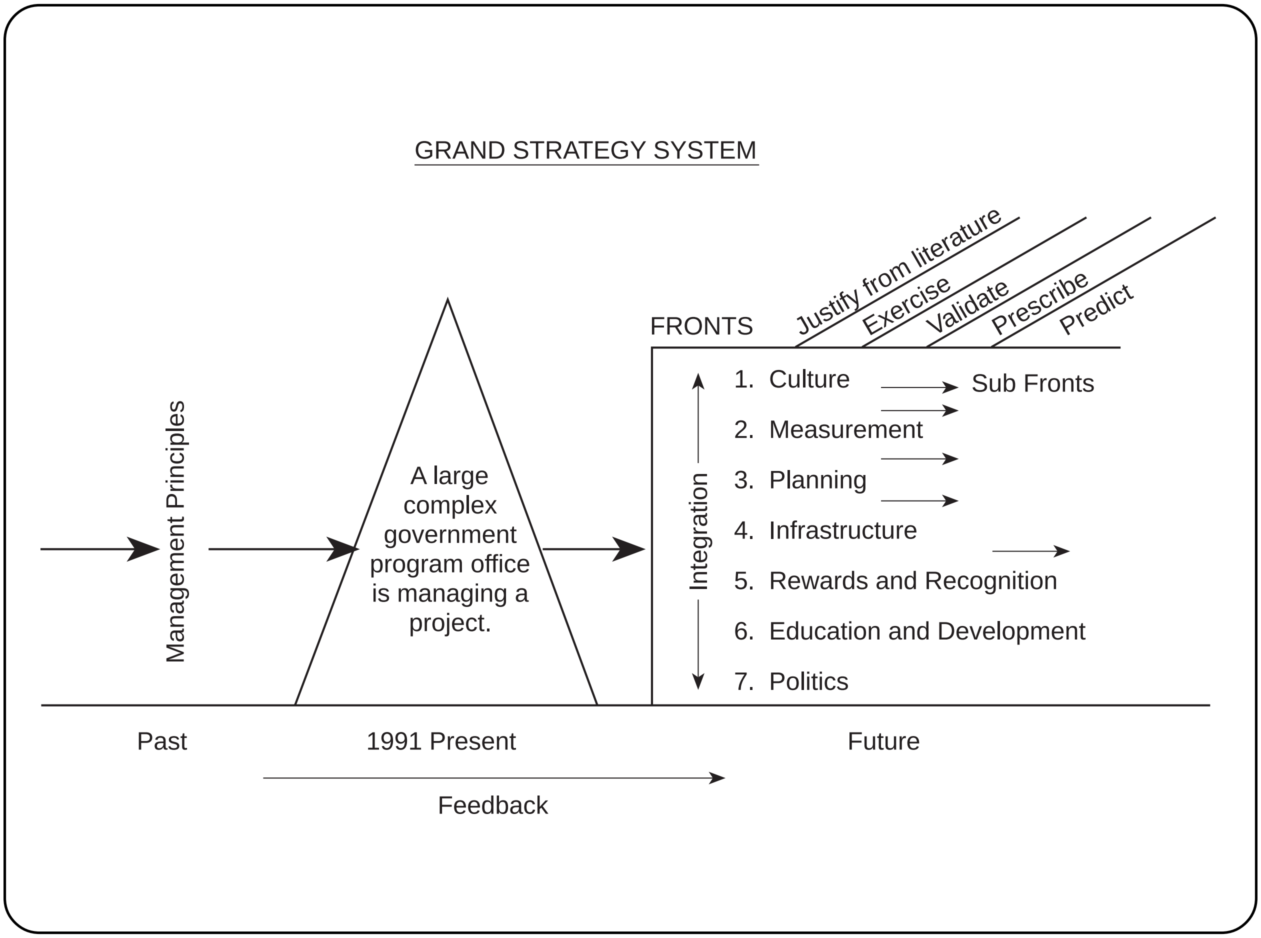

Figure 1.1.23.10. *The Grand Strategy System concept emphasizes the past, present, and future perspectives and the seven fronts for management as we advance from justification to prediction approaches. (taken from Williams, et al)*

1.1.23.11. How to Use the Various Organizational Models

You can use the various organizational models to help stimulate and to help answer management questions. The choice of model or models depends on the question and the situation.

My intent is to find a number of good models to use individually or in combination conceptually within the organization box of the management process framework. When the framework is complete and the application determined, you can add a thorough understanding of the natural laws at play under the umbrella of the systems approach and deal with questions and determine answers to get the most out of your domain of responsibility.

Your choice of model to represent the organization depends on the performance criteria you want to study. Choose a model that works best with the criteria you want. I'll discuss a number of sets of criteria in the modules in Section 1.1.25. Then, you'll be able to do some matching.

I emphasize management tools. You can work all the models together in your mind or select one or two to learn about building and using management tools. Of course, in the cycle of building and using management tools—working within the engineering process—I like the management process functions.

There are more models out there, each based on the author's perspectives, experiences, and needs. As long as people express their individuality, we'll continue to accrue more models. I see this accrual as a good thing. The more arrows we have in our quiver, the more we'll be able to bring home the meat.

Like Kilmann, I say stay away from the quick fix. I recognize the complexity of the situation. I've heard it said that problems are simple; the solutions are complex. I think the strength of this book is that it doesn't favor a single model but provides a definition and scope for a discipline involving the engineering and management processes and the systems approach in a way that the present and future models can make a contribution. If ever there was a discipline where you can't stop growing and learning, it's management systems engineering.

I showed a number of general management questions in Module 1.1.4. and grouped them by Weisbord's systems. You can use other models to stimulate new questions, especially more-detailed questions.

Your choice of model or models also depends on how you want to slice the pie of your domain and what you intend to apply the model to. You see a lot of overlap, but you also see subtle differences among the models. If you want to look at verifying performance, use the management process functions. If you want to look at appraisals, use Kilmann's five tracks. If you want to look at rewards, look at Kilmann, Weisbord, or Sink's seven fronts or a combination of the three. If you want to look at indicators or collecting data, use the management process functions. If you want to look at measurements, use Sink's seven fronts. If you want to look at projects, use the management process functions and/or Sink's seven fronts.

If you want to emphasize your effectiveness as a manager, try Weisbord's people, technical, reward systems. If emphasizing grand strategy and the comprehensive planning apex of the organizational effectiveness pyramid, try

Sink's seven fronts and a model for success criteria I'll discuss shortly. If emphasizing success, use one model. If emphasizing productivity, use another. If emphasizing how tools help managers save time and reduce crises, use the ABC Model. But, I'm getting ahead of myself.

You can see culture as central to DeLisi, reward as the culmination of Kilmann's tracks, and all apexes of the organizational effectiveness pyramid as balanced. When things rotate around a focal point, you have centrality. When things flow, you have sequence. When things work together, you have balance.

You can see a great deal of overlap among the models I've discussed. I don't think you can link the models together very well. You can trace the similarities through the models, like the issues of culture, rewards, and planning. I do think you should consider the biases and strengths of each one and work them conceptually together in your mind and find the model or the combination of models that points you in the direction to answer the question you have.

The situation in an organization is quite complex. Figures 1.1.23.11.1. and 1.1.23.11.2. illustrate an old analytically-oriented joke about how to deal with such complexity. Figure 1.1.23.11.1. asks the fundamental question: How do you eat an elephant? The answer is: One bite at a time. Figure 1.1.23.11.2. asks the next fundamental question: Where do you take the first bite?

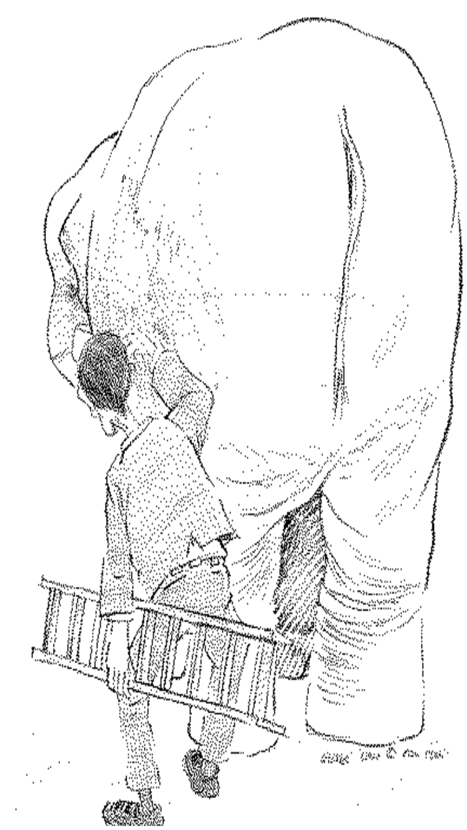

Figure 1.1.23.11.1. *"How do you eat an elephant?"*

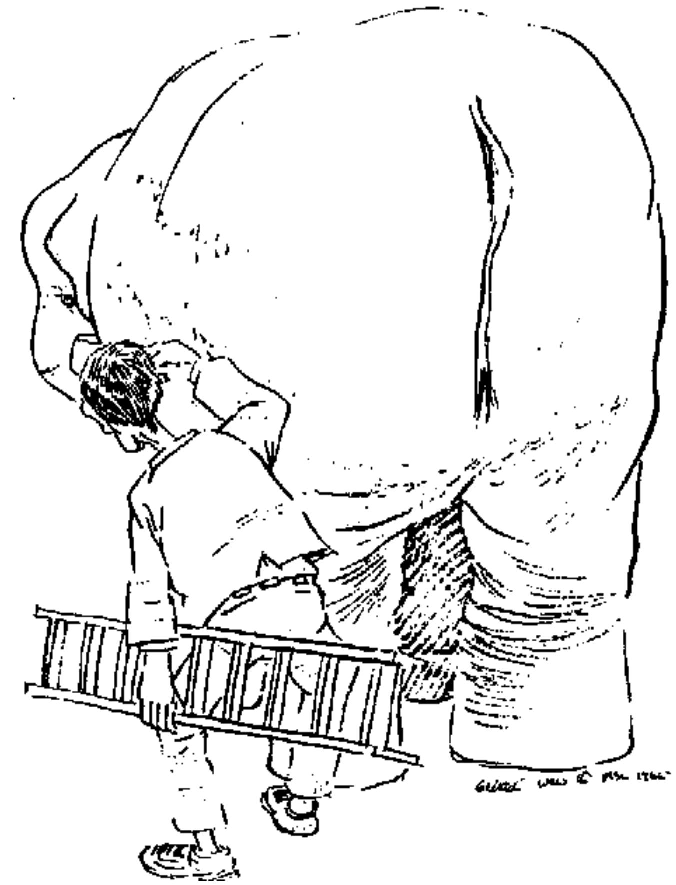

Figure 1.1.23.11.2. *“Where do I take the first bite?”*

1.1.24. The Strength of the Pyramid—Eugene Delacroix *(Liberty Leading the People)*

1. Background

1.1. Introduction

1.1.25. Performance and Success Criteria

1.1.25.1. Alternative Sets of Criteria for Performance in the Management Process Framework.

In addition to the ABC Model, you need useful alternative sets of criteria for performance to use in the management process framework as we work to improve performance, morale, and other measures of how well we're doing.

What are performance criteria for an organization? Status. Progress. Success. Morale. Competence. Satisfaction. Productivity. These and more. The criteria you're interested in depends on what you're looking for. Also, you'll need to match the criteria with your choice of organizational models. Better put, you need to choose a combination of organizational models and performance criteria that help you trace the effect of an intervention through the organization into the results of the organization's work. For example, if your domain is clearly a project, Sink's seven fronts model was designed to model the organization doing projects. I'll soon describe the project management pyramid for the success criteria in projects. The criteria of the project management pyramid apply to more than just projects. And the ABC Model applies to projects as well as other pursuits of the organization. The seven fronts model applies to more than just projects and the 14 functions of the management process framework apply to projects too. The bottom line is that you should consider the various models and sets of criteria for figuring out how to make interventions to improve the performance of the organization.

As we review alternate sets of performance criteria, we'll think about looking at the organization, as shown in Figure 1.1.25.1. We must link the things we see to the things we do. The organizational models reflect the things we do in an organization. The performance criteria reflect the things we see as we do things in the organization. If you have visibility, for everything you do in the organization, there's something you see. Some of the performance criteria highlight this situation. Critical success factors are things we do in an organization and critical success criteria are things we see. As a manager, if you do something, you want to be able to see what you did and the consequences of what you did. Obviously, the issue of visibility and our ability to identify what to watch and how to capture the data will be critical to building and using management tools.

Figure 1.1.25.1. is a slightly different version of the framework we started discussing in Modules 1.1.11.1. and 1.1.11.4. In those modules, the flow went from the organization to the performance criteria. In Figure 1.1.25.1., we're looking back at the organization. We haven't changed what happens. Instead of positioning ourselves outside the boxes as we did in Figure 1.1.11.4., we're positioning ourselves in the performance box looking for performance criteria in the organization.

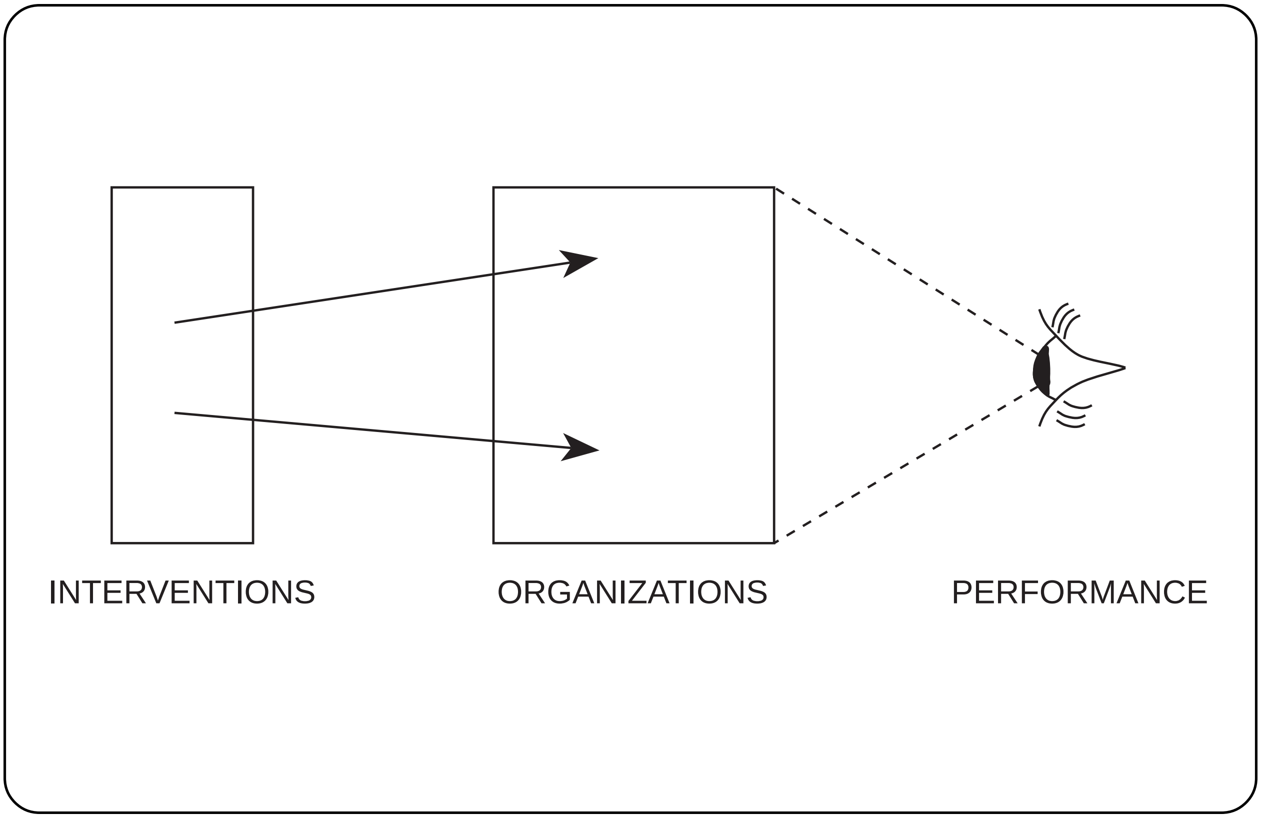

Figure 1.1.25.1. *We can use a number of sets of criteria for observing the organization to determine its performance.*

1.1.25.2. ABC FUNDAMENTALS

[For now, see Section 1.3. on the ABC Model.]

1.1.25.3. Project Management Pyramid

A new management approach recognizes the relationships of critics to the classical success criteria: cost, schedule, and quality.

Successful project management has been defined as balancing the triangle of the cost, schedule, and quality criteria. For example, if the project manager must meet a tighter schedule, he or she must know the effect on the specifications and/or the cost. Except in cases of greater efficiency, the specifications must relax and/or the cost must increase. This classical triangle applies to all levels of management, including program management.

For classical project management, cost, schedule, and quality are success criteria. Success criteria fit well within our performance criteria alternatives in Figure 1.1.11.4. A new management approach introduces a new criterion outside the classical triangle, a qualitative criterion I term *critics*. Cost, schedule, quality, and critics are interdependent. Not only will managers have to include critics along with cost, schedule, and quality; but cost, schedule, and quality will be more affected by critics than vice versa. Success in the critics criterion can buy latitude in cost, schedule, and quality that these three criteria can't buy without it. Critics criteria variables are dynamic, making success even more complex. Managers must recognize and be able to see, real-time, the resulting dynamic relationship among all four success criteria.

Compared to the critics criterion, the cost, schedule, and quality criteria are relatively static. Since the criteria are so interdependent, introducing such a dynamic criterion as critics tends to make the entire system more dynamic.

I've highlighted the importance and complexity of recognizing critics by putting it on the same level as the classical criteria. It's hard enough to succeed under the classical criteria alone—management failures in the past have occurred when critics didn't play such a big role in the manager's responsibilities. The problem then, and the problem will continue to be—only even more so—that all the criteria are interrelated and that a successful manager must be good at integrating them well. The new criterion makes integration more difficult because 1) we don't understand the critics criterion well yet, 2) we don't recognize or understand its relationships with the other criteria, 3) we're not good at showing the cumulative result of the changes in criteria over time and throughout organization levels, and 4) we don't have the tools with their guides and the people who know how to use them to set up, monitor, and affect the success criteria and their relationships.

As a success criterion, critics should include ideas like satisfaction of critics or "delight" of critics. The term critics includes two ideas: 1) the critics are people who not only are interested in receiving information about what's managed but want to have a say about what they know and most often want involvement in what's managed in such a way their involvement affects what's managed during planning as well as executing and verifying activities, and 2) critics include all stakeholders (customers, staff, neighbors, suppliers, and stockholders).

The new management approach makes the two-dimensional problem (represented by the triangle showing the interaction among the cost, schedule, and quality criteria) into a three-dimensional problem represented by the pyramid shown in Figure 1.1.25.3. The pyramid shows not only that the critics criterion must be factored into managers' thinking just like cost, schedule, and quality, but also that this new criterion is inextricably tied to the other three.

The importance of factoring in the new criterion goes beyond the simple relationships with the classical criteria shown in Figure 1.1.25.3. All four success criteria must work together holistically. There is the opportunity for synergy (and the danger of compartmentalism) among the four success criteria, and the new approach to management must take advantage of that synergy (or fail for the lack of it).

Today, qualitative issues dominate our top-management resources. The manager isn't going to get the qualitative issues to go away. But he or she can get some of them under control by predicting the issues and delegating the lower-priority ones. Predicting issues relating to all four criteria requires good information about the states of all criteria and knowledge of the relationships among the criteria. Delegating issues of lower priority requires knowing what the priorities are among issues of all four success criteria. The manager must be able to distinguish the important or difficult issues and intelligently allocate resources and delegate responsibility. The new approach to management requires looking at all issues (qualitative and quantitative) together equally, so intelligent priorities can be discerned.

Since we can't make the qualitative issues go away, we must manage them better. We need not only to get the right information to set priorities and delegate responsibilities but also to automate the more-routine effort so we have time to deal with uncertainty and surprises. Until we understand the critics criterion and how to deal with it better, this criterion will hold the greatest uncertainty and by default be the highest priority.

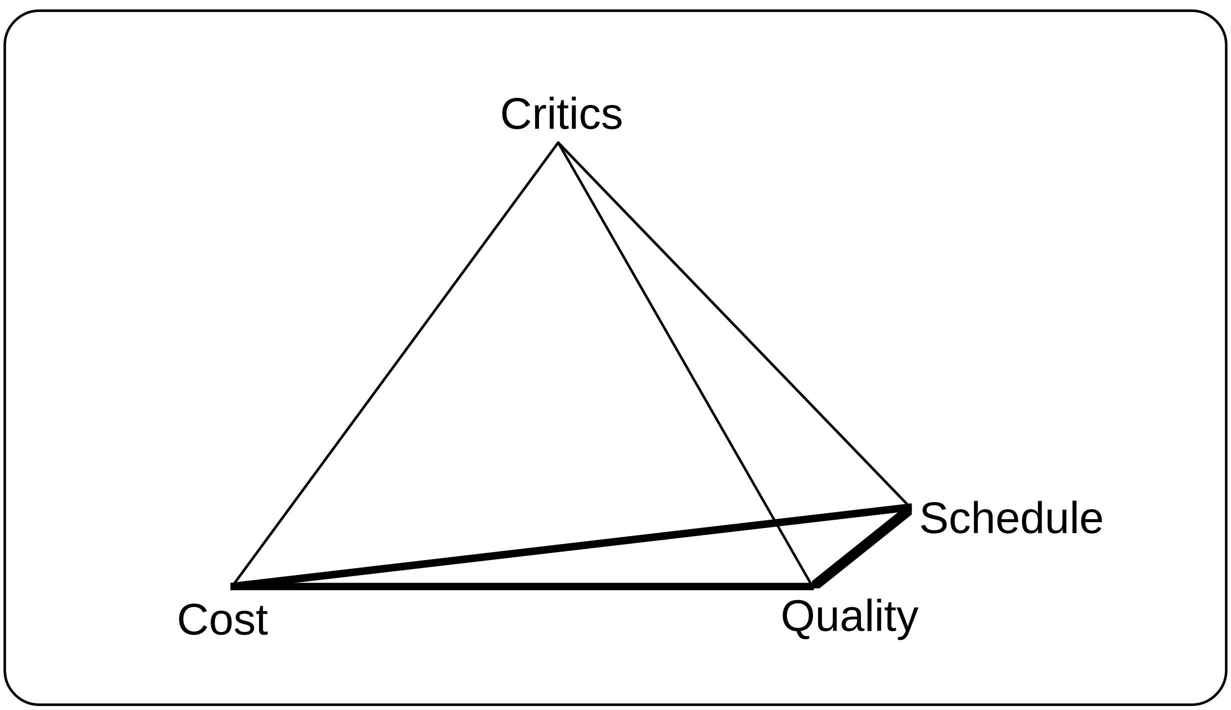

Figure 1.1.25.3. *The complexity of new management challenges is exemplified by the additional dimension of management success shown in the pyramid. The critics criterion is tied inextricably with the classical three success criteria: cost, schedule, and quality.*

1.1.25.4. Origins of the Project Management Pyramid

A new criterion has entered the equation for successful management.

Traditional project management training centers on the tug of war among schedule, resources, and quality illustrated in Figure 1.1.25.4.1. The idea is that if you tug hard on (change) any one of the criteria, the others are necessarily affected. We were able to transfer this training and these success criteria to other types of management. The conventional wisdom was that if you met specifications, within budget, and on time, you were guaranteed success. For decades, we lived by these criteria and were rewarded according to the guarantee. Lately, however, we find something missing. Often we meet specifications, within budget, and on time and fail. Even the idea of simply meeting specifications is in question. What then is the difference? Has a new criterion entered the equation?

As I've worked with environmental issues and projects, clearly, stakeholders have entered the equation in a big way. Management Systems Laboratories received a grant to study consensus. In performing that grant, the idea of critics playing a crucial role in managing projects came out—especially in the public sector. At first, I thought the criterion should be audience because of the need to communicate with stakeholders. Later, however, I discovered the criterion had to include involvement (both listening, responding, and initiating) of the stakeholders; and thus I chose the term critics.

Harold Kerzner, in his book *Project Management: A Systems Approach to Planning, Scheduling, and Controlling* (Van Nostrand Reinhold, 1984) shows the classical project management triangle (p. 5.) surrounding “resources” and surrounded by “within good customer relations.” Kerzner says, “The objective of the figure is to show that project management is designated to manage or control company resources on a given activity, within time, within cost, and within performance. Time, cost, and performance are the constraints on the project. If the project is to be accomplished for an outside customer, then the project has a fourth constraint: good customer relations. The reader should immediately realize that it is possible to manage a project internally within time, cost, and performance and then alienate the customer to such a degree that no further business will be forthcoming.” (pp. 5-6.) Kerzner’s figure is shown in Figure 1.1.25.4.2.

Figure 1.1.25.3. goes beyond Kerzner’s figure. Critics include not only the customer, but also other stakeholders. Later, I’ll discuss stakeholders at length. For now consider a stakeholder, or critic, to be anyone who has a stake in the activity, project, or organization under consideration. Stakeholders include customers, staff, owners, neighbors, and vendors. As opposed to “good customer relations” surrounding the classical triangle, Figure 1.1.25.3. emphasizes the tight linkage of critics to the other criteria.

Ashley, et. al. give six criteria to measure success of a project. The six criteria are: budget performance, schedule adherence, client satisfaction, functionality, contractor satisfaction, and project manager satisfaction. (Ashley, D. B., Jaselskis, E. J., and Lurie, C.B. (1987). “The Determinants of Constructions Project Success.” *Project Management Jour-*

nal, V. 28, No. 2, pp. 69-79.)

The contribution of the project management pyramid is the raising of the idea "good customer relations" from Kerzner and "client satisfaction, contractor satisfaction, and project manager satisfaction" from Ashley, et. al. to a level equal with time, cost, and quality. The idea of critics includes all stakeholders who might want to know about and participate in decisions about what's being managed. The pyramid brings all the traditional concepts of robustness, strength, and internal bonding described in Module 1.1.23.4. The point is that as a success criterion, critics are at least as influential as the other three.

You'll find a number of terms used for the different apexes of the pyramid. Cost can be resources of all kinds. Quality can be performance or meeting specifications.

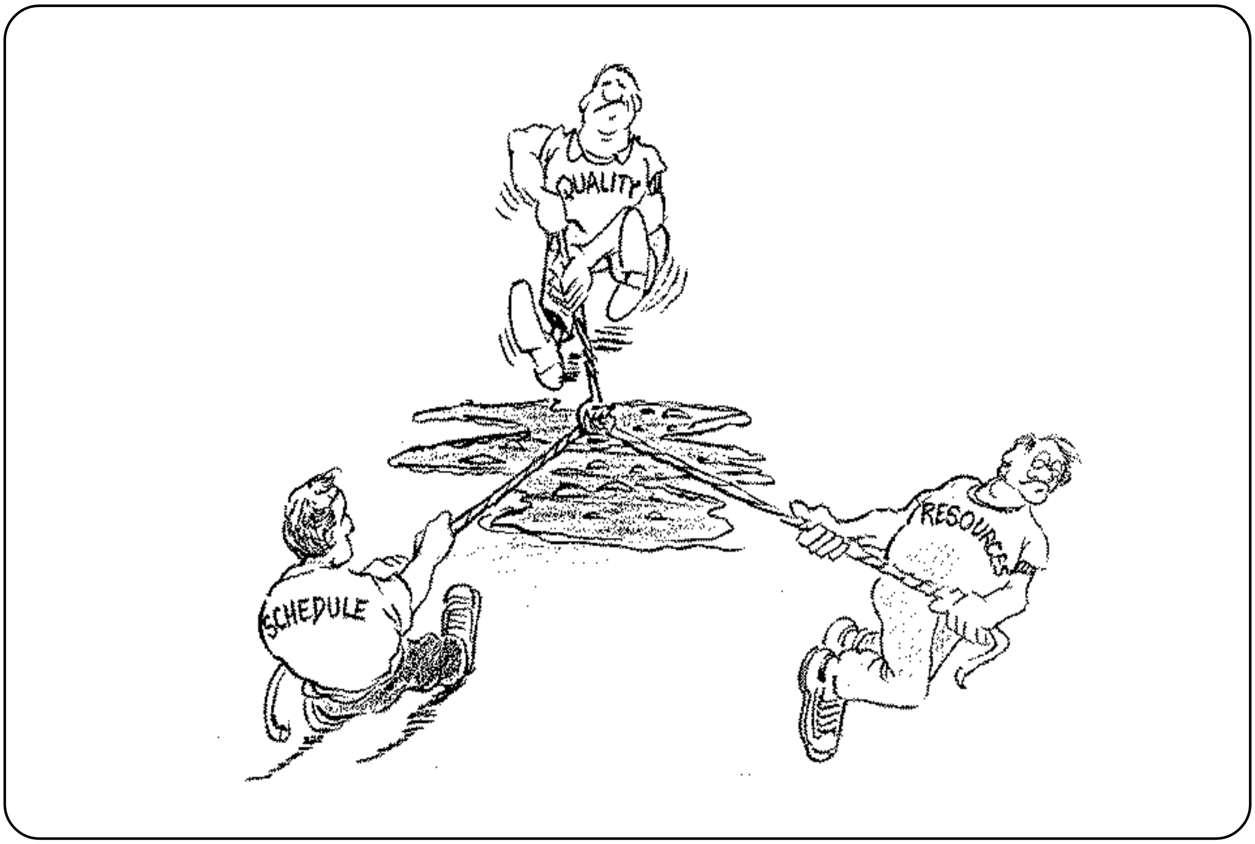

Figure 1.1.25.4.1. *"Who's going to win?"*

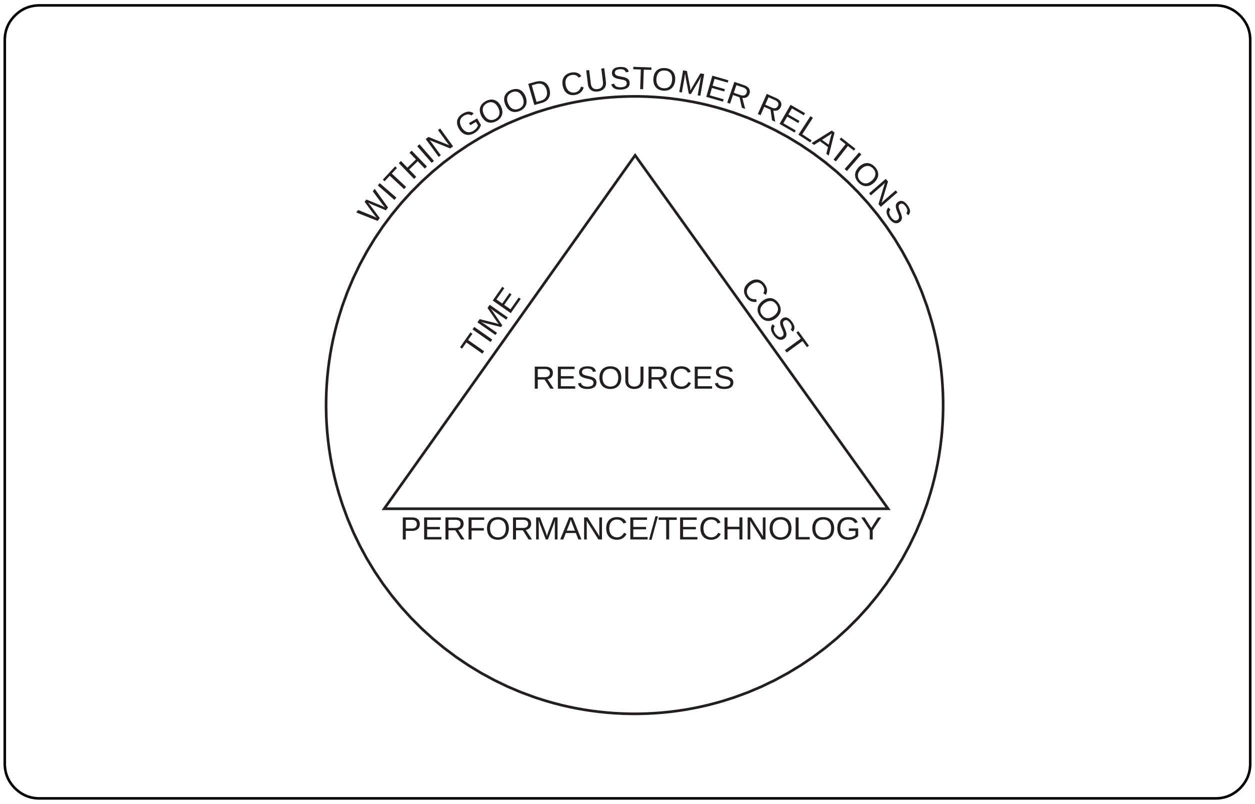

Figure 1.1.25.4.2. *The overview of project mangement shows constraints on the project. (taken from Kerzner, p. 4)*

1.1.25.5. Sink's Seven Performance Criteria

We can use seven criteria to measure an organization's performance; but we have to weight and combine the measures with a measure of art to feedback the results for improving the organization.

In his book, *Productivity Management: Planning, Measurement and Evaluation, Control and Improvement*, (Wiley, 1985) D. Scott Sink calls his performance criteria "distinct, although not necessarily mutually exclusive, measures of 'organizational system' performance." (p. 41.) As corroborated in discussions with Sink, I find that in terms of the Management System Model (MSM) the criteria apply to the what is managed component rather than the management system. From Module 1.1.18.5., we found that organizational performance in terms of the MSM would include management tool performance and the performance of the decision maker. Later, I'll discuss similar criteria for measuring the performance of management tools. Here, I'll discuss Sink's criteria for measuring the performance of the operation.

Sink's seven criteria are: 1) effectiveness, 2) efficiency, 3) quality, 4) profitability, 5) productivity, 6) quality of work life, and 7) innovation. He says, "Every organization in one way or another has systems designed to monitor, evaluate, control, and manage functions utilizing one or more of these seven measures of system performance. Note that productivity is only one measure of performance for a system, and not necessarily the most important one. We might consider these measures of system performance as a multi-attribute or multi-criterion measurement system." (p. 41.)

I'll quote the definitions of the criteria directly from pages 42-45 of his book. "**Effectiveness** is the degree to which the system accomplishes what it set out to accomplish. It is the degree to which the 'right' things were completed. At least three criteria need to be used to evaluate degree of effectiveness: 1. *Quality*: Did we do the 'right' things according to predetermined specifications? 2. *Quantity*: Did we get all of the 'right' things done? 3) *Timeliness*: Did we get the 'right' things done on time?" Peter Drucker defines effective in his book *The Effective Executive* (Harper and Row, 1966) as "get the right things done." (p. 1.)

Gery Patzak defines effectiveness as actual output divided by intended output. Webster defines effectiveness as "the power to produce the intended result."

Sink says, "**Efficiency** is the degree to which the system utilized the 'right' things. It can be represented by the following equation:

$$\frac{\text{Resources expected to be consumed}}{\text{Resources actually consumed}}$$

From this equation, we can see that efficiency is simply the comparison between resources we expected or intended to consume in accomplishing specific goals, objectives, and activities and resources actually consumed." Peter Drucker in his book defines efficient as "the ability to do things right." (p. 2.)

Sink says, "**Quality** is the degree to which the system conforms to requirements, specifications, or expectations. Traditional definitions of quality incorporate the conformity to specifications and a timeliness criterion, which could be considered simply as a kind of specification. The key element of quality that distinguishes it from effectiveness is the concept of *quality attributes*. A quality attribute is a specific quality characteristic for which a product is designed, built, and tested. Quality attributes can be subjective or objective." You can find any number of definitions of quality and I'll discuss those much later in this book. However, Philip Crosby uses a similar definition in his book *Quality without Tears* (McGraw-Hill, 1984) "The definition of quality is conformance to requirements." (p. 59.) The idea of quality as conformance to requirements is also in a book published before 1960 on industrial quality control by Schaafzma and Williamze who worked for Philips Anthoven.

Sink says, "**Profitability** is a relationship between total revenues (or in some cases, budget) and total costs (or in some cases, actual expenses):

$$\frac{\text{Total revenues}}{\text{Total costs}}$$

Profitability can be measured in a number of ways. Typical financial measures of performance are called 'operating ratios' or 'financial ratios.'" Over the years, profitability is the best defined of all the criteria. After the publication of his book, Sink has come to call this criterion "profitability/budgetability" in deference to government agencies as organizations.

I don't like either profitability or budgetability for the government because the government manager doesn't manipulate either profit or the budget like a private sector manager does. I prefer the term for this criterion to be **stewardship of funds**. The private sector manager must be a good steward of available funds to live up to his or her responsibility to the owners of the business. The public sector manager must be a good steward of funds to live up to his or her responsibility to the public represented by the government agency. A good steward of funds gets the most out of the funds available to him or her. The private sector manager has more flexibility in the amount of funds available.

Sink says, "**Productivity** is a relationship between quantities of outputs from a system and quantities of inputs into that same system." Sink goes on to say that if we make a ratio of the definition then the numerator contains an aspect of effectiveness and the denominator contains an aspect of efficiency. Productivity is another well-defined parameter of many years standing.

Sink says, "**Quality of work life** is the way participants in a system respond to sociotechnical aspects of that system." Weisbord asked Fred Emery, the father of quality of work life, to define the term. According to Weisbord, "Said he with a snort, 'It means get the foreman out of the system!'" (p. 165.)

Sink says, "**Innovation** can be defined as applied creativity. It is the process by which we come up with new, better, more functional products and services." Peters and Waterman in their book *In Search of Excellence* (Warner Books, 1984) quote Theodore Levitt as saying "Creativity is thinking up new things. Innovation is doing new things." (p. 206.)

Sink talks about how to use the criteria. "..... one important job of a manager is to determine

1. What the appropriate priorities or relative weights are for each performance measure

2. How to measure, operationally, each performance measure

3. How to link the measurement system to improvement

In other words, managers must determine how to most effectively use the control system to cause appropriate changes or improvements. It is clear that the priorities or weightings for each of these performance criteria will vary according to several factors (size of the system; function of the system—marketing, manufacturing, research and development, etc.; type of system—job shop, assembly line, service, process industry, etc.; and maturity of the system in terms of employees, management, technology, organizational structure and processes, etc.)." (p. 46.)

Sink likens a manager's using these criteria to a pilot's using the gauges in an airplane. You can't weight them and combine them into one indication of how to fly the plane or the organization. Part of the problem is that we can't operationally define and measure all these factors in an operation, which would be easier than for the entire organization. There are too many different types of inputs and outputs and some of them are qualitative. Later, I'll show that for management tools we have a somewhat easier time. The input and output to management tools are data and information, respectively. When we can quantify a datum and a bit of information, criteria similar to Sink's criteria can be quantified. We still have trouble getting one overall factor.

1.1.25.6. Critical Success Criteria

Critical success criteria come out of the process for determining Critical Success Factors, a concept for improving information systems to help managers focus on the important rather than the urgent.

I extract the idea of critical success criteria from Rockart's critical success factors. Simply stated, each manager can look at his or her domain of responsibility and figure out those factors, and herewith the criteria, that spell success. Being success criteria, we'd expect overlap with the project management pyramid. The primary differences between the sets of criteria are that critical success criteria are more specific and operationalized and the process for getting critical success criteria is a participative evolutionary process.

Rockart defines critical success factors (CSFs) as "CSFs are the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department, or organization. CSFs are the few key areas where 'things must go right' for the business to flourish and for the manager's goals to be attained." (*The Rise of Managerial Computing*, John Rockart and Christine V. Bullen, Dow Jones Irwin, 1986, p. 385.) Rockart developed CSFs to improve information systems by reducing DRIP.

The idea of DRIP came from an article on CSFs (*INDICATIONS*, A Publication of Index Systems, Inc., Vol 1, No 2, Winter 1983) in which the authors say, "Senior executives are frustrated and incapacitated by systems which leave them 'data rich but information poor.'" (See Figure 1.1.16.9.) The authors continue, "The effectiveness of managers is being seriously impeded by systems which merely produce a glut of unfiltered information. We have begun to hear a common refrain from senior executives who feel bound by the constraints of ineffective information systems: 'We no longer know how to interpret the information we are getting. We're frustrated by systems which provide too much financial data, unfiltered data, irrelevant operational data, and no external environmental data. We need information about what really counts; just because data is easily generated doesn't mean it's important.'"

Rockart developed CSFs as an interview technique for consultants to help managers find out what information they need in information systems. The technique is supposed to distinguish between objectives and the activities the organization should focus on to meet the objectives. Once you know the CSFs, you can communicate the important issues in the organization. Rockart says, "Critical success factors are the relatively small number of truly important matters on which a manager should focus her attention. For this reason, the term 'critical success factors' is aptly chosen. They represent the few 'factors' which are 'critical' to the 'success' of the manager concerned. There are, in every manager's life, an incredible number of things to which her attention can be diverted. The key to success for most managers is to focus their most limited resource (their time) on those things which really make the difference between success and failure." (388-389.)

Rockart's interview technique can be extended into a participative planning technique. With the CSFs, managers can distinguish between the urgent and the important. The critical success factors process starts with the organization's goals and objectives. Then the consultant or participative group uses the objectives to determine the specific factors most influential on meeting the objectives. These factors are the CSFs. Given the CSFs, the next step is to determine the indicators that reflect the CSFs. Then we know what information systems to build to convert the data from measuring the indicators into information managers can use to manage what's important in their organization.

When reflecting on this process, we can see that *the critical success criteria are the indicators that reflect the CSFs.*

The Index publication reports a study they made on CSFs. They report, "Recently, Index conducted a study to determine the factors which are most commonly cited by executives as being crucial to the success of their businesses. The study produced some surprising results. Using a sampling of managers from a wide cross-section of industries, the study revealed five general categories on which most executives believe attention should be focused:

- Cost structure
- Product quality and innovation
- Customer satisfaction
- Management development
- Change in corporate culture and attitudes

It is interesting to note that only one of the five factors is 'tangible' and reflects a traditional concern with financial control; the other four are 'softer' elements such as corporate culture and employee development. The CSF process indicates that while executives do focus on the tangible and measurable concerns of cost control and return on investment, they are at least equally interested in the less tangible issues of attitude and incentive. A complete management system, then, must include both hard and soft data to be useful as a management information system."

As we focus on the indicators reflecting the CSFs and what the organization is doing on activities relating to the CSFs, we're working with what I call critical success criteria. Compare the five categories of the Index study to the project management pyramid. Notice the importance of critics, where critics includes the stakeholders of the company.

When developing critical success criteria, start with the goals and objectives and then the CSFs of the organization. Answer questions like those in Figure 1.1.25.6. To deal with the figure, you'll have to distinguish between outcomes and outputs of the organization. Webster (*Webster's Ninth New Collegiate Dictionary*) defines outcome as "something that follows as a result or consequence" whereas output is "something produced." Sink (*Productivity Management: Planning, Measurement and Evaluation, Control and Improvement*, Wiley, 1985, p. 25.) defines an output variable as "any controllable factor or resource that results from a transformation of the input variable (for example, energy, people, services, and data/information)" and outcome variable as "the result(s) of selling and/or delivering an output variable to persons or organizations in the environment of an organization (This element does *not* affect productivity, by definition.)"

QUESTIONS LEADING TO CRITICAL SUCCESS CRITERIA REFLECT YOUR STAKEHOLDERS.

- Who is your supervisor?
- Who is your customer?
- Who are your subordinates?
- Who are your neighbors?
- What qualitative outcomes must your domain achieve to be successful in the eyes of your supervisor and/or your customer? Are the outcomes necessary and/or sufficient for success?
- What physical outputs must your domain produce to be successful in the eyes of your supervisor and/or customer? Are the outputs necessary and/or sufficient for success?
- What activities must your domain conduct and what conditions must prevail in your domain for you and your subordinates to feel you're performing at your best and are contributing the most you can to the outcomes and outputs just mentioned?
- What can your domain do to contribute to a better quality of life in the community outside your organization?

Figure 1.1.25.6. *Knowing your goals and objectives and thinking about CSFs, these questions will help lead you to your critical success criteria as indicators to measure to improve performance.*

1.1.25.7. Goldratt's Criteria

For a manufacturing organization, we can measure our goal of making money in terms of throughput, inventory, and operational expense.

The book *The Goal* is popular in manufacturing circles. Eliyahu Goldratt and Jeff Cox tell a story in novel form of how to figure out the goal for a manufacturing organization. I should tell you that at the end of the novel, the exchange between the hero, Alex, and the guru, Jonah, goes like this: "'Making money is the goal for a *manufacturing organization*,' he says. 'But it isn't mine, and I don't think it's yours.'

'Then what is our goal?' I ask.

'What do you think should be the goal?' he asks.

And I say, 'Well . . . ah, I don't know.'

'This is good-bye for now, Alex,' Jonah says. 'We'll be in touch. Meanwhile, I have a suggestion for you.'

'What's that?'

'Think about what the goal should be.'" (p. 262.)

In addition to setting up the sequel, the authors ask a question each of us must answer for ourselves. In stretching ourselves to find the answer, we must learn about ourselves and about the world around us.

Performance is a goal when we envision what we want the performance to be. Performance can be goal, status, progress, and more. Performance can relate to continuous success, motivation, and other factors, measures, or criteria of what you're doing and how well you're doing it. Later, I'll discuss functions for figuring out what you want to do, for doing what you want, for comparing to see if you did what you wanted to do, and for figuring out something better to do based on what you learned. (In short, these activities parallel Deming's Plan-Do-Study-Act Cycle.) For now, I'll discuss different ways of looking at performance. Goldratt's way is for manufacturing organizations.

If you use and manage Goldratt's measurements, or criteria, experience has shown that at the shop floor level, you get spectacular results. But when you extend the criteria to other parts of a manufacturing organization, like sales, you don't get the same results. However, viewing the manufacturing organization as a total system, we sell the product that takes the most value from the bottlenecks. Bottlenecks are capacity constrictions on the manufacturing floor. Bottlenecks apply in any organization. Bottlenecks are one of the most important factors to look for and manage in your domain of responsibility.

From a general perspective, I might argue that the goal is to have a process for continuous improvement—a goal a management systems engineer should be helpful in reaching.

In Goldratt's story, the goal of a manufacturing organization is to make money. Everything else is a means to get to that goal. You can express the goal in a number of ways, but the goal stays the same. Goldratt uses three measures to express the goal. You can use the measures to develop operational rules for running a manufacturing plant.

The measures are throughput, inventory, and operational expense. "Throughput [is] the rate at which the system generates money through sales. ..... Through sales—not through production. If you produce something, but don't sell it, it's not throughput." (p. 59.)

"Inventory is all the money that the system has invested in purchasing things which it intends to sell. ..... Operational expense is all the money the system spends in order to turn inventory into throughput." (p. 60.) All employee time, regardless of direct or indirect charge, is operational expense.

Goldratt summarizes the measures. "Throughput is the money coming in. Inventory is the money currently in the system. And operational expense is the money we have to pay out to make throughput happen. One measurement for the incoming money, one for the money still stuck inside, and one for the money going out." (pp. 72-73.)

Operational rules based on the measures can be condensed into "Increase throughput while simultaneously reducing both inventory and operating expense." (p. 66.) From this generalization, we can develop any number of rules. Sell more product. Decrease inventories. Reduce staff (or the cost of staff). How does increased efficiency affect the measures? Depending on your answer, we can make a rule about efficiency—or at least some particular efficiency.

Obviously, if your domain of responsibility is a manufacturing plant, you should consider using Goldratt's criteria as the performance measures in the management process framework of Figure 1.1.11.4. Goldratt argues that the measures must be applied to the organization as a whole—not the manufacturing department or one plant or one department in a plant. He wants to optimize at the global level not the local level. Indeed, the measures are easier to use at the global level than at the local level. For example, we can see the throughput of the organization, but can we identify the contribution of each person in the organization to throughput?

GOAL = MAKING MONEY

- Increase throughput
- Reduce inventories
- Reduce operational expense

Figure 1.1.25.7. *Goldratt's measures for a manufacturing organization work toward making money.*

1.1.25.8. HUMAN SUCCESS CRITERIA

1.1.25.9. Relationships to Indicators, Reference Points, Standards, and Measurements

1.1.25.10. Exercise on Performance Criteria

Performance criteria need to be comprehensive, measureable, and important.

Explanation
Finding criteria you want to measure your organization (and yourself) against is a difficult task. What's important? What's measurable? Deming says the important things are unknown and unknowable. However, to improve you need to measure something.

Situation Description
Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They bought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. You've been hired as a management consultant to advise them.

Exercise
Identify what performance criteria might be good for the shoe store to use for continuous improvement. For this list, disregard how difficult it might be to measure the criteria. Which of your criteria are process-oriented as opposed to results-oriented? Which criteria are for the organization as opposed to a person? Which criteria are most important for the success of the organization? Compare the most important to the most easily measured.

1.1.26. The Holistic Perspective—Claude Monet

1. Background

1.1. Introduction

1.1.27. Fundamental Concepts III

1.1.27.1. Even More General Concepts Defined Quickly

1.1.27.2. Define Integrator

The integrator is a role a person plays in practicing the systems approach to optimize the whole. The integrator has authority over the parts of the system and understands the working of those parts and their effect on the working of the system.

In an organization, we need a person to orchestrate the parts of the organization into a blend that produces true harmony among the parts yielding the best the organization can do. Leadership can come from anywhere in the organization. Doing integration must come from someone in the organization who has authority over the parts of the organization and the relationships and interactions among those parts. Therefore, the contribution to leadership for finding synergy and optimizing the whole comes from someone with authority. Without authority, the best you can do is conceptual integration. That's why empowerment is important. The organization needs more than one person to make integration happen.

Being an effective integrator is needed for a leader. Integration supports doing strategic endeavors—those endeavors for figuring out what the problems are. Leaders must also be role models. As such, leaders aren't necessarily in positions of authority. People in positions of authority in organizations today have so many demands up and down the organization, there's little time for leadership. However, some people in authority know how to delegate and retain time and effort for effective leadership. These people must be good integrators; and integration is one vehicle through which they exercise leadership.

An integrator is like a stage director. The stage director must orchestrate all phases and functions in the play. Stage directors set the stage, the actors, and support people by producing, coordinating, and directing all props, cues, script, lighting, sound, and rehearsals for a successful production. They have the ultimate feel for what the play should mean to and do for the audience. When the director pulls all the tools and arrangements together with the ability and talents of the actors, their audience and critics respond favorably.

An effective integrator in an organization must integrate along at least four dimensions. First, they must differentiate and select between the urgent and the important. Second, they must balance and address the priorities of the needs of all their stakeholders. Third, they must distinguish and implement activities and resources through the five groups of functions in the system life cycle: analysis, design, implementation, follow-up, and follow-through. In this dimension, the integrator is using the engineering process. Fourth, they must build and use a wide range of management tools to provide information for decisions. In this dimension, the integrator is using the management process.

The purpose of the integrator is to bring all the appropriate pieces together to form a system so each piece does its job and together the pieces meet the aim of the system. The steps are 1) figure out what is moving the system (precipitator), 2) figure out which are the right pieces (participants), 3) figure out the aim of the system (purpose), 4) figure out how the pieces work together (participation), 5) figure out what the system does (problem), 6) set up a process for the system to meet its aim (process), and 7) verify the product of the system (product).

The Effective Integrator Practices Integration and More.

Webster defines integrate as "to form, coordinate, or blend into a functioning or unified whole; to unite with something else; to incorporate into a large unit" and integration as "incorporation as equals into society or an organization of individuals of different groups; coordination of mental processes into a normal effective personality of with the individual's environment; the operation of finding a function whose differential is known; the operation of solving a differential equation." (*Webster's Ninth New Collegiate Dictionary*) I'll discuss the actions of forming, coordinating, blending, and more for being an integrator soon. Now let's focus on bringing the parts into their rightful roles in a system, the coordination of processes into the personality of a system, and differentiation. The integrator must know and address the roles each resource in an organization must play to get the best from the resource and from the organization. Organizations have personalities too. These personalities are significantly affected by the processes of the organization: direct work processes, support processes such as hiring and job definition, and the management process. Now, let's discuss differentiation.

Integration is summation—the integral under a curve. The integrator is more. Integrators bring things together and get them to work their attributes (differentiation) through their mutual relationships toward the aim of the system. Integrators are able to filter (differentiate) and find patterns. They are able to maintain balance and to blend for many components, activities, approaches, issues, and functions in an organization. These activities focus on the parts of the system; and, therefore, are part of the system perspective.

Integration and differentiation are part of the systems approach and are imbedded in the system perspective. The integrator has to integrate and differentiate to do strategic endeavors—know what the problem really is. *The integrator must integrate and differentiate the needs of all stakeholders of the organization.*

The industrial engineering profession addresses and certifies people to be systems integrators. They describe the systems integrator as, "The system, as used here, can refer to one isolated system, or an integration of two or more subsystems. Regardless of system type or size, there are particular functions and processes that should be completed to ensure successful implementation and operation. The Systems Integrator must possess the knowledge and skills necessary to ensure completion of system planning, design, implementation and control activities. This individual may not personally complete every activity himself, but rather must manage the entire project with the knowledge of the activities to be completed, the information, personnel and materials required for completion, and the interface of all involved functional areas to ensure total communication and integration. Along with the functional areas of the organization, the Systems Integrator must be aware of major issues including technical and physical issues, managerial issues, strategic/financial issues, and operational and functional issues." ("IIE Certification Program in Systems Integration," David W. Hess, in *Guide to Systems Integration*, Joe H. Mize, Editor, The Institute of Industrial Engineers, 1991, p. 4) The integrator must know the system life cycle, including planning (analysis), design, implementation and control, follow up, and follow through. *Integration must follow the engineering process.*

Integrators provide continuity, comprehensiveness, and completeness for a system. Through integration, managers reduce redundancy and capitalize on synergistic benefits. The integrator is a catalyst for making the necessary interactions in a system happen. Integrators are good at setting priorities. Integrators are loop closers. In closing process loops, integrators provide for systems thinking, organizational learning, creativity, and empowerment.

If I had to classify integrators, I'd say the types of integrators are coordinators, interdigitators, blenders, and matchers. Distinguishing the contributions of each part of a system and coordinating the interactions of the parts is relatively easy. To interdigitate means to make the parts of a system interweave properly, like your fingers interdigitate when you clasp your hands. Matching is like fitting. Finding the right fit for the parts of a system is relatively hard to do. I've discussed how crucial it is to find the fit of an information system to the decision maker and to his or her responsibilities. The most difficult part of integration is finding a blend. A blend implies that the parts are so well coordinated, iterdigitated, or matched that each part is indistinguishable from the others. Each part is lost in the functioning of the whole.

Industrial engineers aren't the only people good at integration. But, industrial engineers profess to know integration and, therefore, are expected to understand integration. The Institute of Industrial Engineers addresses systems integration. "The term 'systems integration' means different things to different groups of people. To an aircraft design team, system integration deals with the problem of assuring that all major sub-systems (airframe, propulsion, hydraulics, electronics, etc.) are properly inter-related, such that the overall aircraft performance is optimized. .... The major difference is that the industrial engineer must deal with very large and ill-structured systems. Indeed, the entire organization is the 'system' being studied, analyzed, rationalized, and hopefully optimized. Rather than combining electronic components into a functioning system, the industrial engineer must combine functional organizations, equipment, material handlers, policies and procedures, workers at all levels, computer/information systems, suppliers, etc., into a harmoniously working total system." (*Guide to Systems Integration*, Joe H. Mize, Editor, The Institute of Industrial Engineers, p. 25)

Integration Brings the Parts Together into the Whole.

Integrators integrate the interdependencies. They see potential interrelationships among all the parts of the system. Integrators know connections and can see potential connections in an organization. They know unique attributes and contributions of each part of the system. Perhaps the integrator's key job is balance. The integrator blends components and gains harmony among components. The integrator finds links among the components and focuses the linked components on the needs of the system for system improvement. Suzaki address this issue for manufacturing. "Since the problems in organizations are often found at the organizational boundaries, understanding the linkages among different groups within the organization becomes critical for streamlining operations." (Kiyoshi Suzaki, *The New Manufacturing Challenge: Techniques for Continuous Improvement*, The Free Press, 1987, p. 4.)

They can mix so the components are still distinguishable and mix so the components aren't distinguishable. "Scientists sometimes speak of two kinds of qualities—*extensive* and *intensive*—according to what happens to the quality when the system is divided into parts. If we break a chocolate bar in two pieces, each piece has a different mass than the original: thus mass would be called an *extensive* quality, since it depends on maintaining the full extent of the system. On the other hand, when we break the chocolate bar in half, each piece retains the same 'chocolateness', which is therefore said to be an *intensive* quality. Or, to take a more physical example, each half has the same density, so density is said to be an intensive quality." (Gerald M. Weinberg, *An Introduction to General Systems Thinking*, John Wiley and Sons, 1975, p. 152)

An organization often brings a large number of parts together and then has a gap. In this case, the parts don't completely satisfy the needs of the whole. The integrator has to recognize the gaps and then to learn whatever is needed to fill the gaps. Then, the integrator must not only practice the systems approach for finding the gaps, but must be able to learn enough about the specific knowledge relating to the gap to be able to communicate the need and fill it.

Integrators must integrate the management process into the organization's daily work activities. The integrator must decide what resources to spend on administering the management process and on managing brushfires. The functions and rules of the management process can make this balancing job easier by giving the integrator visibility and control in supporting decisions.

The role of the integrator is one of the most difficult, important, and ill-defined roles in managing major projects, programs, and organizations because of the multiplicity of activities at various levels needing to be coordinated. Consider the competing needs for time and resources of the various stakeholders and of individuals in any stakeholder group. Consider the different functions and activities of the organization. Blending all these activities and needs to serve each one and to optimize the whole organization takes profound knowledge, the right information, and a real caring and trusting attitude with people. Recognize that if you optimize the whole, you suboptimize at least some of the parts. The integrator must get people to appreciate and commit to suboptimize their part for the good of the whole.

The Integrator Practices the Systems Approach.

"W. Edwards Deming provides some insight as to how organizational improvement might best be achieved when he defines the three primary roles of a top manager:

1. Provide the theory upon which the individual components of the system can relate to the purpose of the system.

2. Transform the basic structure of the system to one which uses more responsibly the components available to the system.

3. Keep the purpose of the company in harmony with the broader aspects of a healthy, prosperous community and society."

("Fundamentals of Systems Integration," James A. Bontadelli and Kenneth E Kirby, in *Guide to Systems Integration*, Joe H. Mize, Editor, The Institute of Industrial Engineers, 1991, p. 47) Clearly, to do integration, you must view the organization from the systems approach.

The manager must differentiate and balance the urgent and the important and decide what resources to spend on administering the management process and on managing brushfires. The methods and rules of the management process can make this balancing job easier by giving the manager visibility and control in supporting decisions.

The integrator must see cause and effect across dissimilar activities. Seeing cause and effect in one part of a system or among similar parts is relatively easy. Seeing cause and effect across dissimilar parts is relatively hard. An example of dissimilar activities is: How does the installation of a new software package affect the motivation of the worker and the success of the organization? Integrators are able to carry over what they know from one activity or event to another activity or event and to selectively fit (match) solutions to needs in whatever situation arises.

An integrator practices the systems approach with the three perspectives (system, holistic, and generalist) and sets up, operates, implements, maintains, and dismantles systems. An integrator is an agent for systems. Systems come from somewhere. Person-made systems come from integrators. The idea of integrator goes with the systems approach. Integrators are generalists and transfer lessons learned. Therefore, they need to be quick learns.

The Role of the Integrator Requires Information.

The role of integrator in effectively implementing the management process is the key to reducing brushfires to provide time needed to improve performance and advance the organization in the face of a changing decision-making environment. The management process helps you select, use, and integrate management tools. In getting the tools to work synergistically together to support your decision making, you assume the role of integrator. The integration role is critical for reducing the number and disruptive effects of controllable disruptions.

Integrator roles are difficult because of the volume of information integrators must sift through to make decisions. Integrators can't integrate if they don't have the right information in the right place in the right format at the right time. Part of the solution to that problem is mechanical and the other part is human. It's the human part that distinguishes this discussion of the role of the integrator.

Integrators have two information tasks that compete for the same time and resources. One information task is to reduce equivocality so the organization shares a common view of events and alternatives. We call this task external interpretation (Weick, 1979). The other task is to process enough information to coordinate the organization's activities and manage performance. We call this task internal coordination (Galbraith, 1973). People in the role of integrator provide media high in information richness to reduce equivocality and large amounts of information to handle interdependence in the organization. Effective integration and portrayal of information facilitates both external interpretation and internal coordination.

In considering the information needs of the organization and the need for improvement, Powers and Liotte address the idea of an integration engineer. "If you think we have been describing an expanded role for the Industrial Engineer, a role as a partner with the IS [information systems] community in support of the customer, you are absolutely right. Manufacturing and business process improvement requires the power of data analysis and information technology. And the new role of the Industrial Engineer is that of an INTEGRATOR. As a matter of fact, we have written a theoretical job description of the Industrial Engineer as an INTEGRATION ENGINEER. THE INTEGRATION ENGINEER: AN INDUSTRIAL ENGINEER WITH THE ABILITY TO INTEGRATE, POSSESSING THE BACKGROUND AND THE CAPABILITY TO THOROUGHLY ANALYZE AND DEFINE A PROBLEM WITH THE CUSTOMER; TO ACT AS AN INTERFACE BETWEEN THE CUSTOMER AND THE SYSTEMS COMMUNITY; TO SELECT AND COMBINE VARIOUS TECHNOLOGIES INCLUDING INFORMATION TECHNOLOGY (THE BEST FIT SOLUTION FOR THE CUSTOMER). This Integration Engineer is change oriented; and agent of change, sensitive to the customer's social and business system with a specialty BUT willing to get out of the functional silo. (S)he is willing to test new theories and willing to seek out and partner to fully utilize the skills of others and look at the entire process." ("The Integration of Work Redesign and Information Technology," John J. Powers and Anthony T. Liotti, in *Guide to Systems Integration*, Joe H. Mize, Editor, The Institute of Industrial Engineers, 1991, pp. 134-135) As you think about the idea of an integration engineer, think about the fundamentals of the engineering process. Then, an integration isn't necessarily part of the engineering profession. I'd hope we could help engineers learn to be good integrators.

Finally, how might we approach systems integration in an organization? Badiru suggests some questions that can help us with an approach. "Systems integration is particularly important when introducing new technology into an existing system. It involves coordinating new operations to coexist with existing operations. It may require the adjustment of functions to permit sharing of resources, development of new policies to accommodate product integration, or realignment of managerial responsibilities. Presented below are important questions relevant for systems integration:

- What are the unique characteristics of each component in the system to be integrated?
- How do the characteristics complement one another?
- What physical interfaces exist between the components?
- What data/information interfaces exist between the components?
- What ideological differences exist between the components?
- What are the data flow requirements for the components?
- Are there similar integrated systems operating elsewhere?
- What are the reporting requirements in the integrated system?
- Are there any hierarchical restrictions on the operations of the components of the integrated system?
- What are the internal and external factors expected to influence the integrated system?
- How can the performance of the integrated system be measured?
- What benefit/cost documentations are required for the integrated system?
- What is the cost of designing and implementing the integrated system?
- What are the relative priorities assigned to each component of the integrated system?
- What are the strengths of the integrated system?
- What are the weaknesses of the integrated system?
- What resources are needed to keep the integrated system operating satisfactorily?
- Which section of the organization will have primary responsibility for the operation of the integrated system?" ("Achieving Systems Integration through Project Management Techniques," Adedeji B. Badiru, in *Guide to Systems Integration*, Joe H. Mize, Editor, The Institute of Industrial Engineers, 1991, pp. 376-377)

1.1.27.3. DEFINE HOLISTIC PERSPECTIVE

"The significant problems we face cannot be solved at the same level of thinking we were at when we created them." Albert Einstein

For technically-oriented people from western cultures, the holistic perspective requires a way of thinking we aren't conditioned for. We can learn the holistic perspective from people from eastern cultures and from the indigenous peoples. To engineer or manage the significant problems we face today, we must think at a different level from before. We must push the systems approach (something we're not too familiar with) to higher levels of philosophical understanding.

Of the three perspectives I've identified within the systems approach (system, holistic, and generalist perspectives), the system perspective is more analytical and more in line with our cultural and educational experience. The holistic perspective deals with ideas like meaning, purpose, essence, and soul.

A few years ago, I was facilitating a group of people representing a widely-varying range of interest groups who were commenting on the Department of Energy's five year plan for environmental management. The representative from one of the American Indian groups spoke to the group with great concern and passion. He said, "This plan has no soul!" Somehow the plan didn't include the essence of the earth and its creator. The plan failed to reflect not only the culture of the Indian nations but the culture of the environment itself. The plan didn't deal with the essence and the values of the environment. The plan didn't have the holistic perspective.

Being an engineer from a western culture, I was struggling to understand. My problem was that I thought, no I knew, he was right. But, I wouldn't know if the plan had soul if I saw it. And I certainly wouldn't know how to put soul in the plan. Yet, I believe if we can't get soul into our work, like the plan, we won't solve the significant problems we face today.

Webster defines soul as "the immaterial essence, animating principle, or actuating cause of an individual life; a person's total self; a moving spirit." (*Webster's Ninth New Collegiate Dictionary*) The soul of an organization is its spirit. We're familiar with the importance of esprit de corps as the common spirit the members of a military group have for the group and its aim. The spirit inspires enthusiasm, devotion, commitment, dedication, and a regard for the honor and the values of the group. Can a plan have this kind of spirit among its components, attributes, and relationships? I've made the definition of system in Module 1.1.11.5. more inclusive and more general by including the notion of spirit in the system.

For the holistic perspective of the environment (and consequently a level of understanding necessary to solve environmental problems), I look to the Native Americans. They make a unique contribution to our understanding of the cultural perspective of the environment because of their traditional norms, values, and traditions regarding the environment. Indian culture is rooted in environmental culture, whereas the dominant culture in the United States today is not. The holistic perspective of the environment must include at least cultural, technical, and institutional views of the environment.

Delia Grenville in my management systems engineering class extended the range of my holistic thinking discussion. She writes, "I come from Caribbean culture (very rooted in African traditions). As a child, I was allowed to say that my spirit did not agree with someone elses, and that was enough. That was wholly acceptable as a reason not to like or get along with the person. There are so many aspects of holistic thinking in Caribbean culture. African Americans have had to unlearn that to survive in the western world." As our organizations reach for global markets and resources, we must recognize, understand, respect, and make room in our perspectives for the traditions, norms, and values of other people. Holistic thinking is an example of an extension those of us who practice analytic thinking must make if we want to be systems thinkers.

In my search for understanding of the holistic perspective, I found Kosaku Yoshida, who studied under W. Edwards Deming. In the abstract to his article, *Deming Management Philosophy: Does It Work in the US as Well as in Japan?*, Yoshida says, "Japanese business success began when Western ideas were grafted onto the traditional holistic orientation of the Japanese. The success of Deming's philosophy in Japanese business cannot be understood in isolation from the Japanese environment." In discussing the holistic approach and the Japanese culture, Yoshida says, "Understanding the essential difference between Japanese and American thinking processes requires some understanding of Japanese culture. The common heritage and value system of the homogeneous Japanese population meant that the way one Japanese thought tended to resemble how another Japanese thought. This foundation of similar thinking provided the basis for a culture which implicitly encourages individuals to 'read between the lines.'

For example, in high school every Japanese studies haiku, the traditional Japanese short poem with only seventeen Japanese letters, equivalent to seventeen syllables in English. In a few phrases, haiku tries to express a deep feeling or thought. By studying haiku, Japanese students are trained to perceive an entire atmosphere or feeling by reading between the lines, that is, by paying attention to subtleties such as context and what is merely implied or suggested. A study has shown that Japanese magazines devoted to haiku or waka (another form of short Japanese poem) are widely circulated among workers who have bought over a million copies. The spirit of haiku has had such a tremendous impact on Japanese writing in general that even scientific papers and legal documents tend to be short and terse, similar to haiku and very unlike American scientific and legal documents.

Furthermore, the Japanese are educated to pick up more meaning from blank spaces than from written words. Indeed, this ability is the hallmark of the Japanese. According to the Japanese critic and philosopher Hideo Kobayashi, this characteristic is largely the result of the influence of Basho, the most famous haiku poet of seventeenth-century Japan, who considered silence to be the most eloquent expression of poetry.

Consequently, people accustomed by heritage to these societal traits do not need detailed specification of a corporate philosophy. This heritage is also the major reason why corporate philosophies exist in most Japanese companies but in few American companies, although a number of American companies have established corporate philosophies in recent years. Unlike many Americans, the Japanese are comfortable with far-reaching, broadly encompassing, abstract statements unsupported by specific examples or elaboration.

Eastern brush painting is another aspect of Japanese culture that has influenced the Japanese in ways apparent in Japanese business today. The Eastern brush painter traditionally works quickly, his concern being to capture the total feeling about the perceived object rather than individual details of the object itself. By contrast, the emphasis in traditional Western art has been upon accuracy of detail. In Western civilization, painting has gone through a history of detailed drawing. Similarly, Western scientific development began with the analytic approach, in which most statements are detailed and specific." (*Columbia Journal of World Business,* Fall 1989, pp. 12-13.)

I've discovered one of the key elements of the organization today is its MVP, or mission, vision, and guiding principles. MVP is a statement of the present and future and beliefs all the people in the organization buy into. Through the MVP, the organization can achieve a constancy of purpose and a consistency of purpose needed for success.

In the holistic perspective, we have to be able to read between the lines; interpret empty space (blank space on a page or silence in discussion); understand the flow and feeling of a single line, word, or image; and realize the meaning or essence of the system. In this way, a word, line, or image isn't necessary to meet the aim of the system. The meaning, essence, flow, or soul is. The meaning comes as much or more from what isn't apparent than from what is. So, changing one tangible part of a system doesn't necessarily change its meaning.

In the system perspective, each part of a system is necessary to the aim of the system. All components play an important role. In the holistic perspective, we deal with the system at a higher level than the components, thus rendering the components to be contributors to the essence of the system. Each component can add to the essence, but the essence so permeates the system, removing a component doesn't hurt the aim. We form closure around the empty space.

We show a process as a flow diagram connecting components, activities, and resources. In truth, the process is invisible. What you see is the individual worker, the individual machine, the individual product. You must look beyond the physical into what the workers, machines, and products are, what they do, and what they do it for. That's the totality. You must see the forest rather than the individual trees.

In the systems approach, we need both the system perspective and the holistic perspective—and one more perspective: the generalist perspective. With the three perspectives, we recognize the importance of each component, the supremacy of the aim or purpose, and the significance of learning.

1.1.27.4. A Holistic Model Has Human Components and Results in Synergy.

If we try to include the holistic perspective in a model, we must include humans who can smell out the situation.

Those of us who are rooted in Western, or European, culture and are analytically trained (e.g., engineering, accounting, sciences, law, and medicine) have great trouble even conceiving of how to go about holistic thinking, let alone understanding holistic thinking well enough to model it. But, even the most devoted analytic thinkers may slip into holistic thinking a time or two, when dating or buying a house or a car, for example. As Dr. Kosaku Yoshida says when illustrating the holistic approach: "When you go out on a date, would you evaluate whether your date has intelligence: 95 points; Appearance: 96 points; Emotional stability: minus 20 points? Do you evaluate your partner like that? If you get a date, turn off the light and get the smell and get the total understanding. You [are] not going to analyze. You're going to capture the entire feeling. That I call ultimate understanding." (transcript of the videotape *Made in Japan "Whole"-istically*, Petty Consulting/Productions, Cincinnati, Ohio, 1990, p. 11.) In holistic thinking, we strive for ultimate understanding. I believe a successful management process or engineering process requires holistic thinking through the holistic perspective and, therefore, ultimate understanding.

Have you ever ranked alternatives when buying a car or house or choosing a school to attend. You carefully list all the criteria important to your decision and even consider the relative importance of the criteria. By intuition or calculation, one car, house, or school clearly excels over the others. But you buy a different car or house or choose a different school instead, just because it feels right! Analyzing the date, car, house, or school doesn't work. You can't or don't list all the criteria and their importance. You don't want to admit a gadget in the car or the personality of the salesperson affects you. Or, for holistic thinking, you really aren't hiding anything from yourself; you just, in your heart, prefer a particular car.

Industrial engineers call the process for identifying, weighting, and ranking criteria multiattribute utility analysis. They argue that in complex evaluations you should decompose the object of your evaluation into more and more detailed parts. The assumption is that "the decomposition will lead to more accurate solutions than direct or holistic methods." (Young Jin Cho, *Effects of Decomposition Level on the Intrarater Reliability of Multiattribute Alternative Evaluation*, Dissertation at Virginia Tech, July 1992, p. 2.) The problem here is that we have to define what we mean by accurate. Cho describes accuracy as repeatability. How would you like to operationalize the idea of accuracy when you tell your date that holistic thinking is inappropriate and you rank him or her a six out of ten?

Consider an example of setting priorities for distributing limited funds to a wide range of waste clean up needs. The top government or company official for environmental management could turn off the lights (like in the Yoshida example) and come up with the priorities for the agency's or company's environmental management funding. That would be an holistic approach. He or she could either forget the analytic model for priorities or compare the results of the analysis to the holistic result. But, the top official's analytic-thinking constituents wouldn't accept the result of his or her individual holistic thinking. (The constituents drive different cars, don't they?) If any one constituent turned off the lights, he or she would come up with priorities somewhat different from the top official. So how can all the constituents collectively come up with holistic priorities? Not through an analytic model and not by tallying up all our individual results. The constituents need to come together and work as a group so they get synergy through the holistic perspective, and we get more for our environmental management money.

The way I know of for how to come up with priorities as a group is to bring everyone, or their representative, together who has a stake in the priority decision and collectively derive holistic priorities. That's the holistic perspective. So far, only the human mind can come to a conclusion with incomplete or missing data. The human mind can come to a gestalt with some criteria and importances clearly defined and others only in their hearts, undefinable. (I'll describe gestalt in the next module.) A group of human minds can consider things no analytic model can and the group can render a synergistic answer. So, we have to figure out how to effectively bring stakeholders together to come up with the best answer through holistic thinking.

I believe the holistic model requires human minds rather than equations, algorithms, or computers because only the human mind and heart can bring together and relate all the issues, characteristics, nuances, meanings, essences, alternatives, and importances needed for the holistic perspective. My understanding is that only humans can deal with soul. Animals can't; and computers certainly can't. (However, at a meeting I attended in the Netherlands, researchers from the University of Miami discussed computer systems with a survival instinct. At times like those, I'm glad I'm as old as I am.) The group of participating stakeholders must include everyone (or their representative) who will gain or lose by one alternative being selected or ranked over another. This holistic model allows the emphasis of perception over reality. Analytic models can't deal with perception. We must accept that in endeavors like environmental management a perceived barrier can be as effective as a real one. Until we include perception, we'll not get acceptable answers when solving environmental problems.

Consider a note here on how decision makers use the results of a model, whether it be analytic or holistic. The model results aren't answers, they're only suggestions. However, information is the difference between a guess and a decision. The decision maker will have to use holistic model results just like they do analytic model results--as input to their decision. The decision maker knows an analytic model's results are only as good as the variables and their relationships in the model, the boundary conditions, and the data put into the model. Likewise, an holistic model's results are only as good as the representativeness of the stakeholders thinking and feeling together, the data or information they have to work with, and the process through which they interact. The decision maker can use the holistic model as support for their decision just like he or she would use an analytic model. The decision maker can show the results of the model and describe the makeup of the model and how it works, describe the strengths and weaknesses of the model, and state the decision. The advantage of the holistic model duplicates the advantage of holistic thinking—synergy. Synergy is what you get when the holistic perspective is working. In synergy the whole is greater than the sum of its parts.

Deming uses the example of an orchestra. Each musician can play his or her part perfectly and the orchestra doesn't sound right. After much practice, the orchestra sounds better and better until one day the orchestra soars—

it's wonderful. On that day the orchestra achieved synergy. You can analyze the music and technique of each musician and all musicians together and never get synergy. Something you can't analyze, clearly hidden deep in the hearts and minds of the musicians one day clicks and you get synergy. The same thing is true with a basketball team or the cast of a play or movie. If the humans involved click together you get a championship or an oscar. Otherwise, you have an okay team or movie, but no synergy.

If we consider the holistic model to be getting the right human minds together to solve a problem, we need a uniform value system among participants and a vision for the group to build or implement the model successfully. For an analytic model, we need correct variables and relationships and we need accurate data for input. The holistic model tends to be qualitative or human—a meeting of the right people with mutual respect, good communications, a good process for participation, and a shared purpose. The analytic model tends to be quantitative—a computer with algorithms. If we use an analytic model to support decision making on the significant problems we face, 1) it can't incorporate a vision, 2) we'll spend more time than we have debating acceptability in criteria and importance, and 3) probably we'll never get data everyone agrees on to put in the algorithm.

The answer is to optimally blend holistic and analytic thinking and to trade off individualism and technology against unified values and management. Holistic thinking is in itself oriented toward this blend. The significant problems of today deserve a profound understanding of the harmonious blend of science and management.

1.1.27.5. The Holistic Perspective Includes Gestalt.

You use gestalt when you fill in the blank spaces and read between the lines to apply the holistic perspective.

Webster defines gestalt as "a structure, configuration, or pattern of physical, biological, or psychological phenomena so integrated as to constitute a functional unit with properties not derivable from its parts in summation." (*Webster's Ninth New Collegiate Dictionary*)

The idea of gestalt has been studied by psychologists as gestalt psychology and gestalt therapy and has been applied to organizations. Gestalt involves interactions among the parts of the whole that we don't understand. But, the key to gestalt is the interactions. The interactions are what makes the whole work, and most of all work synergistically. Likewise the holistic perspective must key on interactions, interactions among the minds, feelings, and perceptions of the stakeholders of the activity being managed. In the gestalt idea, you're dealing with characteristics and variables you can't put into words. You have to experience the system you're managing. That's why those who have experienced the system, in the whole, have the gestalt to help us apply the holistic perspective to the system.

Not only should we borrow from psychology concepts that help us learn about the holistic approach, we can probably borrow from other disciplines. Gestalt psychology has been around for years and getting information about gestalt psychology is relatively easy. Consider a more modern issue affected by gestalt. Consider the holistic perspective around the death bed. When sustaining body function for the terminally ill, hospitals today bring together the physician (technical approach), the lawyer (institutional approach), and the clergy (spiritual, or cultural, approach) to help the family make the holistic decision leading to removing the patient from life support systems. This subject is new, and getting information is difficult.

I'm going to ask you to do something in this paragraph. If you look ahead to the next paragraph for the answer, you'll destroy the fun. Look at Figure 1.1.27.5.1. What do you see?

If you said you saw a circle, you formed closure. What you really saw is a ring of ten dots. The principle of closure is a gestalt principle. If you sense something in incomplete form you'll give it closure (jump to conclusions, resolve the problem). In seeing a circle you've formed closure based on incomplete information. This is a strength of the human mind necessary for holistic thinking that if misunderstood can cause us to jump to the wrong conclusions (smell out the wrong date, car, house, or school). What I had in mind when I put the dots in the figure were opposing five-pointed stars. Now, does your mind form closure on the stars? Of course, what I had in mind was a more complex idea than a simple circle.

The Holistic Approach Requires Vision or Fundamental Philosophy

Part of the holistic perspective is establishing an overarching fundamental philosophy or aim of the system. Once we have a long-term philosophy we set a constancy of purpose so everything can follow the philosophy, including goals, objectives, priorities, and task specifications. In analytic thinking, we can't function without clear-cut objectives and detailed task specifications. The holistic perspective then asks us to first agree among all stakeholders on an overarching philosophy for the system—a philosophy for both the goals and the process of our management activities. A difficult requirement for using the holistic perspective is the need for ultimate understanding and for dealing with the logic of the informed. The significant value of this perspective is that holistic thinking focuses us on what is desirable, whereas analytic thinking puts acceptability first. Figure 1.1.27.5.2. illustrates the difference between the acceptability and the desirability concepts. (Yoshida, Kosaku, *Deming Management Philosophy: Does It Work in the US as Well as in Japan?*, Columbia Journal of World Business, Fall, 1989, p. 12.) In analytic thinking, anything inside a given boundary is acceptable. In holistic thinking the most desirable is the center of the area of interest. As we get farther from the center, the result is less desirable.

When common ground is limited, we reach for acceptability, not desirability. In a management system, when stakeholders have different value systems (cultures) we tend toward analytic thinking. Therefore, trying to get holistic thinking from people of different value systems is difficult. Analytic thinking supports science, individualism, and discovery. Science and discovery certainly are important for corporate goals. Holistic thinking supports management, consensus, and optimization. Management, consensus, and optimization are also important for corporate goals. For dealing with significant problems today, clearly we want to blend both holistic and analytic thinking in a situation where before our differences force us toward analytic thinking.

We don't have to define desirability precisely. A rough estimate will do. So defining the area's center is easier than precisely defining the area's boundary. When judging whether an activity is acceptable or unacceptable we define the boundary exactly and argue over the definition and whether the activity in question meets the definition. So a rough definition of desirability is not only easier, it's better. Furthermore, when we define exact boundaries, people will focus on the boundary and meet lower requirements.

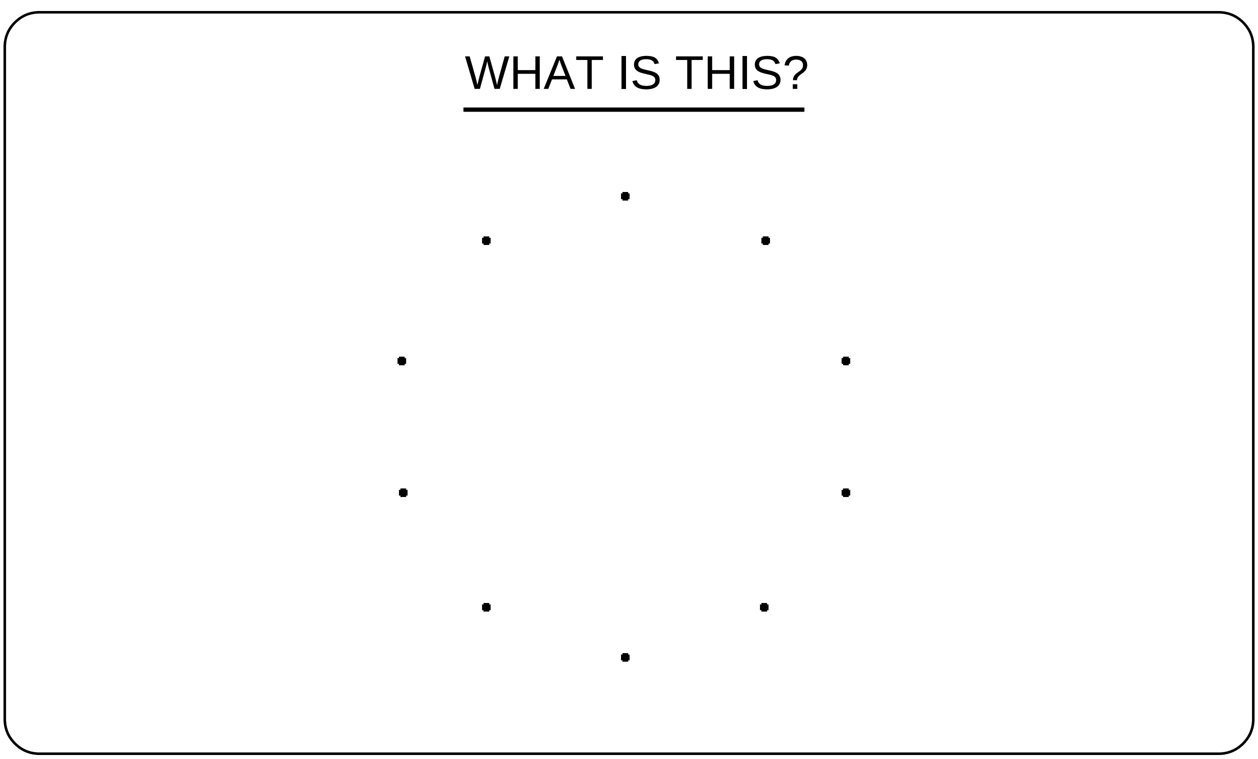

Figure 1.1.27.5.1. *What do you see in this figure?*

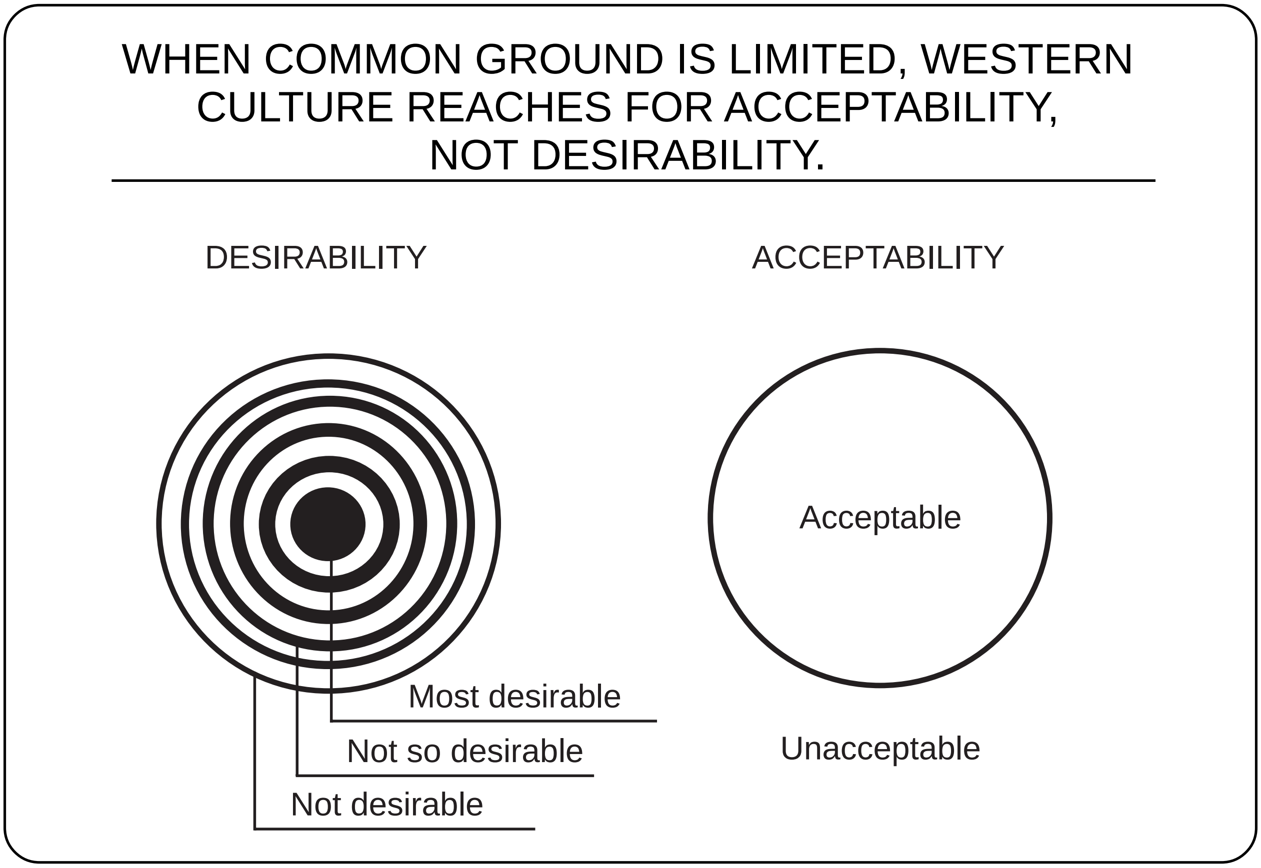

Figure 1.1.27.5.2. *When common ground is limited, society reaches for acceptability, not desirability. (taken from Yoshida)*

1.1.27.6. The Importance of Reading between the Lines—Japanese Art

1.1.27.7. DEFINE GENERALIST PERSPECTIVE

Mother nature is consistent.

How is a frog like a snowflake? How is poetry like mathematics? From the generalist perspective, the similarities are extreme. For example, I know that capacitors in electric circuits, radioactive decay, heat transfer, the propagation of muskrats, and the world population problem are really the same issue—at the heart of the matter. All of these things display exponential growth and decay. Once I understand the exponential character of one of these things, I understand the exponential character in all of them—only if I can make the leap from capacitors to muskrats. Isn't it interesting that Pareto developed a curve for income distribution that industrial engineers think is specifically suited for inventory analysis and Juran finds applicable to customers. The Pareto curve has become known as the 80-20 Law and means that 20% of your customers give you 80% of your business. Some years ago, I found that 20% of the engineering professors at Virginia Tech were responsible for 80% of the research funding in the College.

The generalist perspective makes the systems approach a learning approach. We can learn about management by applying what we know about the laws of nature and engineering analysis to management activities. Two such laws are the First Law and Second Law of Thermodynamics. The First law says we don't manufacture energy in our organization, we convert energy from one form to another. Max DePree says of the Second Law, "I am using the word 'entropy' in a loose way, because technically it has to do with the second law of thermodynamics. From a corporate management point of view, I choose to define it as meaning that everything has a tendency to deteriorate. One of the important things leaders need to learn is to recognize the signals of impending deterioration." (Max DePree, *Leadership is an Art*, Dell Publishing, 1989, pp. 110-111.). The only way to decrease entropy (chaos) is by putting energy into the system. The manager can decrease entropy in an organization by inputting energy.

Two examples of engineering analysis are the control loop for the dynamics of an organization and stress-strain diagrams for understanding strength of culture.

Because engineers are application oriented, they must think like a generalist. You want to bring the lessons learned from one application to another application. You don't want to start from absolute scratch for every problem you try to solve. Applying lessons learned from building one bridge to building another bridge is one level of the generalist perspective. Applying lessons learned in electrical circuit analysis to heat transfer is another level. Applying lessons learned in art and physics to management is yet another level. When you're dealing with this level, you're ready to see a frog in every snowflake.

Because engineers must deal with technology, they must think like specialists. I believe engineers experience specialist thinking during most of their education. Generally speaking, each course and professor offers to the student a set of tools representing one specialty that is advertised to be applicable to anything. Many people have their favorite tool and spend their lives searching for something to apply that tool to. The specialist perspective is just as important to the engineer and the manager as is the generalist perspective. I emphasize the generalist perspective because of my perceived vacuum in the background of engineering students.

A specialist has a tool in search of an application. A generalist has an application in search of a tool. The engineer must be both. Balance is the answer to everything.

A generalist builds bridges between disciplines and different ways of thinking. A generalist is good at metaphors and functional relationships.

To understand the generalist perspective, we can consider the act of generalizing. How do we generalize from a frog to a snow flake? "We say a finding has generality, or it can be generalized, if the finding holds in situations other than the one in which it was observed. By definition, then, generalizing always means extrapolating to conditions not identical to those at the time original observations were made..." (Alphonse Chapanis, *Some Generalizations about Generalizations*, Human Factors, 1988, 30(3), 253.)

From the article by Chapanis, I conclude that the key to generalizing one situation to another are the areas of similarity between situations or phenomena. We can generalize from a frog to a snow flake only in the way a frog is similar to a snow flake. Neither is made by humans. Both are affected by gravity. For widely differing situations, similarity is usually confined to qualitative measures rather than quantitative ones. The similarity, or dissimilarity, can be in origins, processes, characteristics, results, observer, purposes, and many more concepts. We can generalize within the concept where we find similarity. In short, a generalist focuses on similarities, not differences. Therefore, to a generalist, a frog is more similar to a snow flake than it is different from a snow flake.

I can remember times when I learned the most important lessons from the darndest places. In graduate school, I needed something different in my life, so I took a course on how to upholster furniture. Thirty years later I don't remember too much about the details of upholstery. But I do remember a lesson I learned. When you work on something, most of your effort makes the thing look worse. In upholstery, you strip the paint or stain, you tear off the covering, and you watch the springs fly in all directions. You take off the loose arm and nail back the missing part. Then the last little effort makes the thing beautiful. The lesson is that you have to persist through seemingly fruitless effort, or even seemingly destructive effort for a long time before you get to feel the joy of the effort coming together in a beautiful result. I'm sure farmers learn this lesson a thousand times over, but not in an upholstery course. I find that this lesson of upholstery applies to everything I do. I can generalize the lesson because the lesson is fundamental. The lesson applies both to engineering and management. The generalization often occurs as an ah-ha in discovering connections, as I described in Module 1.1.23.8.

Summing up the three perspectives

I've taken the traditional analytical approach to explain the systems approach, which is much more than the analytic approach. Therefore, I've kind of contradicted myself. The systems approach is holistic and I've divided and analyzed the systems approach. My only hope is that for people who aren't raised from childhood understanding the systems approach holistically, they can gain an awareness of what's involved in the systems approach. Also the three types of thinking provide skills for continuous performance improvement.

According to Webster, a perspective includes the capacity to view things in their true relations or relative importance. I believe this kind of perspective includes *all* perspectives. At the moment, I've identified three perspectives for the systems approach. When someone sees things from all perspectives, we say that person has their stuff together. Each thing they do or believe works toward their aim. (The system perspective includes an aim.) They have meaning in their life. (The holistic perspective includes soul.) They learn from each part of their life to improve other parts of their life. (The generalist perspective includes learning.) With the three perspectives taken together, they always learn from everything they do and everything they do plays an important role in their total life to reach their aim and to have meaning in their life. An individual is a one-person organization. An organization with more than one person can have its stuff together too.

1.1.27.8. What's the Difference Between a Specialist and a Generalist?

A generalist plows between furrows, while a specialist plows a furrow deeper. You need both to get the most out of the land.

To a generalist, there's not one right way to do a thing. There are any number of good ways to solve a problem. Sometimes we spend so much time and effort trying to find the absolute best way to solve a problem we don't end up with enough time and effort to use any one of the good-but-not-best ways to get that problem behind us and move on to the next problem. Depending on the application, you can find a solution that will fit the situation. You can't always optimize. Make one of the good ways work. Waiting to discover the optimum isn't always worth the time and effort to find the optimum. Simon says we often should satisfy rather than optimize.

A generalist looks between disciplines or crosses disciplines. I've always believed that plowing between the furrows is more lucrative than plowing the furrows deeper. The reason is that nobody's been between the furrows in a while, if ever. There's no telling what you'll find. But you better be prepared for anything and flexible enough to deal with it. My analogy is that a generalist plows between existing rows looking for fertile ground. The specialist plows existing rows deeper. Of course, you need both to get the most out of the land.

Jane Fraser describes the importance of generalists in solving today's significant problems. "What specialist can solve society's energy problem, the inflation problem, or the problems of the cities? ...These problems are simultaneously technical, economic, political, sociological, and ethical. Perhaps a team of specialists could do better than any individual specialist, but even a team lacks the perspective necessary to integrate specialized knowledge. We need generalists: people who can combine knowledge from many specialties into a comprehensive attack on a problem." (*In Respect of Generalists*, Research Memorandum 84-14, School of Industrial Engineering, Purdue University, 1988, p. 1.) The Three Mile Island and Challenger problems were only partly technical. To deal with those problems, we needed technical knowledge integrated with much more. We needed the generalist's perspective.

Jane Fraser expands the difference between specialist and generalist into a description of the generalist perspective. "But a specialist doesn't know just facts about his field, he has a point of view, a way of perceiving problems, methods for solving them, and an overall perspective. ...A generalist then is someone who can use concepts from more than one field. ...A generalist doesn't simply sum fields, he combines them. He is able to stand outside of, comment on, and combine his fields of expertise because he has a broader perspective that integrates the fields. ...A different type of generalist is someone who <u>challenges</u> the existing framework of knowledge by combining fields that haven't been combined before. If this kind of generalist is successful he becomes the first specialist in a new field. A generalist who combines economics and sociology creates the field of economic sociology or sociological economics. Indeed, the goal of such a generalist is to challenge the existing structure of knowledge, the traditions boundaries of specialties. ...The broadest type of generalist is someone who <u>ignores</u> the existing structure of knowledge. Sometimes there emerge people who combine such a large number of fields that they seem to be "super-generalists"; da Vinci is the obvious example. ...All these types of generalists have in common the trait of combining fields in a perspective that transcends any one of the fields. It is this trait of using a larger perspective that identifies the generalist in comparison with the specialist. ...The generalist provides something a specialist or a nonspecialist cannot provide, the integrating perspective. ...The generalist thus is valuable not just because he contributes new answers, but also because he asks new questions." (pp. 1-3.)

I believe the management systems engineer asks new questions and approaches the time-honored fundamental management questions with different insights in non-typical ways. The management systems engineer asks questions like, "What does the comparator in the control loop tell us about how to resolve bias in the information we get and bias in the way we use the information to make decisions?" The management systems engineer approaches the question of how to motivate people with the insight of how the principles of stress and strain affect strength of culture.

If we need more generalist thinking in management systems engineers, how do we put that thinking there? Jane Fraser answers by quoting J.M. Ziman's book, *Public Knowledge*, Cambridge University Press, 1986, p.62.) "It is much easier to join a specialty, and satisfy its cosy internal criteria (however tough these may be, in a strict professional sense) than to create interests embracing a number of these little villages of the mind... It requires a deliberate and intellectual effort to make an appraisal of a large science and to direct one's attentions towards serious problems that are not being studied by other people. ...Once generalist students are gathered, how and what should they be taught? Since a generalist knows many fields, a generalist education must be wide ranging. He must learn the concepts and perspectives of many fields. But being a generalist also requires integrating those fields." (p. 5.) The management systems engineering discipline strives to broaden the education of the student and to integrate both quantitative thinking and qualitative thinking to solve complex (or wicked) problems.

Finally, Jane Fraser answers the question of this module: How do generalists and specialists differ? "Generalists and specialists differ in their aesthetics of knowledge. A specialist sees the world as naturally organized into domains, but a generalist sees a whole with domains imposed by humans. They have different intellectual goals. A generalist gets pleasure from statements like 'this idea is similar to that one' while a specialist gets pleasure from working out the details of one idea. It may be that a certain personality trait, that of simply liking to make connections, is necessary for being a generalist. Or it may be that generalists are the people who worry about missing out on something exciting if they narrow their interests.

Because of this difference, generalists and specialists will tend to differ in the methods they use to create knowledge and in the types of knowledge they value. Understanding anything requires taking it apart, analyzing the working of each part separately, reassembling the parts into a whole, and finally understanding how the parts work together. Analyzers emphasize the taking apart and the detailed examination of each part; better understanding is gained by finer and finer decomposition until the smallest essential unit is reached. Synthesizers emphasize the connection of parts and ideas. Both analysis and synthesis are necessary for understanding and both generalists and specialists do both, but generalists tend to emphasize synthesis and specialists analysis.

Generalists and specialists also tend to emphasize different types of knowledge. Knowledge is the organization of ideas and theories that enables us to understand the world. Specialists emphasize the discovery of new facts and the creation of new ideas as the way to increase knowledge while generalists emphasize the creation of new links among existing ideas and the organization of existing facts and theories." (pp. 11-12.)

One of my objectives in this book is to illustrate how a generalist thinks. Not everyone has to think like a generalist. My point, and I believe Jane Fraser's point, is that the generalist will be an important player in solving the significant problems we face today. You will either think like a generalist or work with people who think like generalists. You need to understand where the generalist is coming from.

1.1.27.9. PARETO'S CURVE IS A UNIVERSAL TOOL

As generalists, we should be able to transfer the learning from Pareto's curve to almost anything, never forgetting the origin of the tool.

Pareto's curve is a valuable tool in total quality management. Both the Deming and Juran teachings include the lesson from Vilfredo Pareto. Juran talks about customers and knowing the customer as the first step in planning for quality. "One of the most critical classifications is that of *importance* of the customer. To respond to differences in importance we make use of the **Pareto principle**. Under that principle we classify customers into two basic categories:

1. A relative few ('vital few'), each of whom is of great importance to us.

2. A relatively large number of customers, each of whom is only of modest importance to us (the 'useful many')." (Juran, J. M., Juran on Planning for Quality, The Free Press, 1988, p. 26.)

Deming followers look to Pareto too. "[Pareto charts] are among the most commonly used graphic techniques. People will speak of 'doing a pareto' or say, 'Let's pareto it.' This chart is used to determine priorities. The pareto is sometimes described as a way to sort out the 'vital few' from the 'trivial many.' ..... In this fashion, pareto charts can be used to narrow down problems." (Walton, Mary, *The Deming Management Method*, Putnam Publishing Group, New York, 1986, pp. 105-106.)

Pareto didn't develop his curve for either total quality management or for inventory analysis. Vincent Tarascio describes what Pareto did. "Pareto found that the distribution of income for various countries tended to take the form of a particular curve when plotted as a cumulative frequency function. His income distribution curve, also known as 'Pareto's Law,' can be cast in the following statement: If we call N the number of income receivers having the income X or greater, A and (alpha) being parameters, then the distribution of income is given by the formula:

$$\log N = \log A - (\text{alpha}) \log X.$$

The issue of whether this income distribution curve is a 'law' or not centers on the constancy of (alpha). Pareto found (alpha) to be relatively constant using statistical data available to him from such diverse countries as England, Ireland, Germany, Italy, and even Peru. Subsequent empirical studies by others involving different countries indicated (alpha) to have only slight average variations of value, and these were within statistical error. Today, this formulation applies to certain parts of the cumulative frequency function." (Vincent J. Tarascio, *Pareto's Methodological Approach to Economics: A Study in the History of Some Scientific Aspects of Economic Thought*, The University of North Carolina Press, Chapel Hill, 1968, p. 115.)

Figure 1.1.27.9. shows the graph Pareto had in mind. Plot the logarithms of income limits on the y axis. The x axis is the logarithms of income receivers. Alpha is the tangent of the angle OAB made by the line with the log x axis. One question is whether the tangent of the angle is the same for all applications of the "law." For example, does the 80-20 rule apply to everything? Or, is it the 75-25 rule?

Industrial engineers can't talk about Pareto without mentioning inventory analysis. In fact, Pareto never dealt with inventory analysis. But James Riggs uses Pareto in discussing inventories. "It is obviously uneconomical to devote the same amount of time and attention to inconsequential items and to vital supplies. This widely applicable concept has become famous as 'the Pareto principle,' named after the Italian economist Vilfredo Pareto. In simple terms, it says that a few activities in a group of activities, or a few items in a group of items made, purchased, sold, or stored, account for the larger part of the resources used or gained. Its application to inventory policy recognizes that a small number of production supplies accounts for the bulk of the total value used.

The division of inventory into three classes according to dollar usage is known as **ABC analysis**. The usage rating for each item is the product of its annual usage and its unit purchase or production cost.

The Pareto principle translated into general management functions concentrates on a few important tasks that should receive the most skillful treatment because those functions produce the most good in the organization." (Riggs, James L., *Production Systems: Planning, Analysis, and Control*, John Wiley & Sons, New York, 1987, p. 479.)

Consider the last sentence of Riggs' comments in light of the idea of bottlenecks. I'll discuss bottlenecks as a crucial management concern later. We deal with bottlenecks in critical path analysis for project management and in just-in-time for manufacturing.

We can consider Pareto analysis as a method for control in inventory management. "In the problem definition phase of inventory management, a technique is needed that will isolate those items requiring extremely precise control as opposed to those items that can be controlled with less precision.

In defining the inventory management problem, the recommended starting point is the application of Pareto's *Principle of Maldistribution*, which has been expressed as follows: 'Very often a small number of important items dominate the results while at the other end of the line are a large number of items whose volume is so small that they have little effect on the results.' ..... Many managers believe that an ABC analysis is the most rewarding study technique they have ever used. It can be applied, not only to inventory, but also to value engineering, sales planning, quality control, and cost estimating among other operations. (Killeen, Louis M., *Techniques of Inventory Management*, American Management Association, 1969, pp. 19-20.)

"It is rather apparent that extremely precise control of the A items will certainly yield great leverage on the inventory investment required to run the business. Conversely, precision control of the C items probably will not be worth the expense." (p. 26.) (Don't confuse the ABC analysis for inventory policy with the ABC Model in Section 1.3. for understanding how you spend your time.)

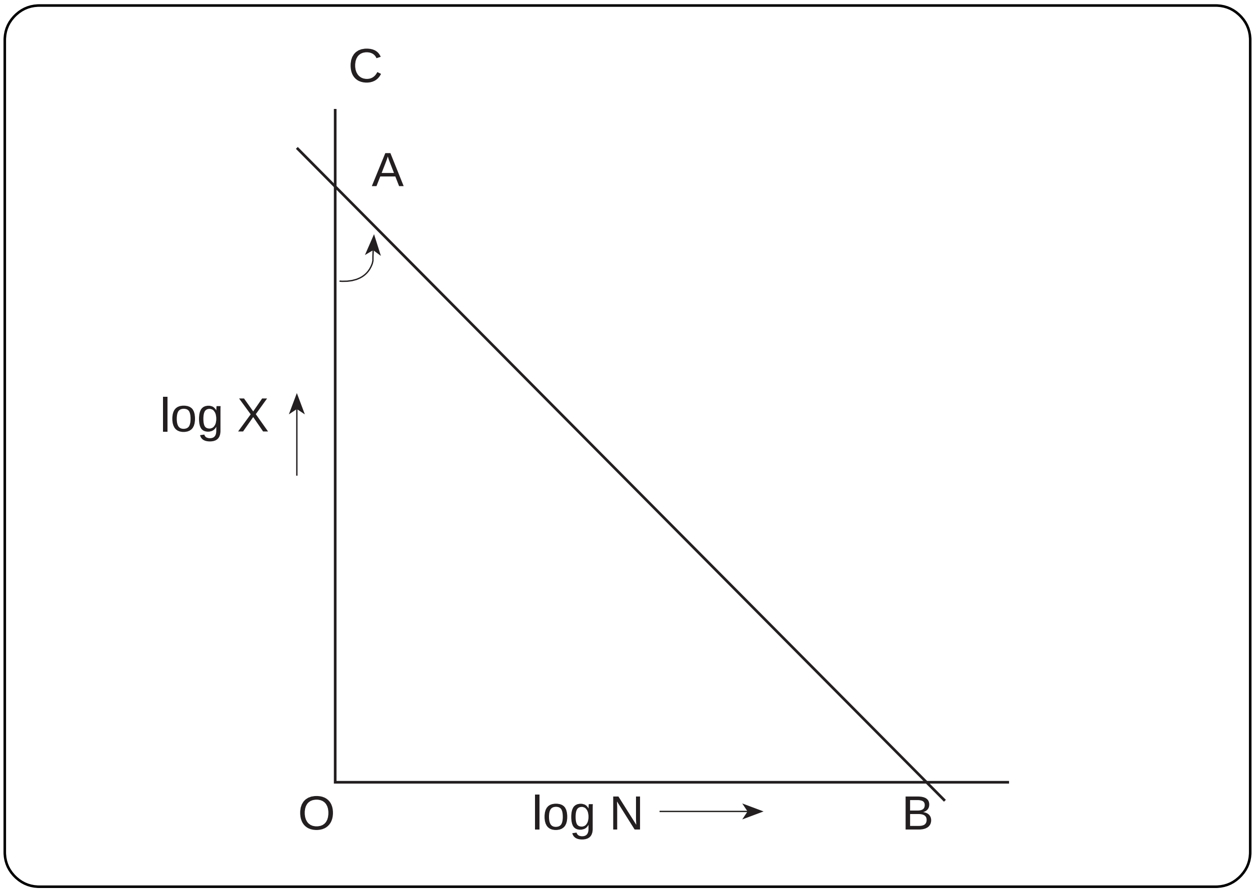

Figure 1.1.27.9. *Pareto's Law is really a straight line on log-log graph paper. We transfer what Pareto learned in income distribution to just about everything.*

1.1.27.10. Balance Art and Science

1.1.28. Mother Nature is Consistent—Michelangelo, the Painter

1. Background

1.1. Introduction

1.1.29. Illustrative/ Conceptual Model

1.1.29.1. Description

The model for the management process framework is illustrative in that the model shows the ideas of the book and is conceptual in that the model embodies the concept of the management process.

I can argue that the model for the management process framework shown in Figure 1.1.29.1. isn't a conceptual model. The concept of the management process isn't fully cooked yet. We don't understand the management process like we know the process for the internal combustion engine or the process for converting mechanical energy into thermal energy. For those processes, we have conceptual models and we can write equations to represent all or parts of the conceptual models.

We'll understand the management process framework and have a conceptual model when we demonstrate that the model consistently and repeatedly can meet the purposes contained in the framework I'll discuss in the next module. Strictly speaking, in the meantime we have an illustrative model.

The model in Figure 1.1.29.1. does gather together the ideas for the management process framework I've described in earlier modules together and puts them into context with one another. This model is the closest thing we have to a conceptual model.

Figure 1.1.29.1. brings together the various models we've discussed for the organization and its performance and places them with the interventions to improve the organization and its performance together within the general framework of Figure 1.1.11.4. As an intervention-organization-performance path, the model has been called holistic construal. Figure 1.1.29.1. shows the combination of management system analysis and management system synthesis as the organizational model. Any of the alternate organizational models can fit in the center box in the figure. You use the organizational model(s) that's best for showing the relationship between the interventions you want to make and the performance criteria you're trying to affect. In previous modules, I've discussed a number of candidates for the organizational model. I haven't provided you with a complete set of organizational models. There are more. The problem with Figure 1.1.29.1. is that I can't stuff everything into the figure that rightfully fits into the picture.

Not only can we have more or different models in the organization box in the center of Figure 1.1.29.1., we can have a number of models in the performance box to the right. In previous modules, I've discussed a number of candidates for sets of performance criteria. I haven't shown you all there are. Figure 1.1.29.1. shows three of the candidates for performance criteria in the right-hand box. In building or using management tools as an intervention, you may want more than one model in the performance box.

In the left-hand box of Figure 1.1.29.1., you can see theory, tools and their guides, skills, and technique. The theory behind the tools and their use dictates what the intervention is and what it does. I've listed a couple of tools. The Gantt chart is a technical sort of tool, while the meeting is a human sort of tool. Also, I've listed a few skills. Two are skills in thinking I've discussed earlier. Communication is a multiple skill for behavior that includes reading, writing, listening, and speaking. I'll discuss communication later. Technique is defined by Webster as "the manner in which technical details are treated (as by a writer) or basic physical movements are used (as by a dancer); *also*: ability to treat such details or use such movements (good piano technique).” (*Webster’s Ninth New Collegiate Dictionary*) Technique then involves both tools with their guides and skills and is something you develop through understanding and practice.

Figure 1.1.29.1. shows an example set of paths through the model. We can build and then use the Gantt chart tool. In building the tool we need all building management tool functions, but I’ve identified two key ones. First, we must know what information we need from the Gantt chart to support time-based decisions on project tasks. Second, we must know what data to collect and use in the Gantt chart to provide the best information for those decisions. I show the use of the Gantt chart in all three groups of using management tool functions described in Module 1.1.21.4. First, we use the Gantt chart in planning to set expectations about when we intend to perform tasks. We show the planned task duration as an open bar on a Gantt chart. Second, we use the Gantt chart in executing to gather status and progress data and show those data as a filled-in bar on the Gantt chart. Third, we use the Gantt chart in comparing status and progress against plan in verifying our performance.

I’ve shown the effects of the Gantt chart on the two building management tool functions and the three using management tool functions as dotted vectors in Figure 1.1.29.1. Also, I’ve shown as another dotted arrow the idea that developing data for building the Gantt chart affects how we convert data to information in using the chart.

When we verify performance using the Gantt chart, we’re guided by and wish to affect the amount of time we spend on A, B, and C activities shown in the performance box. We also want to evaluate how the information on performance in the Gantt chart affects the schedule apex of the project management pyramid. I’ve shown these effects in Figure 1.1.29.1. as dotted arrows. I could show many more effects of the Gantt chart on other functions in the organization model or, either directly or indirectly, on the performance criteria in the performance box. I didn’t show these additional effects because I didn’t want more lines on the diagram.

To begin to link the path of the analytic thinking skill through the figure, I’ve shown a dotted arrow linking the skill to the exercising personal effectiveness function of the using management tools set of functions. By affecting personal effectiveness, analytic thinking will affect the reviews (or meetings) we conduct to verify performance. I haven’t carried the effects of analytic thinking throughout the model because I didn’t want more lines on the diagram.

In the grand strategy system research conducted by the Virginia Productivity Center and the Management Systems Laboratories, we put Sink’s seven (or eight) fronts in the organization model box and the project management pyramid and Sink’s performance factors in the right hand box. By using these models we focus on the project characteristics of that study. Interventions include things like affinity group meetings, personnel process flow charts, and framed credo statements.

In the managing through cooperation research conducted by the Management Systems Laboratories, we put the management process functions (as shown in the figure) in the organization model box and the ABC Model in the right-hand box. We use these models to focus on the process characteristics within a headquarters group and between field sites and the headquarters group in a government agency. Interventions include things like materials management information systems.

To improve a manufacturing situation at the shop floor level, I would put the management process functions in the organization box and Goldratt’s criteria in the right-hand box.

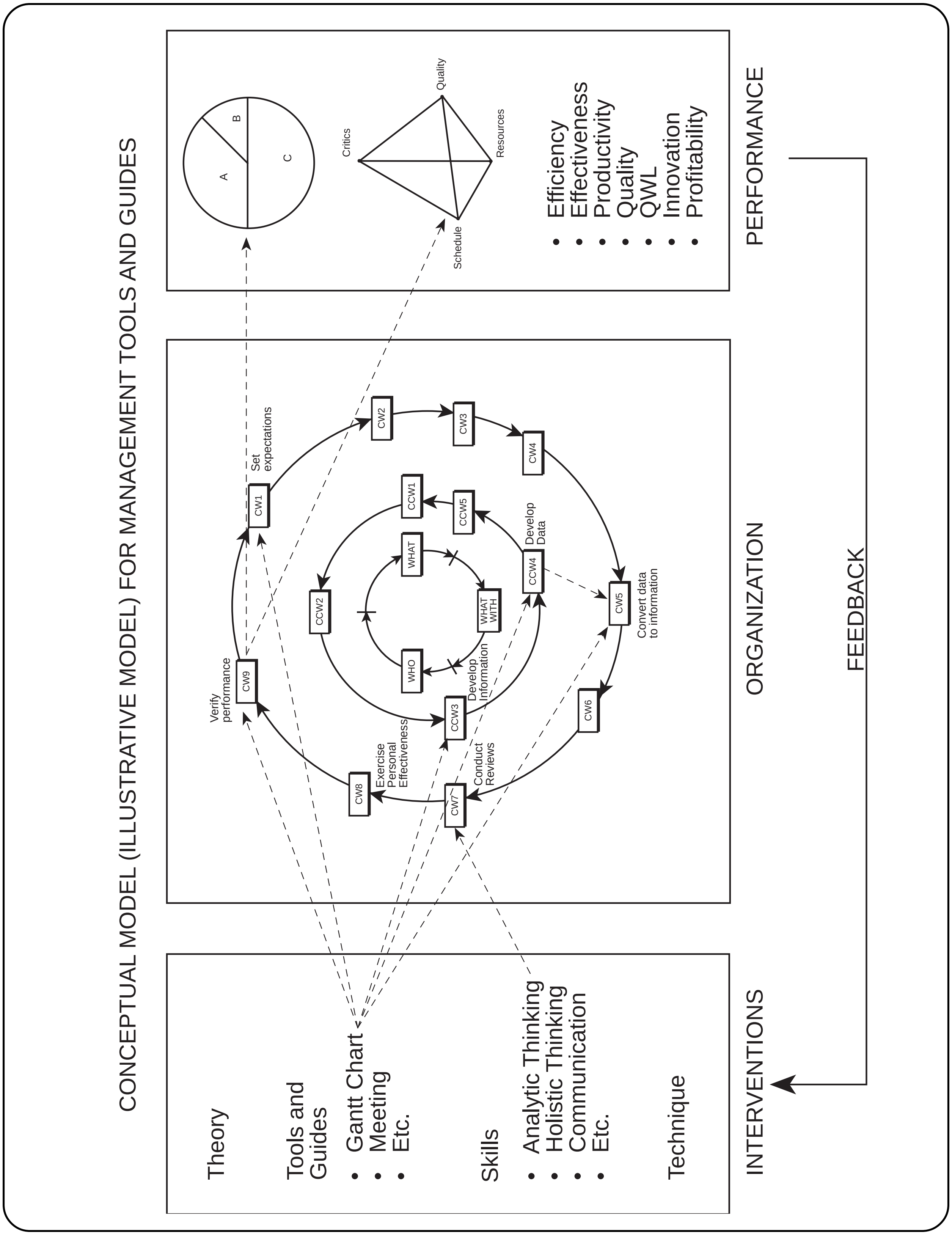

Figure 1.1.29.1. *The framework for the management process helps us determine the linkages between the interventions we make and parts of the organizational models and between these models and the changes in performance resulting from the interventions.*

1.1.29.2. Purposes of Models

To most effectively choose models for improving the organization and its performance, you must know what purpose you want the models to serve.

I'll describe five potential purposes for a model, each progressing to a higher level of contribution. Be careful not to combine too many purposes into a single model. Doing so complicates, and often reduces the effectiveness of, the model, especially for models you intend to serve higher levels of contribution. The management process framework model in the previous module has the problem of being very complex, or at least very cumbersome. That's why I've shown the submodels in the management process framework independently. I want to get the most power out of each model.

The first-level, and lowest-level, model is a descriptive model. The descriptive model describes what the system looks like. The Management System Model is such a model. When I use the illustrative model in Module 1.1.29.1. to show the context for modules in this book relative to the management process, the illustrative model acts as a descriptive model.

The purpose of a descriptive model is to describe something as clearly and completely as possible. A descriptive model usually identifies components and linkages in a system. In that we can't always be complete in complex descriptions, we often choose to highlight certain parameters in our description. As with all models, each of us needs to know the constraints or bias of the designer of the model before we know the applicability of the model. A descriptive model focuses on what the components and linkages are.

The second-level model is an explanatory model. The explanatory model describes how the parts of a system work together to get the output shown. When I use the illustrative model to show how the Gantt chart affects the management process functions which in turn affect performance criteria, the illustrative model acts as an explanatory model.

The purpose of an explanatory model is to show relationships in a system. Beyond showing that one component is linked, or connected, to another, the explanatory model shows how the component is linked but not the effect of that linkage or the input or output of the entire system being modeled. An explanatory model focuses on how the components and linkages work together in a narrative rather than an analytic way.

The third-level model is a prescriptive model. The prescriptive model shows you what to do to a system to get a given result. When you know what you want or must get, the prescriptive model prescribes what you must do to get it. When I use the illustrative model to indicate what tools or skills to use in certain functions to get a desired change in improvement in performance of the organization, the illustrative model acts as a prescriptive model.

The purpose of a prescriptive model is to prescribe certain cause to get a given effect. A prescriptive model focuses on inputs rather than outputs. The output is considered as fixed and the inputs are variable. Alternatively, we can consider how the components and linkages of a system can be adjusted to get the effects we want from certain causes.

The fourth-level, and very powerful model is a predictive model. The predictive model tells you what will happen if you do something to a system. The control loop is a predictive model. Of course, the control loop, which is more complex than the Management System Model, can be used as a descriptive model too. When I use the illustrative model to show what changes in performance will result from using a tool or skill in a certain way, the illustrative model acts as a predictive model.

The purpose of a predictive model is the inverse of that for a prescriptive model. The predictive model focuses on outputs rather than inputs. We're most used to predictive models. The predictive model predicts the outcome for fixed causes.

The fifth-level model is a normative model. The normative model tells you what the system should look like in the future. When I apply the illustrative model to a certain case, like the grand strategy system or the management through cooperation study described in the previous module, the illustrative model acts as a normative model.

The purpose of a normative model is more like a prescriptive than a predictive model. The prescriptive model focuses on achieving an output or result—something tangible or quantitative at the end of a process or the back of a system. The normative model focuses on achieving an outcome or future goal—something general or qualitative beyond the end of a process or the back of a system.

The disadvantage of the illustrative model is that the model is complex and takes many different forms and shows different faces. The advantage of the illustrative model is that I can use the model for so many different purposes. The purpose I serve depends on how I use the model.

1.1.29.3. The Illustrative Model in Context

The illustrative model is the structural part of the management process and, for anyone using the model, portends a continuous learning curve for the rest of their lives.

The control loop and the illustrative model for the framework of the management process show you the value of a descriptive model like the Management System Model (MSM). The simple MSM laid the groundwork for the more complex, more flexible, more powerful models. Now we have prescriptive and predictive models. Without the MSM, I at least would not have developed the other models.

I can use the illustrative model to follow the linkages of a tool, like the Gantt chart, through the intervention to organization to performance construal. The Gantt chart affects many functions in the organization, some of which I highlighted in Module 1.1.29.1. Knowing the effects of the Gantt chart on the organization, I can relate the needed skills to the building and use of that tool. Later, I can build an instrument to evaluate the organization to determine the relative need and the best use for that particular tool. I'll need the illustrative model and a series of frameworks I'll describe soon to diagnose the need in the organization and select the right tool to meet the need.

The illustrative model illlustrates the framework for the management process. To do the management process, you need more. You must live and breathe the systems approach. You must understand the fundamentals of management and of the laws of nature. You must fully understand the domain of responsibility representing the application. You must understand the rules governing the functions. (I'll describe the rules when I discuss using management tools.) You must know about a large number of possible tools and the associated skills so you can match tools with the need.

The illustrative model is probably the easiest part of the management process to understand. The systems approach is probably the hardest part to understand. The hardest part to do is scoping the domain of responsibility. If the domain is yours, scoping the domain is much easier than if the domain is someone else's.

Using the illustrative model and the management process it represents is a continuous learning process. The feedback loop applies not only to making better interventions based on changes in organizational performance, the loop applies to the increased knowledge of the user of the model. As you use the model in one application or for a series of applications, you'll develop an insight for what is most effective. As others develop better organizational models and better sets of performance criteria, you can improve the illustrative model. You must not only learn from your experience, but you must learn from the experience of others. To do management systems engineering well, you must continue learning about management and engineering for the rest of your life.

1.1.29.4. Example Use of the Illustrative Model

An example shows the illustrative model as an aid in understanding how interventions affect organizations and their performance.

To show how to use the illustrative model, I'll choose two different interventions to make in an organization. The more you know about the organization, the better off you are in choosing which models to use in the center and right-hand boxes in the illustrative model and in interpreting the results. Since I don't want to spend a lot of space describing an hypothetical organization, I'll work with my two examples for interventions as they might be applied to any organization. I won't describe the organization in detail and a summary won't help much.

I choose to look at the effects of 1) changing the organization's management information system and 2) rethinking the organization's mission/vision/principles statements. These two interventions are quite different. Changing the management information system is more physical in the extensive review, modification or building, and implementation of software and hardware as well as the change in procedures for using a different management information system. Changing the mission/vision/principles is more conceptual in the dealing with what the organization is, wants to be, believes in, and stands for.

I'll start with the management information system. The organizational model needs to emphasize the workings of the organization in terms of data and information. The performance model needs to reflect the reaction of the organization due to a change in the information available, either in terms of timeliness, accuracy, or relevance. Just having more information is counter-productive. We want all the relevant information, not just more information. When reviewing the organizational models in the earlier modules, I believe the nine functions of the management system synthesis cycle will emphasize the use of the management tool, which frequently and routinely converts data to information. I assume we have chosen the management system we want to change to. If we haven't, I'll need to include the five functions of the management system analysis cycle. When I do that, I can show interactions between the two cycles as I work on both building and using the management information system. The information-oriented performance models or frameworks are Sink's seven performance criteria and the project management pyramid. I'll use them both to see if either or both help me understand the effects of the management information system.

In Figure 1.1.29.4., I show the nine functions of management system synthesis at the top of the center box. I want to leave room for other models in the organization box to help me see the effects of rethinking the organization's mission/vision/principles statements. I probably also will find that the two interventions will affect one another; they will do so through the model(s) in the center box. My arrow from the management information system intervention should go directly to the converting-data-to-information function, since that's what the information system does. However, that function is linked to other functions as shown in the management system synthesis cycle arrows. I show both Sink's seven performance criteria and the project management pyramid at the top of the right-hand box. I may want another model for performance criteria when I look at the other intervention. I show several arrows from the organizing and presenting information function of the management system synthesis cycle to several of the factors in Sink's criteria. (I don't show arrows to all the criteria, because I don't want to clutter Figure 1.1.29.4.; however, I think about all the possible effects.) I show several arrows from the verifying performance function to the project management pyramid. I also show arrows from the project management pyramid to Sink's criteria. The advantage of the models and arrows at this point is to cause me to think through what the management information system will do to the organization and what I might look for to measure and see if the management information system really helps.

My second intervention is rethinking the mission/vision/principles statements. The organizational model needs to emphasize the workings of the organization in terms of what the organization is, wants to be, believes in, and stands for. The performance model needs to reflect the reaction of the organization to a new direction and new values. I believe the organizational effectiveness pyramid will emphasize the strategic and value-laden characteristics of this intervention. However, Kilmann's five tracks and Sink's seven fronts have culture-oriented components that would highlight these characteristics. I'll use the pyramid to represent those three models so I can keep the clutter down and because all pyramid apexes rotate around these characteristics. However, I'll include the planning process model because I believe that model will highlight linkages between the effects on the two different interventions on the organization. I'll use the critical success criteria in the performance box because of the strategic nature of those criteria and because of the linkage of the mission/vision/principles statements to the company's success.

In Figure 1.1.29.4., I show the organizational effectiveness pyramid and the planning process in the center box. I show arrows from the intervention to several of the apexes. I also show an arrow from the comprehensive planning apex to the setting expectations function of the management system synthesis cycle. How about other arrows between the two models in the middle box? I know most of the elements in the models are related. I want to think through the various options and show the more-significant ones. I show the critical success criteria in the right hand box. I show arrows from several of the apexes of the organizational effectiveness pyramid to those criteria and a few arrows between those criteria and the other performance models. I also show arrows from the planning process model to critical success criteria in the performance box.

Now look at the overall view of Figure 1.1.29.4. Do you see the interventions acting on the organization through its components as shown by the elements in the three models in the center box? If not, we may need more appropriate models or to think through the arrows (relationships) more. Do you get an idea of what to look for to see if the interventions are doing the organization any good? Do you get a feeling for how the interventions affect each other as they work on the organization? If so, you can make some decisions on how to sequence interventions.

There is no school solution to this example. The objective isn't to check the answer at the back of the book. The objective is to get some understanding of whether the interventions you plan are good ones and then to see if you can verify whether or not they are good ones and to get some understanding of how to sequence the interventions. The illustrative model is an aid. It isn't the school solution.

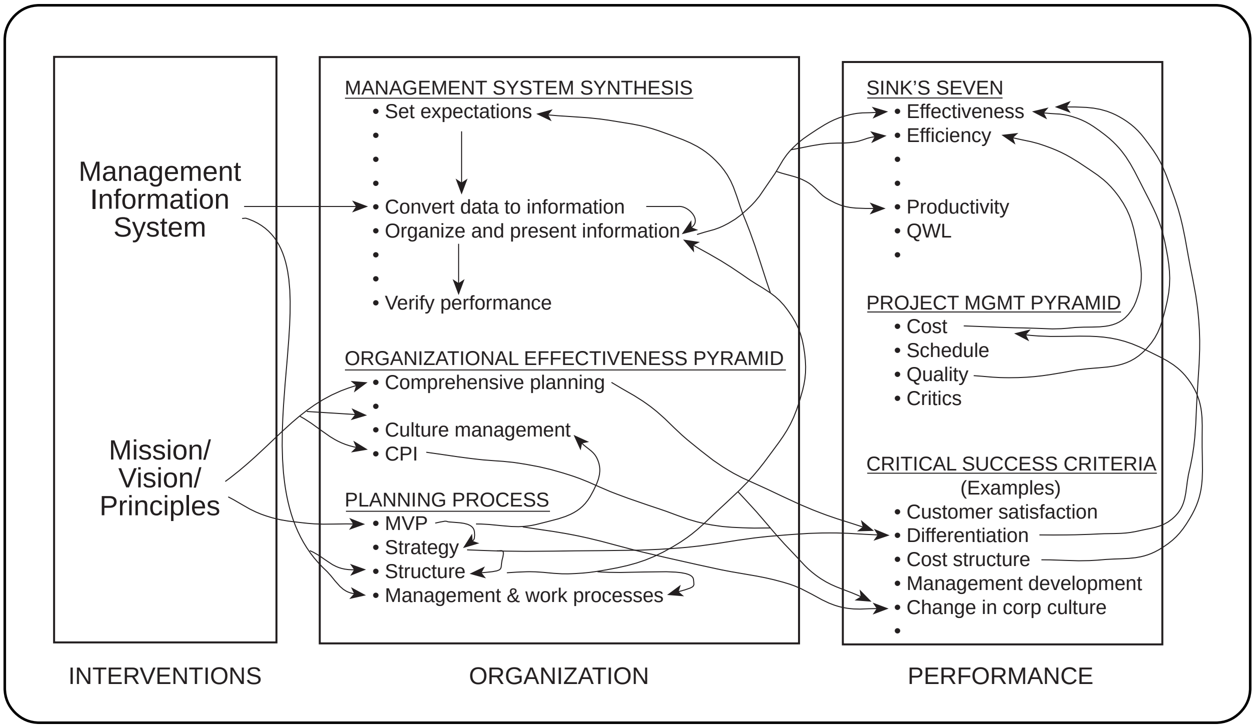

Figure 1.1.29.4. *The models and relationships shown for the example represent the kind of thinking you do as you use the illustrative model.*

1.1.29.5. Cyclic, Recursive, Reversible Characteristics of the Illustrative Model

1.1.29.6. THE DIRECTION

1.1.29.7. SUBPROBLEMS

1.1.29.8. Exercise on the Illustrative Model

You can trace relationships from interventions to components of organizational models to performance criteria for any domain of responsibility.

Explanation
The meeting is one of the most valuable management tools we can use for an intervention to improve performance in an organization. However, the meeting usually is one of the greatest timewasters in an organization. Therefore the meeting is a tool we need to apply carefully. I'll discuss different types of meetings and their use later. I'll also discuss how to improve meetings to make them more effective.

Situation Description
Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They brought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. You've been hired as a management consultant to advise them.

Exercise
Start with the people involved in the shoe store. To communicate well and without ambiguity, they need to meet from time to time and discuss what's going on in the shoe store. Consider one or more of the sets of organizational criteria in Modules 1.1.23. and one or more of the sets of performance criteria in Modules 1.1.25. Describe or show the linkages from the meeting (a tool in the interventions box of the illustrative model) to the organizational model (in the center box) and from the organizational model to the performance criteria (in the right-hand box). Don't try to distinguish among the many different types of meetings the people in the shoe store could implement. Also, don't try to improve any meetings they may be having. Describe or show the linkages and then summarize your work by writing 50 words or less to Bob on what you might advise for meetings in his shoe store.

1.1.30. An Interpretation of Infinity—M.C. Escher

1. Background

1.1. Introduction

1.1.31. Hypotheses of the Approach

1.1.31.1. ASSERTIONS/ASSUMPTIONS/PREMISES/PROPOSITIONS

1.1.31.2. Relationships to Time-Honored, Fundamental Management Questions

1. BACKGROUND

1.2. ANECDOTES

1.2.1. General

1.2.2. Comprehensive Situation Description

1.3. ABC Model

1.3.1. How You Spend Your Time

As practitioners and researchers evaluate how managers spend their time, a simple model helps identify problems and develop solutions.

What do managers do? By our definition they make decisions. And they need information to make decisions. But not just any information. They need relevant information and just the right amount of it. Managers make decisions, not for the heck of it, but, rather to accomplish something through actions resulting from the decisions. In getting the decisions to become actions, managers play many different roles. Matter of fact, being an actor and being able to switch from one role to another rapidly as the need arises, isn't a bad idea. Playing different roles at the same time isn't bad either. By roles I mean things like spokesperson, leader, coordinator, figurehead, and many others.

Remember the actions resulting from your decisions affect the what is managed component of the Management System Model (MSM). Remember also the what is managed component, or operation, includes capital, people, equipment and facilities, materials, and energy. Mostly people! And it's mostly these people (and also people outside your domain) who'll respond to your decisions and actions through their perception of you through the role you're playing.

Another way to look at management is through the function you're carrying out. Basically, a manager plans, executes, and compares. You plan what you and your organization are going to do. You do what you planned to do and then see if you did it. The better you plan it, the better you'll do it. So, it makes sense to analyze (separate into tractable pieces) what a manager does, and simply say you plan it, you do it, or you see if you did what you planned.

The words commonly used for planning, executing, and comparing are plan and control, where control implies both executing and comparing. Note before we go any further that the word plan can be either a verb or a noun. You can plan (verb) and you can generate a plan (noun) or a procedure or a budget or whatever. Generally speaking, a plan (noun) doesn't always result from planning (verb). Sometimes, planning will produce a policy or a procedure.

As you plan or control, you'll want to organize your resources to do so. As we look at our domains, we'll find different endeavors. Each type of endeavor is really different complexities of assemblages of very simple, automatable actions. So, the more complicated part of management is just organizing very simple actions. For strategic endeavors, the number of actions is so great and the arrangement of them into functioning entities so cumbersome, our ability to organize the actions or to understand how they've been organized is crucial to our management. Now, we have three things managers do: plan, control, and organize. These are the most universally accepted three.

But, if we look at the word control a little closer, we find it has at least two meanings. We've considered the idea of channelling resources against time to meet an objective when we thought of execution. Another meaning of control is to direct. That is, to orient or to point. And, the main recipient of this directing is our people. And we want to direct the right people. We have to staff our organization with the people we need to help do our work. So, commonly we find five things managers do:

plan, control, organize, direct, and staff. Managers do these things regardless of pursuit, endeavor, decision type, or stage of maturity. (Pursuits, endeavors, decision types, and maturity stages are the frameworks for diagnosing a domain of responsibility I'll describe soon.)

A good manager does planning, controlling, organizing, directing, and staffing well. Excellent managers excel at one or more of these. I show the five things managers do in Figure 1.3.1. as five undertakings: plan, control, organize, direct, staff. I use the word undertakings so I don't use function to mean two different things in this book. The sixth undertaking, executing, is a doing undertaking rather than a managing undertaking. The endeavors on the left side of Figure 1.3.1. are three managing endeavors and one doing endeavor. I'll describe the endeavors later in the endeavors framework.

Managers need many skills to be good at or to excel at the things a manager does. But, clearly, the most important skill of all is that of communicating. We can communicate in many forms: spoken, written, body language, etc. All forms have a sending and a receiving side to the transfer of information, or communication. So, once again, we find managers' jobs rotating around information. They need information to make decisions with and they have to be good at transferring information. Considering just the spoken and written forms of communication, managers must be good at speaking and listening and writing and reading. Many experts will argue the most important management skill is listening. Other skills are obviously important, such as interpreting what you hear. But the communication skills are a good starting point—and one you can do a lot about.

Since Henri Fayol introduced the management functions (undertakings) of plan, organize, coordinate and control in 1916 and Henry Mintzberg contrasted the functions with management roles in 1975, many authors have supported, criticized, or integrated these landmark studies. (H. Fayol, *General and Industrial Management*, translated by Constance Storrs, Pitman and Sons, London, 1949; H. Mintzberg, *The Managers Job: Folklore and Fact*, Harvard Business Review, 53 (4), pp. 49-61, 1975; J. C. Carroll and D. J. Gillen, *Are the Classical Management Functions Useful in Describing Managerial Work?*, Academy of Management Review, 12 (1), pp. 38-51, 1987; L. B. Kurke and H.E. Aldrich, *Mintzberg Was Right: A Replication and Extension of the Nature of Managerial Work*, Management Science, 29(8), pp. 975-984, 1983.) Mintzberg lists as a fact that "Study after study has shown that managers work at an unrelenting pace, that their activities are characterized by brevity, variety, and discontinuity, and that they are strongly oriented to action and dislike reflective activities." He says "The manager is simply responding to the pressures of his job." and "the manager is a real-time responder to stimuli, ..." Kurke and Aldrich say that "These diary and observational studies together reveal a general portrait of managers who are very busy, frequently interrupted, and have little control over what they do." Catering to crises isn't new.

Mintzberg has identified three types or groups of roles managers play in their organizations. The first is a group of interpersonal roles managers play to work at relationships in their domains and among related domains. The second is a group of informational roles managers play to get and transfer information in their domains and among related domains. The third is a group of decisional roles managers play to choose from alternatives they've identified for solving their problems or making the most of their opportunities.

The manager's interpersonal roles arise through his or her authority. As a figurehead, the manager performs duties of a ceremonial nature. As a leader, the manager motivates and encourages their people. As liaison, he or she makes contacts outside his or her chain of command.

The manager's informational roles arise from his or her contacts and through his or her network. As a monitor, the manager perceives unsolicited information. As a disseminator, the manager passes information directly to the people who work for him or her. As a spokesperson, the manager informs and satisfies influential people inside and outside the organization.

The manager's decisional roles arise from his or her position. As an entrepreneur, the manager initiates development projects. As a disturbance handler, the manager responds to pressures and crises. As a resource allocator, he or she authorizes important decisions. And as a negotiator, the manager resolves contracts and grievances.

The decisional roles have to do with choosing from alternatives, which is another way of saying solving problems. Simon says that problem solving includes three phases: intelligence, design, and choice. All three phases are important, but each gets more demanding as we step through the phases. First, we must gather information about the problem. Then we must develop a number of feasible alternatives for solving the problem. Finally, we choose the best alternative. This choice results in a decision.

I show some of Mintzberg's roles in Figure 1.3.1. Roughly speaking, you can trace endeavors, roles, and undertakings across the diagram. For example, when doing the strategic endeavor, you tend to play a leadership role and be in the mode of directing the organization. Also, in Figure 1.3.1. I've shown that at the strategic level, you'll be contributing to effectiveness, or doing the right things.

Now, I'll compare Mintzberg's roles to the activities of the ABC model. In Mintzberg's terms, his entrepreneur role is clearly building the business, or B, and disturbance-handler role is clearly catering to crises, or C. I described A, B, and C activities briefly in Module 1.1.7. I'll describe the activities in more detail in Modules 1.3.3. and 1.3.6. His resource allocator role is clearly administer the process, or A. Certainly for internal needs, the interpersonal roles of figurehead, leader, and liaison are more A activities, as are his informational roles of monitor, disseminator, and spokesperson. The manager plays negotiator in all activity types. Carroll and Gellen fault Mintzberg because they recognize that much of what we do is based on "unplanned conversation with a subordinate, resulting from an accidental meeting" and that many of us "... work many hours even before coming in to the office." The telling blow to the Mintzberg approach is that much of management activity is mental and not physical and that "mental time is not the same as physical time." So, how can we use the long lists of five functions, ten roles, nine activities, and so on these authors argue will help us prescribe what we should be doing as managers? I believe a valuable alternative to these lists is a simple model—A-B-C. And the effort to figure out what we do and what we should do is complicated. The uniqueness of the ABC model is it recognizes the importance of dealing with C—catering to crises.

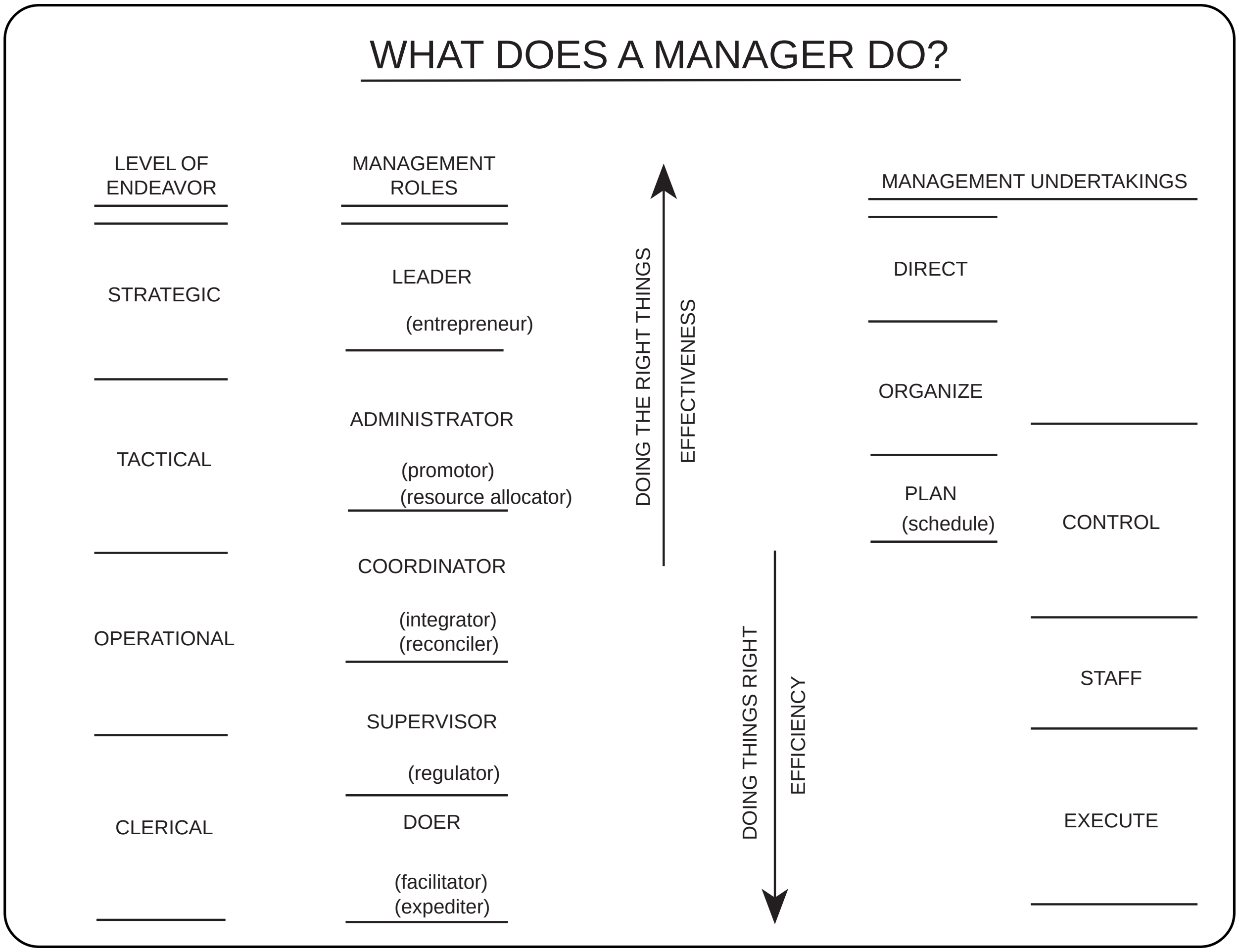

Figure 1.3.1. *Roughly speaking, you play different roles and participate in different undertakings while doing a given endeavor.*

1.3.2. Know Your ABC's for Getting Control of Your Day.

By successfully implementing your management process and continuously improving your work process, you'll reduce daily crises and have more time to build the business.

Figure 1.3.2. implies that managers spend their time doing only three different types of activities: 1) doing the routine work of the business, administering the work process and the management process; 2) extending and improving the unit's product or service to its stakeholders, building the business; and 3) dealing with disruptions, catering to crisis. Recognizing that for many years scholars have studied and hypothesized the many things managers do, as discussed in Module 1.3.1., the model in Figure 1.3.2. has a good combination of simplicity and robustness. By considering everything that managers do in one of the three slices of the pie, researchers and practitioners alike can effectively audit the manager's time.

When you do A, or administer your work process, you look inward at the organization to make it do what it's supposed to do as well as possible. You focus on getting visibility of the organization and gaining control so you can manage change initiated within your internal world. You do whatever improvement is necessary to do your job better. You need a structured management process to help and guide your efforts in your work process.

A activities are process focused. They look at the quality of the input and output of your unit; but, most of all, they look at your unit's work process and they include all activities of the management process. *A activities keep the organization stable and functioning day in and day out.* They address more immediate needs and have more short-term effects.

When you do B, or build your business, you look outward at your external environment to be competitive in your industry and to manage change initiated by the outside world. You focus on improving your product or service, customer base, and competitive position. You do whatever visibility and control are necessary so you can be in tune with your external environment.

B activities are results or outcome focused. They look at quality outside the boundaries of your unit; but most of all, they look at your unit's customers. *B activities move the organization forward*. They address more distant needs and have more long-term effects.

You want the right mix between A and B activities, and you want to increase the amount of time you spend on B activities without abusing your A activities. A big question is: How do you allocate your time to A and B activities when you seem to be consumed with C activities?

When Deming runs the funnel experiment, he shows that if you focus on the outcome, or result, of a system, you get problems, or crises. I translate that to mean if you focus on B you get C. Deming shows that you want to focus on the process to get the best out of the system. I translate that to mean if you focus on A, you reduce C to get time to improve the organization's product or service for the stakeholders.

When you do C activities, or cater to crises, you deal with good or bad surprises—the bane of management. When you go home at night and haven't accomplished what you set out to do, most likely, you've spent your day dealing with issues you didn't expect—surprises. By catering to crises and putting the urgent before the important, you neglect your work and management processes, your world becomes more unstable, and you never have time to move the organization forward. The greatest number and most crucial surprises are of your own making. Some are outside of your control.

C activities are disturbance focused. They destroy quality, productivity, and morale. *C activities attack the stability of the organization and keep you from moving forward.* They appear to be immediate and hurt you in both the short-term and in the long-term.

One way to look at A, B, and C activities is that A activities are process oriented, B activities are outcome oriented, and C activities are in response to unexpected situations.

You want a good mix of A and B activities to keep your organization stable *and* moving forward. You want to reduce C activities so you can spend more time on A and B activities. Consider the analogy of your organization as a ship on a journey across an ocean. Your job is to move the ship toward its destination while keeping the ship upright. Meanwhile, forces from within the ship and from outside the ship can move the ship off course or capsize the ship. B activities move the ship forward. A activities keep the ship upright. C activities react to the forces acting to disorient or capsize the ship. If you spend all your time upside down or going in the wrong direction, you'll fail.

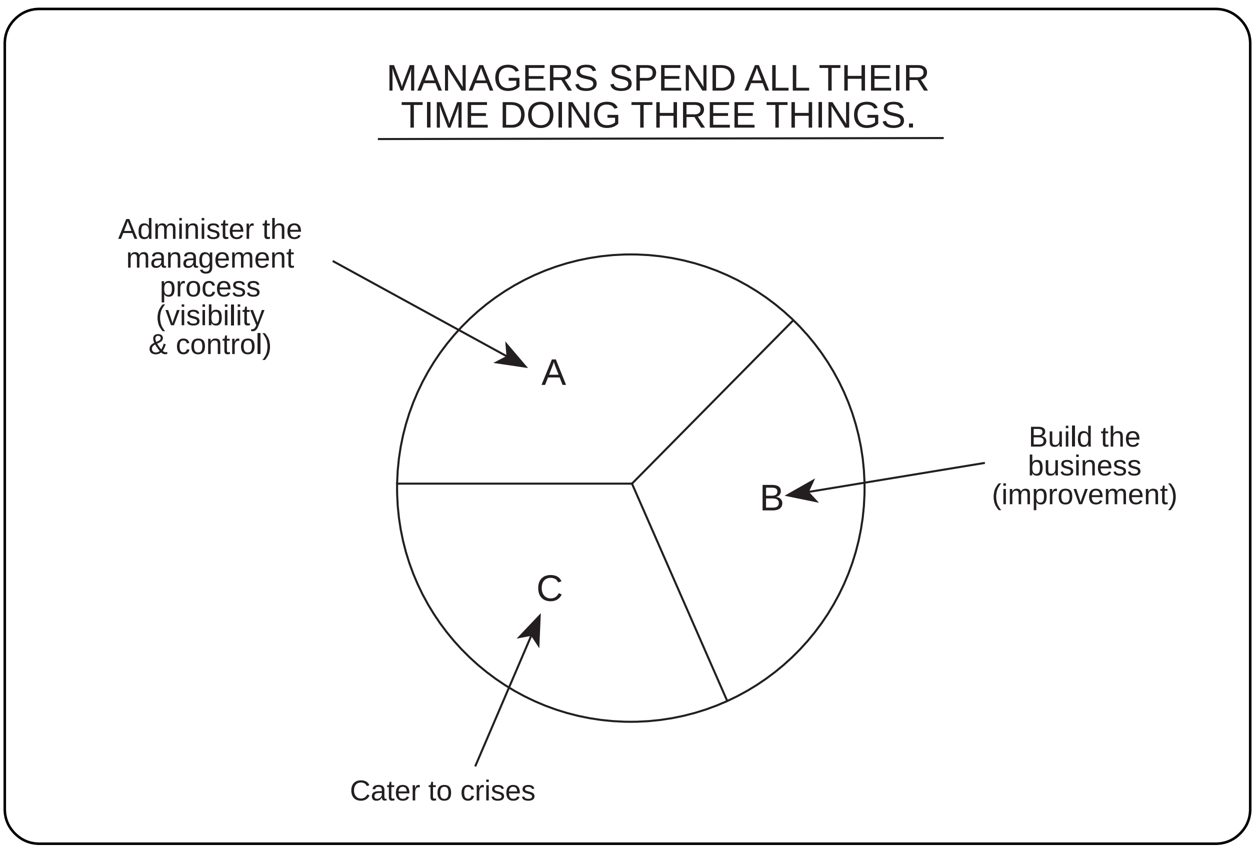

Figure 1.3.2. *The ABC model classifies all your time into categories you can use to discover how to get control of your day by getting control of yourself.*

1.3.3. Our Crises Are of Our Own Making.

We spend the vast majority of our time dealing with crises we made for ourselves.

As you consider your surprises, focus on their source. Organizations in the United States, on average, spend 40 percent of their time doing rework. Service organizations spend this much time on correcting errors.

Add to this 40 percent the time lost in making up for doing work at the last minute. You spend additional time walking documents through the approval chain or explaining to customers late products and services because you did the work at the last minute.

Add to this amount of time the frustration, spinning wheels, and time lost because of miscommunication. As a sending and receiving process, communication can fail at many points.

How much time do you spend looking for a document you need? Do you ever receive a notice, follow up on it, and find you already took care of the situation when you received the original notice a month ago? In the case of this last question, you wasted your time and the time of the person you interacted with to follow up on the notice a second time. Meetings are terrible time-wasters. We put up with the waste of time because we need meetings for communication and to set expectations and review status and progress. How many times do you wait for late meetings? For that matter, how much time do you spend waiting for late people?

Setting expectations is an important function in the management process. When we have no expectations or perceive the wrong expectations, we scurry around doing things that aren't needed or are counter productive. We work hard on the wrong things. In the end, someone still expects somethings of us. We'll waste time doing the wrong thing, re-establishing what the right expectations are, and rushing to meet that expectation at the last minute.

If you aren't yet convinced the C slice of the ABC pie is huge, consider this. Stephen R. Covey, in his book *Principle-centered Leadership,* (Simon & Schuster, 1990) talks about the destructiveness of time spent on gossip, "politicking, defensive communication, protective communication, interpersonal rivalry, interdepartmental contests, positioning, and manipulating." He says, "I ask you: what percent of the time and energy in your family or business is spent in some kind of defensive or protective communication? What percent of the energy is spent on things that do not contribute to serving your spouse, your children, or your customers—wasteful things like internal squabbling, interdepartmental rivalries, politicking, and interpersonal conflicts? Most people admit that 20 to 40 percent of their time and energy is spent in these destructive ways." (p. 117.)

You can think of other time wasters that aren't an act of God or an unexpected opportunity for the customer. What percentage of your day is spent catering to crises of your own making?

The roots of much of the destructive behavior described by Covey stem from our penchant for competition over cooperation. We need both focus and spirit. To reduce C, we need to focus on A with a spirit of cooperation. Then we get to enjoy doing B.

Even people whose job is to prepare for and respond to emergencies find the vast majority of their surprises are internally driven. An

ABC Audit is one way to give physical evidence on what the percentages are in your unit and to monitor your improvement as you work to reduce crises. I discuss the ABC Audit in Module 1.3.7.

In his book *The New Manufacturing Challenge: Techniques for Continuous Improvement*, (The Free Press, 1987), Kiyoshi Suzaki says,"...we often find that more than 95 percent of an operator's time is not being utilized to add value to the product." (p. 10.) His Exhibit 1.2 (my Figure 1.3.3.) shows how people, machines, and materials spend time in a factory. His drawing shows about 5 percent as value-added time for people and materials and about 10 percent for machines. The rest of the time he calls waste. Waste for people includes "waiting for materials, watching machine running, producing defects, looking for tools, fixing machine breakdown, producing unnecessary items, etc." Waste for materials includes "transportation, storage, inspection, and rework." Waste for machines includes "unnecessary movement of machine, setup time, machine breakdown, unproductive maintenance, producing defective products, producing products when not needed, etc." You get the picture. It's not pretty. But look on the bright side. The leverage is huge. For Suzaki's exhibit, improve people's waste by 5 percent and double the value added.

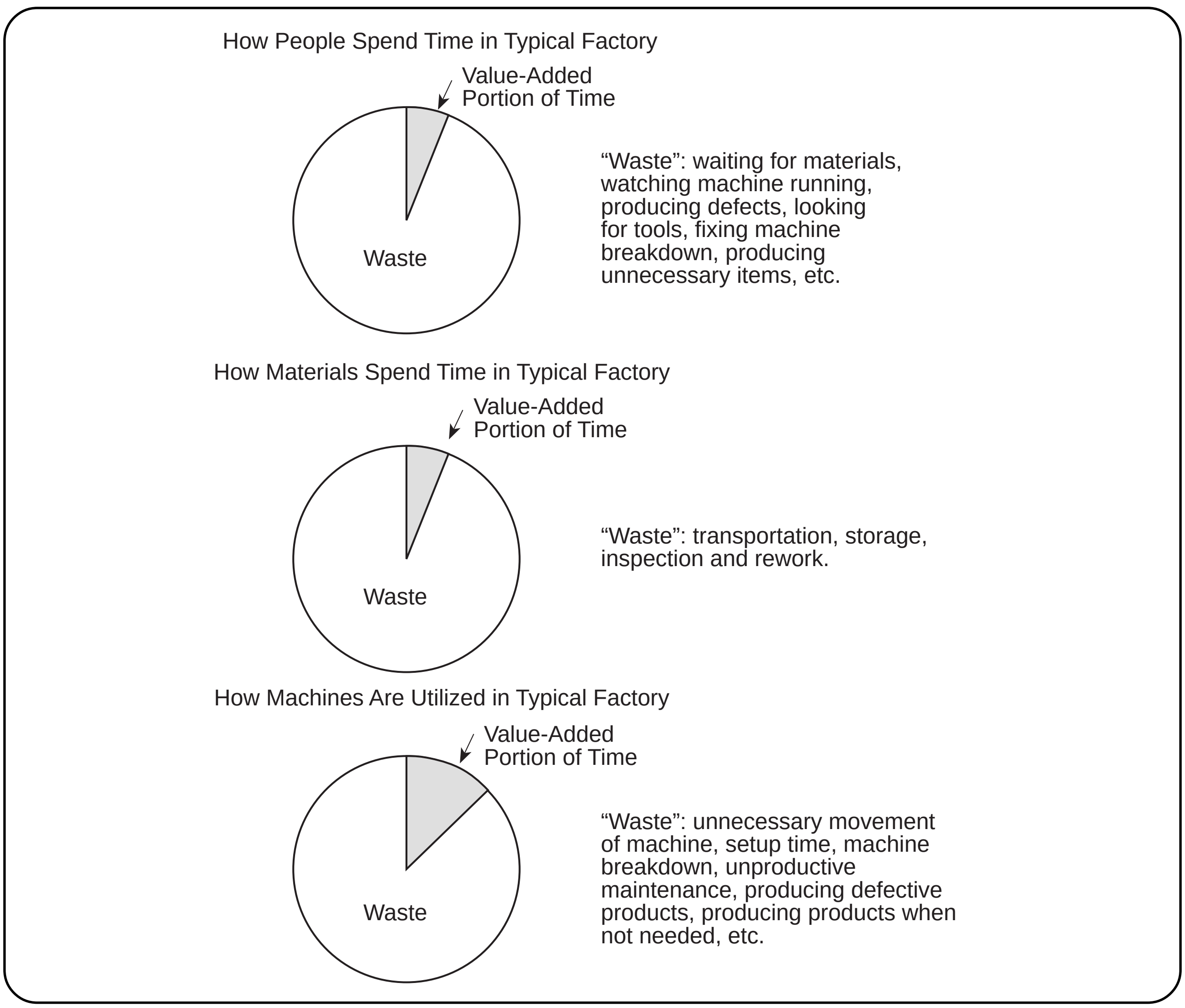

Figure 1.3.3. *How Man, Machine, and Material Spend Time in the Factory. (taken from Kiyoshi Suzaki, p. 11)*

1.3.4. Distinguishing the Important from the Urgent.

You want to work on the important before the urgent.

As we spend our most valuable and nonrecoverable resource—time—we not only need to think about how much time we spend but our priorities for spending time. We tend to spend time on crises before we spend time on making sure we don't have so many crises. That is, we tend to spend our valuable time on crises and then see if we have time for anything else. The ABC Model suggests that we consider crises on a par with how else we can spend our time and often put aside the crises to spend time on eliminating future crises. Without so many future crises, we can consider which of the old crises still exist in the time saved.

Putting aside crises is hard for some people to do. I believe many people and organizations become addicted to crises. Even though they know crises are bad for them, they have to have their crises anyhow. Many people and organizations get their self-worth from handling crises. They won't admit it, but they look forward to crises so they can make what they believe is their contribution. Unfortunately, they don't realize the real contribution is heading off crises. But heading off crises doesn't bring the attention solving crises does. How many times do we reward people for dealing with crises by working long and hard—often to the detriment of their health and their families? When we reward solving crises, we promote more solving of crises; *but*, usually at the expense of not working at eliminating future crises. How many times do we search out and reward instances of making improvements in our work that will keep the little, self-inflicted crises that eat up our days from happening? When people keep crises from happening, they keep themselves from making the contribution they've been led to believe is so valuable.

Covey calls heading off crises putting the important in front of the urgent. When describing his third habit of highly effective people, he says, "*Put First Things First* is the endowment of *will power*. ......a highly disciplined life that focuses heavily on the highly important but not necessarily urgent activities of life. It's a life of leverage and influence." (Stephen R. Covey, *Principle-centered Leadership,* Simon and Schuster, 1990, p. 44.) In describing the effect of his first three habits, Covey says, "On the continuum, you go from being driven by crises and having *can't* and *won't* power to being focused on the important but not necessarily urgent matters of your life and having the *willpower* to realize them." (p. 44.) The concept of the important before the urgent relates to time management, personal effectiveness, discipline, and willpower—all part of the eighth function in the management process described in Module 1.1.21.5.

In discussing the four generations of time management, Covey says, "...the best thinking in the area of time management can be captures in a single phrase: Organize and execute around priorities." (Stephen R. Covey, *The Seven Habits of Highly Effective People,* Simon and Schuster, 1989, p. 149.) He describes the generations as: "The first wave or generation could be characterized by notes and checklists, an effort to give some semblance of recognition and inclusiveness to the many demands placed on our time and energy.

The second generation could be characterized by calendars and appointment books. This wave reflects an attempt to look ahead, to schedule events and activities in the future.

The third generation reflects the current time management field. It adds to those preceding generations the important idea of prioritization, of clarifying values, and of comparing the relative worth of activities based on their relationship to those values." (pp. 149-150.)

Covey adds, "But there is an emerging fourth generation that is different in kind. It recognizes that 'time management' is really a misnomer—the challenge is not to manage time, but to manage ourselves. .... Rather than focusing on *things* and *time*, fourth generation expectations focus on preserving and enhancing *relationships* and on accomplishing *results*—in short, on maintaining the P/PC Balance." (p. 150.) ["P stands for *production* of desired results ...... PC stands for *production capability*, the ability or asset that produces...." (p. 54.)]

Covey introduces Figure 1.3.4. by saying, "The essential focus of the fourth generation of management can be captured in the time management matrix [in Figure 1.3.4.] Basically, we spend time in one of four ways. .... Urgent matters are usually visible. They press on us; they insist on action. ..... *Importance*, on the other hand, has to do with results. ..... We *react* to urgent matters. Important matters that are not urgent require more initiative, more proactivity. We must *act* to seize opportunity, to make things happen. ..... Quadrant II is the heart of effective personal management. It deals with things that are not urgent, but are important. It deals with things like building relationships, writing a personal mission statement, long-range planning, exercising, preventive maintenance, preparation—all those things we know we need to do, but somehow seldom get around to doing, because they aren't urgent." (pp. 150-154.)

Covey adds, "To paraphrase Peter Drucker, effective people are not problem minded; they're opportunity-minded. They feed opportunities and starve problems. They think preventively." (p. 154.)

Before I relate Covey's four quadrants to the ABC Model, consider this story. "One of my favorite essays is 'The Common Denominator of Success,' written by E. M. Gray. He spent his life searching for the one denominator that all successful people share. He found it wasn't hard work, good luck, or astute human relations, though those were all important. The one factor that seemed to transcend all the rest embodies the essence of Habit 3—putting first things first.

'The successful person has the habit of doing the things failures don't like to do,' he observed. 'They don't like doing them either necessarily. But their disliking is subordinated to the strength of their purpose.'" (pp. 148-149.)

The C activities in the ABC Model fall more into Quadrant III and somewhat into Quadrant IV than into Quadrant I. Only when the crises of our own making get quite out of hand do they become pressing. They are in Quadrant I. The A activities in the ABC Model fall into Quadrant II. The key issues here are: 1) Focus on Quadrant II activities (A activities) and 2) Reduce Quadrant III and IV activities (C activities).

To make matters worse, because we have a tendency to put the urgent before the important, we do C (cater to crises) first and foremost. In many cases, that's all we do all day. We try to do A (administer the process) by taking our work home at night. When we neglect A, we make C worse and B (build the business) is out of the question. We must recognize the importance of doing A, discipline ourselves to do A well, and reap the rewards of being able to do B when C eventually diminishes.

I find that when we build and use good management tools in an effective management process, we don't change the fraction of time we spend on A much. As we increase the amount of effective time we spend on a good management process we reduce the time we spend on the work process. We reduce time on our work process by streamlining and upgrading the work process and gain approximately the same amount of time we increased for the management process. After some transition, the upshot is that we don't change A much. What good tools and processes do in terms of the fractions of A, B, and C in the figure is to reduce C to make room for more B.

The potential for making a difference is huge. If you spend six hours of each eight-hour day unproductively (75% on C), then you double your productivity by regaining one-third of the time you spend on crises. Use the leverage associated with the unfortunate amount of waste in our professional lives to your advantage and make dramatic improvements in your productivity, the quality of your work, and the dignity, meaning, and community (Weisbord) of your workplace. Later, we'll recognize this activity as an example of the rule: make lemonade out of lemons.

We all want to be creative and gain the joy of doing good work in a productive workplace. We do that by reducing rework, noncompliance, poor communication, waiting around, and other wasteful activities.

	Urgent	**Not Urgent**
Important	**I** ACTIVITIES: Crises Pressing problems Deadline-driven projects	**II** ACTIVITIES: Prevention, PC activities Relationship building Recognizing new opportunities Planning, recreation
Not Important	**III** ACTIVITIES: Interruptions, some calls Some mail, some reports Some meetings Proximate, pressing matters Popular activities	**IV** ACTIVITIES: Trivia, busy work Some mail Some phone calls Time wasters Pleasant activities

Figure 1.3.4. *Covey's time management matrix stresses the importance of important, yet not urgent activities. (taken from Stephen R. Covey,* The Seven Habits of Highly Effective People*, Simon and Schuster, 1989, p. 151)*

1.3.5. ORIGINS OF THE ABC MODEL

Government agencies eaten up with brush fires settle into addictive behavior feeding on the excitement of the crises and their ability to cope rather than standing back and getting control of their processes to ultimately be more responsive to their stakeholders.

In working with government agencies in 1981-1983, I found oversight agencies spent most of their time dealing with what they called brush-fires and very little of their time (perhaps 10% or less) dealing with what they perceived as their real work. I found two associated problems. First, the agencies spent their time trying to build or select management tools to help them do what they perceived as their real work, when they'd get more leverage if they focused on reducing brushfires. Second, the agencies didn't face up to what their real work was. They were organized like they manufactured a product rather than brokering information. In fact their mission was to broker information and much of what they perceived as brushfires was really their work process. The result was frustration and waste. The lesson learned is that to distinguish A activities from other activities you must tangibly define your work process and your management process. These ideas were included in workshops and presentation to DOE in 1985.

You might consider unexpected requests for information as a crisis. However, to these agencies, dealing with information requests is their business. Information requests should be A activities. By realizing their work was information brokering, they could focus on the information process not the manufacturing process they were brokering information about.

People in government and industry who are good at coping with crises gravitate to organizations working in the more-uncertain business environments (e.g., journalists, police, etc.). The crisis behavior becomes addictive; and refocusing from crises to processes seems mundane and boring. However, the excitement returns when we get time to build the business. Then the excitement is more proactive than reactive.

In working with Max Gould of Citibank during 1985 and 1986, Pamela Kurstedt and I were taught two important concepts. First, the management process could reduce internally-caused waste and brushfires. Second, the objective of working the management process is to gain time to be creative and build the business. Pamela and I put Max's ideas in the form of a pie chart illustrating all of a manager's time and named the slices A for administer the process (at that time not distinguishing the management process from the work process), B for build the business, and C for cater to crises. The model was included in an internal Citibank book in 1987. The lesson learned was that to gain time to be creative and build the business you had to focus on the management process to reduce crises to make room in the pie for more B. We hadn't distinguished the effects of management process or work process affecting the fraction of A in the pie. Also, we hadn't distinguished the difference between internally-caused crises and externally-caused crises.

We first disclosed the ABC model in a panel presentation at the Fall IIE meeting in Nashville in 1987 and published the model in the 1988 IIE meeting proceedings in Atlanta. In 1989 we confronted internally versus externally caused crises in doing a workshop for the U.S. Navy and recognized that in maintenance or emergency environments externally-caused crises could be part of the work flow. This isolated the crises we cater to in the model as being primarily those of our own making.

The ABC model has been modified a number of times to make a variety of points. The original point was to focus on process A as opposed to result B and thereby reduce waste and frustration C. This point isn't new in that the point parallels the lessons of the funnel experiment taught by Deming. The model is simple and visual, and thereby aids understanding.

1.3.6. How Much Time Should You Spend on A, B, and C Activities?

If you spend more time on A activities, you'll get time for B activities by reducing C activities.

Practically speaking, most managers feel they spend more than a reasonable amount of time catering to crises. Managers feel the time they spend on crises is spent at the expense of the things they need to do to get the most out of their responsibilities.

Everyone is eager to be creative and build the business. They're focusing their quality and productivity efforts more on moving the organization forward than on stabilizing it. I believe we're looking at things out of sequence. We're so busy working on building the business, we're neglecting our work and management processes. And, we must have our processes working well before our efforts to build the business will work. As a consequence, our productivity and quality efforts aren't reaping rewards as advertised.

If your other efforts are competing for time for crisis efforts, crisis efforts will win. You can either ignore the crises (Put the important before the urgent.) or you can reduce them. Only after we reduce crises enough to make time for productivity and quality efforts can we use these techniques to our advantage. The crux of the matter is how we spend our time, how we should spend our time, and how that changes as we spend our time doing the right things.

Based on observing many organizations, I'm convinced most of us spend too much time tending to brush fires—catering to crises. And it doesn't have to be that way. Most of us want to spend as much time as possible building the business. But, the harder we try to spend time on performance improvements, the more we seem to get crises. Apparently, we're missing something. That something is the time we spend on administering our management process and our work process. Until we get good at administering our management process, nothing much will help eliminate the crises that steal time from building the business. So, administering our management process and our work process comes first.

To reduce most surprises—at least those you have some effect on—look internally at the organization; increase visibility and control; and focus on A, administering the work and management processes. The amount of time you spend catering to crises is inversely related to the amount of time you spend administering a comprehensive, structured management process. You spend less time with crises if you spend more time on a good management process. The amount of time you spend building the business is inversely related to the amount of time you spend catering to crises. You have more time to build your business if you have fewer crises to deal with. Then the amount of time you have to build the business is directly related to the amount of time you spend on your management process. So, to get time for building the business, focus on administering the management process.

How do you distinguish among the slices of the pie? When you administer a management process, you look inward at the organization. When you deal with disruptions, you face surprises (both good and bad) that disrupt the workflow. Many brushfires pose immediate needs and cause the organization to focus short-term. You need to reduce the number of internal disruptions and improve the way you handle external disruptions so you have time to concentrate on extending and improving the service to your stakeholders.

What A activities are and what B activities are is a function of your unit of interest, or your domain of responsibility. For example, the Assistant Dean for Enrichment Programs in the College of Engineering develops and implements an MIS from a database to monitor graduate student support for the Associate Dean of Research and Graduate Studies in the same college. Is this an A activity or a B activity? It depends on the domain of responsibility. If the domain is the Office of Enrichment Programs, the activity is a new service to support graduate studies, and is therefore a B activity. If the domain is the College of Engineering, the activity is improving the work and management processes already part of the set of responsibilities of the college, and is therefore an A activity. The point is that the Assistant Dean for Enrichment Programs wouldn't have time to offer a new service or to contribute to the improvement of the work of the larger organization if the Office of Enrichment Programs was consumed with crises.

Today, you may consider the time you spend on C activities of your own making to be part of your day-in, day-out work. Don't! Distinguish unnecessary work from the necessary work on a task. Focus on this distinction so you work to reduce rework and other unnecessary work. From this idea comes the slogan "Do it right the first time." As Deming says, you can't do it right the first time without a method. The method for reducing unnecessary work is the management process. Consider your original work on a task to be A activities. All unnecessary work on that same task is C activities. Now, you'll find you don't spend as much time on A activities as you thought. As you add management process activities to your work, you'll increase A activities, but decrease C activities more. You'll also find ways to streamline your work process and to reduce frustration so you spend less time doing right what you did wrong before.

You have a finite amount of time, and the time spent on disruptions is taken off the total reservoir of time you have. Brushfires can be important, but often they are urgent, rather than important. To gain more time for improvement, managers must reduce the time spent on disruptions. The way to reduce time spent dealing with disruptions is to spend more time (and do a better job of) administering a management process.

Figure 1.3.6. suggests that without a good management process you spend half your time or more on crises, and you spend a relatively small amount of time on building the business. Figure 1.3.6. further suggests that after you install the management process, you'll find you spend about the same amount of time on both your work and management processes as you did on your work process without the management process before. The time you spend in maintaining the management process will save an equivalent amount of time in doing the work. The management process overlays the work process and becomes integrated with it. But the significant result is that you switch the amounts of time you spend between B and C activities. You'll spend half of your time, or more, on your customers and orienting your product or service toward the customer and a relatively small amount of time on crises. The difference between the before and after figures is that after you install the management process, work is less stressful and you're moving a more-stable organization forward to better meet the needs of the customer.

Ultimately, administering the management process has diminishing returns. If you spend 100 percent of your time administering the management process, you have no time for anything else. You should, at first, spend 50 percent or more time, if necessary. Start with key using-management-tool-management-process functions (refer to Module 1.1.21.5.) such as reviewing, logging data, and setting expectations. If you do these functions right, within two or three months you'll see a dramatic decline in C. Don't rest on your laurels. Continue through the functions until you can do them all well within the time you spend on your work process. When you're good at the management process you should spend *no less than approximately 25 percent* on A activities involving the tools and methods of the management process. (Of course, you'll spend more time on the work process.) Otherwise you'll get C. The management process activities get integrated so tightly with your work process activities, you won't be able to separate out the time you spend on them.

When you consider the time you spend on A, include three factors: 1) the amount of time, 2) doing the nine using management tool functions (doing the right things), and 3) doing the nine functions well (doing things right). Consider the following as an indication of how well you're doing. Low C implies good A. Then you should review A, get into B, and not let time on A activities involving the management process fall below 25%. High C implies lax A. Then you should spend as much as 50%, or more, on A and forfeit whatever of B is necessary.

In the beginning, how much time can you afford to spend on A? Depending on how much your organization's goals are survival-related, you should spend as much as half your time coming to grips with what you do with the other half of your time.

A startling implication of Figure 1.3.6. is that if you truly want more time for extending and improving service, you must do something different from what you might expect. You should focus on visibility and control of your work process. Visibility and control help reduce brushfires and thereby gain time for improvement. In an ideal situation, this figure suggests that you should set aside an overflowing in-box, install an effective management process, then work off the in-box as backlog to make time for building the business.

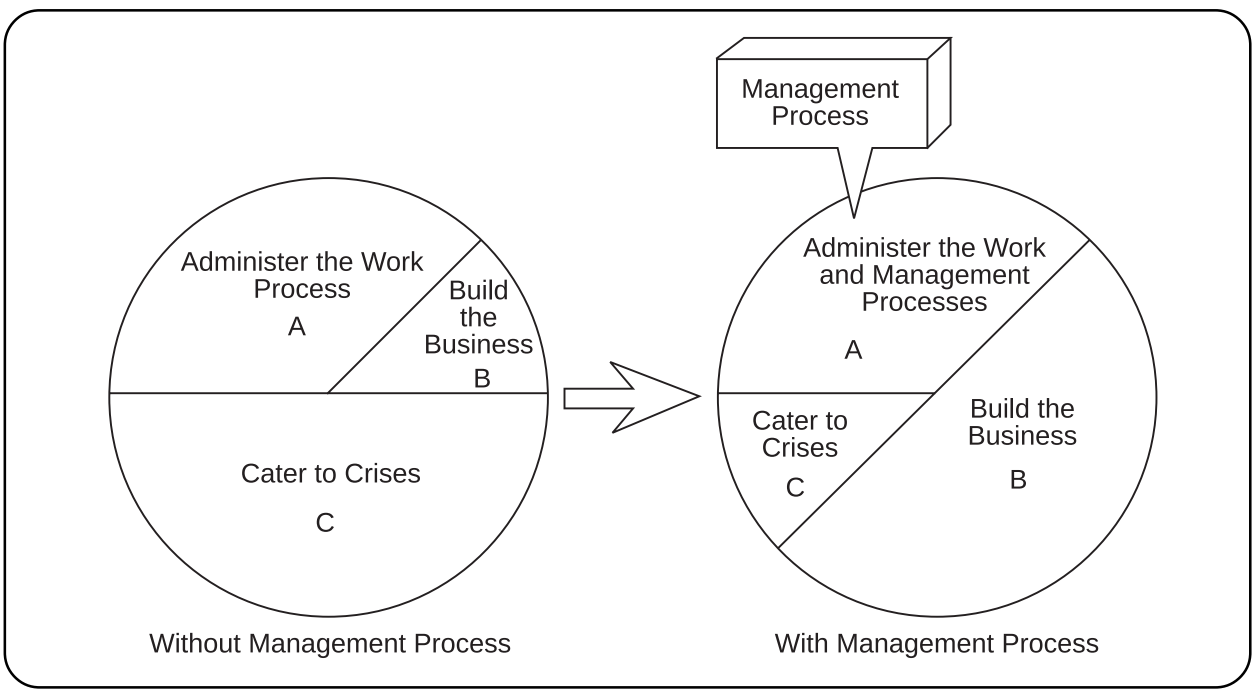

Figure 1.3.6. *Applying the management process to routine activities pays immediate benefits in reducing surprises and leaves more time for managers to focus on growth and improvement.*

1.3.7. ABC AUDIT

Once you know how you spend your time, you can change what you do and spend your time more wisely.

You want to measure performance so you can make your performance better by managing better, know you made it better, and know what you did to make your performance better. My performance measurement is simple and global. I call it an ABC Audit. The ABC Audit is based on the ABC Model from Module 1.3.3. The principle behind the ABC Audit is that if you do your management process well you'll reduce and manage your crises (surprises). So, we equate good performance to few surprises. Any action you take to reduce crises improves performance.

A-B-C Audit Categories

On the next page, you'll find an ABC Audit form for logging data on how you spend your time during each day. As opposed to a time log where you monitor specifically what you do in 15-minute blocks (This is also a good idea.), in the ABC Audit you'll monitor generally what percent time each morning and afternoon you spend on A, B, and C activities. You don't have to be perfect in how you distinguish A, B, and C activities. You don't have to define or distinguish A, B, and C activities just like another person does. You, however, must be consistent over time on how you categorize your activities into A, B, and C. If you're not sure how to categorize a particular activity, make your best estimate and leave that activity in that category for the duration of your audit. Remember, you want to estimate how you spend your time and how the amounts of time per category change as you improve your work.

The following three paragraphs briefly describe the A, B, and C activities for the ABC Model. Please refer to these descriptions as you audit the types of activities you spend your time on during the day.

"A" activities are administering your work process using the management process. These activities keep the organization stable and reduce surprises. For example, a routine meeting to evaluate the day's production or backlog is A.

"B" activities are building the business. These activities move the organization forward. A strategic planning meeting or a meeting to change the organization's niche is a B activity.

"C" activities are catering to crises. These activities are the good and bad surprises you experience as you manage. A surprise meeting to figure out what to do with unexpected profits (or budget funding) or a subordinate's unexpected absence is an example of a C activity.

ABC AUDIT FORM

For each day you track your management activities, please complete one of these forms.

Date:__________________

1. At the end of your morning, please take a few minutes to indicate to the nearest hour how much time you spent in each of the ABC activities. At the end of the day, repeat this for the afternoon activities. The morning and afternoon time should add up to your total work time for the day. Try to estimate your time to include both physical and *mental* efforts.

Morning	Afternoon
____A activities	____A activities
____B activities	____B activities
____C activities	____C activities

2. List below some of the activities you classified as A, B, and C activities. You'll use your examples here to discuss with others to develop a better understanding of A, B, and C activities. If you want to aggregate your unit's results, you'll want to share understanding of the categories so your unit can be consistent, which is more important than to be correct.

A activities	B activities	C activities
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________
____________________	____________________	____________________

3. Please circle to what degree you feel you captured the real A, B, and C activities. (1 = very little, 4 = a great deal)

1 2 3 4

1.3.8. Exercise on ABC Audit

You can review your day and estimate how much time you spend on A, B, and C activities.

Explanation

One way to record A, B, and C activities is to recall what you did over a period of time and estimate how much time you spent on each type of activity. Recording what you do and how much time you spend on each task, interruption, question, or whatever as the day proceeds is a better way to keep track of what you do. One problem with any recording of your time is in distinguishing what you do physically from what you do mentally. Talking to someone on the phone about plans for the future while thinking about your current personnel problem could be called either a B activity or a C activity. Looking back over a time period, for example a day, has the advantage that you can surface the dominating concurrent activity. Being able to recall your actions in terms of dominant activities without overlooking tasks takes a bit of skill.

Exercise

With Module 1.3.7. as a guide, look back over your day and identify everything you did. Don't ignore short tasks. Separate what you did into A, B, and C activities. Make a table showing time and duration and activity by type. Tally up how much time you spent on A, B, and C activities.

You should describe (short phrase) each of your activities so you (and I) can see how you type (A, B, or C) the activity. Your classification into A, B, and C activities doesn't have to be perfect. Once you determine your classification, you want to place activities into your classification consistently.

You may want to separate out domains of responsibility. By that, I mean you may want to look only at school-related tasks, work-related tasks, or family- (or personal) related tasks. You'll find that the proportions of C could be greater for family-related tasks, then work-related tasks, and finally school-related tasks. The difference is in the amount of structure and certainty in each of your domains, or subdomains—depending on your unit of interest. Your school work tends to be relatively well structured and certain.

1. Background

1.4. Theory

1.4.1. The Important Components of Life—Mary Cassatt

1. Background

1.4. Theory

1.4.2. A Management System

1.4.2.1. SYSTEM BASICS

1.4.2.2. ORGANIZATIONAL SYSTEMS

1.4.2.3. INPUT/OUTPUT ANALYSIS

1.4.2.4. Models and Their Strengths and Weaknesses

You won't find a model that's perfectly general, simple, and accurate.

Models give structure to experience. They bring together concepts to show relationships and represent complex situations. Usually the more simple models are more distinct from reality. As we move toward reality the models become more complex. We never do reality; we only do models. We use models to abstract or reduce reality. Are we modeling one situation, one type of situation, or all situations? Remember the sign that says: price, speed, accuracy, pick two. For models we could have a sign that says: simple, accurate, general, pick two.

The management system model is for one management system, or one domain of responsibility. But, we don't change the model one bit for any other domain of responsibililty. I've seen the management system model extended to other practices than management. For example, who teaches, what is taught, what we teach with. Therefore, the model is general. Given the complexity of management, the model is simple. However, the management system model is accurate only when we want to view the domain of responsibility as a closed system. We got our two: simple and general.

Morris, in discussing models says, "Similarly, attempts to develop a consciousness of some of the characteristics of models appears helpful. Beyond the rough description of a model as 'simple' or 'complex,' one might usefully consider:

> *Relatedness.* How many previously known theorems or results does the model bring to bear upon the problem?
>
> *Transparency.* How obvious is the interpretation of the model? How immediate is its intuitive confirmation?
>
> *Robustness.* How sensitive is the model to changes in the assumptions which characterize it?
>
> *Fertility.* How rich is the variety of deductive consequences which the model produces?
>
> *Ease of Enrichment.* What difficulties are presented by attempts to enrich and elaborate the model in various directions?"

(William T. Morris, "On the Art of Modeling," *Management Science*, 13 (12), August 1967.)

1.4.2.5. Scherkenbach System Model

Matching the voice of the process to the voice of the customer gets you balance just like matching the Management System Model interfaces gets you balance.

Bill Scherkenbach, in his book, *Deming's Road to Continual Improvement*, begins with a classical input-output model for a system, or, as he calls it, a process. He shows people, method, material, equipment, and environment as inputs to and as outputs from a transformation. He shows downstream customers for the outputs and upstream suppliers for the inputs. In this way, he links successive processes, or systems, or domains of responsibility. You are the customer of your supplier. You supply your customer. Your customer is the next person's supplier.

In my view, your management system gets input from one or more of your stakeholders (customers, staff, owners, neighbors, and suppliers) and gives output to one or more of your stakeholders. Then, the external environment isn't part of the input or output, but is on the other end of these transfers to and from you. Scherkenbach sees environment as an internal thing, like the work environment. Also, the method is part of the system, isn't part of the input or output, but is on your end of these transfers. Scherkenbach sees method as the work flow. Now, I've resolved differences between his terms and mine.

Scherkenbach brings the power of his model to Figure 1.4.2.5.1. He says. "If you look (with careful attention to detail) at the process model in [Figure 1.4.2.5.1.], you see that these customer and supplier transactions are facilitated by two sources of communication: One voice is from the customer, and the other is from within the process itself. I call these the **Voice of the Customer** and the **Voice of the Process**. Like any voice, they can be active or passive." (pp.11-12.)

I might argue that the voice of the customer is really the voice of all the stakeholders. Scherkenbach says, "The **Voice of the Customer** communicates to you the producer, the wants and needs of your customers, as you perceive them. It can also be more generally viewed as the forecast, goal, plan, aim, prediction, objective, target, "druthers," or as Dr. Deming sometimes says, "fact-of-life." ..... If you listen to only a single voice, you do so with incalculable risk." (p. 12.) The point is that this voice tells you the reference input in the control loop model in Figure 1.1.21.8. You learn from your customer or stakeholders where you need to operate your work process (the plant in the control loop). You can translate the voice of the customer as a target, as upper and lower limits, and as a parabolic loss function. The voice of the process tells you what you can do. Just because the customer tells you what he or she wants doesn't mean your work process can deliver.

Scherkenbach describes the voice of the process. "The **Voice of the Process** is the *actual* output, or what Dr. Deming describes as the *result* the process gives you. It also can be translated in different ways. Its translation, like the Voice of the Customer, is heavily dependent on the sampling method that you choose." (p. 14.) This short description resolves much of the confusion over Deming's words. Deming both says to focus on the process and shows how to measure results. Obviously, both process and result are important, but each has its place. The result is a voice speaking to you. Don't carry out your desire to act on the voice. Don't shoot the messenger. I say the result is the window into the process. You want to act on your work process, and on your management process. You don't know what your process is doing or if the process has improved unless the process tells or shows you. The process tells or shows you through the result of the process.

Scherkenbach says the key words for balance. "The job of every person who is in the role of a process manager is to **match** the Voice of the Customer with the Voice of the Process." In Figure 1.4.2.5.1., you want to move both voices so they match. "In a deterministic world, or one that does not admit to or understand variation, if the *actual* (Voice of the Process) does not match the *plan* (Voice of the Customer), you are asked to explain what happened. It is common in business to 'explain all variances.'" The questions that follow from a deterministic view of the difference between plan and actual give rise to C, as in catering to crises, put there by your own hand.

You have variability both in the voice of the customer and in the voice of the process. We know all customers don't want the same thing. Likewise, our process isn't the same every day. Therefore, we must learn to deal with variation in everything we do. Scherkenbach introduces one of my favorite cartoons to highlight our problem in dealing with variation in our lives. "The late Professor David Chambers often used this cartoon [Figure 1.4.2.5.2.] to emphasize the fact that although variability is commonplace in our life, we are surprised when it happens in our formal places of work.

We do not expect the popcorn to pop all at once! In fact, we understand and even expect that the individual kernels will pop at different times. Why should we be surprised that our businesses perform in a similar fashion?" (pp. 17-18.)

For success, you need to balance the components of the Management System Model by paying close attention to matching the interfaces between pairs of components. For success, you need to match the voice of the customer and the voice of the process by recognizing the variation in both and moving either one to match the other. Variation is important in matching the voice of the customer and the voice of the process because you can quantitatively measure both as, for example, number of widgets demanded each day and number of widgets produced each day. You can't so easily quantitatively measure information portrayal or information perception—at least to the point you can get picky about the variance within them.

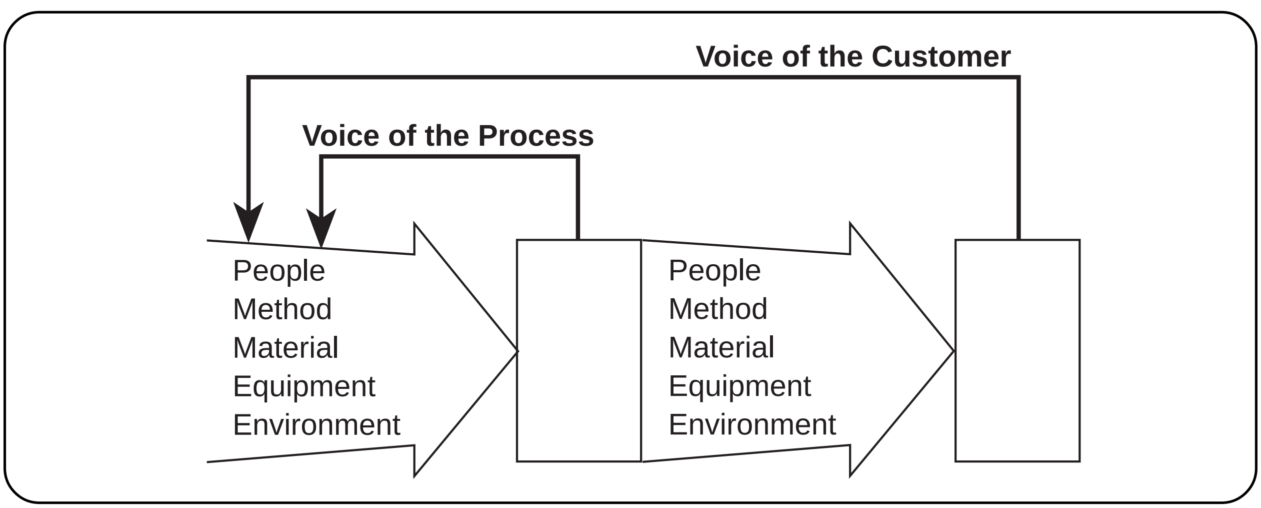

Figure 1.4.2.5.1. *For success, we bring the voice of the customer together with the voice of the process to make a match. (taken from Scherkenbach)*

Figure 1.4.2.5.2. *We clearly understand variation in the popping time for corn kernals. (taken from Scherkenbach, who took the cartoon from David S. Chambers, who took the cartoon from an unknown artist)*

1. BACKGROUND

1.4. THEORY

1.4.2. A MANAGEMENT SYSTEM

1.4.2.6. MANAGEMENT SYSTEM MODEL COMPONENTS

1.4.2.6.1. Who Manages

The who manages component of the Management System Model converts information into actions through the decision making process.

Who manages is, in terms of Peter Drucker's definition of an executive, anyone who uses information to make decisions resulting in actions that affect what is managed. In addition to presidents, directors, and controllers, who manages includes scientists and the secretary who uses information to decide who does or does not get in to see the boss. Each of us has one or more domains of responsibility; and to achieve the purpose of any domain, the way who manages is integrated into the system is critical.

In other models similar to the Management System Model (MSM) of Figure 1.1.18.1.3., models designed to describe the mechanics or internals of the domain of responsibility, who manages is only implied. The absence of the human element has been recognized as a major weakness of these similar models. Motivated by Henry Mintzberg's important paper, *Impediments to the Use of Management Information Systems*, the who manages component plays a primary role in the MSM.

A number of characteristics of the who manages component affects how the who manages component works in the management system. I describe who manages by three terms: history, cognitive style, and human characteristics.

A person's history includes their experience, education, and record. Webster says experience is, "direct observation of or participation in events as a basis for knowledge." We know that our experience conditions how we perceive information and what we expect from the decisions we make. The value of experience in a given domain of responsibility depends on the domain. For example, your international experience is directly valuable to an organization dealing in international activities. Any experience is valuable indirectly, in that you can generalize from one situation to another.

Your experience can have both positive and negative effects on how you perform within the Management System Model. Taylor found that more managerial experience leads to 1) greater accuracy in judging the value of information, 2) quicker decisions, and 3) less chance adverse consequences will cause changes in the decisions. (Ronald N. Taylor, *Age and Experience as Determinants of Managerial Information Processing and Decision Making Performance*, Academy of Management Journal, 18:1, 1975, 74-81.)

Your education should be an indicator of academic maturity. Academic maturity affects how you deal with conflicting, incomplete, or inaccurate information. In some cases, education can be a surrogate for experience. We assume you can learn from the experience of others.

In the MSM, who manages perceives information and makes decisions based on the perceptions. The perception of information and the way a person acts on that information is a function of their personality type. You can find any number of classifications for personality type or cognitive style. Typically, the classifications reflect a person's preference in perceiving information and acting on information. The most popular measurement and classification scheme today is the Myers-Briggs Type Indicator (MBTI). This scheme can be both enlightening and, if used improperly, harmful. The key to using the scheme is knowing that what you find is preference, not ability. I'll discuss the MBTI in more detail soon.

Human characteristics are traits and qualities of the human decision maker. The characteristics include knowledge, skill, ability, and traits, like age. Age usually reflects education and experience, but not necessarily. We hope education and experience affects knowledge and skill and, indirectly, ability. The objective of this book is to increase the knowledge and skill of the who manages in building and using management tools to get the best information to make decisions with.

Macintosh and Daft recognize human traits as important information in designing information systems. They say, "Manager's personal traits are important and should not be overlooked. New information systems often are linked to changes in behavior patterns, so change strategies need formulation. In addition, relevance, timeliness and accuracy should be considered by designers." (*User Department Technology and Information Design*, North Holland Publishing Company, 1978, p. 124.) When building a management tool, we must carefully consider the user, or the who manages component in the domain of responsibility we're using for our unit of interest. We must consider all characteristics of the who manages. Later, I'll discuss the importance of the measures of relevance, timeliness, and accuracy for managing data and information. The who manages component affects at least the first two of these measures. For example, what is relevant or timely for one person may not be for another.

As I mentioned in Module 1.1.14.2., the MSM has one who manages. Who manages is responsible for and accountable for the domain of responsibility making up our unit of interest. Who manages can delegate the authority to manage part or all of their domain and can hold the people they delegate to accountable to them. Ultimately, who manages is held accountable for all of his or her responsibilities, including those he or she delegates to others. The dilemma of mixing the ideas of coaching, directing, and being a cop as a supervisor and the issue of a single who manages is highlighted by a McGregor quote in Weisbord's book. "I believed...that a leader could operate successfully as a kind of adviser to his organization. I thought I could avoid being a 'boss'. Unconsciously, I suspect, I hoped to duck the unpleasant necessity of making difficult decisions, of taking the responsibility for one course of action among many uncertain alternatives, of making mistakes and taking the consequences. I thought that maybe I could operate so that everyone would like me...I couldn't have been more wrong. It took a couple of years, but I finally began to realize that a leader cannot avoid the exercise of authority any more than he can avoid responsibility for what happens to his organization." (Douglas McGregor, *On Leadership*, 1954, pp. 2-3; in Weisbord, p. 123.)

In some organizations today, the who manages employs a participative management style, and decisions are made collectively. Weisbord states Lewin's core principle as: "*we are likely to modify our own behavior when we participate in problem analysis and solution and likely to carry out decisions we have helped make.*" (p. 89.) I would like to add that we also modify our attitude to include a feeling of responsibility for and commitment to the output and outcomes from the decisions we help make and the corresponding actions we help carry out. This feeling is important for teamwork, but doesn't change the ultimate accountability of the who manages component of the domain of responsibility.

Max DePree, after mentioning Drucker's definitions for efficiency and effectiveness, says "Leaders can delegate efficiency, but they must deal personally with effectiveness." (Max DePree, *Leadership is an Art*, Dell Publishing, 1989, p. 19.) He then says, "Participative management is not democratic. Having a say differs from having a vote." (p. 25.)

For a more-detailed discussion of the who manages component of the MSM, see Larry Mallak's thesis *Applying the Management System Model to a Federal Government Organization*, September 1986.

1.4.2.6.2. What Is Managed

The what is managed component of the Management System Model converts actions into performance indicators about the operation's products and services and the work process that produced them. The what is managed component also converts capital, labor, equipment, material, and energy inputs into products and services and associated waste outputs.

What is managed includes the tangible physical things that are managed (including operations tools, not to be confused with the tools we use to manage with). The physical things are not requisition forms but cars and vans in the motor pool; not pick tickets and packing slips, but nuts and bolts in the warehouse; not supply and demand forecasts but oil in wells, tankers, refineries, trucks, and service stations; not MIS and organization structure but fork lifts and hammers. In the service business we manage documents, dossiers, cases, and briefs, but not calendars and checklists. We use calendars and checklists to manage with. As teachers we manage students, books, and class meetings, but not grades, rolls, and registration forms. We use grades, rolls, and registration forms to manage with.

Collectively, the people, facilities, and materials we manage and their interrelatedness we call our operation. The output of our operation is our product or service—our result—an indicator of our performance to be measured, evaluated, controlled, and improved. The output and its characteristics relate to our purpose.

I characterize the what is managed component in terms of its physical parts, their attributes, and their relationships. The what is managed component is the operation, or work process, of the domain of responsibility. The work process converts resources into products and services. Some of the resources make up the work process and some flow through the work process. For example, a bank uses money as capital to support all the parts of its work process and a bank has money flow through the process. If your business is managing information (like a radio station), information plays the role of your materials in CLEM. You also need information from your management tools to tell you how well you're managing the information flow through your business (radio station). In characterizing the work process, we need to incorporate time. When does the project start? What is the flow rate? The attributes of the work process parts and products form performance criteria.

The work process can be formed in many ways. The work can be workstation type work, where a large effort is carried through the process by a single person. An example is a job shop or approving credit in a bank. The work can be assembly line type work, where many small efforts are passed from station to station and person to person as each person adds value to the work flowing through the process. Of course, the work can include combinations of workstation and assembly line, where one person does a number of steps to the work and passes the work to someone else who does more steps.

The what is managed component is the focus of major disciplines, like production and operations management. The focus of the Scherkenbach system model in Module 1.4.2.5. is the operation and its input and output.

One difficulty in dealing with the what is managed component is the duality involved with the difference between the management system, or the domain of responsibility, and the work process, or operation. The physical support structures for the management tools, such as notebooks for plans, charts for organization structures, and computers for management information systems are part of the what is managed component. The substance of the management tools is conceptual. The substance is data and information, intangible things we keep in our head. When the person who's responsible for the domain isn't making decisions but is doing tasks within the work flow, he or she becomes part of what is managed. The who manages is the decision maker.

Macintosh and Daft emphasize the importance of understanding what is managed when trying to build management tools. They say, "In our investigation of information systems in a variety of organizations we discovered a central factor that apparently has been overlooked in conventional thinking. And systematic study suggests the same result: work-unit technology places a critical constraint on the design of the information system. There is a relationship between the technology of a work-unit and the amount and type of information it requires to perform effectively.

Simon defines technology as the knowledge of how to do things and how to accomplish organizational goals [*Technology and Management*, Management Science, June 1973, p.1110.]. Thompson defines technology along similar lines as the beliefs about cause/effect relationships to produce desired outcomes [*Organizations in Action*, McGraw-Hill, 1967]. Technology, then, includes the knowledge, procedures and techniques used to perform a given organizational task.

Work-unit technology can be analyzed along two dimensions [C. Perrow, *A Framework for the Comparative Analysis of Organizations*, American Sociological Review, April 1967, pp. 194-208.]: (1) the degree to which the task process is understood (task knowledge) and (2) the variety involved in the task. Task variety is the frequency of unexpected problems that occur during task activities. Task understanding pertains to the availability of concrete knowledge about work-unit activities." (*User Department Technology and Information Design*, North-Holland Publishing Company, 1978, p. 123-131.)

Technology isn't the only feature of an operation that should influence the development of management tools. The idea of classifying an operation in terms of its technology against dimensions related to information systems suggests that we can build better management tools if we know what the operation is in the right terms. Later, I'll suggest a number of dimensions and associated frameworks we can use to figure out what management tools (of which the information system is but one) will work best for the organization.

1.4.2.6.3. What Is Used to Manage

The what is used to manage component of the Management System Model converts data to information.

What is used to manage comprises our management tools. The pick tickets, forecasts, grades, plans, information systems, procedures, budgets, and many more are such tools. Routine paperwork is part of this component, along with the MIS, culture management tools, and the organization structure.

With the exception of those of us whose direct responsibility is to design and print new corporate or government forms, develop information systems, and write plans, we don't manage these tools, we use them to manage with. Operations tools, we *manage*—trucks, hammers, or process lines. Management tools, we *use to manage.* When we manage a plan, it sits on the shelf. When we manage paperwork, it restricts us. When we manage an information system, it's a thing of beauty that nobody uses.

We use management tools to manage with. All management tools convert data to information. Management tools are conceptual. They are in your mind. They take up no space. We embody management tools in physical containers like computers, files, calendars, etc. When you think of management tools, you typically think about their physical containers. I want you to think about the concept of converting data to information. The physical containers are part of the what is managed component. The concepts are the what is used to manage component.

The overlap of the components needed for us to effectively use management tools shouldn't surprise you. Remember, I separated the two components to analyze the management system by looking at the system components. That's the system perspective. In the holistic perspective you don't separate components. It's like the wave and particle forms of mass and energy. Sometimes mass behaves like energy, and vice versa. Mass disappears and energy appears, and vice versa. We consider a particle to be mass and a wave to be energy. I also consider the physical container to be an operations tool and the concept to be a management tool. Mass and energy are the human mind's attempts at understanding. So are the operations tools and the management tools—the what is managed component and the what is used to manage component.

For analysis, you use the form that helps you understand. The thing in question is really in both forms simultaneously. It's just how you look at a thing analytically.

You use many tools to support management decisions. As opposed to situational analysis (who manages adjusts to bring the management system into balance) and contingency theory (what is managed is modified to balance the management system), I focus on developing, modifying, or improving tools that produce successful, balanced management systems. The what is managed component is the ends for management and what is used to manage component is the means.

You have a system of tools which comprises all your decision support tools (what is used to manage) and their greater or lesser degree of interrelatedness. I classify this system of tools into the five functional groups or categories shown in Figure 1.4.2.6.3. The methods, guides and rules, precedents, and data-to-information chain are tied together within your domain and between your domain and those of other domains through the relationships and structures.

Relationships and structures provide the glue.

Examples of management tools in the relationships and structures category are organization structures, work breakdown structures, budget and reporting structures, flow charts, and other communication and coordination tools. Relationships and structures also tie together what is managed and who manages within your domain and between domains. You don't manage your organization structure; you use it to manage with. Therefore, your organization structure must suit you, the who manages component, and fit what is managed rather than vice versa or it won't help you. Relationships provide for stability in your domain mostly through structure because, to be successful, all your tools and your people, materials, and facilities work together through their relationships.

Your methods suggest solutions.

Examples of management tools in the methods category are expert systems, operations research models, and paperwork. We use many methods to help us manage. Whether quantitative model, paperwork, rule of thumb, or expert system, we look for a suggested solution based on the assumptions and limitations inherent in the method. As managers, we compare our solutions and judgment to the method and either agree with the solution, adjust our solutions, or question the method by adjusting constraints or quizzing alternatives.

Guides and rules help you control your domain and support other tools.

The subcategories of management tools in the guide category include policies, plans, procedures, and instructions. Examples of management tools in the rules category are maxims, guiding principles, norms, directions, constraints, specifications, conditions, laws, and orders.

Precedents provide the stability of the organization.

Examples of management tools in the precedents category are the social system, awards and recognition, credos, and socialization. Your domain of responsibility has an attendant history and culture or, if you're forming a new domain, you'll translate your ideas of precedents into it. Richard Pascale believes we should take socialization out of the closet and recognize the degree to which corporate culture influences our management efforts. (Richard Pascale, *The Paradox of "Corporate Culture": Reconciling Ourselves to Socialization*, California Management Review, Vol 27, No. 2, winter 1985.) Waterman and Peters in *In Search of Excellence* highlight the importance of culture in success. Precedents should be used to manage; however, precedents don't just happen to help—you must use them according to your purposes.

The key to the data-to-information chain is the word chain.

The data-to-information chain is the information system, usually embedded in file cabinets, notebooks, rolodexes, magnetic boards, and other devices. The data-to-information chain operates routinely to acquire, store, retrieve, and manipulate data to generate and portray information. The other groups of tools involve data and information; but focusing on the word chain, the data-to-information chain singles out routine, repeated steps for regularly and frequently converting data into information.

DECISION SUPPORT TOOLS, THROUGH THEIR INTERRELATEDNESS, CONSTITUTE A DSS.

- Relationships and Structures - organizational, work breakdown, formulation and executions (B&R), communication, and coordination
- Methods - expert systems, quantitative models, heuristics, paperwork, and participative management
- Guides and Rules - policies, plans, procedures, and instructions; and directives, constraints, specifications, conditions, and laws
- Precedents - history, culture elements, and social system
- Data-to-Information Chain - MIS (EDP, IS, etc.)

Figure 1.4.2.6.3. *A decision support system (DSS) is a closed set of management tools, working together synergistically to support the decision making process. This statement for DSS differs from the traditional definition originally made in the landmark paper by Gorry and Scott Morton in that all data-to-information converters play a role in decision support, not just computer-based management information systems.*

1.4.2.6.4. Each Management System Model Component Plays a Unique Role

From the systems perspective, each component of the Management System Model is essential in helping the system achieve its aim: success through balance.

From Figure 1.1.18.1.3. we see that if we fail in any component, we fail in our responsibility. In the management system, no component is an island. While operational performance is measured at the what is managed component, organizational performance is also a function of who manages (personal performance) and what is used to manage (management tool performance).

In addition to being essential to balance the management system, each component plays a unique role in the system. We consider capital, labor, materials, equipment, and energy as the input and output of what is managed and measure operational performance there. Data and information linkage with other management systems that include ours, are included in ours, or are in parallel with ours, occurs through what is used to manage tools such as organization structures, communications (formal or informal, routine or non-routine), and the management information system.

Forcing Functions

The who manages component is the forcing function for the operation, or work process. Most change is initiated there. When the system is in balance, who manages will want better information to make better decisions and the system will mature.

A key to continuous performance improvement is through the who manages component as the internal forcing function. When the Management System Model (MSM) is in balance, the manager is getting exactly the information he or she needs (The information properly reflects the what is managed component.) exactly the way he or she likes the information. (The portrayal matches the preferred perception.) Even when the manager is happy with the balanced management system and his or her information input and action output, he or she will want to make an improvement. By making an intervention, the manager makes the management system out of balance, and the work process and the management tools must adjust to provide the manager the information he or she needs. In this way, the management system keeps moving to better and better levels of performance.

Since the management system isn't a closed system, the environment will act as a forcing function on the domain of responsibility. From the control loop analogy in Figure 1.1.21.9., we recognize that the environment can act on the who manages through the reference input and on the what is managed through a disturbance. The who manages looks to the environment (the stakeholders, usually the customer) to determine the needed operating level for the system. Then the who manages compares the reference input (voice of the customer) to the information about the work process (voice of the process) to determine how to act on the operation. (See the small circle, the comparator, in front of the controller in the control loop analogy in Figure 1.1.21.8.). Disturbances to the system are felt in the capital, labor, equipment, materials, and energy parts of the operation. When the person who acts as the who manages component isn't making decisions but, instead, is doing something, he or she becomes part of the labor in the operation. In that way, a disturbance first felt by the who manages component is felt within the what is managed component.

As I carefully distinguish among the three MSM components, I'll remind you that when I derived the MSM, I artificially separated the components. That is, the differences among the components aren't as distinct as I imply, and to touch the system anywhere is to touch the system everywhere.

The tools (computers, for example) aren't the forcing function for either the system or the age of information. The forcing function for the age of information is the need for more, rapidly-changing information as manifested through who manages. As we'll see shortly, computers and other products of information technology do more harm than good if they're taken as cure-alls that can simply be added to a managerial domain without being accurately and precisely *fitted* into it.

Especially with computer-based systems, we hear of successes of other managers, and we run out and buy that system. As in Figure 1.4.2.6.4., a salesman appears at your door and says, "I have an automatic this or that. Do you want one?" You remember you're doing this or that and you buy one. How many times do we begin with a tool obtained almost at random and, because of that investment, try to convert our operation, our management style, our other tools, and the new tools we buy to suit the original purchase? How often do we ignore the real needs of the operation and the need to understand our management system well enough and from the proper perspective so the tools will work?

Figure 1.4.2.6.4. *"Howdee. Take in the little guy and your house will never be the same."*

1.4.2.6.5. Exercise on Management System Model Components

To delimit a domain of responsibility and to build and use management tools for the domain that are useful to the decision maker and that faithfully reflect the operation, you have to identify each of the components for the domain.

Explanation
You should see domains of responsibility, or management systems, all around you. Some are large and some are small. Within your domain, you have several subdomains: your work, your family, your community service. You want to get practice at being able to delimit domains and identify the three essential components in each domain. You should also be able to identify the aim of the system. In the example below, you can see an identifier for a domain and the three components and the aim for the system. In the example, the management system is a single class, as contrasted with a course, or discipline, or a group of students. If the management system was one of the alternates I just listed, the components would most likely change. The focus of the system would change to something besides one room with students using texts to prepare midterms, etc. There is but one who manages. There are any number of things that make up the operation. Those I've listed give a range of physical things within the domain of responsibility. There are also many management tools. I've listed a variety in the example.

Example
Recall the classroom example from Module 1.1.14.4. I'll use a specific class here.

Management System: ISE 4015 (Index 7151)

Who Manages: Harold Kurstedt

What is Managed: students, texts, class room, visual aids, etc.

What is Used to Manage: syllabus, roll, drop/add forms, homework, midterms, etc.

Aim: to teach management systems engineering as an approach for dealing with the world

Exercise
List ten different management systems and identify the three essential components and the aim for each domain of responsibility.

Thought Question
My example clearly was from the perspective of the teacher. What would change if we looked at ISE 4015 (Index 7056) from the perspective of one of the students?

1.4.2.7. Information Portrayal with a Purpose—Francisco de Goya

1. Background

1.4. Theory

1.4.2. A Management System

1.4.2.8. The Interfaces

1.4.2.8.1. We Match the Interfaces to get Balance.

You'll focus on the three interfaces between pairs of components of the Management System Model so you can diagnose and fix problems of mismatch that lead to internally-caused crises.

I need to dedicate more time to keeping my calendar and to-do list so I can act rather than react. I want a working, useful information system and I must figure out what to tell someone to do to fix or replace the one I have. My decisions ought to be leading to meaningful actions. I should start measuring the right things, because I really don't use all the data I have. I must determine what isn't getting done and find a way to reflect back to my people our performance and what we need to do to the process to improve. I need to put my finger on what is really going on here. Have you ever heard, said, or thought thoughts like these?

If the components of the Management System Model (MSM) were balanced and if your management tools fit your domain of responsibility properly, you'd be thinking about how to improve your management system rather than how to catch up to it. Figure 1.1.21.3., which shows the MSM, highlights the very spots you need to concentrate on to make this happen—the interfaces between the MSM components.

The three essential components are balanced by the interfaces between them. Who manages makes decisions based on useful or preferable information. Converting information to action through these decisions is the crux of management (the decision/action interface). Through measurements to assess performance, data are generated that represent characteristics of what is managed (the measurement/ data interface). Information results from biasing data and is portrayed in one of four portrayal formats (1) a table—least biased, 2) a graphic—a pictorial representation with a math equation of symbols is least biased graphic, 3) check list, and 4) text—the most biased and richest); and who manages perceives information based on his or her individual characteristics (the information-perception/ information-portrayal interface).

The words information and data are often used interchangeably. As I stressed in Module 1.1.16.10., I choose to make distinct differences to illustrate the difference between what Blumenthal calls "an uninterrupted raw statement of fact"—data—and "data recorded, classified, organized, related or interpreted within context to convey measuring"—information. This interpretation with context is bias and makes information less pure but more useful and powerful than data. (p. 30.)

For balance, our management tools must accurately reflect what is managed. If our operation is budgeted by both budget structure and geographic distribution, spreadsheets by budget structure alone will not do the job. If our operation provides customer-oriented goods or services, a technical-function oriented organization structure will work against us. Our management tools must be acceptable (comfortable and useful) to who manages. If the manager is systematic and prefers definition and detail, the most modern, colorful graphics output package will not be liked or used. If the manager is young and inexperienced, a highly sophisticated financial plan will overwhelm him or her.

An effective information portrayal/information perception interface helps you get your tools, including your information system and long-range plan, to do what you want. You get the right data by concentrating on measuring the right performance variables. Informed decisions addressing the tangible, physical need of your operation will lead to actions that affect your operation. At each interface, you must match up the components involved. The problem is most puzzling for more-uncertain pursuits, global endeavors, and unstructured decisions. Remember, as shown in Figure 1.4.2.8.1., while no one piece completes a puzzle, all necessary pieces must be in proper relation to their neighbors.

For better or for worse, your management tools will make the difference in achieving a balanced management system through the interfaces. These tools contribute directly to two of the interfaces and heavily influence the third. Since the who manages is the one who all this is addressed to and who must ultimately carry through with the balancing act, I'll begin with the interface between you and your tools. Then I'll proceed to the other interface directly involving you—the decision/action interface. The who manages is anyone who uses information (through the first interface) to make decisions that lead to actions (through the second interface) affecting the operation, for comparison to evaluate the effect of the decision (through the third interface). The third interface (the measurement/data interface) is between your operation and your management tools.

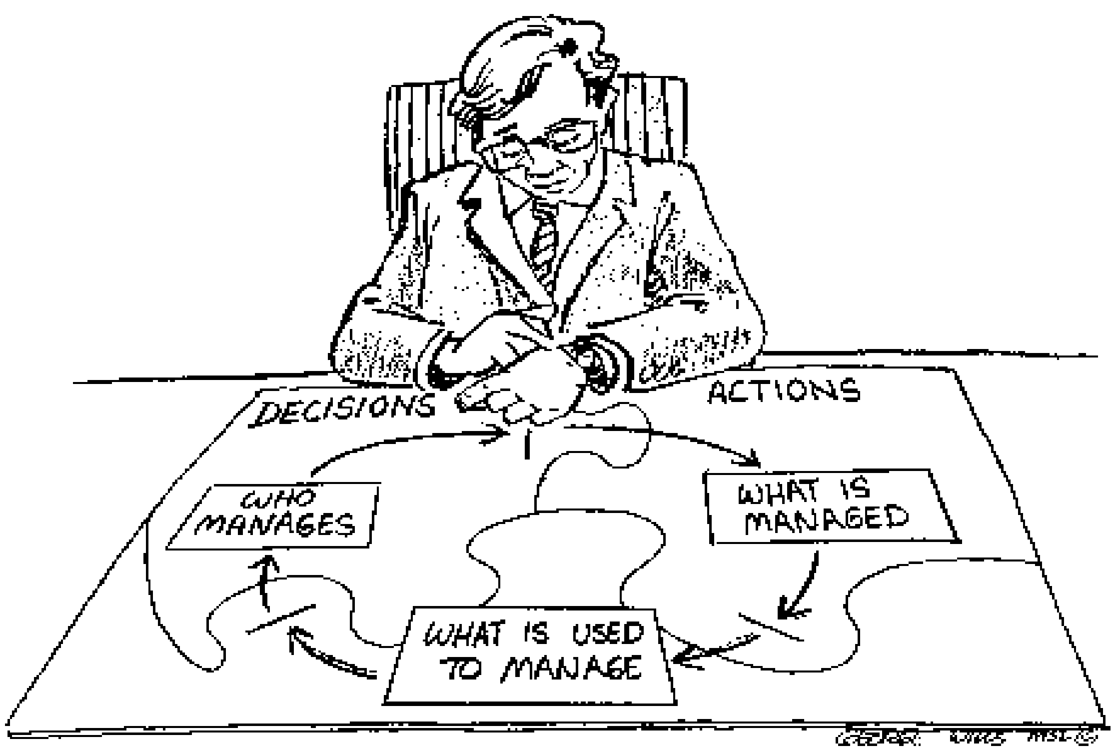

Figure 1.4.2.8.1. *The pieces fit at the interfaces.*

1.4.2.8.2. THE INFORMATION PORTRAYAL/INFORMATION PERCEPTION INTERFACE

You must portray information to best suit the objective and the data available and must portray information the way the who manages wants to perceive the information.

The information portrayal/information perception interface both is the most neglected of the three interfaces and is the most important. This interface is difficult to deal with because of the ill-defined and changeable human factors involved.

An important issue is if or when to develop a new management tool. Why not develop another software package, reorganize, or write a new plan? We can develop these tools and can show something for our efforts. The tool will be functionally better, but will the user, or decision maker, like the new tool better and therefore use the tool?

We have to work hard to show any significant improvement at the information portrayal/information perception interface. All management tools should present information to the manager. Although we generally review plans, information systems, and communications, in the end they all have the requirement of portraying information in a useful way for a human being.

How do you perceive the output of your management tools? Are you comfortable with the information you get? Would you prefer something else if you just knew what it was you wanted? To help you deal with these questions, I'll begin with an exercise for you to do in your mind. I intend for this exercise to persuade you that information is biased and most information is confusing because of hidden agendas, too many conclusions in a single presentation, and a misinterpretation of who should bias the information.

Drawing Conclusions from Data

To begin the exercise, look at the budget table in Figure 1.4.2.8.2.1. and draw a conclusion about the XYZ Program based on the data in the table. Tables are the least biased of all information portrayal formats, so your conclusion will be based on the purest possible representation of the facts. You may draw a conclusion based on all the data or any conclusion based on a subset of the data. Take a second and write down a sentence stating your conclusion and then summarize your conclusion in a short sentence of ten words or less. (To see the outcome of this exercise, you must state your conclusion as a complete thought with subject, verb, and object). Don't use the sentence I have for the title of the chart in Figure 1.4.2.8.2.1. I'll bet I've biased your thinking with my title.

Now have one or more of the people in your family or office do the same thing without knowing what you're thinking or what you wrote. The first of several surprises I expect for you resulting from this exercise is that you'll find the conclusions drawn are different. I've had hundreds of workshop attendees do this exercise and as yet haven't had one group in which there were two identical conclusions (sentences). Some were close, most were radically different.

You and those who participated have shown biases through different education, experiences, cognitive styles, and perhaps other human characteristics.

Representing Your Conclusions in Graphic Form

Now, to continue the exercise, you should draw how you believe you could most effectively represent in a graphic form your conclusion from the table in Figure 1.4.2.8.2.1 so anyone who sees your graphic will come to identically the same conclusion you did. Don't feel limited by the available choices for graphics. If you're artistic, you can even make an illustration. Otherwise, you might prefer a line graph, bar chart (vertical or horizontal), stacked bar chart, surface chart, pie chart, or one of many others. Write down (or at least think about) the title you'd use for the graphic. I believe you'll discover two more surprises from this part of the exercise.

The first surprise is that one graphic format will work best in presenting the conclusion you chose. You may not have selected the best one. Just using bar graphs because the computer package does that easiest or first is a mistake. If your conclusion alluded to a trend, a line graph works best. If you saw comparisons between components or comparisons of the components against their total, a bar chart or a pie chart works best, respectively.

Other Information Portrayal Formats

The choice of information portrayal format can be an extremely logical process based on the structure, type, and amount of data and the conclusion you wish to communicate. I've developed a procedure of designing effective graphics through a structured set of logic diagrams. I'll show you that tool soon. While graphics can be a concise way to communicate information in a book, paper, report, briefing, management information document, or any other management tool presentation, they can also be confusing or misleading when not properly designed.

The increased availability of computer-generated graphics has led to a proliferation of charts and graphs. Graphics should simplify, not confuse. They must focus, not distract.

In my logic diagram procedure, I add to graphics three other information portrayal formats. The four choices for portraying information are table, graphic, checklist, and text listed in order of ascending degree of bias and descending level of detail.

The table shows bias through title, column and row choices, and entry precision. The graphic is biased in kinds of comparison, scale, and visual presentation and enhancement. The checklist (government forms or tickler files, for example) reflects arrangement and word choice and amount of attention. The text provides great flexibility in presenting ideas, degrees, and justification.

Your second surprise is that the title for your graphic should be the short sentence of less than ten words you developed. Since the graphic drives home your conclusion (bias), to be "up-front," the audience should be able to determine instantly what that bias or conclusion is. (You may want to be obtuse or to confuse, but you only want to do that on purpose.) Not everyone would have chosen the same conclusion, and the audience needs to know what he or she is being driven toward.

The Problem with Multiple Conclusions

Don't try to bring the audience to two or more conclusions from the same graphic. He or she will receive mixed messages and won't come to any of the conclusions. Show one conclusion at a time, and everything on the graphic should support that conclusion. For example, two pie charts on one graphic are used together to make one conclusion, not two. The two graphics in Figure 1.4.2.8.2.2. present the exact same monthly research expenditure for the 1985 calendar year for my organization. However, I've chosen two different conclusions and used the graphic format which best makes that conclusion. You should choose the conclusion, and therefore the chart, to meet your needs.

If you attend one of my seminars, briefings, or workshops, you'll find that every briefing chart is titled with a sentence (including the period). Whether you read the title to yourself or I read it aloud, you'll know exactly what I want you to conclude from my briefing of that chart. I call the approach "the Perry Method" after the person who teaches developing briefing charts that way. I've extrapolated the idea not just to information presentations using briefing charts, but all information presentations: titles for tables and graphs, titles of reports or major headings therein. Preparing a briefing using the Perry Method is difficult; presenting that briefing is easy.

You may put a briefing together by listing chart titles as introduction, summary, results, expenditures, personnel, and so on. Then you take all the points you want to make and put them as bullets on the chart in which they seem to fit best. Now look at what you've done. One or more bullets don't develop the same conclusion as the others, and the audience is confused. With a conclusion for a title, a given bullet either helps make that conclusion, or it is on the wrong chart, a new chart is needed because the idea the bullet makes is important, or the bullet doesn't really help and should be discarded. The conclusion as a sentence must say something. The title "I'm taking four actions." doesn't count. The title "Four actions will get us out of debt." does.

Bias

An important idea not to forget is: Since, information is biased, whose bias should it be? Yours, the manager. Now you must worry that when you make decisions based on information presented to you, if you didn't dictate the bias and the person bringing you the information is good, you'll naturally come to his or her conclusion and probably make the decision he or she would. Who's running this railroad, anyway?

As the decision maker, the consequence of not providing a bias to the person who'll make information out of gathered data to present to you is you'll make your decision based on his or her bias. The more bias you establish for the information gatherer, the less bias available for the information gatherer to interject. Therefore, as decision maker, tell the information gatherer the information you want. For example, tell the information gatherer you want a list of all milestones listed in the strategic plan that are more than ten days late. Don't tell the information gatherer to give you information on milestone problems.

PRIORITIES WILL CHANGE IN A CONSTANT PROGRAM.

PROGRAM ACTIVITIES	XYZ PROGRAM FOUR-YEAR BUDGET (Dollars, in thousands) FY95	FY96	FY97	FY98	TOTAL
Plant Operations	50	60	70	80	260
Steam Generator R&D	10	10	10	10	40
Recycle Processing	10	40	15	10	75
New Processing Facility	15	5	5	15	40
Laser Technology R&D	30	0	15	0	45
TOTAL PROGRAM	115	115	115	115	460

Figure 1.4.2.8.2.1. *A fiscal budget table shows little bias.*

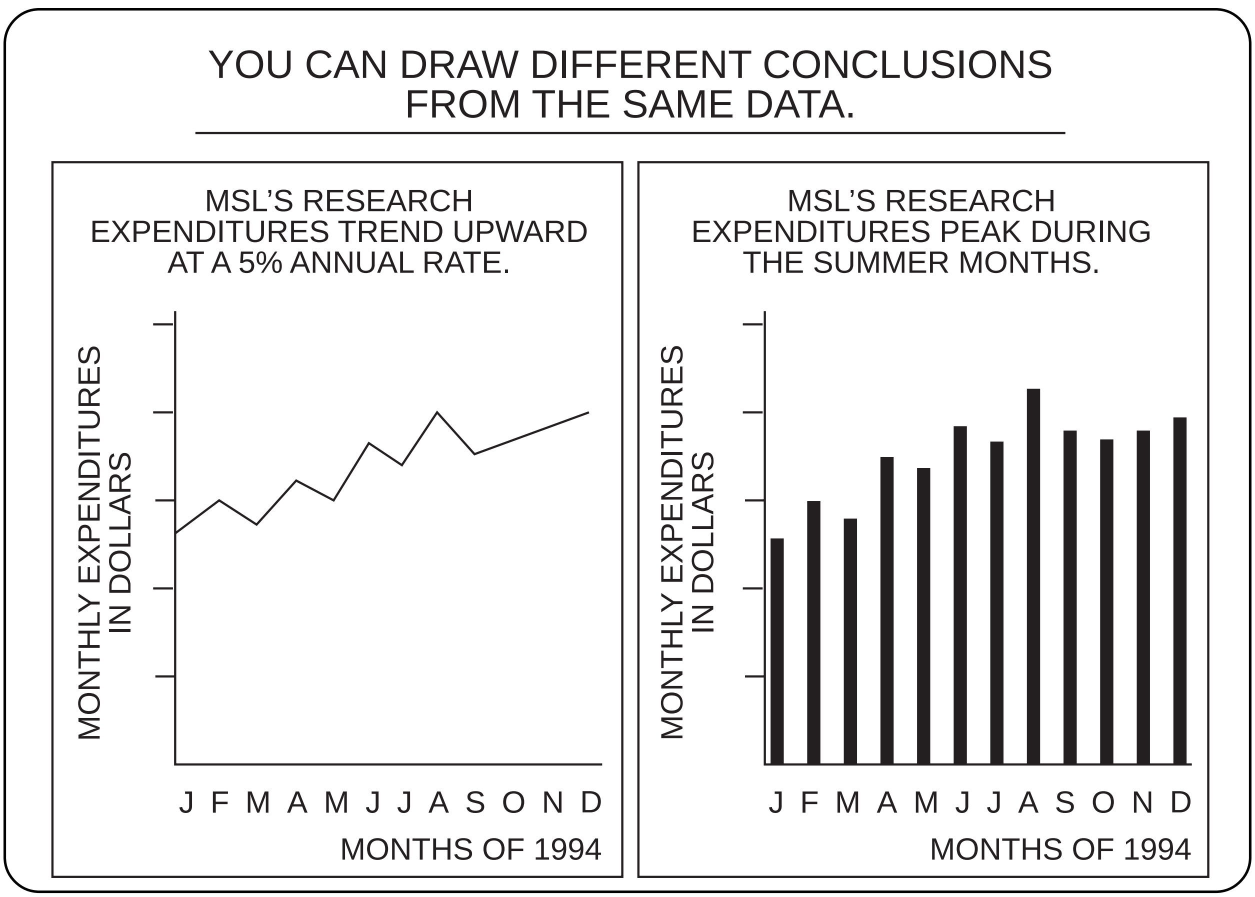

Figure 1.4.2.8.2.2. *Your conclusion is expressed as a sentence in the title.*

1.4.2.8.3. Information and Noise

"Information informs, but noise annoys." (Louis I. Middleman, *In Short*, p. 40.)

A dangerous problem is information overload. The great quantities of information that many managers are forced to consider become even more of a concern when we introduce the dramatic findings of cognitive psychologists that subjects in a situation of information overload use less information in decision-making than do those with some near-optimal amount of information. In other words, more information is not necessarily better. We believe that our short-term memory has a limited capacity—about seven "chunks" of information.

In module 1.1.16.10., I distinguished between data and information. Now I must distinguish information from noise.

Consider the situation in Figure 1.4.2.8.3. In my class, there is an intermitting fluorescent fixture. During class, it makes noise and interferes with my lecturing. But when someone comes into my class to fix it, the first thing he will do is tell us all to be quiet, because now the sound from the fixture is information and the class is noise. The conclusion is that nothing is absolutely information or noise, but becomes one or the other in response to a question (bias). The purpose of the system (unit of interest) determines what's noise and what's information.

Information overload is a misnomer because what we call information overload is really a high ratio of either noise or unprocessed data.

Engineers deal with situations where the ratio of signal to noise is relatively high. When we deal with inanimate objects or machines, we can predict cause-and-effect relationships based on our understanding of the laws of nature. Relatively speaking, inanimate objects are predictable. Using Deming's definition of management as prediction, inanimate objects are relatively easy to manage. When we are supervisors and work with people the ratio of signal to noise reverses. The noise is quite high. We haven't learned how to apply the laws of nature very well to people and especially to people interacting in groups. When you're in a sea of noise, the ability to pick the information out of the noise becomes crucial.

You can be overloaded with noise, data, or information. If we have to be overloaded with something, we'd prefer the something be information. However, information overload is a frustrating and counterproductive experience. Our job is to identify and try to separate (if we can't eliminate) noise, to use only the data necessary to make the information we need, and to only deal with the information we need to make the decisions we have to make.

Some people prefer more information than other people. So, information overload is a function of the person making the decision. In fact, some people prefer detailed information, or even data. These people either like details or they want to be positive the bias in the information they use is their own.

As builders of management tools, we must understand the characteristics of the decision maker in terms of the noise, data, and information they prefer. We can't always give the decision maker what he or she wants in terms of noise; but if we don't know the decision maker's needs and preferences and the characteristics of the operation, we can't even do our best.

Lou Middleman tells me that Ernest Hemingway spoke of an author's need for a built-in, fool-proof crap detector. That's exactly what a decision maker needs. A detector that can surface bias and filter out noise, leaving behind pure information to support decisions.

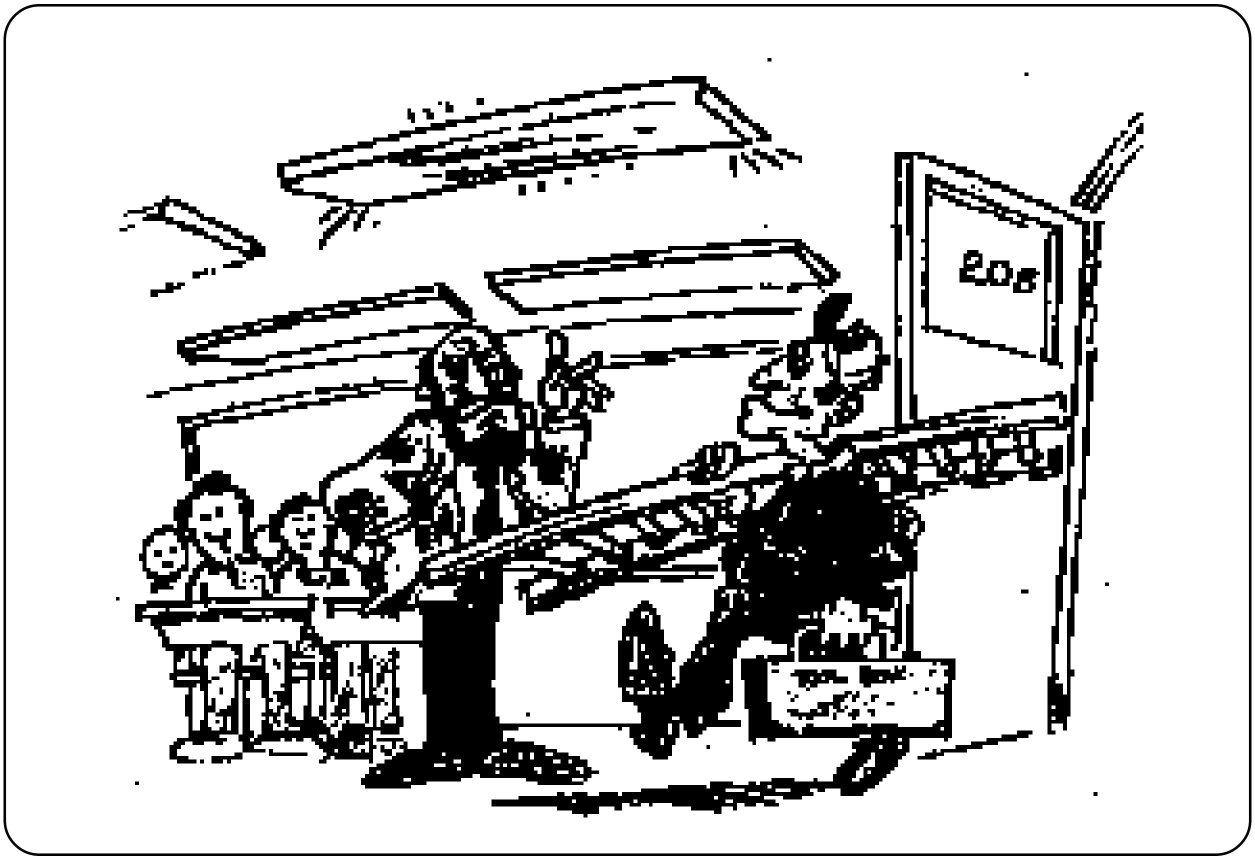

Figure 1.4.2.8.3. *"Can't you tell? That's the one."*

1.4.2.8.4. Approaching an Interface from Its Two Sides

Matching the two sides of one of the Management System Model's interfaces isn't easy because each side is affected by the closest component.

In Module 1.4.2.8.2., I used the exercise of drawing a conclusion and preparing a graphic based on a tabular format to lead you through the interface from information portrayal toward information perception or in the direction that is the specialty of the information specialist. However, regardless of the structure and quantity of data and the desired conclusion to be presented, some of you will prefer to work with the tables (perhaps a simple table highlighting just the conclusion) and some will prefer the graphics.

I'm leading you now to the left-brain, right-brain discussion and I'll choose to call the preference for structure and detail that we see in specialists systematic, or sensing, and the preference for bottom lines and trends that we see in generalists intuitive. Your position and your task can shift your information processing style toward systematic or intuitive but you prefer one or the other. I'm now leading you through the interface from information perception toward information portrayal or in the direction that is the specialty of a human factors specialist.

To make a match at the interface and have it contribute to balancing the components of the Management System Model (MSM), both directions must be considered because the interface is not a finite line but rather a continuum. For the information portrayal/information perception interface, the continuum contains some of the management tools and some of the human decision maker. As a manager you have a unique combination of experience, education, and cognitive style with your more human traits. These will influence how you perceive information. The immediate effect on the design of management tools isn't clear, but the effect on the use of the tools is. A.P. Sage argues ". . . . it is necessary to incorporate not only problem characteristics, but also problem solver or decision maker characteristics, into the design of information systems for planning and decision support." (Andrew P. Sage, *Behavioral and Organizational Considerations in the Design of Information Systems and Processes for Planning and Decision Support*, IEEE Transactions on systems, Man, and Cybernetics, Vol SMC-11, No. 9, September 1981.) G.P. Huber argues that, ". . . we do not know if DSS designs should (1) conform to the user's cognitive style or (2) complement the user's cognitive style." (George P. Huber, *Cognitive Style as a Basis for MIS and DSS Designs: Much Ado about Nothing?*, Management Science, Vol 29, No 5, May 1983, p. 571.) Note that DSS stands for decision support system.

I believe the direction of considerations about designing management tools to fit the cognitive preferences of different users should be toward the idea of responsive systems, or systems that can adapt to different users, which I'll describe later. Huber further says, ". . . the DSS design effort should be directed toward creating a DSS that is flexible, friendly, and that provides a variety of options. If this focus is adopted, the matter of an *a priori* determination of the user's style *as a basis for identifying the most appropriate design* becomes largely irrelevant." (p. 575.)

Regardless of the design of our management tools, within the context of the MSM and matching the interface, the human differences between managers must be considered. In short, a manager who doesn't like a particular tool generally won't use it and will develop ad hoc methods of getting the information he or she wants. People with different cognitive styles prefer information presented in formats that reflect those styles. Managers and management tool designers must recognize the issue and plan for preference and deal with possible failure when the who manages component changes.

Most of the time you have data from measurements that are best suited to a given portrayal format. I'll describe the rules for choosing the best portrayal format for a given use of the data and for a given set of data later. For now, realize that, without considering the who manages, we can logically derive a most effective portrayal format. What do you do when the so-called best portrayal format isn't what the who manages likes? Many information coordinators will befriend the data and information and insist on the format best for the information. Then the decision maker won't like what he or she gets and won't use the information. The information portrayal/information perception interface breaks down. There is no match.

The dilemma we face as we build management tools is that very often what is best for one side of an interface isn't best for the other side. This dilemma is a case of the typical engineering problem. Of all the conflicting options, which do you chose? In a case like this, there is no perfect answer. You have to make the best match you can. You have to choose the best portrayal formats *given the constraints of the manager's needs and desires*.

Proctor and Gamble isn't known for its managers using graphical information formats and graphics packages on the computer. (personal communication, Laurie Laning) I believe the rigorous selection process of Proctor and Gamble, which includes testing of applicants, filters managers who are more systematic and wouldn't prefer graphics.

Why do you choose the formats you do? If you believe the choice is because your favorite formats are better, you may be trying to turn a subjective feeling into an objective fact. Guess which person finding his way out of the woods in Figure 1.4.2.8.4. is systematic and which is intuitive. Which would you be?

I'm an intuitive person and like examples and illustrations. The illustrations in this book and to some extent all the figures are for people like me. For us, the illustrations and figures make the points of information clearer and more meaningful. Most managers in my workshops agree. Some, and those who are typically systematic, feel my illustrations aren't helpful. In fact, for some people, the figures are a bore at best and confusing at worst. For them, I not only have to make the point in the illustration but have to carefully explain the connection between the illustration and the point of information the illustration supports.

I've made a terrible mistake in some of the oral presentations I've given. At one time, I assumed that for all audiences the illustrations would require less explanation and time to cover than would the typical briefing charts with written phrases. I felt the illustrations would reinforce the point in the briefing chart containing words and would save time over the entire oral presentation. What I learned was that for a sensing audience, I need to spend more time on illustrations (or not use them); and, if I don't, the presentation fails.

Does the point I'm making in Figure 1.4.2.8.4. jump out at you? Can you see one person intuitively following the sun, using qualitative, bottom-line type information? Can you see the other person with all his detailed measurements and data, using structured, detailed information? Does this figure drive home the difference between a sensing person and an intuitive person who are both dealing with the same problem? Can you carry those ideas over to how we should portray information differently to different decision makers faced with the same decision? If you answer yes to these questions, you're probably intuitive. I've portrayed information to you in a way that you get the most information quickest. If you answer no to these questions or if the ideas in the questions didn't occur to you based on the illustration, you're probably sensing. I've portrayed information to you in a way that I slow you down in your understanding of the information.

Most people in the world are sensing. I'm intuitive. Now what do I do with my information portrayal? (One important issue in comparing two information portrayals to distinguish preferences between intuitive and sensing people is that both portrayals must have the same information content, only in different form. Getting the exact information content into two different forms isn't easy because information is biased and the form contributes to the bias.)

An interesting point arises here. As a presenter, I do a better job (I'm more confident and enthusiastic.) with illustrations. When I present to a group of largely systematic people, they'll prefer not to deal with illustrations. For an effective presentation, both presenter and audience should work well together. Whose preference should dictate? Obviously the presenter's and the audience's preferences should be balanced. Now I'm dealing with a different interface with two sides. This interface is between sender and receiver of information. This interface is much like the information portrayal/information perception interface.

I've seen staff people complain when the manager who must present the organization's case is picky over the words the staff has prepared for his or her presentation. I argue that if the manager's preference is satisfied, he or she is going to be more comfortable and confident—necessary characteristics for an effective presentation to benefit the organization.

In processing information, our brains tend to perceive stimuli in terms of their own past experiences and may systematically filter out information not in accordance with these experiences. Brains have difficulty processing all the relevant information—there is too much, it may not fit with expectations and previous patterns, and some of it simply may be too threatening to accept.

Figure 1.4.2.8.4. *"We'll probably get out of here about the same time."*

1.4.2.8.5. CAN WE PREDICT HOW YOU WANT YOUR INFORMATION PORTRAYED?

If you know what a person prefers, you can support their information perception and action taking better.

Who can predict what a person will do? Or what they'll prefer? We certainly believe people are different. Each person has his or her own way of doing things—his or her own style. Each person has his or her own experiences, capabilities, and preferences. Can we measure something about a person to determine how the person will behave given a certain situation (environment)? I believe we can measure a person's personality type or cognitive style. This measurement will tell us how they *prefer* to behave, not necessarily how they *will* behave. If we can distinguish among people and how they perceive information and how they act on the information they have, then we should be able to choose the best way to portray information for them.

Scott Geller tells us that to look at the output of a person we must consider a triangle of three factors: person, behavior, and environment. We're interested in decision making and action behavior on the part of the person who's the who manages. I'll describe some people differences and how those differences affect tool building. I'll start by distinguishing among personality types. Then I'll match ways of portraying information to those different types.

In 1920 C.G. Jung suggested that people are different in fundamental ways. All people are driven by the same group of instincts. One instinct is no more important than another. But what is important is a person's preference for what he or she does. The person's preference for what they do is characteristic. So the person can be "typed" by these characteristics. And Jung developed personality types. For decades scholars have spoken of different temperaments for people and they usually have decided on four different temperaments. In the l950's Isabel Myers and her mother Katheryn Briggs picked up the ideas of temperaments and personality types and produced the Meyers-Briggs Type Indicator, or the MBTI. The MBTI is in the form of a questionnaire where people select answers according to their preferences.

When we see the results of a person's preferences, we determine their MBTI type. The MBTI type is a four-letter code devised from the words symbolizing the four polarities suggested by Jung shown in Figure 1.4.2.8.5. The second pair of polarities is of greatest interest to us now. The sensing/intuitive polarity tells us how a person prefers to perceive information. In short, sensing people like details and structure and intuitive people like pictures and trends.

From Figure 1.4.2.8.5., note that most of the people in the world are sensing. Note also how they like to perceive information So, if our state-of-the-art computer-based information system is based on color, graphics, and images, most of the people in the world won't like the information system. Unless managers are selectively intuitive, most managers in the world won't like our information system. Surely, what a manager doesn't like, a manager won't use. Since a manager is anyone who uses information to make decisions, people in general won't like or use such a system.

From Figure 1.4.2.8.5., note how different people act on information. The thinking/feeling polarity is the only one where we've found gender differences. 60% of men are T; 60% of women are F. T and F are, however, evenly distributed within the overall population.

The fourth polarity distinguishes between those who prefer to perceive information and those who prefer to act on it. A perceptive person wants more information to perceive before acting on it (making a decision). A judgmental person wants to make a decision with as little information as possible. Judgmental people are into closure. They make decisions. They have clean desks. Perceptive people expand the problem. They're into possibilities.

Think about interacting with your boss. Suppose your boss is judgmental and likes to close on a problem given the least amount of information needed. Suppose you're a perceptive person and see possibilities in everything and want to bring as much information as possible to the decision to ensure no alternative is neglected. Won't your boss be frustrated as you're doing your best—unless you know about the differences between those people who like to act on information and those who like to perceive information?

The first polarity shown in Figure 1.4.2.8.5., has to do with whether you prefer to deal with people and things (the extrovert) or ideas and concepts (the introvert). The extrovert is energized at a party and is ready for action afterwards. The introvert isn't and wants to be alone and needs to rest from the exertion.

We identify the four temperaments I mentioned earlier as the NT, NF, SJ, and SP type people. We call them 1) the visionaries, architects of systems, builders; 2) the catalysts, spokespeople, energizers; 3) the traditionalists, stabilizers, consolidators; and 4) the trouble-shooters, negotiators, fire-fighters; respectively.

Certainly, no one personality type is better than another. Also, in team building, we find a good mix of personality types makes the most effective team. Personality typing is popular today. Team building and marriage and family counseling are often based on the personality types of the participants. Marriages tend to be good if spouses share at least two of the four polarities. Having three polarities the same is better. Introverts tend to marry extroverts. If you marry your polar opposite, good luck. The marriage can work, but the pair wakes up every morning with two completely different theories of and attitudes toward the world and human existence.

Some companies even hire based on certain personality types for certain jobs. This practice is not only unethical, and probably illegal, it's foolish. My wife is an introvert; but, you wouldn't know it at a party. I'm the extrovert and she's much more social and gracious at the party than I am. She's good at being an extrovert. She just doesn't prefer it. You'd know my wife is an introvert when we get in the car after the party, she's exhausted and I'm energized. Dealing with people and things draws energy from her and builds energy in me. The bottom line is that if you choose me over my wife to get the best extrovert, you'd make a terrible mistake. My wife has all the energy she needs to be all the extrovert you can handle. Never rank people's behavior based on their preferences. Deming tells us never to rank people on their performance. Similarly, we should never rank behavior based on preferences either.

Bariff and Lusk propose that "generally accepted psychological tests be used by the systems analyst to evaluate user preferences for report presentation modes" in designing information systems. They list dozens of psychological tests and measures of user and organizational behavior variables. The MBTI is but one of the tests. Many more tests have been devised since the time of the Bariff and Lusk article. However, the MBTI continues to be the most generally popular personality typing instrument today. (*Designing Information Systems for Organizational Control: The Use of Psychological Tests*, North-Holland Publishing Company, 1978, pp. 113-121.)

The bottom line is people don't all like the same things. Or use the same things. Or do the same things. To be successful in management tool building, we have to consider what's special about the who manages component of the Management System Model. We need to know what's special about the manager in terms of how he or she likes his or her information portrayed. I've offered the MBTI as a way of predicting not only how information ought to be portrayed in a given domain, but as a way of predicting how the information will be acted on and the relative dominance of perceiving or acting. Regardless of the measures you use to interpret a person's preference, be sure to consider the individuality of the manager when you develop a management tool.

JUNG'S THEORY CONTAINS FOUR POLARITIES.

Extrovert (75% of population)....................	*Introvert* (25% of population)
People and things	Ideas and concepts
Sociability	Territoriality
Many relationships	Few relationships
Expending energy	Conserving energy
Interest in external events	Interest in internal reactions

Sensing (75% of population)......................	*Intuitive* (25% of population)
Detail and structure	Generality
Experience	Hunches
Realistic	Speculative
Fact (data)	Fiction (stories and pictures)
Practicality	Ingenuity

Thinking (50% of population— 40% females 60% males)..................	*Feeling* (50% of population)
Logic and rationality	Relationships
Objective	Subjective
Laws and orders	Circumstances and social importance
Firmness	Persuasion
Analysis	Sympathy

Judgmental (50% of population)................	*Perceptive* (50% of population)
Less information	More information
Limit the problem	Expand the problem
Fixed and decisive	Flexible and tentative
Closure	Open options
Sees deadline	Sees possibilities

Figure 1.4.2.8.5. *Key words help distinguish between pairs of identifiers for each of Jung's four polarities.*

1.4.2.8.6. Managing Informal Information

Important information is too current, sensitive, or opinionated to formalize. We automate formal information to save time so managers can deal with informal information.

Communication is effectively transferring information. You have formal and informal communications and routine and non-routine communications and internal and external communications. You must recognize the types and extent of information flow necessary to accomplish your mission. Additionally, you must be concerned about the huge opportunity for allowing critical information to fall through cracks, generating inaccurate information, sending multiple and conflicting signals, and lacking timeliness.

Furthermore, let's look at informal information used by managers more often than the formal information we can get from an information system. Next time you're in a meeting and someone comments on a sensitive subject, listen to his words and watch his face and body language. Do the words agree with his gestures? Which do you believe the most? We all have people we call to get informal information that is too current, sensitive, or opinionated to formalize. We make our critical decisions based on our most trusted sources of informal information. ("Your applicant's credentials may look great, but after a week working for us he had everyone hating him, so don't hire him. What? No, I couldn't put that in writing.") We don't have time to verify or corroborate the information to formalize it. After the decision is made, the information will be formalized and kept for historical reference and trends.

We formulate data easier than we formulate information. Facts tend to be less sensitive and less threatening than bias. Automation won't help for informal communication because judgment is used. Nevertheless, informal communication is necessary, good, and must be managed. (Isn't this something? The best stuff we can't automate. Deming says the important information is unknown and unknowable. Now what?) Our goal is to automate as much as we can to save more time for judgment.

A government manager upon hearing I thought informal communication should be managed said, "Oh, then informal communication must be bad." Of course not. Control can mean directed or curbed. Directed is good, curbed is bad. If we plan on and use informal communication, we're acting, not reacting. This manager was reacting to the fact that he spends so much time dealing with problems, he sees management as curing rather than preventing or maintaining. (In management today we want to head off painful cures like the one in Figure 1.4.2.8.6. Instead, we want to act ahead of time based on important information, much of which is informal and unvalidated to head off painful problems.)

A major reason managers don't use formal information as specialists think they should is that managers find difficulties with the MIS—too limited (data not rich, ignore non-quantitative data, loses verbal channels, weak in external communication) and often too general (need tangible detail and more intelligent filtering process), too late and too unreliable. Instead, managers turn to ad hoc, informal information systems that they design and prove for themselves.

Routine information is expected and we've planned for it. Nonroutine information (both formal and informal) relates to change, and change relates to opportunity. Our management tools have to be responsive to help with nonroutine information.

Internal information is that in which both the sender and receiver are within your domain of responsibility. Often informal communication is quite effective for honesty and speed. The consequences of ineffective internal communication are mostly internal. External information must be furnished. You're responsible for either the sender or the receiver and can document what is done.

Figure 1.4.2.8.6. *"This won't hurt a bit...."*

1.4.2.8.7. The Decision/Action Interface

"If information is not utilized even a technically well designed system may be considered a failure." Macintosh and Daft, 1978.

Since in most cases humans make the decisions, we must provide only information *absolutely needed* for the decisions of who manages. With this thought, we proceed to the decision/action interface. Decisions that don't lead to actions aren't worth making and certainly aren't worth supporting with information. You must be selective with your information requirements, or you'll inundate yourself with the data needed to produce your information. As you can see in Figure 1.4.2.8.7. if you don't know who does what to whom as a result of information (makes a decision that leads to action affecting what is managed)—don't invest your precious resources in that information.

Think about the decisions you make. We're interested in 1) how or which decisions lead to actions that count and 2) what you need to make good decisions. Decisions require information and information requires data, and there we have the linkage between the interfaces of the Management System Model (MSM) looking in the direction from actions toward decisions. Ask yourself questions like, "What are the first three things I want to know about the office when I get back from vacation?" Jay Forrester says that management is the process of converting information into action. The conversion process we call decision-making. Decision-making is in turn controlled by various explicit and implicit policies of behavior. Management success depends primarily on what information is chosen and how the conversion is executed. The manager then is an information converter.

List a sampling of the decisions you make—not just different instances of the same type of decision. Follow-up with a corresponding list of the impact of each example decision. Every decision must have a purpose. Don't ask for information you aren't going to use. What idealistic information document (text as in plans, letters, or reports; checklists, as in forms or tickler files; graphics, as in pie charts or illustration; and tables) would you like to put you in the best position to make an effective decision. Ask yourself why you chose the document you did.

Many studies scrutinize the decision-making process, most notably those of H.A. Simon. He developed three phases of the decision making process. The first phase involves searching the environment for conditions calling for decision, the intelligence phase. The second phase is the design phase—inventing, developing, and analyzing possible courses of action. The choice phase is the third and includes selecting a particular course of action from those available.

I relate effective actions based on decisions to lessons learned in emergency management. Emergency management highlights the decision/action/impact relationship. Emergency management has three stages cycling in the following order: planning, preparedness, and response. Emergency management, being the most intense form of anticipating and managing can direct us toward dealing with any change—the things we make decisions for. In planning, the manager needs to think and analyze, structure, and proact. (Although not in the dictionary, proact is a much-used term today when talking about a manager's actions. Proact means to act in a way that you cause something you want to happen, as opposed to react, where you act as a result of something that has happened. In terms of a control theory analogy, you want to be in a feed forward mode, rather than in a feedback mode.) In preparing, the manager needs to make ready, to critique, and react. The object of preparing is to identify where we aren't ready. Reacting is necessary and valuable at this time. In responding, the manager reviews, decides, and acts.

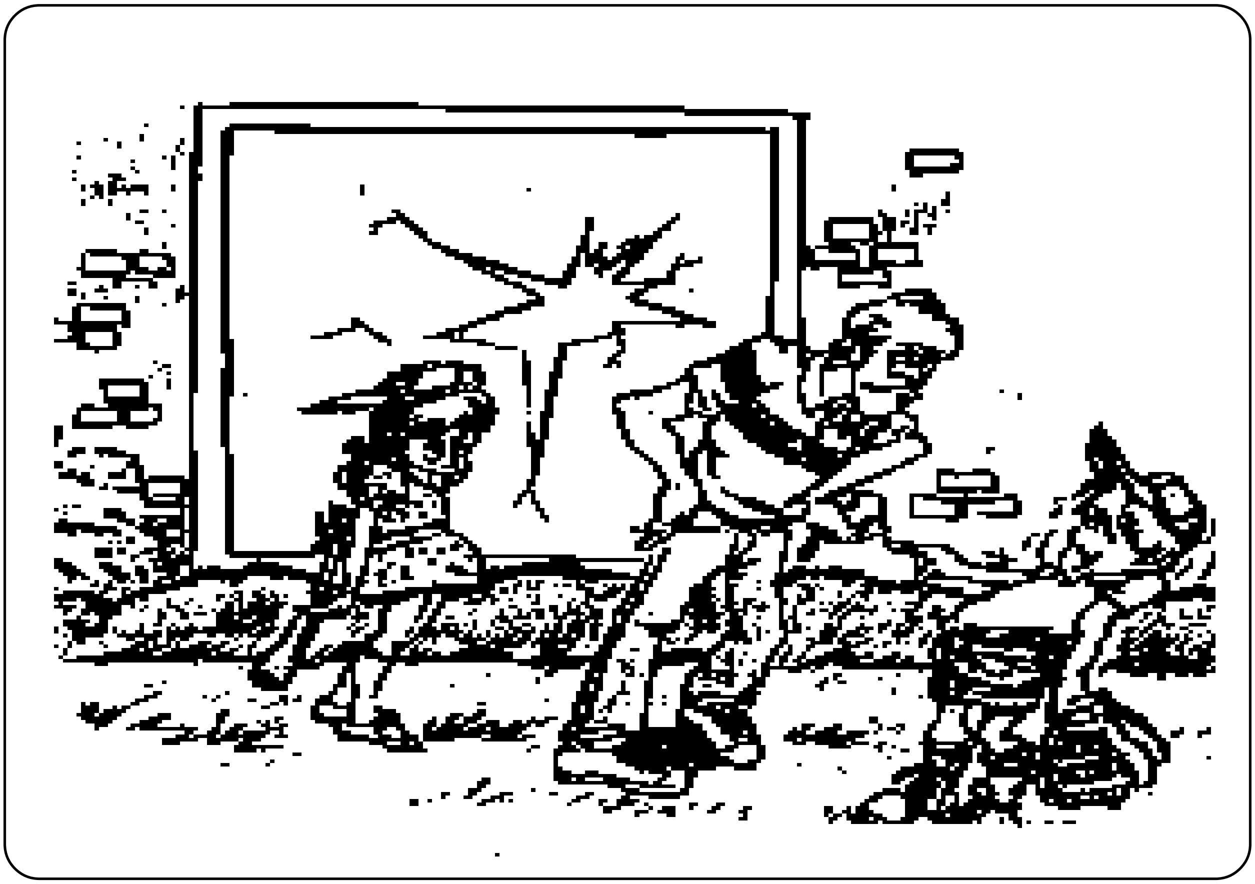

Figure 1.4.2.8.7. *Guess who does what to whom as a result of which information.*

1.4.2.8.8. Peter Drucker's View

1.4.2.8.9. The Measurement/Data Interface

We often use mechanisms for sensing indicators, collecting data, and making information in a single container, thereby making the division between measurement and data difficult to see.

Recall the information portrayal/information perception interface for a moment and generalize to the measurement/data interface. The information tools perform a conversion process and present, or portray, the result of that process. The manager looks for and perceives that presentation. The manager needs the result of the management tools' process to do his or her job, which is a decision making process. Likewise the operation performs a conversion process and presents, or portrays, the result of that process. The result is the product or service and associated waste streams. The portrayal includes indicators for measuring the conversion process, or work process, and the result of the process, or the product, service, and waste. The management tools look for and perceive that portrayal. If you will, the sensors, whether mechanical or human, focus on an indicator (a parameter to be measured) and generate data. If the sensor is an optic, magnetic, or proximity device, the output is voltage. What the sensor senses is the indicator, or the measurement, and what the sensor generates is data.

With this conversion in mind, we realize we can generate another component including a conversion process at the measurement/data interface. With my voltage example, the sensor only generates data. Not until we calibrate the sensor against a standard or compare the voltage or its interpretation against another datum do we get information.

I recognize that in many devices today, we find the sensor and the data-to-information convertor in the same container. I separate the sensing function from the information-generation function for understanding the Management System Model (MSM). Recall that in the using management tool functions in Figure 1.1.21.5., we have one function for determining indicators and reference points and another function for collecting and logging data. These functions reflect the two sides of the measurement/data interface.

To continue the discussion of possible additional components and conversion processes at an interface of the MSM, consider the decision/action interface. We would call a component making the decision-to-action conversion an actuator. We can also consider a component to make the portrayal-to-perception conversion at the information portrayal/information perception interface. The glaring disadvantage of adding components to the MSM, and of course more interfaces between pairs of components, is the rapid increase in complexity. However, if your focus is on the conversion process from decisions to actions in an actuator, you may want to encumber the MSM.

Just as management tools (the what is used to manage component) form a conversion process yielding good, bad, and relevant information (based on measures of timeliness, accuracy, and relevance), the operation (what is managed component) forms a conversion process (work process) yielding good, bad, and relevant data. I'll describe good, bad, and relevant in terms of data and information when I discuss information-oriented performance factors in more detail.

The operation also yields output to the environment, including the product or service and the waste and by-products. From an internal view, we're interested in data from the operation showing the status and progress of the operation in terms of the operation's expectation in the form of reference points and standards. Just as who manages reflects a bias for choosing and interpreting information, management tools reflect a bias for the data they can use and what they do with the data. Since management tools are in your head, they're more conceptual than the word tools suggests. The mechanization of a management tool, like a book for a plan, a chart for an organization structure, or a computer for the data-to-information chain are part of the operation tools. The data and information and their form are the management tools. You can see that formal management tools as we deal with them spread across the measurement/data interface and include part of what is managed and part of what is used to manage. Informal management tools usually include people providing the informal data and information (usually heavily biased information). The people are either part of the what is managed component or part of the environment of the management system. The what is used to manage component is a conceptual component. That's okay; so is the who manages component.

1.4.2.9. Inputs and Outputs to Components

1.4.2.10. The Control Loop Analogy

1.4.2.11. Hierarchical Systems

1.4.2.12. Other Analogies

1.4.3. Information Richness—Vincent Van Gogh

1. BACKGROUND

1.4. THEORY

1.4.4. FOUNDATION CONCEPTS IV

1.4.4.1. Yet Another Set of General Concepts Defined Quickly

1.4.4.2. DEFINE INFORMATION RICHNESS

Information richness is the potential information-carrying capacity of data, and some media carry richer information than others.

Not all information is created equal. Some information is better than other information. What does better mean? Information that leads to successful decisions resulting in actions to improve performance of the organization is better. What kind of information is that?

Richard L. Daft and Robert H. Lengel respond to what information leads to ultimate success in an organization in their article *Information Richness: A New Approach to Managerial Behavior and Organization Design* (Organizational Behavior, vol. 6, 1984, pp. 191-233.). Their premise is that the "accomplishment of these information tasks [equivocality reduction and the processing of a sufficient amount of information] as well as the ultimate success of the organization are both related to the balance of information richness used in the organization." (p. 191.) Webster defines equivocal as "subject to two or more interpretations and usually used to mislead or confuse; of uncertain nature or classification." (*Webster's Ninth New Collegiate Dictionary*)

The issue of balance, or fit, rises again. The implication here is that information of different richness is best for different needs. Richer information is probably harder to come by, and we need to fit richness of information to the need and use of the information. We want to reduce equivocality to the point that when people communicate they establish a shared view of events, especially external events affecting the organization.

Daft and Lengel set the scene by saying, "Organizations face a dilemma. They must interpret the confusing, complicated swarm of external events that intrude upon the organization. Organizations must try to make sense of ill-defined, complex problems about which they have little or unclear information (Weick & Daft, 1982). Inside the organization, more confusion arises. Departments pull against each other to attain diverse goals and to serve unique constituencies and technologies (Lawrence and Lorsch, 1967). Divergent frames of reference, values, and goals generate disagreement, ambiguity and uncertainty. In response to the confusion arising from both the environment and internal differences, organizations must create an acceptable level of order and certainty. Managers must impose structure and clarity upon ambiguous events, and thereby provide direction, procedures, adequate coupling, clear data, and decision guidelines for participants. Organizations must confront uncertain, disorderly events from within and without, yet provide a clear, workable, well defined conceptual scheme for participants.

How do organizations perform this miracle? Through information processing." (p. 192.) Managers must deal with the forces for disorganization (entropy) by developing structure—in this case, a structure for information and a structure of the organization for better use of better information.

Daft and Lengel and others, most notably Jay Galbraith in his book *Designing Complex Organizations*, model the organization as an information processing system. Clearly, some organizations, like government oversight agencies, are exactly that—information processors. However, all organizations have at least an information overlay to everything they do. So, in my mind, the conceptual model of an organization as an information processor is a good one. Also, since I'm most interested in management tools, which convert data to information, the information processor model works right into my hands. Daft and Lengel's premise is "*that organizational success is based on the organization's ability to process information of appropriate richness to reduce uncertainty and clarify ambiguity*." (pp. 194-195.) If success is one of our performance criteria in the illustrative/conceptual model in Module 1.1.29.1., then we need an information-based organizational model in the center box to best view success from Daft and Lengel's perspective. As information processors, organizations must solve the problems of interpreting the environment and coordinating diverse internal activities. One problem is external, the other internal.

In defining information richness, Daft and Lengel first address language. "Daft and Wiginton (1979) proposed that human languages differ in their ability to convey information. The concept of language was used in the broadest sense to encompass various ways to transmit ideas, emotions, and concepts. High variety languages are those in which symbol use is not restricted and the language can communicate a wide range of ideas. Examples include art, music, and painting, which are subjective in interpretation. Low variety languages have symbols that are restrictive in their use, and the languages communicate a narrower range of ideas. Low variety languages include mathematics and statistics, which convey exact, unequivocal meaning to users. Daft and Wiginton argued that high variety languages were appropriate for communicating about difficult, ephemeral, social phenomena. Low variety languages communicate effectively about well understood, unambiguous topics.

The notion of language seems plausible, but it doesn't explain information processing in organizations. Managers typically don't use art, poetry, or mathematics to communicate about organizational phenomena. The range of language used within organizations is typically limited to natural language and simple numbers." (p. 195.)

Engineers, who spend at least half their time communicating, and indeed managers (supervisors), who spend much more of their time communicating, are taught to use low variety languages at best. (Mintzberg shows that managers spend over 80 percent of their time communicating (Daft and Lengel, p. 201.)) Math and statistics and even the spoken language leave us well short of the mark in rich information for rich communication, especially when dealing with the systems approach. Since communication skills are fundamental to both the engineering and management processes, we must learn high-variety languages and transfer what we learn to our attitudes and behaviors, especially in regard to those people who excel at high-variety languages.

Daft and Lengel define richness as "the potential information-carrying capacity of data. If the communication of an item of data, such as a wink, provides substantial new understanding, it would be considered rich. If the datum provides little understanding, it would be low in richness. ..... [The] communication media used in organizations determines the richness of information processed. ..... Communication media include face-to-face discussion, phone calls, letters, written documents and numeric documents. The face-to-face medium conveys the richest information while formal numeric documents convey the least rich information. ..... Face-to-face is the richest form of information processing because it provides immediate feedback. With feedback, understanding can be checked and interpretations corrected. ..... Each medium is not just a source, but represents a difference in the act of information processing. Each medium utilizes differences in feedback, cues and language variety. Richness is a promising concept for understanding information behavior in organizations." (pp. 196-198.)

Daft and Lengel include a figure to characterize the different media in terms of information richness and the contributors of that media to richness. I've reproduced the figure here as Figure 1.4.4.2. Daft and Lengel talk about the uses of information of different richness. Sometimes less-rich information is better. "... rich media are needed to process information about complex organizational topics. Media low in richness are suited to simple topics. ..... Factors such as inventory control or employee attendance are not difficult to conceptualize. Managers can communicate about these phenomena through paperwork and quantitative reports. Other variables, such as organizational goals, strategies, managerial intentions or employee motivation, are intangible. These factors are not clear and discreet, and they can be difficult to interpret. Making sense of these factors requires a rich medium that provides multiple information cues, immediate feedback and a high variety language. Rich information enables managers to arrive at a more accurate interpretation in a short time." (p. 200.)

Precise, clear information isn't always best for decision making. "Memos, reports and other written media can oversimplify complex problems. They do not provide a means to convey personal feelings or feedback. These media do not transmit the subtleties associated with the unpredictable, messy, emotional aspects of organizations. On the other hand, extensive face-to-face meetings for simple phenomena may also be inefficient. Face-to-face discussion sends a variety of cues, which may not always agree with one another. Facial expression may distract from spoken words. Multiple cues can distract the receiver's attention from the routine message." (p. 200.)

In face-to-face communication people receive most of their information non-verbally. Body language is more effective than spoken language. Mehrabian (1971) showed that in face-to-face communication only seven percent of the context was transmitted by verbal language. Ninety-three percent of the content was transmitted through facial expression, tone of voice, gestures and other nonverbal means. Suppose I say to you "That was a great piece of work you did!" You'll interpret my meaning differently if I use a sarcastic tone and angry facial expression then if my tone is enthusiastic and my expression happy. (A. Mehrabian, *Silent Messages*, Belmont, CA: Wadsworth, 1971)

The key to information richness is communication. Is the richness of information more in the portrayal of that information or in the perception of that information? If richness has to do with the potential information-carrying capacity of the communication, does sending or receiving deliver most on that potential? Communication has to do with the transfer of information. So, both the sender and the receiver of the information participate in the richness of the information transfered. Look at the feedback column in Figure 1.4.4.2. The more connected the sender and the receiver are during the transfer of information, the richer the information. So, the richness is not in the information, but in the process and mechanisms by which that information is transfered. Notice also that the more biased the format of the information and of the process for transfering the information, the richer the information is. Richness, biasedness, and ambiguity tend to go together. How valuable is biased information? How valuable is rich information?

Daft and Lengel relate information richness to management tools. They say management information systems are at the low end of the richness continuum in Figure 1.4.4.2. The conclusion is that computer-based management information systems aren't very useful to managers. The computer has the lowest variety language. Indeed, the computer strips the specifiers from data and stores fact in one place and meaning in another. To get even low-variety information, you have to search the data stores for fact, meaning, and reference points and then construct information. Daft and Lengel say, "Tushman and Nadler (1977) believe that information designers are more concerned with fitting data to their hardware than with understanding the overall information needs of managers. Information system designers lack a theory about manager needs and behavior. By limiting data to those things amenable to machine hardware, information designers miss the root causes of manager information processing. Most managerial tasks are too ill-defined for quantitative data, yet system designers assume that computer output is sufficient for management decisions. MIS systems are able to capture and communicate about the stable, predictable activities, but not about the important, subjective, ill-defined events relevant to decision making." (p. 204)

Information Richness	Medium	Feedback	Channel	Source	Language
High	Face-to-Face	Immediate	Visual, Audio	Personal	Body, Natural
	Telephone	Fast	Audio	Personal	Natural
	Written, Personal	Slow	Limited Visual	Personal	Natural
	Written, Formal	Very Slow	Limited Visual	Impersonal	Natural
Low	Numeric, Formal	Very Slow	Limited Visual	Impersonal	Numeric

Figure 1.4.4.2. *The characteristics of media that determine richness of information processed show us reasons why some information carries more information to decision makers than other information. The decision maker wants the amount of information needed for a particular situation. We can have information overload from too rich a medium when used for a very structured decision. (taken from Daft and Lengel)*

1. Background

1.4. Theory

1.4.5. Frameworks

1.4.5.1. THE NEED FOR FRAMEWORKS

Frameworks help you characterize your domain of responsibility.

What kind of domain of responsibility (management system) do you have? How is your domain like those of others? What tools work well for domains like yours and may or may not work for you? Why? Which tools work well for domains unlike yours and will not work for you? How do you tell the difference?

In the next several modules, I'll describe four frameworks to classify what you do and put your domain of responsibility in context. Systems and their components have attributes. The frameworks get at the attributes (characteristics) of the management system and its three components.

The frameworks look at 1) pursuits in terms of uncertainty, 2) endeavors in terms of comprehensiveness, 3) decisions in terms of unstructuredness, and 4) stages in terms of maturity. These frameworks are management tools supporting a manager or a consultant in diagnosing an organization. The frameworks are what I would use today to observe, diagnose, and classify the organization as described in the "vision" part of module 1.1.13. The first and fourth frameworks are mine, and the middle two are adapted from R. N. Anthony and H. A. Simon, respectively. These frameworks will help you answer questions like: I know I have a critical path, but why can't I determine slack time? Why do I need query systems when I can't yet get good data into the system? Shouldn't I data-log in my process before I try to optimize it?

Unlike the models or frameworks that describe the mechanics or internals of your domain, such as the Management System Model (MSM) or the earlier work of Forrester, Blumenthal, and Dearden, now I'll describe the context or externals of your domain. The contextual and mechanical frameworks reinforce one another; together they strive to provide a full and accurate description of any manager's domain of responsibility.

Each framework shows a dimension for characterizing an organization. Like human characteristics, you don't have a good view of the organization until you see as many of its characteristics as possible. Also like human characteristics, the organization may show one version of a characteristic now and another version later. A person may act like a sensor today and an intuitive tomorrow. But beneath it all, one version dominates, at least in terms of tendency or preference. That is also true for an organization.

For the organization, the visibility stage of the maturity dimension is but one characteristic of many. The organization may display this version today, and look like the control stage tomorrow. I like to think the organization is both but in different proportions.

In studying nuclei we can develop spectra; that is, different behavior of the nucleus at different energy levels, for example. The spectrum looks like Figure 1.4.5.1. Depending on the energy level, the nucleus looks different. If I show a dimension for maturity of the organization, I say the organization looks different for different maturity levels. Figure 1.4.5.1. is a maturity spectrum for an hypothetical organization.

I don't know how to describe or operationalize maturity (for decision making) of the organization and/or its components as a continuous variable. So I take the easy way out and approximate the continuous variable as a variable with discrete levels. For the maturity dimension, I've settled on three levels. Since maturity is really continuous, another person can argue for fewer or more levels. I like three because I feel I can identify the levels in the organization.

The organization represented in Figure 1.4.5.1. displays all three levels of maturity; although relatively more visibility and relatively less control. I'd start developing management tools for visibility before tools for control because they'd be used more in this organization. Another organization with a different spectrum would lead me to develop a different set of management tools.

Thorngate has a postulate of commensurate complexity. For theories of social behavior, he states that the theory, model, or framework can't be simultaneously simple, accurate, and general. (W. Thorngate, *'In general' vs. 'It depends': Some comments on the Geigen-Schlenker debate*, Personality and Social Psychology Bulletin, 1976, pp. 404 - 410.) The frameworks I'll describe in the next set of modules are simple and general. The fact that we can argue about how I've approximated continuous variables as discrete variables speaks to the accuracy of the frameworks.

Using our understanding of the maturity of the organization for decision making together with our understanding of the other dimensions helps us figure what management tools to select or build to support decision making. Looking only at the spectrum for maturity in the hypothetical organization in Figure 1.4.5.1., we need tools for visibility most of the time and tools for control or optimization some of the time. Other organizations would have different spectra supporting different needs for tools. Clearly, we'd like a host of tools, each matched to its support of a need in one of the levels of organizational maturity. If we consider the importance of the instances of visibility, control, and optimization as being equal, we should put our first energies into building and using visibility tools (strong sensor capability) for the organization represented by Figure 1.4.5.1.

For Figure 1.4.5.1., I've addressed stages in terms of maturity, one of the four dimensions described in my four frameworks. No dimension is necessarily more important than others. Importance depends on what you're looking for. Within a given dimension, one of the levels, or discrete pieces, dominates as shown in Figure 1.4.5.1. for the hypothetical organization.

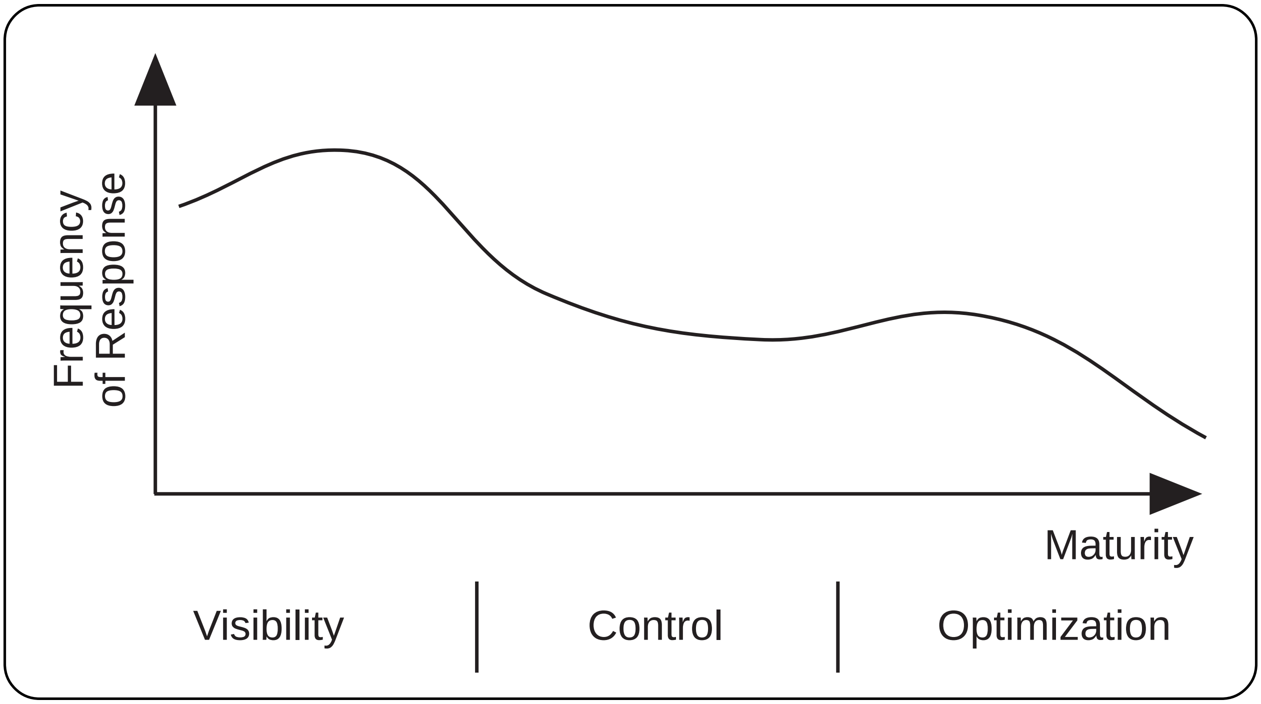

Figure 1.4.5.1. *This spectrum for the maturity dimension for an hypothetical organization shows that we might simplify the characterization of the organization as being in the visibility stage; however, the organization at different times and in different places displays characteristics throughout the spectrum.*

1. Background

1.4. Theory

1.4.5. Frameworks

1.4.5.2. The Framework of Pursuits

1.4.5.2.1. Characterizing the Domain by Uncertainty

Uncertainty has to do with not knowing Where We Are, Where We Want To Be, nor How To Get There.

Sometimes You Know Where You Are Going, and Sometimes You Don't.
In my first framework, I classify your responsibility by uncertainty (or lack of definition). I use Jay Galbraith's definition of uncertainty: "*Uncertainty is defined as the difference between the amount of information required to perform the task and the amount of information possessed by the organization.*" (Jay Galbraith, *Designing Complex Organizations*, Addison Wesley Publishing Company, 1973, p. 5.)

I define uncertainty simply as the ratio of the information you need to the information you have. If you need a lot of information and have a little, your domain is uncertain. Relatively speaking, if you need a little information and have a lot (enough), your domain is certain. You need relatively more information if you 1) have a diverse set of complex products and services and processes for producing the products and services, 2) use diverse and complex inputs from diverse suppliers, 3) the aim of your system is difficult to achieve, 4) the consequences of your activities are severe, and 5) if your work is highly visible to diverse stakeholders.

Galbraith says, "It is information processing, and specifically information processing during actual task execution, that is the key concept." See also Michael L. Tushman and David A. Nadler, *Information Processing as an Integrating Concept in Organizational Design*, Academy of Management Review, July 1978, page 616. "As work related uncertainty increases, so does the need for increased amounts of information, and thus the need for increased information processing capacity."

Later, in Module 2.1.9.3., we'll discuss the differences among bad, good, and relevant data and information. If information lacks accuracy or timeliness or both, it's bad information. If information is both accurate and timely, it's good information. To be relevant, good information must also be relevant to the decision being made. I believe relevant information adds the most to certainty. Therefore, uncertainty is the ratio of the information you need to the *relevant* information you have.

In Figure 1.4.5.2.1., I define five classifications of pursuits, depending on uncertainty. I call the major, broad efforts for which you're responsible pursuits. The engineering approach includes knowing where you are, where you want to be, and how to get there from here. I define a perplexity as a pursuit in which you know neither where you are, where you want to be, nor how to get there. I define a process as a pursuit in which you know all these things. I use the word pursuits as opposed to functions or activities because I use these other words to mean other things.

The Five Pursuits
A *process* is a pursuit that routinely and repeatedly achieves the same known end through well-defined intermediate steps from start to finish. An example of a process is a bottling plant for soft drinks or preparing an annual budget.

A process is very certain in that I know where I am, where I want to be, and I'm refining how to get there so I can get there better and better each time. I defined process very carefully in module 1.1.16.5. You can now see why I distinguish a process from a system (unlike

Scherkenbach) because your management system can have a process in it or one or more of the other pursuits I'll describe now.

A *project* is a pursuit for which you know the starting point (where you are) and have full quantitative specifications for the end (where you want to be). In a project, you do a given pursuit once. Although it is the first of its kind (not a process), you have drawings and detailed specifications for the end. An example of a project is the first version of a plan or a prototype instrument or constructing a new production plant. In a project, figuring out how to get there is relatively straight forward because you know where you are and where you want to be. When you do a project, you're always changing a process. Your project changes the process from what it is now to what you want the process to be.

A *program* is a pursuit with a definite starting point but for which you have only a qualitative fix on the end. Programs include research and development programs or pursuits where you evaluate alternatives, each of which provides a different solution to the given problem. An example of a program is an economic analysis for choosing between new product lines or research and development on high-level radioactive waste disposal. In the first example, the qualitative end is to maximize profit and satisfy customers; in the second example, to isolate all high-level waste from the biosphere. Figuring out how to get there is difficult because you don't have a definitive fix on the end. You don't know exactly where you want to be. Research (as in research program) involves discovery—discovery of the end and of how to get there. After you discover the end, you can make a project out of a program.

A *problem* is a pursuit with a definite starting point but a completely unspecifiable end. In emergency response you can define the beginning, but you can't define where the emergency might take you and what else it might affect. An example of a problem is the resolution of the Three Mile Island incident, the highjacking of TWA Flight 847 from Athens to Rome, or the introduction of a competitive product on the market.

At the highest level of uncertainty, a *perplexity* is a pursuit for which you can specify neither the start nor the end, and hence nothing in between. In emergency management you must be ready to manage whatever comes along without any (or much) forewarning. Federal emergency managers may receive a call on a situation similar to Three Mile Island, Love Canal, Mount St. Helens, the Cuban refugees in Florida, the errant re-entry of a Soviet spaceship, or some incident totally unpredictable. They just have to manage it, whatever it is. The classic example of a perplexity is emergency preparedness.

Your Domain Includes All Classifications of Pursuit to Some Degree.

A comment regarding all four frameworks is in order. As you review the classifications of the framework (e. g. the different pursuits) you will realize that you really have some of all (or almost all) of the classifications in your domain of responsibility. Indeed, in your domain, you have a spectrum of responsibilities across the classifications. Therefore, you need many management tools so you can use the right tool for the right thing. You'll also realize that to a greater or lesser extent, one of the classifications dominates and that predominance should influence the priorities in obtaining and improving your management tools.

As I showed in Figure 1.4.5.1. for the maturity dimension, you'll have a spectrum of pursuits for the uncertainty dimension in your domain of responsibility. The person responsible for emergency preparedness may feel their whole life is a perplexity. But they go through a budget process once a year, a hiring process every time they add a new person to their staff, and so on. In a similar fashion, the person responsible for a bottle manufacturing plant may feel their whole life is a process, but they're not certain that the line might not break down tomorrow or a worker won't show up today, or were perplexed with the problem of materials having to be back ordered yesterday. In short, each domain has its unique spectrum of pursuits across the uncertainty dimension.

The emergency manager needs different management tools from the bottle plant manager most of the time, but when he or she does the hiring process they need tools like anyone else doing a process. I've used some thought to divide the continuous variable for uncertainty into five discreet categories. Because the categories are an approximation, you can expect the dividing line between the categories to be fuzzy.

FIVE PURSUITS RANGE FROM UNCERTAIN TO CERTAIN.

UNCERTAINTY

PURSUITS

PERPLEXITY	-	Can specify neither the start nor the end.
PROBLEM	-	Can specify the start but not the end.
PROGRAM	-	Know the start and have a qualitative fix on the end.
PROJECT	-	Know the start and have the specifications for the end.
PROCESS	-	Repeatedly achieve the same known end.

Figure 1.4.5.2.1. *Uncertainty is a matter of what you know and what you don't.*

1.4.5.2.2. How to Manage Pursuits

How you manage your domain of responsibility and the tools you need depend on the mix of pursuits and the resulting degree of uncertainty in your domain. You want to reduce the uncertainty.

Pursuits without a Defined End
Note from Figure 1.4.5.2.1. that for the top three pursuits, the end isn't well defined. Many of you do or will manage pursuits where the end isn't specified. You may have an uncertain task in a structured environment (e.g. some government organizations). Uncertain tasks are most easily managed in flexible environments. For those of you in some form of government organization, notice how much of what you do involves the top three pursuits. National defense, disease control, environmental protection, and welfare aren't exactly well defined with well-defined ends.

If you look at Figure 1.4.5.2.1. and draw an imaginary line between programs and projects, the pursuits above the line are prevalent in government organizations. For such pursuits, how do you do networking and apply CPM and PERT? How do you do life-cycle costing? How do you do personpower and resource loading? How do you do scheduling? You can't, because the end must be specified to apply any of these techniques.

If you find yourself unable to use the traditional techniques just listed, your frustration is that you still need to deal with bottlenecks, cost projections, resources, and time. The management consultant response to your plight is, "You don't manage right!" The truth of the matter is that you manage something different. You've already surmised that tried-and-tested techniques successful for one pursuit will probably fail for another.

Rule for Managing Undefined Pursuits
Without detailed discussions of how to develop techniques for the uncertain pursuits, a single sentence can describe how these pursuits should be managed. *Drive the management of the uncertain pursuit to the next more certain pursuit.* For example, we manage emergency preparedness (a perplexity) by defining and planning for responses to as many contingencies as possible; and, by considering the various contingencies, we determine a generic response. Of course, contingency-specific responses are used wherever possible. By looking at emergency preparedness as hypothesizing responses to different classes of problems (flood, fire, chemical releases, security incident), we try to drive the perplexity to a problem and then manage the problem.

In a program we research as many alternatives as possible—the best researcher being the one who can effectively limit the number of alternatives that must be studied. We research the alternatives and ultimately, based on the research results, choose one or more alternatives to prototype (i.e., make a project out of the program).

Over the long haul then, we begin with a perplexity, such as "I wonder what the customer might need someday?" Then we move the perplexity to a problem, such as "The customer needs a product or service for moving heavy luggage through airports." We move the problem to a program, such as "We must do research and development to see what the possibilities are for energized luggage." Then we move the program to a project, such as "Let's build a prototype for an electric-motor-driven wheeled suitcase meeting certain size, weight, speed, and other specifications." Finally, we move the project to a process, such as "We'll build and operate a manufacturing line to produce intelligent mechanized suitcases for finding their way through airports."

Choosing Tools for Pursuits

I'm always amazed at how many organizations admit that 25-50% or more of their time is spent in managing brush fires (especially information brush fires), which lead to discontinuity of organization, and whose management tools (organization structure, plans, information systems) are modeled after those that work well for processes. For one sponsor, consumed by information brush fires as part of their perplexities and problems, I designed an organization structure which considered brush fires as routine. Part of the organization would be responsible for brush fires and these situations would be handled routinely as the rest of the organization continues with its other responsibilities.

Many algorithms and quantitative models fail for uncertain pursuits. In quantifying the concepts, tools like material requirements planning (MRP) and critical path method (CPM) have been constrained. Even though MRP and CPM *packages* don't work for perplexities or programs, the *qualitative concepts* behind these techniques are general and apply to all pursuits. If we consider the concept in its general form, different models can be developed that will work for other pursuits. We must be careful not to quantify a qualitative model too soon or inappropriately.

I like to describe a tongue-in-cheek history of critical path. I imagine that critical path was figured out by a caveman who recognized that he had activities in his domain that caused bottlenecks. In Figure 1.4.5.2.2., he couldn't eat until he killed his dinner, and he ate whatever he killed. He focused his attention on the bottlenecks to most effectively manage his existence. That way of thinking helped cavemen manage for years. The bottleneck concept was exercised in its purest form.

Then one day an academician decided to quantify the concept of bottlenecks into minimum slack time—a parameter which depends on duration of activities and knowing the end of the pursuit. This quantification restricted the concept (as trying to write equations for highly nonlinear concepts does). Now we think in terms of quantifiable slack times instead of qualitative bottlenecks. We have to know what dinner is going to be and when dinner is going to be before we can network the process of preparing it.

Jay Forrester, in his book *Industrial Dynamics*, emphasizes the dilemma of trying to work with only quantifiable data. "Many persons discount the potential utility of models of industrial operations or the assumption that we lack adequate data on which to base a model. They believe that the first step must be extensive collecting of statistical data. Exactly the reverse is true. . . . . A model should come first. And one of the first uses of the model should be to determine what formal data need to be collected. . . . .What is the relative importance of the many different variables? How accurately is the information needed? What will be the consequences of incorrect data? These questions should be answered before much time or money is expended in data gathering.

Much of the value of the mathematical model comes from its 'precision' and not from its 'accuracy.' Constructing a model implies nothing one way or the other about the accuracy of what is being precisely stated. . . . There seems to be a general misunderstanding to the effect that a mathematical model cannot be undertaken until every constant and functional relationship is known to high accuracy. This often leads to the omission of admittedly highly significant factors (most of the 'intangible' influences on decisions) because these are unmeasured or unmeasurable. To omit such variables is equivalent to saying they have zero effect—probably the only value that is known to be wrong!

Our verbal model, when converted to precise mathematical form, may be inconsistent with the qualitative nature of the real world we observe around us. We may find that cherished prejudices cannot, by any plausible combination of assumptions, be shown to have validity. Through any of these we learn.

A model must start with a 'structure,' meaning the general nature of the interrelationships within it. Assumptions about structure must be made before we can collect data from the real system." (pp. 57-58.)

For my real-world program example of the high-level radioactive waste disposal research and development program, by anecdotal observation the critical path includes public acceptance, congressional approval, and environmental impact—activities for which we cannot develop minimum slack times. The basic concept of bottlenecks applies but isn't now receptive to quantification because the quantification that exists is too restrictive. So, we can't use critical path. Recognizing this and dozens of other limitations in definition, structure, and quantification uncovered by viewing domains of responsibility according to this uncertainty framework, Management Systems Laboratories concentrates on tools for pursuits without defined ends for organizations which enjoy a high level of scrutiny—that is ill-defined problems with potentially severe consequences.

For the more certain pursuits, we can concentrate on management tools for productivity and efficiency, which Peter Drucker says means doing things right. For the more uncertain pursuits we must attend to performance or effectiveness, which Drucker says means doing the right things.

Regardless of the pursuit, you need management tools to work with four entities: resources, schedule, quality, and critics. For example, if your resources are cut, either the schedule must slip or the quality must suffer, or both, and the result will affect your critics.

Changing Pursuits Means Changing Tools. During their careers, many managers find that their responsibilities change among the pursuits. Most often their programs develop into projects requiring an entirely different set of management tools. Sometimes the manager changes jobs or is reassigned to a responsibility involving a pursuit different from his or her experience.

As the manager is organizationally moved around, the characteristics of the manager may or may not fit well with the type of pursuit for which he or she is responsible. I worked with a government manager who was responsible for the high-level nuclear waste research and development *program*. A consultant convinced him to get control of his effort he needed a very expensive, elaborate networking system. After spending three million dollars installing the system and tying to convert his practices to align them with his new management tool (the means driving the ends rather than visa versa), the manager was frustrated, angry, and had learned critical path and networking were expensive useless tools. The computer-based networking model failed because, for a program, we don't know the end and the model required specifications for the end. Several years later, a new President of the United States (Reagan) caused the research and development program to choose an alternative and proceed to a project. The plant to deal with a high-level waste was to be built. Guess who was put in charge of the *project* for building a plant for which we now had specifications? The same manager who had learned painfully of the uselessness of networking. Guess what tool was exactly right for the project? The computer-based networking model. The program had become a project and the end was known. The manager wouldn't touch the right tool with a ten-foot pole. Had the manager understood the difference between the spectra of pursuits between the two domains (the program before Reagan and the project after Reagan) he would have been able to choose the right tool.

Effective leadership style depends on pursuit. According to Fred Fiedler, task-oriented leaders are best in very certain and very uncertain environments. For uncertain environments, the leader doesn't have time for relationships and must get the task done. For certain environments, the task is clear and the leader must concentrate on it. Relationship-oriented leaders are best in the other environments. I draw the simple correlation between Fiedler's environments and my more structured pursuits, and the relationship between leadership style and pursuits applies.

Obviously what is managed, who manages, and especially what is used to manage are different for successfully managing different pursuits. As we briefly view the other three contextual frameworks we'll note the same results.

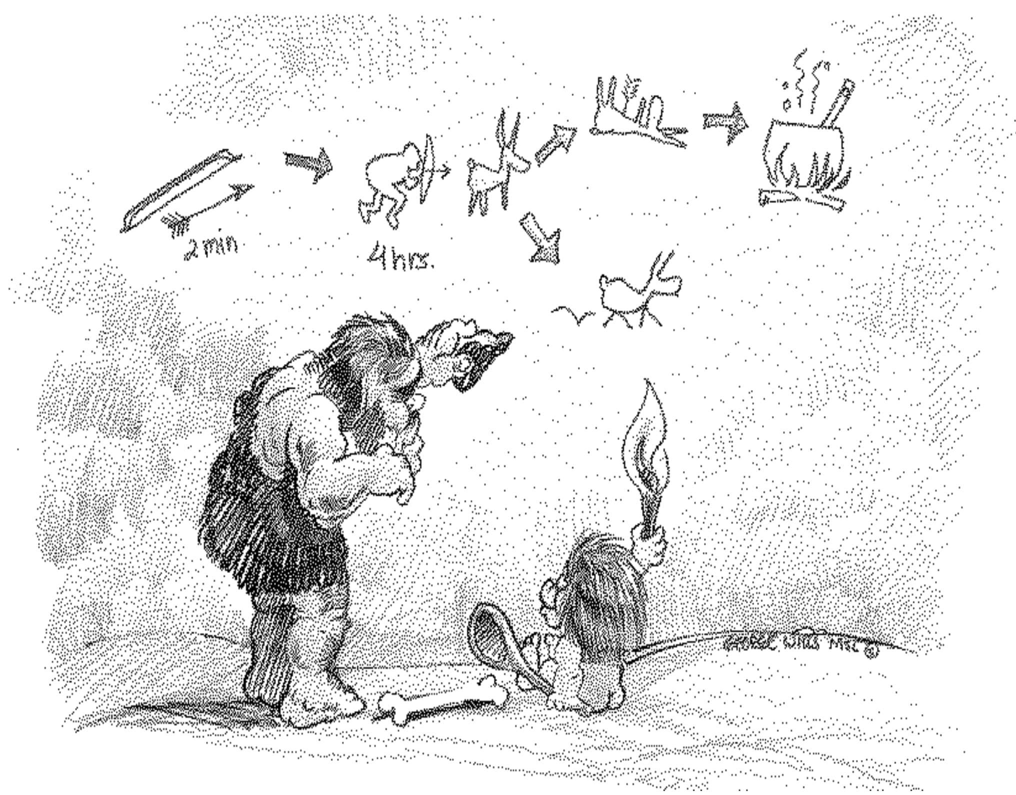

Figure 1.4.5.2.2. *"The shortest path between here and dinner is a dead mastodon."*

1.4.5.2.3. Origins of the Pursuits Framework

1.4.5.3. We Begin with Visibility—Rembrandt Van Rijn

1. BACKGROUND

1.4. THEORY

1.4.5. FRAMEWORKS

1.4.5.4. THE FRAMEWORK OF ENDEAVORS

1.4.5.4.1. Characterizing the Domain by Endeavor

Sometimes you solve problems and sometimes you figure out which problems to solve.

A Broad Effort Extends Your Effect and Limits Your Support.

The second framework is adapted from the work of R. N. Anthony. I classify the things you do in your domain of responsibility as levels of endeavors. (I save the word activity for another meaning and another purpose.) I define endeavors as your serious determined efforts directed toward a result. These endeavors, which are performed at sequentially greater levels of broadness of perspective, generality in direction, and responsibility (answerability), are shown in Figure 1.4.5.4.1. In the framework of pursuits, you really have a range of pursuits with one dominating your domain. In this framework of endeavors, you have a spectrum of endeavors, for which you're responsible and in which one predominates.

Often the same word (e.g., activity) is used to mean several slightly different things. Problems occur when we try to discuss two of those things at the same time or to compare them. At those times we substitute another word for one of the things (task, effort, endeavor, undertaking) and what we mean by that thing becomes more confused rather than clearer. Therefore, I've taken some pains to choose words I can use consistently throughout the discussion on management systems engineering. Sometimes I've had to make distinctions between words that are synonyms in the dictionary.

Anthony's framework, intended for thinking about management planning and control systems, categorizes organizational activities as strategic planning, management control, and operational control. His interest was in the *purpose* of management activities (endeavors). Most information system problems have occurred when managers try to be successful with a management information system (MIS) at the strategic planning level based on successes of the MIS at the operational control level. I've adapted Anthony's framework to include strategic, tactical, operational and clerical endeavors.

Anthony specifically stayed away from equating management control with "tactics" because "a military tactical maneuver has a definite beginning and end, whereas the management control process relates to recurring cycle of operations." (Robert N. Anthony, *Planning and Control Systems: A Framework for Analysis*, Graduate School of Business Administration, Harvard University, 1965, p. 56.) I choose the term tactical to describe those endeavors within the recurring cycle of operations which are carried out to meet more quantifiable results using smaller efforts, fewer resources, and more specific guidance than for strategic-level endeavors.

Strategic Endeavors

Your strategic endeavors are of greater importance within your integrated efforts; they embrace all considerations, entail greater risks and consequences, and are global in nature. The resources required are more substantial, more varied, and are not easily integrated. There are fewer precedents upon which to base decisions. There are few, if any, higher-level rules or directions upon which to base decisions. The strategic endeavors are aimed at directing and organizing the operation. In short, you do strategic endeavors when you're figuring out which problem to solve or when you're figuring out what kind of problem you really have.

Be careful not to confuse strategic-level endeavors with strategic-level managers. The corporate president is a strategic-level manager whose domain of responsibility should be dominated by strategic endeavors. However, he or she still has many endeavors at the tactical, operational, and even the clerical levels. For performing clerical endeavors (e.g., finding the bathroom or operating the new phone system) a management tool for strategic endeavors (e.g., policy for constructing sky scrapers or for corporate communications) is far removed from the needs of the clerical endeavors. A strategic tool (like a corporate communications policy) is only helpful in dialing the telephone under the new phone system in as much as the instructions you need to dial the phone relate to the organization's communications policy. Simple, highly specific, constrained tools are needed for the clerical endeavor (e.g., a map or list of instructions).

Just as the strategic-level person does some clerical endeavors, the clerical-level person does some strategic-level endeavors. The janitor finds a mess and has to figure out what kind of problem he or she has before he or she can determine what cleaning tools and solvents or cleansers he or she needs to clean up the mess.

Recall in Module 1.1.14.3. I indicated that the difficult endeavor of determining your unit of interest was a strategic endeavor. If you work on the wrong unit of interest you're solving the wrong problem.

Recall also that I've discussed how we don't teach people how to figure out what the problem is. We end up with people working hard on wonderful solutions to the wrong problem. (See, for example, module 1.1.14.3.) We don't help people learn about doing strategic endeavors. That's why strategic endeavors seem so hard to do. In grade school, both math teachers and students hate to do word problems. We don't like word problems because we're not sure exactly what the problem is and what method we should use to solve the problem. We prefer number problems where everything is given and we plug numbers into the formula we know we're supposed to use. We teach people how to do clerical endeavors.

Tactical Endeavors

Your tactical endeavors are aimed at controlling your operation. Plans are critical in tactical endeavors even though planning is done at all levels. Organizing and effectively using resources and controlling the operation are tactical endeavors. In short, given that you've figured out what problem you have when doing the strategic endeavor, in a tactical endeavor you now figure out what resources you need and what controls you need so you can solve that problem.

Operational Endeavors

Of the four types of endeavors, the top three are supervisory in nature. The operational endeavor is the lowest level of supervision. This level assures that specific tasks are carried out effectively and efficiently. Operational endeavors focus on execution and on staffing of workers to carry out the operations. For operational endeavors, you schedule and control individual tasks rather than appraising the performance of the operation; you procure needed items rather than supervising procurement; you staff your tasks rather than doing personnel management; and you control costs rather than develop budgets. In short, given that you've figured out the problem by doing a strategic endeavor and know what resources you need to solve the problem by doing a tactical endeavor, in the operational endeavor you now figure out the steps to take to apply the resources to the right problem to solve the problem.

Clerical Endeavors

The clerical endeavor is a doing endeavor rather than a supervisory one. The word clerk relates to keeping records, working at a sales counter, or assigning hotel guests to their rooms; but, used generally, the clerical endeavor includes all hands-on effort to generate the goods and/or services of your operation. We could also call a clerical endeavor a worker endeavor. In short, now that you know the right problem by doing a strategic endeavor, the right resources to apply to the problem by doing a tactical endeavor, and the right steps to take by doing an operational endeavor, you use clerical endeavors to apply the resources to the steps and solve the problem. If done properly, people doing clerical endeavors are the problem solvers, whereas people doing the strategic endeavors are the problem figure-outers.

Different Endeavors Require Different Tools.

On a production line in a manufacturing plant, the operator does a preponderance of clerical endeavors, as does a secretary. However these people do have operational endeavors involving staffing, scheduling, and procurement. From time to time they may plan procurement or measure performance—tactical endeavors. The foreman on the same production line is concerned with scheduling maintenance and keeping the line at peak performance and has a preponderance of operational endeavors. The shift supervisor has production goals and considers product changeover and other mostly tactical endeavors. The plant manager is concerned with profitability and long-range planning. These endeavors are strategic.

Business computers and their predecessors were employed historically to solve problems at the operational and clerical levels of the organization. They focused upon the day-to-day, transaction-oriented functions which were structured, definable, had specific input and output, were repetitious, and were very precise.

Computers were capable of doing these functions better than people because they were faster, more accurate, and more predictable than people. Therefore, people displacement (or automation) was the primary justification for computer applications addressing operational and clerical endeavors in an organization.

Two factors have changed this early view of how computers could be used to best advantage. The first factor is that because of the rapid and unceasing increase in technology since computers were conceived, more data could be maintained in more flexible databases, information could be displayed in formats resembling accepted manual reports, and the time saved in overseeing operational tasks could be spent on endeavors requiring more judgment. Thus, we could begin to focus on tactical endeavors and on resource allocation problems which had considerably greater impact on profitability than merely automating the transaction processing procedures.

The second factor is that for higher levels of endeavors, and especially the strategic endeavors, the logical question to ask was, “Since I’m spending so much money on computers, why aren’t they solving my problems?” The answer is “Because tactical and strategic levels of management include a different mix of the kinds of endeavors.” Strategic-level people with a preponderance of strategic endeavors want help with their work too. But we haven’t developed computers to figure out which problem to solve or what kind of problem we really have. So, for strategic-level people, we use computers to help them do clerical endeavors and sometimes operational endeavors just like we do for operational-level and clerical-level people. By helping strategic-level people with their clerical and operational endeavors we preserve more of their time for strategic endeavors.

The Endeavor Spectrum
Just as you did for pursuits, you can determine how much of each endeavor you do in your domain. Since comprehensiveness is a continuous variable, I've approximated the situation by developing four endeavor categories for comprehensiveness. If you could measure comprehensiveness precisely and you distributed what you do against a comprehensiveness dimension, you'd find a spectrum. Typically, your spectrum would peak somewhere and that somewhere would determine which category of endeavor dominates in your domain.

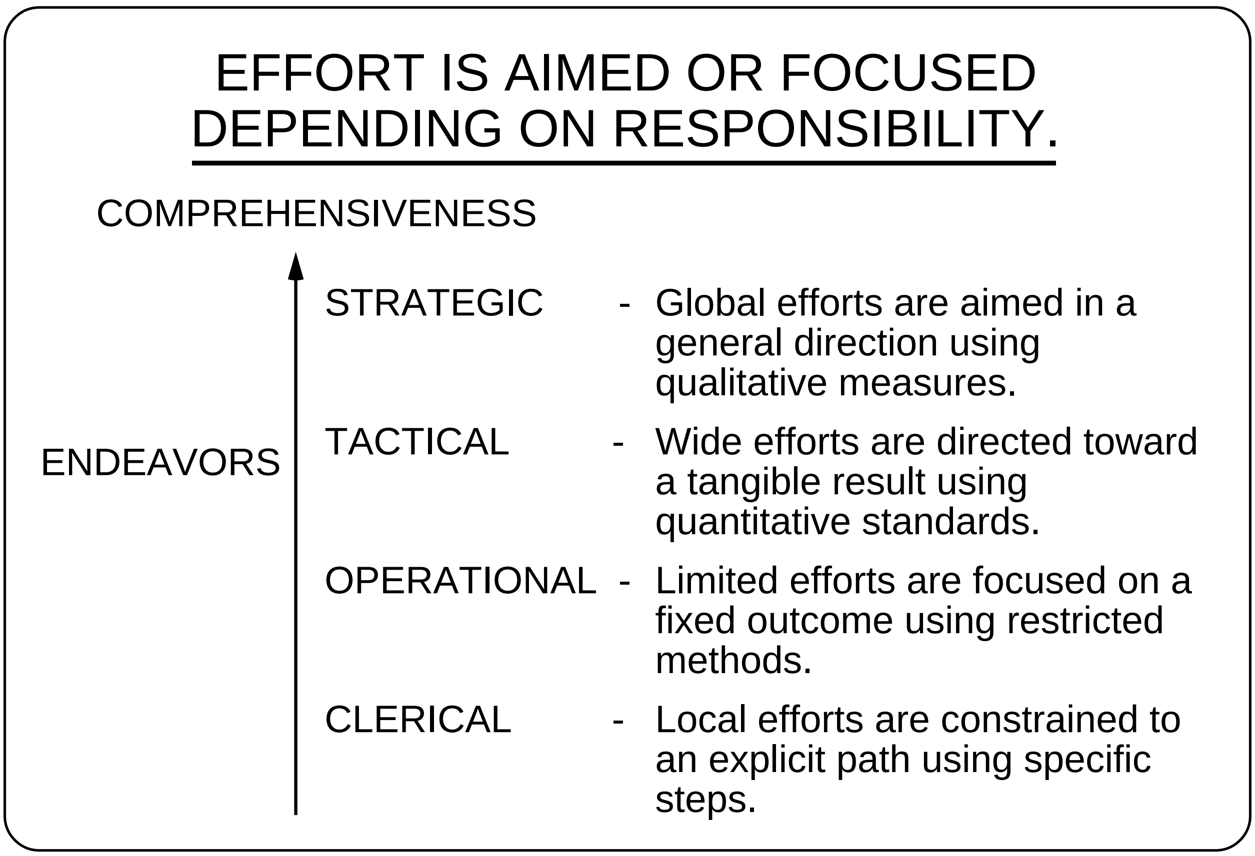

Figure 1.4.5.4.1. *Your endeavors are more comprehensive and take broader understanding of the issues involved and relationships with other endeavors at the strategic level of effort (not necessarily of the organization) than at the clerical level.*

1.4.5.4.2. DISTINGUISHING BETWEEN ORGANIZATIONAL LEVEL AND ENDEAVOR

A manager at any organization level can do any of the endeavors. We expect strategic-level people to do more strategic endeavors than tactical-, operational-, or clerical-level people; but the reverse may occur, depending on the person and the situation.

I want to distinguish between levels in an organization and what managers do (endeavors). At any level in an organization, people do a mix of endeavors, although a level is characterized by the relative amounts of endeavors a person does at that level. For example, a person at a strategic level in the organization does strategic, tactical, operational, and clerical endeavors, but he or she does (or should do) more strategic endeavors than people at other levels in the organization. A strategic-level manager figures out how to deal with new competition or if the organization's culture should change and which is more important at the moment (strategic endeavors); but they may also dial their own phone and open their mail (clerical endeavors). As a strategic-level manager finds ways for clerical-level people to do more of his or her clerical endeavors for him or her, he or she gains time to spend on strategic and other endeavors.

The spectrum of endeavors is continuous, but can be approximated by discrete categories, and four categories are conventional from the literature. Work is planned from the top down and executed from the bottom up. So the bottom organizational level, clerical, is a doing level, not a supervisory one. Strategic, tactical, and operational levels are supervisory levels. Management is decision making. So all endeavors are management endeavors. But not all levels are supervisory.

Figure 1.4.5.4.2. is a typical representation of hierarchical levels in an organization. John Zachman uses the figure when he says, "In combining the ideas of the Hierarchy of Management and Planning and Control, it is evident that the different levels of management have different responsibilities relating to the levels of planning and control as shown in Figure [1.4.5.4.2.]." (John A. Zachman, *Control and Planning of Information Systems*, Journal of Systems Management, July 1977, vol 28, no 7.)

On the right side of Figure 1.4.5.4.2. you can see Anthony's strategic planning, management control, and operational control activities. You can see the triangle representation for organizational hierarchy everywhere. The idea is to show the top manager on top doing the general management (broad global efforts), middle management in the middle, and the large number of workers at the bottom doing the work. This representation is dangerous. Be careful.

The reasons the representation in Figure 1.4.5.4.2. is dangerous are: 1) top management is separated from the workers, 2) middle management is seen as span breakers, and 3) the endeavors look like they're exclusively level oriented. Deming, who dislikes hierarchical-level representations of the organization prefers process-oriented representations like the one in Figure 1.1.16.5.3. The idea is that middle managers have more important things to do than delay and distort communication up and down the hierarchy. Everyone in the organization shares in all the endeavors. As we move more and more decision making from a select few to all the people in the organization, we realize people everywhere make strategic decisions about strategic endeavors.

Referring to what's wrong with Figure 1.4.5.4.2., not only do operational managers (a title showing level in the organization only) do some strategic endeavors, so do the workers who would be shown on the triangle below them. I recognize that the chief executive officer usually has a lot of experience and proven ability, thereby making him or her well equipped for doing strategic endeavors. We hope that the chief executive officer does more strategic endeavors than others. That's why we pay them so much. But, unfortunately some top managers spend too much time on operational and clerical endeavors they should be delegating to others.

I worked with a top manager in government who was incensed when I said top managers should do strategic endeavors; that is, figure out what problems to solve and what the problems really were. He said, "But, I'm a problem solver." He had an engineering background, and engineers pride themselves on being problem solvers. Sure, he solved problems. But who was figuring out the right problems to solve? This story raises two issues: 1) too many people work on solutions without having done the strategic endeavors, thereby solving the wrong problems and 2) strategic-level managers do tactical, operational, and clerical endeavors too. Strategic endeavors are difficult to do and lack immediate gratification. Anyone would want to do the problem solving and see results. But we pay strategic-level managers to do difficult things.

Today, we don't separate levels of management. I define management as decision making; and everyone makes decisions. We want to empower our people and empowerment means we move the right types of decisions to those who have the right experience and capability and are closest to the information they need to make the decisions. We recognize that top managers aren't at the top: managers are everywhere and they deal with endeavors throughout the endeavors framework as does anyone with a domain of responsibility. In the foreword of Max DePree's book *Leadership Is an Art*, James O'Toole describes his first visit to a Herman Miller factory. "I was given *carte blanche* to go anywhere and talk to anyone, managers and workers. The only problem was that I couldn't tell one from the other! People who seemed to be production workers were engaged in solving the 'managerial' problems of improving productivity and quality. People who seemed to be managers had their sleeves rolled up and were working, side by side, with everybody else in an all-out effort to produce the best products in the most effective way. 'The signs of outstanding leadership are found among the followers,' Max writes in this wonderful little book." (Dell Publishing, 1949, p. xxii.)

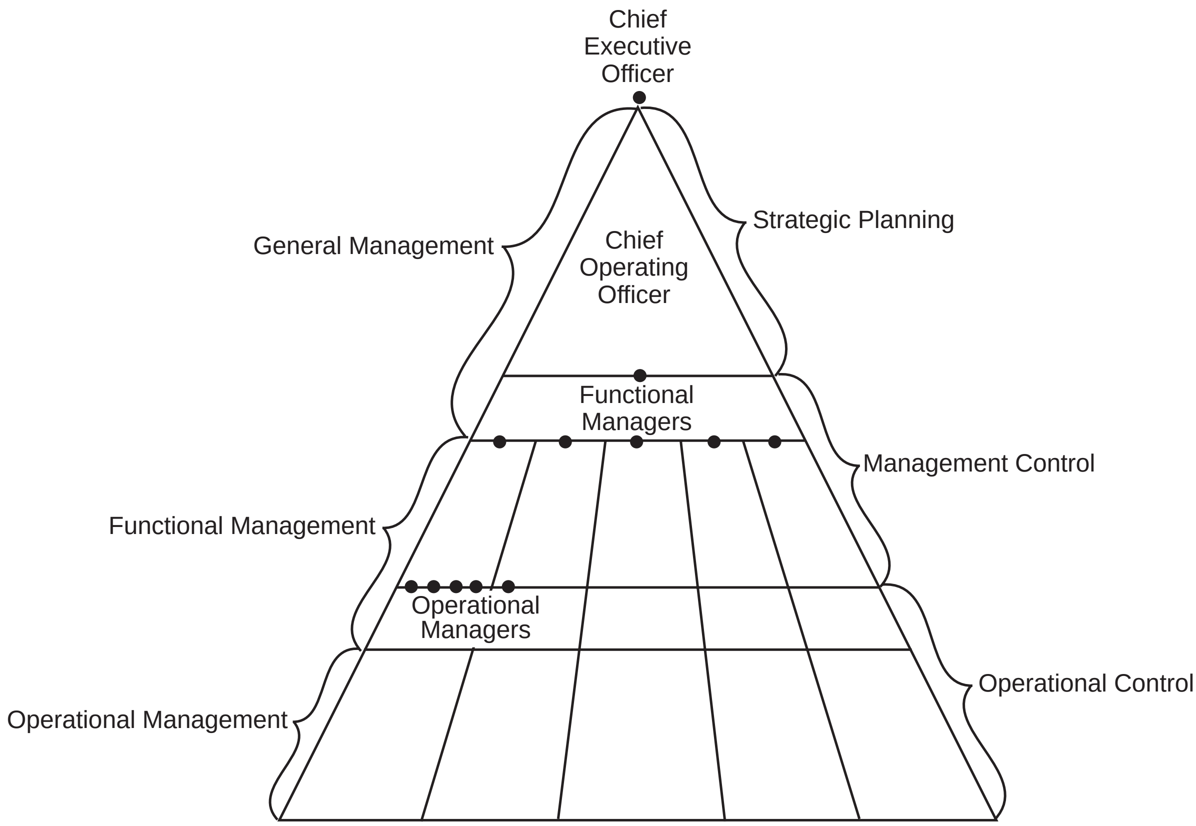

Figure 1.4.5.4.2. *The classical illustration for organizational levels implies endeavor corresponds one-on-one with organizational levels. Not! (taken from Zachman)*

1.4.5.4.3. A Detailed Description of Endeavors

The four endeavors help us figure out what contribution we're making to problem solving and what management tools we need to help make our contribution.

Clerical endeavor decisions are structured, automatable. Information to support clerical decisions is primitive (straight-forward comparisons with a simple static, well-defined reference). The decisions we make in doing the other endeavors are more and more complex combinations of the automatable decisions as we go up the hierarchy. The complexity of the combinations requires intuition and judgment to deal with them. The complexity and type of combinations of automatable decisions distinguish among the upper endeavors. Information to support upper decisions is more sophisticated (complex comparisons with many dynamic, ill-defined references). As we go up the endeavors, the automatable decisions fit into complex combinations, with some left over. That's why strategic-level managers have some clerical endeavors to do. Those particular ones haven't been assembled into operational, tactical, or strategic combinations or haven't been delegated. Two objectives of supervisors are 1) to delegate endeavors down organizational levels and 2) to intuitively combine automatable decisions and/or endeavors to make higher-level endeavors.

No research has defined and operationalized the endeavors to the degree that we can measure them and thereby study who does what and why and what information and tools they need to do it with. So we can study information and tools in the upcoming modules, I've developed working definitions of the endeavors. As we research what managers do and what management tools they need to do their work best, we can verify or update these definitions. For now the definitions are assumptions and this module is the reference. I'll now carefully define the endeavors. My recognition of the definitions as working definitions to be verified through study and test also applies to the other frameworks.

I've identified a few functional criteria for the four types of endeavors. I show these criteria in Figure 1.4.5.4.3.

Strategic Endeavors

The strategic endeavor is the most comprehensive complex, and complete (global) with internal and external (to the unit of interest) range. The strategic endeavor consists of global efforts aimed in a general direction using qualitative measures to evaluate the efforts. You set (planning) and meet (executing) goals using policy for guidance. You distinguish types of efforts by different pursuits (the uncertainty framework) and provide relationships among plans, which guide tactical endeavors.

A manager doing a strategic endeavor: 1) chooses the outcomes, opportunities, problems, and thereby the implied tasks to deal with, 2) sets priorities of outcomes and implied tasks based on importance and urgency, 3) uses the organizational environment and the internal and external forces as forcing functions, 4) uses a knowledge of resource availability and requirements for implied tasks as constraints, and 5) interfaces with the time, people (number and type), materials, and other resources required to do implied tasks to see if some outcomes and implied tasks are feasible within resource constraints. In short, managers doing strategic endeavors figure out which problems to solve or which opportunities to take advantage of.

In doing strategic endeavors, you see tasks as names, or ideas, and you consider the implied outcomes of tasks. Your job is to choose needed outcomes to meet policy, culture, etc. and to change policy, if necessary. Peterson (*Improving Academic Planning*, 1980) 1) says strategic planning focuses on an institution's relationship with its large environment (p. 140) and 2) shows the activities of institutional, values, and environmental assessment and master planning (p. 130) as part of strategic planning.

Tactical Endeavors

The tactical endeavor is oriented toward figuring out what inputs (resources) get what outputs (results), looking internally at the organization. The tactical endeavor consists of wide efforts directed toward a tangible result using quantitative measures to evaluate the efforts. You set (planning) and meet (executing) objectives using plans for guidance. You distinguish types of efforts by different activities and provide frameworks among procedures, which guide operational endeavors.

A manager doing a tactical endeavor: 1) chooses the outputs to satisfy the desired outcome, the challenges to meet to take advantage of the appropriate opportunity, and the resources to solve the designated problem, and thereby the implied resources to deal with tasks, 2) sets priorities of time allocation and people and other resource allocation based on outputs (results) needed to meet outcomes and implied tasks to do and based on availability of people, materials, equipment, etc. and time to do tasks, 3) uses the chosen outcomes, organizational goals, and priorities in importance and urgency as forcing functions, 4) uses a knowledge of the steps needed to implement the resources in carrying out implied tasks as constraints, and 5) interfaces with the designs and processes for doing tasks and the procedures for delivering outputs to see if it's feasible to do the job with available resources. In short, managers doing tactical endeavors figure out what resources are needed to solve a given problem or to take advantage of a given opportunity.

In doing tactical endeavors, you see tasks as outcomes and consider the implied outputs, or results, of tasks. Your job is to choose needed outputs to achieve the outcomes and meet plans and to change the plans, if necessary. Peterson 1) says tactical planning focuses on an institution's internal planning issues and 2) shows the activities of program planning, priority setting and resource allocation, and program review as part of tactical planning.

Operational Endeavors

The operational endeavor is oriented toward how to convert inputs to outputs—the transformation processes, their design (planning) and implementation (executing). The operational endeavor consists of limited efforts focused on a fixed outcome and output using restricted methods to accomplish the efforts. You set (planning) and meet (executing) missions using procedures for guidance. You distinguish types of efforts by different tasks and provide the value of instructions, which guide clerical endeavors.

A manager doing an operational endeavor: 1) chooses the path to transform inputs to outputs (resources to result) and thereby the implied steps to deal with tasks, 2) sets priorities and sequence of steps based on efficiency of tasks, 3) uses the knowledge of where we are and where we want to be as forcing functions, 4) uses a knowledge of the work needed to carry out the steps for implied tasks as constraints, and 5) interfaces with the actual effort to do the job to see if the steps and their sequence are feasible. In short, managers doing operational endeavors figure out what steps to take to use the designated resources to solve a given problem or to take advantage of a given opportunity.

In doing operational endeavors, you see tasks as inputs and outputs and consider the implied steps to get the outputs from the inputs. Your job is to choose needed processes, steps, sequences, tools, and methods to get the outputs and to meet procedures and to change the procedures, if necessary. Peterson says operational planning is implementing programs.

Clerical Endeavors

The clerical endeavor is oriented toward how to do the steps and use the tools, looking at each step or instruction individually. The clerical endeavor consists of local efforts constrained to an explicit path using specific steps to accomplish the efforts. You set (planning) and meet (executing) jobs using instructions for guidance. You distinguish types of efforts by different actions and provide yes-no evaluations on the steps, which determine the success of the tasks.

A manager doing a clerical endeavor: 1) chooses to use a tool in a step and decides if the step did what it was supposed to do, 2) monitors and implements priorities in material availability, equipment maintenance, and throughput, 3) uses the knowledge of the steps and their sequence as forcing functions, 4) uses the knowledge of the status of the work as constraints, and 5) interfaces with the materials and machinery to see if the work is going smoothly. In short, managers doing clerical endeavors do the designed steps to use the designated resources to solve a given problem or to take advantage of a given opportunity and figure out whether the work they've done accomplishes the step.

In doing clerical endeavors, you see tasks as steps and you consider the work to do the tasks. Your job is to make on-the-spot adjustments to deliver the service or product within standard operating procedures and to meet design specifications. Peterson doesn't discuss clerical planning.

The Parallel Structure for Researching Endeavors

Note that the long sections describing the endeavors each contain three paragraphs and that the second paragraph has five ideas set off by commas. I've tried to make the thoughts in the paragraphs parallel for the endeavors and to be consistent with Module 1.4.5.4.1.

Each first paragraph contains four thoughts. The second sets of thoughts tie in Figure 1.4.5.4.1., and the third and fourth sets of thoughts tie in the five different categories of tools I'll describe soon. At the end of each discussion on the endeavors, I've referenced Peterson who doesn't say anything about clerical endeavors because he writes about planning. I can write parallel sentences on the endeavors reflecting other literature in addition to planning.

FUNCTIONAL CRITERIA	STRATEGIC ENDEAVORS	TACTICAL ENDEAVORS	OPERATIONAL ENDEAVORS	CLERICAL ENDEAVORS
WHAT THEY DO	Decide What Problems to Solve	Decide What Resources to Use	Decide How to Solve the Problem	Solve the Problem
WHAT THEY MANAGE	Outcomes	Outputs	Transformation Path	Execution of Steps
WHAT IS ACCOMPLISHED	Goals	Objectives	Missions	Jobs
SETS PRIORITIES FOR	Outcomes and Implied Tasks	Allocating Resources	Steps	NONE (They Monitor and Implement Priorities)
TYPES OF EFFORT	Pursuits	Activities	Tasks	Actions
FORMULATION TOOL OR GUIDANCE	Policies	Plans	Procedures	Instructions
EVALUATION OF FORMULATION TOOL	Relationships of Plans	Frameworks for Procedures	Value of Instruction	Yes/No on Steps
FORCING FUNCTIONS	Internal and External Organization Environment	Chosen Outcomes, Goals, and Implied Tasks	Objectives and Resource Allocation	Steps and Their Sequence
INTERFACES	Time, People, Materials, and Other Resources	Decisions, Procedures, and Processes	Effort to Do Job	Materials and Machinery
CONSTRAINTS	Resource Availability and Requirements	Steps Needed to Allocate Resources	Work Needed to Carry Out Steps	Status of the Work

Figure 1.4.5.4.3. *The four types of endeavors help us find the right problem and solve it.*

1. Background

1.4. Theory

1.4.5. Frameworks

1.4.5.5. The Framework of Decisions

1.4.5.5.1. Characterizing the Domain by Decisions

The amount of information versus the amount of intuition, experience, and judgment you use in your decision determines what kind of decision you're making and what kind of decision support you need.

Which Decisions Are Based on Definite Procedures?

As managers, we all must make decisions; and these decisions should result in actions that affect what is managed. For different domains of responsibility, different types of decisions predominate. These types are classified in Figure 1.4.5.5.1.

Originally, H. A. Simon distinguished two polar types of decisions: programmed decisions and unprogrammed decisions—those decisions made based on a definite procedure and those decisions for which there are no specific procedures. Gorry and Scott Morton used "the terms structured and unstructured for programmed and unprogrammed because [the new words] imply less dependence on the computer and more dependence on the basic character of the problem-solving activity in question."

In the structured situation, all of Simon's phases of the decision-making process—intelligence, design, and choice—can be automated. In the unstructured situation, the human decision-maker must provide judgment, intuition, and insights into the decision. Gorry and Scott Morton added a semi-structured classification for those decisions just below unstructured decisions but not yet structured decisions. As our ability to automate improves, the semi-structured decisions will become structured. I've adapted the three classifications as follows.

Structured Decisions

A structured decision is one that can be arrived at by routine analytical procedures. The structured decision is easily susceptible to automation; or, in the case of a non-computerized information system, the structured decision can confidently be left to people who follow clearly established instructions. Typical examples include inventory management, manufacturing control, and some forms of financial analysis.

Semi-structured Decisions

Decisions involving information and requiring management judgment (i.e., some people-input needed) are semi-structured and can be supported by management information systems. Semi-structured decisions involve tasks such as tactical and financial planning, budgeting, forecasting, and project evaluation. The techniques that apply to semi-structured decision making include financial modeling, risk analysis, statistical analysis and simulation.

Unstructured Decisions

Decisions involving judgment alone are known as unstructured decisions (i.e., only people input) and exceed the powers of current management information systems. An unstructured decision requires human judgment and intuition; it cannot be programmed because the decision is highly non-routine and cannot depend on any firm basis of established knowledge or rules. Unstructured decisions normally involve tasks such as strategic and long range planning. Artificial intelligence and perhaps porpoises aside, the only proven judgmental source is the human being.

Management Tools Ultimately Support Decisions.

Historically, the biggest problem with the management information system concept has been the application of a structured-decision approach to cases where judgment is necessary.

Your decisions will range over a spectrum from structured to unstructured. The management tools that will work best are those that make decisions for structured situations and support your decisions for semi-structured and unstructured situations.

The framework for decisions has enormous and practical consequences in light of the Management System Model. The mix of decision types regularly required within a domain of responsibility for a given pursuit or endeavor indicates the parts of that domain to be delegated to various subordinates and to machines to effectively accomplish the manager's needs. In other words, these frameworks help answer the question, "Who decides what, and with what kind of information?" The idea is to free as much managerial time as possible for the making of the least-structured decisions. In short, a manager's responsibility is to accomplish his or her objectives in what Frederick Taylor called the "one best way," by configuring the people (who manages), the information tools (what is used to manage), and the interface between people and tools so 1) every element of the domain works efficiently in his, her, and its sub-responsibility, and 2) all work together effectively as a system.

Even for types of decisions, the unstructuredness dimension represents a continuous variable. The division into three discrete ranges of decisions is arbitrary but convenient. When we learn about a given decision and move the decision from unstructured to semi-structured, there's no point where we know we've moved from one type to the other.

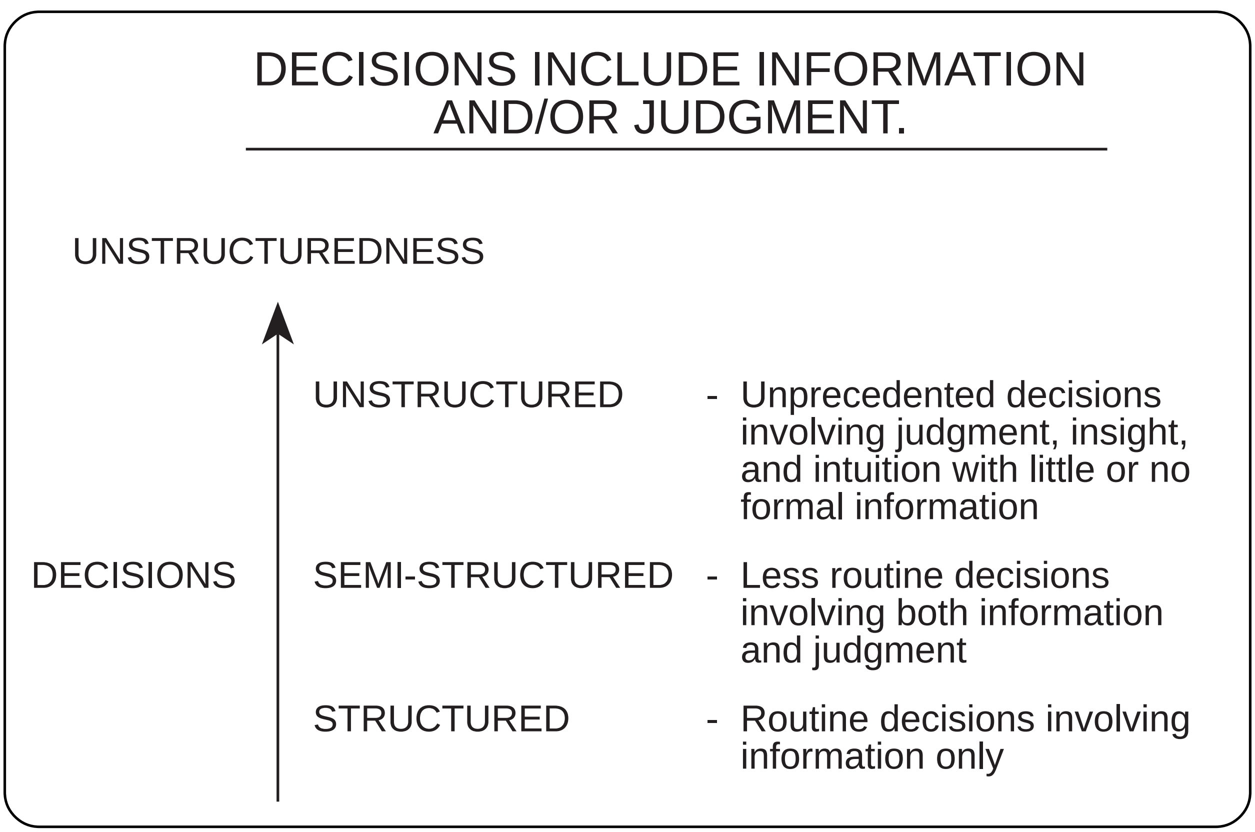

Figure 1.4.5.5.1. *You need different information from different management tools to support the different decisions you make.*

1.4.5.5.2. The Framework of Gorry and Scott Morton.

1.4.5.5.3. The Evolution from Unstructured to Structured Decisions Based on Better Information

Yesterday's human expert becomes today's expert system, which is destined to become tomorrow's automation. That's because expert systems help managers move from unstructured to structured decisions. The expert system is the management tool that helps the manager make semi-structured decisions.

I'll show how we can diagnose what management tools are needed by describing a situation involving at least two of the frameworks—the framework for decisions in terms of unstructuredness and the framework for stages in terms of maturity. This situation involves conditions in plants making cigarettes in the 1970's. By diagnosing the situation as moving from making unstructured decisions through semi-structured decisions on the way toward structured decisions, we realize that expert systems is a type of methods tool that helps the manager at the time he or she needs to make semi-structured decisions.

My description of the situation shows the relationship of the expert system, a management tool in the methods category, to semi-structured decisions in our attempt to move from visibility to control in the front part of the cigarette factory. I'll describe the characteristics of the methods category of management tools and of expert systems as an example tool of the methods category in Module 1.5.1.3.4. In this discussion, I'll reinforce the notion that the expert system, as a management tool, converts data to information as opposed to being a computer-related thing in which some expert systems are housed.

I choose to believe that the automation line in the local plant evolved through a stage of semi-structuredness requiring the help of an expert system. Forsyth (Richard Forsyth, *Expert Systems: Principles and Case Studies*, Chapman and Hall, Ltd., 1984, p. 7.) says, "[an expert system].... actually works. It does a job that takes a human years of training." I note the word "training" instead of "education" and think of all the jobs that have been automated that took years of training to learn in years past. The expert system and then the automation system support the "who manages" in a very limited, well-defined management system.

Describing automation is as difficult as describing an expert system. Remember the following definitions of automation so you can compare automation to the definition of an expert system. "A scientific definition of the place of automation in the development of technology can not refrain from taking into account, on the one hand, the inseparable bond connecting automation with the entire history of the gradual strengthening and extension of the power of man over the forces of nature, and on the other, the qualitatively novel features which distinguish automation from the preceding stages of technological development. .... Therefore, the conversion to automation completes the liberation of man from the immediate participation in the industrial process and changes abruptly the entire character of human labor. Up to now, the machine replaced the hands and the muscles of man; at present, it begins to replace, within certain limits, his brain and nervous system." (Jan Averham, *Automation and Society*, Moscow, USSR, 1960, U.S. Joint Publications Research Service, Washington, DC, July 1961, p. 2.) James Bright indicates that some authors equate automation with "decision-making machinery." (James R. Bright, *Automation and Management*, Division of Research, Graduate School of Business Administration, Harvard University, Boston, 1958, p. 4.) He emphasizes that

"Automation has a way of shifting with time. Yesterday's 'automated' plant is surpassed today, but how else except by something 'more automatic'?" (p. 7.) Bright suggests this definition: "....automation simply means something significantly more automatic than previously existed in that plant, industry, or location." (p. 6.)

Simply stated an expert system 1) captures an expert's facts and rules, 2) applies the facts and rules to a limited domain of responsibility, 3) leads the user toward intelligent advice or solution about that domain, and 4) is able to replicate the line of reasoning from which the advice or solution evolved.

At one time, even today's best defined, most routine, and very likely highly-automated domain of responsibility needed an expert to manage it. By expert, I mean someone with years of training who has made intelligent decisions based on facts and inferences related to their limited domain. By following the same facts and inferences, the expert would repeat the same decisions. We couldn't immediately replicate the expert because we couldn't quantify and measure the expert's experience, judgment, and insight. We considered the decisions of the expert largely unstructured, or non-programmable, or at least semi-structured.

I have many times experienced a sequence of events in replicating an expert, and will share one such experience for illustration. In the leading part of a cigarette factory, the tobacco is moistened, dried, and blended to just the right consistency for compaction. In the following part of the factory, the infinite cigarette rod is compacted and cut into proper lengths. In this leading part, an old man of many years experience would sift the tobacco blend through his fingers close to his face and decide if the tobacco was ready for compaction in a cigarette rod. See the old man in Figure 1.4.5.5.3. Is he tasting the tobacco? Looking at it? Feeling it? Smelling it? The old man couldn't tell you what he did; but, he did it everyday. He was making unstructured decisions because the variables were undefined, and he couldn't identify any information as the basis for his decisions.

When the old man said the blend was right, the blend was right. He intuitively knew what he was doing. But he couldn't tell you what he detected or the rules he used to determine if the tobacco was ready to go to the maker floor. A key question in all this was how to train someone to take the old man's place when he retires.

The tobacco company would hire someone new to work with and learn from the old man. The new person would follow behind and sift the tobacco close to his face. The younger person would guess whether the tobacco was ready. He or she was usually wrong. The younger person would guess, "It's ready." "Nope," the expert would say. The younger person would keep on trying through many "nopes" and "yeps" until one day there were almost all "yeps." After years of being corrected by the old man, the younger person could replicate what the expert did. But he or she didn't know how he or she did it. The younger person had replaced the old man, both in ability and mystery. (In the old days, many recipes were handed down through families this way.) The younger person had picked up the judgment, intuition, and experience to do the job. How in the world could you develop an expert system to replicate the old man?

With much data logging, many wrong guesses, and studying cause-and-effect relationships among variables (gaining visibility), we found the old man was measuring moisture history of the blend. He was recognizing when moisture should be added and removed at various times during the blending process.

We couldn't depend on finding younger people to be mentored by and learn from the old man. So, we developed an expert system to contain the facts and inferences of the expert. To replicate that expert, we used sensors and computers, consistently reported variables (indicator data), and compared them to reference points for decision making. We made an expert system. Then we used the reported information to make repeatable decisions, to control actuators, and to debug and maintain the process by repeating the facts and inferences leading to decisions. The expert system could not only *report* things based on the expert's knowledge, but could *do* things based on the expert's knowledge. We automated the whole thing and have progressed to the point where what we once considered expert is now only automation. The decisions are now all structured, or programmable.

Whether we have an expert system or automation depends on where we stand in perspective and maturity. Gorry and Scott Morton point out that perspective and maturity affect whether a decision is unstructured, semi-structured, or structured. They realized decisions would evolve from unstructured toward structured as the facts and inferences used by the decision maker were defined and structured. So will go expert systems. As the expert's facts and inferences became known and replaced intuition and experience, we produced an expert system.

The old man in the cigarette factory saw his domain of responsibility evolve from where he just maintained visibility of his operation. Now, through measurement and understanding, we not only have controlled but optimized the old man's expertise; we call this computer optimization, or automation. The expert system led to automation. In any new problem, it starts out fuzzy, but when we understand it—turns intuition into information, facts, and inference rules—becomes simple and clean.

From the system perspective, the leading part of the cigarette factory is a relatively- closed system which, together with the rest of the factory, forms a larger, relatively-open system with many complex social, economic, and legal implications of the world outside the factory. From the systems approach, we see each domain as part of a larger domain. Therefore, the automation of a simple domain shifts our attention to a larger, less-defined domain with more unstructured decisions and another opportunity for expert systems.

Which expert shall we replicate for the management expert system, for example? Whose bias do we want? The one that best fits the software/hardware package? The one with the best defined line of logic? The one whose premises we like the most? Anthony Stevens asks, "Does anyone these days admire anyone who can dig a hole or paint a car quickly? We shall soon feel the same dullness about brain work." (Richard Forsyth, *Expert Systems: Principles and Case Studies*, Chapman and Hall, Ltd., 1984, p. 39.) Is there no brainwork in painting a car? Have you tried it? How about determining if the blended tobacco is ready to go to the compaction process in a cigarette factory? For years, we couldn't figure out what the worker who decided the right blend was doing or measuring. Nevertheless, the process is now automated.

Are we talking about "professional expertise" here or just "expertise?" We have automated much of what people were trained to do and what people were trained to report. Expert systems are focusing on what people are trained to advise: law, medicine, and accounting. They are moving from blue-collar to white-collar activities. We'll still have these counselors, because we pay most for their judgment and insight—and also their experience (a characteristic future expert systems are supposed to accomplish through learning). In my opinion, in regard to judgment, above the advisors are the teachers, leaders, and perhaps the clairvoyants. To learn from teachers, leaders, and clairvoyants, we must first develop a global scheme to ask questions to represent, if not capture, their intuition and judgment in a structured package. The bottom line: experts are specialists—they know more and more about less and less—and leaders are generalists—they know less and less about more and more. The connections among all the specialties are what stumps our thinking and the future expert systems.

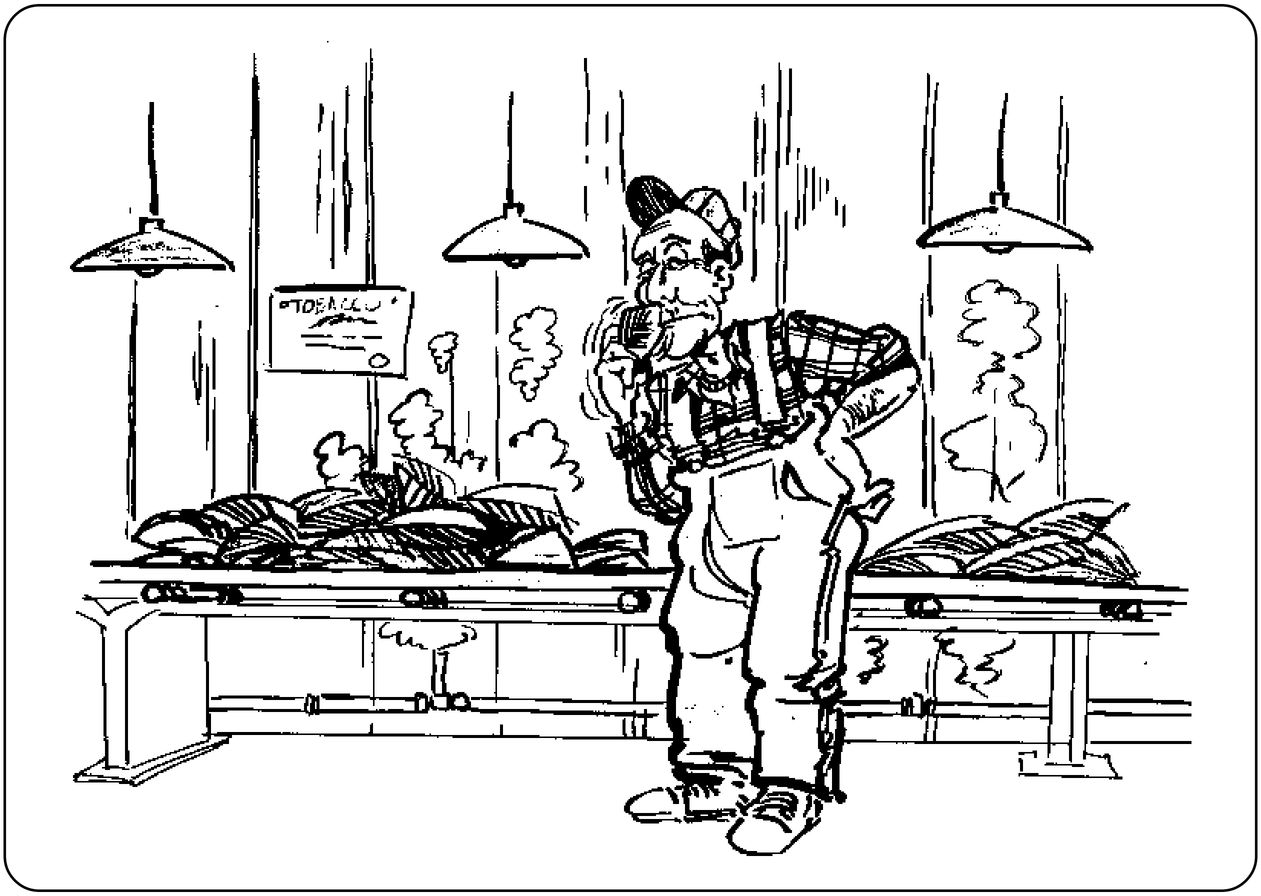

Figure 1.4.5.5.3. *"Yep, it's ready. I feel it in my bones."*

1. Background

1.4. Theory

1.4.5. Frameworks

1.4.5.6. The Maturity Framework

1.4.5.6.1. Characterizing the Domain by Maturity

You can't improve or optimize a system until you have visibility and control.

Your Management System Matures through Three Sequential Stages.
The fourth framework deals with the maturity of your management system. Figure 1.4.5.6.1. illustrates the three stages. Your management system, your operation, and your management tools must mature sequentially through these stages. To try to skip a stage is to fail. The internal driving force for maturity is who manages and requires the three essential components of the MSM be in balance for a preceding stage before the succeeding stage can be successful.

For a successful management system, the components of the MSM must be in balance. We essentially have an impedance matching problem, which we will someday model mathematically to observe cause-and-effect relationships and conduct sensitivity analyses.

If the information from an information system is accurate and timely but too sophisticated for the decision maker, the elements are not in balance and the management system fails. The interfaces keep the components in balance.

When the components are in balance, the manager is happy and successful. Then, he wants more. Then the manager's manager wants more. This series of demands induces a dynamic, always-maturing system.

We can define the stages through which managers mature with a successful management system. Managers first gain visibility of their physical operation. They learn how to control their domain by being able to reduce the number of changes that occur and hold the operation constant. Finally, they optimize their domain to get the most out of the operation that they can. A management system matures through the stages of visibility, control, and optimization.

Visibility
Visibility is gained by effective presentation of key information based on complete, comprehensive, coordinated, accurate, and timely data. Key information varies throughout the life of an organization. Without effective visibility, management action is not completely informed.

All elements of the system must be monitored and assessed to judge the critical elements in cause-and-effect relationships. In a manufacturing plant, we data-log.

Often, a few parameters are indicators of the throughput of the system. In making bottles, the temperature history in the furnace indicates the quality and amount of material that flows from the forehearth. Once monitored, these parameters are related to the elements to be controlled to stabilize the system. Then, in bottle-making, only the temperature of the furnace and the mix of the batch may be the important control parameters.

Visibility is the first stage in the approach required for effective management. Visibility leads to control which, in turn, leads to optimization. Those of you with very uncertain pursuits typically aren't in balance because you lack visibility.

Control
An operation is stable when it can be held to steady-state and decisions don't have to be made based on variations outside unpredictable limits. Even if the throughput is held within control limits—not at the best throughput experienced—the stability provides im-

proved performance. In bottle-making, if the fraction of molten glass gobs which comes from the forehearth and becomes bottles packed for shipment remains stable at a relatively low fraction of four-fifths, performance is improved.

Managerial control depends upon visibility and is based upon managerial planning. Managerial control is the monitoring and measuring of performance of the operation for comparison with pre-established plans and standards. Control means taking corrective action if performance deviates too far from plans and standards and, thus, integrates activities by keeping them all within established bounds.

When I worked for Citibank they had just acquired majority interest in a small midwestern management consulting firm. In they moved with their "control book," a loose-leaf binder in which they daily updated all operating, personnel, financial, logistical, and production data. They spent as much as half their time measuring what they did with the rest of their time. After a while they saw what was needed and moved to set things right. I claim their book was really a "visibility book." After they logged all possible data to observe cause-and-effect relationships, they used the key relationships to act and stabilize and then improve the operation. Of course, with the key relationships in hand, much less time and effort is needed to measure and control the important parameters.

Only after visibility can the manager move to control—the "prescription" stage in which he or she keeps the system on track through direction and correction. Finally, the manager optimizes the system to get the most possible out of the pursuit.

Optimization

Optimization is the accomplishment of maximum effectiveness, efficiency, and/or usefulness. Optimization is accomplished by varying plans and standards as a result of experience and controlling to the new plans and standards .

Obviously, a system can't be controlled without visibility; and optimization requires control.

Scott Sink describes the steps to productivity as measurement, evaluation, control, and improvement. ("You can't manage what you can't evaluate and you can't evaluate what you can't measure.") The parallel between Sink's steps to productivity and the maturity stages is clear, for measurement and evaluation together are equivalent to visibility. "Lord Kelvin said we do not really understand until we can measure. But before we measure, we should name the quantity, select a scale of measurement, and in the interests of efficiency we should have a reason for wanting to know." (Forrester, page 59.)

I find that data reflect the same maturity stages. Data can be kept current to yield status or used with historical data to generate forecasts. This kind of data represents the visibility stage. If management input is part of the database in the form of reference points, goals, strategies, and priorities, we can obtain plans. Including planning data, the database reflects the control stage. Note that we often have trouble writing plans because our data haven't matured to the point where they support plans. To determine variations and exceptions, measurement and evaluation criteria are needed in the form of data. These data, together with the others just described, constitute the optimization stage.

However, in general, we're frustrated with our plans because we can't really write them and can't really use them. When our data have matured to the control level, planning should be easy.

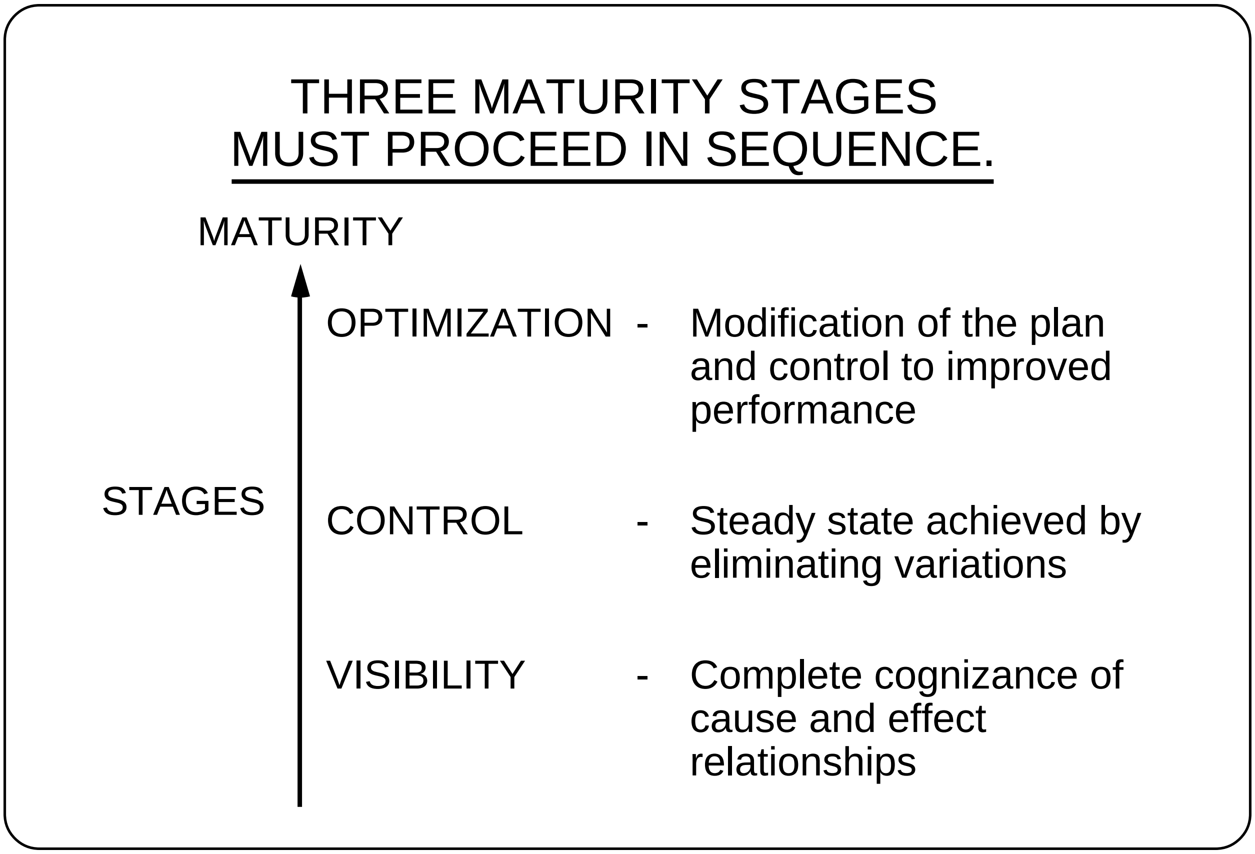

Figure 1.4.5.6.1. *Your management system, your operation, and your management tools must mature sequentially through three stages. To try to skip a stage is to fail.*

1.4.5.6.2. ORIGINS OF THE MATURITY FRAMEWORK

1.4.5.7. Considering the Frameworks Together

Taken together, the frameworks for characterizing your domain give you a sense for what management tools will fit you and your operation.

My favorite example of how a person usually deals with management tools is choosing a tool for time management. In my lifetime, I've unsuccessfully tried dozens of different tools for helping me manage myself over time. Something will happen that highlights the fact that I'm out of control with respect to time. I'll go to the office supply store and browse through their shelves of calendars, reminders, priority planners, and other such tools. I've been known to respond to one of the many ads in the airline magazines for a corinthian leather-bound executive-style holder for slightly-adapted 3"x5" cards for identifying and sorting my tasks to set or change priorities and schedule my work. I've even tried a computer package or two for scheduling.

I usually choose either a tool that's totally different from the one that most recently failed me or a tool that's similar to the one my friend said the other day that he or she is most recently excited about. I take the time to setup the tool to apply to me and my domain of responsibility. The tool starts to live up to its advertising.

Then a crisis hits. I have too many things to do in too short a time. The urgent starts dominating the important. Now my new tool can show its stuff and keep me straight in getting through my time and priority crunch. Right? Wrong! The tool falls by the wayside. I don't have time to diddle with the thing. I have work to do and I'm getting farther behind every minute. Not to fear. Before long my problems will be overcome by events and I'll get time to breathe again. Remembering the pain, I'll resolve to fix the situation and when next at the office supply store or reading the airline magazine I'll try another tool. I'll start the entire sequence again. Since I can find hundreds of versions of time management tools, I won't run out of opportunities to fail again.

I'm old enough where through dumb luck I've worked out some tools and associated guides that work for me. Clearly, I've found the answer. I think that since other younger people are going through the pain of my younger years, I can make a contribution and get rich at the same time by manufacturing and selling the solution I've found. Now, what I'll do is put the latest version of a time management tool in the shelves for someone to try at random when they're searching through the office supply store.

My story exemplifies the issue of fit. How do we find the tool (what is used to manage) to fit both the user (who manages) and the user's work process (what is managed)? Not any tool at random will work. There has to be a better way than dumb luck. Don't depend on the computer salesperson with a dollar to make. Don't depend on the specialist with a stock answer searching for an application.

I believe the answer is that we have to be able to characterize our domain of responsibility in terms of dimensions that lead us toward an existing or new tool that will fit the domain and meet its needs. We can try information-related dimensions like uncertainty (ratio of information needed to information processed). We can try endeavor-related dimensions to distinguish among the things we do. We can try other dimensions related to the operation, the decision maker, the management tools and their process for converting data to information, and the status (such as maturity) and progress of our efforts to manage our domain. I've described four frameworks to provide a guide or aid for you to characterize your domain and to choose the tool you need. You can choose the tool you need either deductively or inductively. These frameworks work best at reducing the pool of alternatives by showing groups of tools you *don't* want. This way of approaching the decision is called strong inference. (John R. Platt, "Strong Inference," *Fundamental Considerations in Organizational Research*, Science, 1964, 146, 347-353.) The idea is that you'll get to the answer faster by reducing feasible alternatives than by trying to identify the single best answer.

I show the four frameworks together in Figure 1.4.5.7. Taken together, the frameworks look at the organization, not just the decision maker or the operation. I've not determined a firm linkage among the frameworks as the figure might suggest. However, some frameworks clearly are affected by the same issues in the organization.

Individually, the purpose of the frameworks is to characterize the organization in standard ways; for example, we can transfer, or generalize, what we know about perplexities from one domain to another. Collectively, the purpose of the frameworks is to guide the manager or the management tool builder more to eliminate the tools that don't work than to find the perfect tool. An example of the elimination is saying CPM won't work for perplexities.

Collectively, the frameworks also help you search for the meaning behind the tools that do work. For example, CPM works for projects, the meaning behind CPM is bottlenecks, and people responsible for perplexities have bottlenecks too. If we can strip away the constraints on bottlenecks (e.g., We must define the end.) as applied to projects through CPM, we can then apply different constraints to bottlenecks to design a tool to help people manage perplexities.

How many frameworks are enough? I've shown four frameworks in Figure 1.4.5.7. I've shown a framework for what managers do in relation to endeavors in Figure 1.3.1. I've also shown the ABC model as a way of characterizing what a manager does. We can address a couple of questions about how the ABC model relates to the effort of finding the management tools that fit your domain. Does the ABC model help you choose tools? Do A, B, and C activities relate to the pursuits? Are the activities related to the maturity framework? Do you use visibility tools for C, control tools for A, and optimization tools for B? Is the Macintosh and Daft model another framework we can use to help choose management tools? I discussed that model in Module 1.4.2.6.2. How many other frameworks are out there that we can use to find the tools we need?

When you characterize a person (who manages) for cognitive style, for example, you can use a number of dimensions. MBTI uses four dimensions. To use what you learn from the four dimensions of MBTI, you have to holistically view the person in terms of their experience, capability, and education as well as personality type. That's why you'd see my wife as the person who can do extrovert tasks better than I can and at the same time respect the energy required for her to do that task so well and how the expenditure of energy affects her and her relationship with you. Now, you're holistically integrating experience, capability and the four dimensions of MBTI as measures of cognitive style.

You want to be able to characterize the organization much like you characterize a person. In my discussion of the vision for this book in Module 1.1.13. I emphasized my desire to develop instruments to characterize organizations so we can apply the engineering process to the management process.

Scholars discussed conceptual frameworks like those shown in Figure 1.4.5.7. during the 1960's and early 1970's. Conceptual frameworks represent attempts to more clearly and completely structure our domain of responsibility. In the 1980's and early 1990's, the conceptual frameworks were abandoned after the progress of the 1960's and 1970's to concentrate on managerial frameworks.

Henry Lucas is a scholar of conceptual frameworks. He says, "We've shifted from conceptual to managerial frameworks. We now are into Hersey and Blanchard's how do you do it rather than what it is. We're now more practical than theoretical. The conceptual frameworks give us the big picture; now we use managerial frameworks to figure out how to do it." (*Personal Communication*, Henry Lucas).

The fact that our tools still aren't working for us tells me we haven't yet successfully evolved our conceptual frameworks. In many cases, the managerial frameworks are telling us how to do the wrong things well. We're coming up with elegant solutions to the wrong problem. Of course, the answer is balance. Deming implores us to develop a foundation of theory and profound knowledge; then we can answer the question, "By what method?" So, our progression is from conceptual frameworks (what it is) to managerial frameworks (how to do it) to results (what we got). Many people today are looking at and acting on results (what we got) without any understanding of the theory (what it is) and without relating to and acting on the process (how to do it).

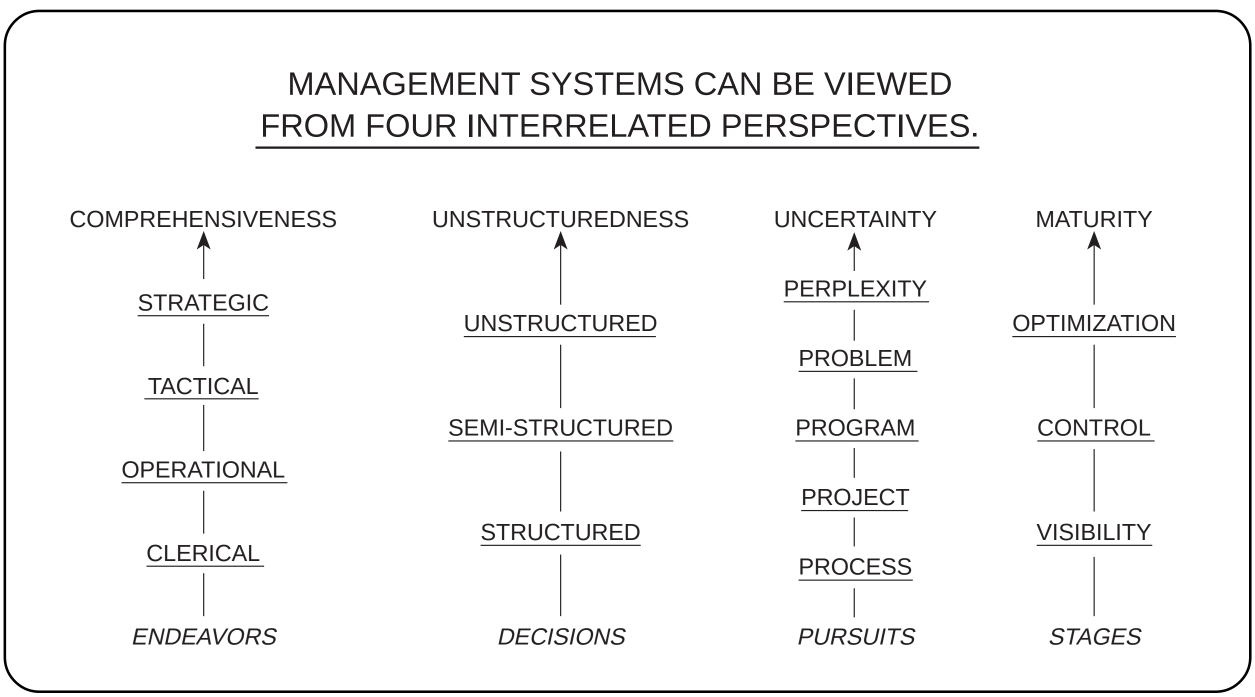

Figure 1.4.5.7. *Whereas we can interrelate four frameworks holistically, the four together may not show the complete picture or provide firm linkages among frameworks.*

1.4.5.8. Exercise on Developing a Spectrum for One of the Frameworks Characterizing Your Domain

Based on analyzing your domain for one of the frameworks for characterizing your domain, you can develop a spectrum representing the distribution of effort you spend against the categories of the framework.

Explanation
Each of us have several subdomains in our set of responsibilities. Choosing one of your subdomains for analyzing the domain against one or more of the frameworks is easier than analyzing everything you're responsible for. You have subdomains for your work, school, family, personal life, community service, professional service, and other sets of responsibilities.

You can evaluate your subdomain against any number of frameworks. I've emphasized four frameworks in this section of the book, including endeavors, decisions, pursuits, and stages. I've recalled a few others in Module 1.4.5.7., including the ABC Audit. Whereas, the frameworks aren't totally independent, I suggest you evaluate your subdomain against one framework at a time and then try to integrate what you learn.

Within each of your subdomains you do things you can classify against each of the categories for any of the frameworks. In the example below, I've listed a few activities a college student might do for each category for the pursuits framework as applied to his or her personal subdomain (as opposed to subdomains for school or community service, for example). You'll notice that being a student, two activities in the example relate to school. They are what to do after graduation and changing majors. I show them in the personal subdomain because they each have far-reaching effects on the who manages' personal life.

Your subdomains are each systems within the larger system of your domain of responsibility. Evaluating your subdomain by frameworks and dividing the frameworks into categories is an analysis activity. You should try to keep the aim of the domain and the subdomain in mind as you analyze them. You'll want to view your subdomain holistically too, but I don't know a structured approach for doing that. Be careful of over-weighting what you discover analytically to be more important than what you feel holistically just because your analysis is more structured and tangible.

Example
Consider activities of the personal subdomain categorized by the pursuits framework.
Process: brushing teeth, paying bills, eating, bathing.
Project: buying a computer, repairing the car, renting an apartment, choosing a job.
Program: what to do after graduation, what to do now that the dog ate your homework.
Problem: changing majors, ending a relationship.
Perplexity: health status (disease, accident), financial security (loss of job, stock market crash), status of a relationship.

Exercise
Choose one of your subdomains. You'll need to delimit, or scope, the domain both for yourself so you can analyze the domain and for your audience so they know what you're dealing with. Write a 50-word (or less) paragraph to describe the domain you're analyzing. Rec-

ognize that you're the who manages for the subdomain you choose.

Choose either the endeavors or the pursuits framework. I want you to use one of the four frameworks that has more than three categories representing its continuous variable.

Make a representative list of things you do in your school, work, service, or personal subdomain. If you choose pursuits for your personal domain list things you do in addition to or instead of the ones I listed in the example.

For the framework you've chosen and based on the list you made, divide 100 points among the categories. Use the 100 points to show emphasis for that category. Even though what you're doing is rather analytical, you can use your gut feeling to help divide the 100 points and allocate them to your categories. Don't give any two categories the same number of points. Make sure your allocations for all of the categories add up to 100.

Write down the decisions you made in dividing the 100 points. Write down the questions you have as you work through the process and make the decisions.

Draw a spectrum for your framework as applied to your subdomain. Write a 25-word (or less) paragraph describing your spectrum. Summarize your 25-word paragraph with a sentence (subject, verb, and object) in ten words or less. Use the short sentence as the title for your spectrum.

If I draw a spectrum for the pursuits in my earlier example, I first need to divide 100 points among the categories. I feel that even though I don't spend a relatively large amount of time on activities like eating in the process category, those activities are important to me. So, I choose 25 points for process. Long ago, I figured out what I want to do after graduation, I have no dog, and I'm not so concerned about other activities I'd classify as a program. So, I choose 5 points for program. Based on the kind of gut feeling for the other activities in my categories, I choose 15 points for project, 20 points for problem, and 35 for perplexity.

In making sure my points total 100, I'm not comfortable with as much as 35 points for perplexity. I'll adjust my points to be: 30 for process, 20 for project, 5 for program, 25 for problem, and 20 for perplexity. Oops; I have two categories with the same number of points. Now, I'll have to choose whether to give more points for project or perplexity. I believe perplexity needs a few more points. My final spread for my spectrum is: 30 for process, 18 for project, 5 for program, 25 for problem, and 22 for perplexity, for a total of 100 points.

My spectrum in Figure 1.4.5.8. shows me that I need management tools at both ends of the spectrum. Knowing how hard it is to find management tools that work for any one purpose, I probably can't find one tool to serve both processes and perplexities. So, I guess I'm in for an expensive tool set. I think I'll start with tools for process first and get that part of my responsibility under control. Then I'll work to see if I can find something that will work for problems and perplexities.

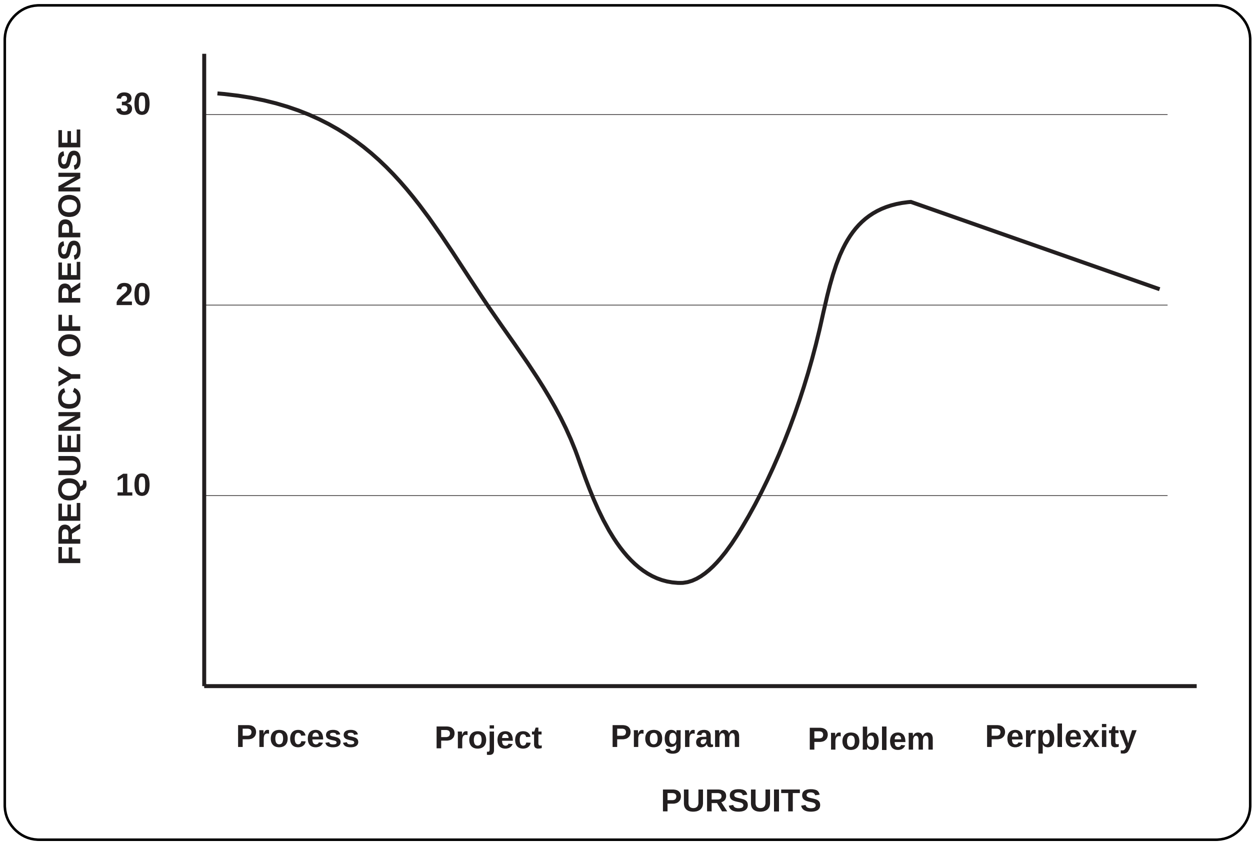

Figure 1.4.5.8. *My pursuits indicate that my largest need for managment tools is for use at both ends of the spectrum.*

1.4.6. The Right Tools Are Like a Melody—Henry Ossawa Tanner

1.4.7. Historical Background

1. Background

1.5. Tools and Skills Categories

1.5.1. Tools

1.5.1.1. You Need the Right Management Tool for the Right Job

A good management tool in the wrong situation will fail. You need to make sure the tools you have fit you and your operation.

If you produce plans that sit on the shelf, maintain data in a milestone tracking or financial management system that doesn't seem to have the right answers, or wonder where expert systems are supposed to help you, you need to organize your tools, identify where each one works, and determine which tools are superfluous and which are missing. The Management System Model (MSM) places your management tools (what is used to manage) into a structured relationship for successfully meeting your goals and objectives in your domain of responsibility. I'll now concentrate on the management tools and how you can make them work for you and with each other. If your tools don't work for you, they'll work against you. If they don't work together synergistically, they'll work at odds with each other.

Many managers, as a hedge on the age of information, develop in-house automation support much like the person in Figure 1.5.1.1. He's one of the guys in the office who bought a home computer and developed expertise in playing computer games. Wanting to extend his capability, he put his home budget and even his bowling scores on his IBM computer using Lotus. After he came to the office and showed off his expertise, management put him in charge of all computer-based automation and/or information systems. The result, of course, is that everything he does uses IBM and Lotus, whether those are the right hardware and software or not.

For identifying, improving, or automating your information needs, you want a specialist who considers a wide range of alternatives and solutions. To help you, an automation specialist, or better yet an information specialist, (or better yet an information generalist), must be an expert in the bottom part of the MSM, including both the measurement/data and the information perception/information portrayal interfaces. One of the guys in the office isn't the kind of specialist you want developing and maintaining the tools that are going to make or break you. He or she should be managing his domain of responsibility and focusing on the decision/action interface in the MSM.

The profundity of the "make or break you" comment is clearer when you consider the relationships, communications, and coordination between domains of responsibility. Your domain is yours and those working for you and your peers have theirs and your boss has his or hers. Being a system means your domain is part of a larger system and has subsystems. All these systems link through the what is used to manage component. Most breakdowns are in communication and coordination within and among management systems. Thus, your information specialist will significantly influence your communication and coordination needs. He or she will influence the situation where most breakdowns occur and will develop and maintain the tools that are going to make or break you.

Typically, specifications for the measurement/data interface (where data is acquired) and the information portrayal/information perception interface (where information is presented) provide the starting point and ending point for management information systems design. Some designers start at the measurement/data interface in the MSM and work clockwise and other designers start at the information portrayal/information perception interface on the MSM and work in the opposite direction. The point is that these interfaces are where you deal with your management tools—where they're interfaced and either do or do not properly reflect what you manage and your preference in management tools. Put the horse before the cart. You concentrate on who manages and what is managed and manage information specialists who concentrate on what is used to manage.

Figure 1.5.1.1. *"I can do for the plant's production what I did for Ted's and Mary's."*

1.5.1.2. Management Tools Should Make Information, Not Hide Information.

Both aggregating and differentiating data make information, but differentiating data usually makes richer information.

The part of the Management System Model the manager knows most about is the most important yet is usually overlooked and neglected. As manager, you should focus on your operation and your interventions to improve your work process. No information specialist will know you, your operation, and your decisions and actions as well as you do. However, you tend to want to focus on the automation specialist's part of the management system because that part is better defined and allows for toys and fads. (Don't we all want to play with toys and fads as we can see in Figure 1.5.1.2.)

When managers want a computer on their desk for status or to play at being an information specialist, they're wasting effort on the wrong things. You want to focus on getting the right information from the information specialist to make the decisions you know most about. Spend your time thinking about what kind of information you need and whether the information is as rich as it can be.

By aggregating, averaging, or summarizing data to deal with the problems of overload, an information system provides bland, sterile inputs to the manager. We lose as much, or more information than we gain through aggregating, averaging, and summarizing. The tendency is to place excessive reliance on the computer, which generally reduces information in simplistic ways (e.g., aggregating it).

In fact, managers need far more sophisticated tools for reducing information; specifically, filtering tools that will systematically and carefully select the relevant facts from the mass of incoming data (e.g., not costs aggregated by quarter, but specific reports showing which costs are above normal and showing the reasons for the increases). The manager also needs help in pattern and trend recognition; he needs tools that will detect changes in streams of incoming data.

The best filters and pattern or trend recognizers are intelligent human beings. Presently, computer programs are not sophisticated enough to filter appropriately the rich array of data currently available to managers.

Before you know what kind of information you need, you must evaluate what you do with or to information. We usually think that we process information directly for decisions, actions, and/or assessments. However, much of what a manager does with information is better characterized as a different process. For example, many of you (especially if you are in a government agency) broker information, in that you receive it from someone else and pass it on to someone else. Especially if your organization is decentralized, you will be apt to be playing a broker role. You can generate information; adjust, update, re-create, or interpret it; manipulate it; or verify it.

I find that for many government offices, 80% of the time is spent on responding to communication brush fires and the budget cycle and 20% is spent on monitoring and managing milestones and program progress and providing overview technical input. Thus, it's more important to automate the 80% than the 20%. Lucky for us, the 80% part is easier. Working on the 80% yields bigger dividends which can be reinvested in the 20%. We find most people want to work on the 20% because it's more exciting—but because of the 80% you never get to take advantage of the advances made on the 20%.

As information flows come into your domain, there should be a use of the information. Information is of value only if someone does something to or for someone as a result of the information. Who does what to or for whom as a result of information? If you don't define what the information is to be used for, you shouldn't commit the resources it takes to obtain and maintain the data from which the information is to be made—or more likely information is not to be made.

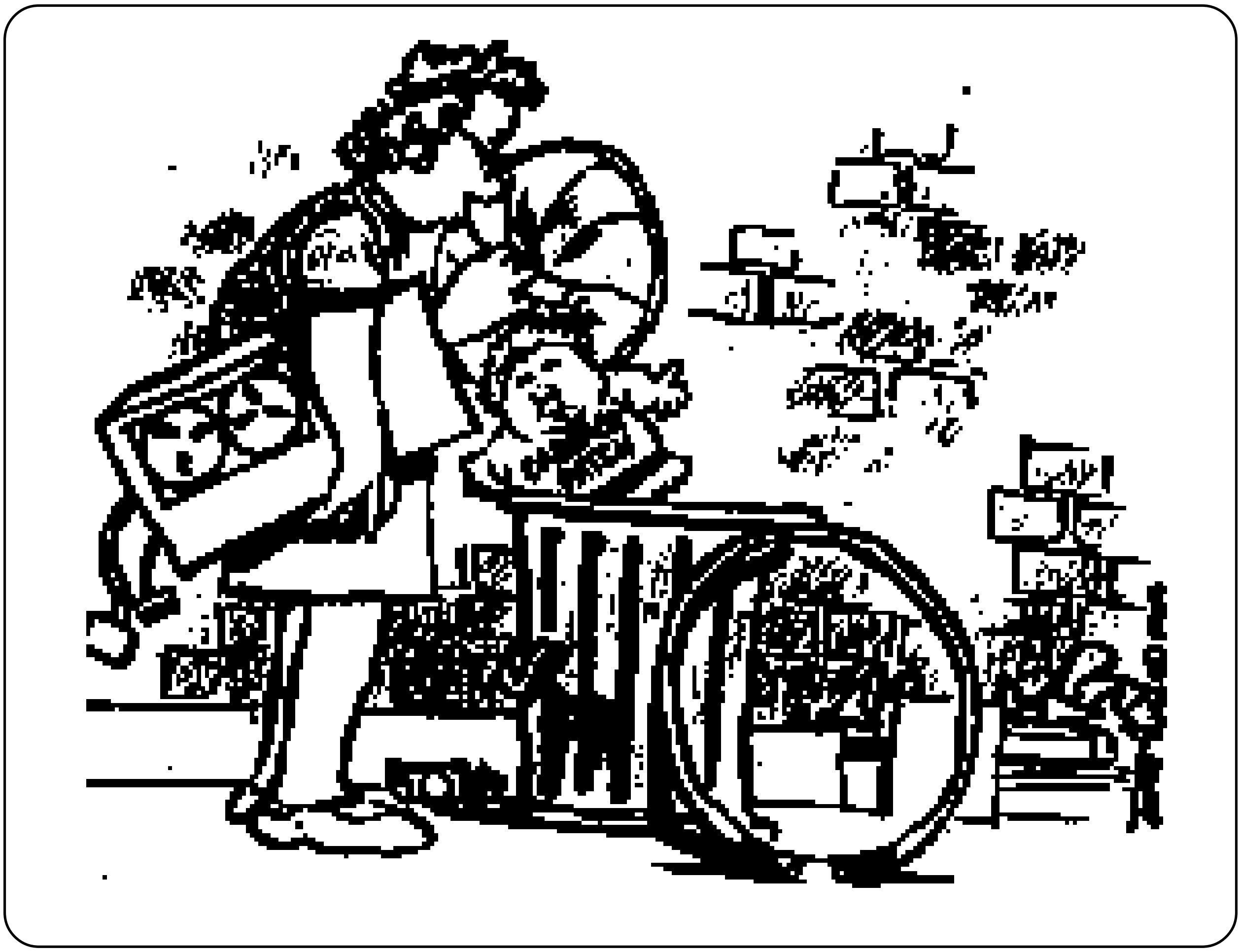

Figure 1.5.1.2. *Toys and fads, even if they're electronic, end up in the trash. That's not what you want to devote your effort to.*

1. BACKGROUND

1.5. TOOLS AND SKILLS CATEGORIES

1.5.1. TOOLS

1.5.1.3. THE MANAGEMENT TOOLS

1.5.1.3.1. You Use Five Groups of Management Tools

1.5.1.3.2. Management Tools Convert Data to Information

1.5.1.3.3. Relationships and Structures Help Link the Elements of our Work, Including Other Management Tools.

We use structures to help keep track of our relationships.

Elements of our work, including people, materials, capital, tasks, decisions, customers, products and services, information, and other elements link both with like elements and with different elements. People link with capital through the organization's pay structure. Capital links with other capital through the organization's chart of accounts. People link with other people through the organization structure. People link with tasks through work definition and job descriptions. Tasks link with other tasks through the work breakdown structure. The linkages are the relationships; and the structures are the tools we use to make sure we have the right relationships. We use structures to make sure we don't have counterproductive gaps and overlaps in our relationships. Both the relationships and the structures that help us organize the relationships convert data to information to support decision making.

We can structure tasks or activities through both a work breakdown structure and a work flow chart. The work flow chart looks like a process diagram shown in Figure 1.1.16.5.3. The work flow chart captures precedence and dependence. The chart shows which task(s) must go before and which task(s) must follow any given task in the work flow. The given task depends on the result of the preceding task and the succeeding tasks depend on the result of the given task. When you work on a task, you need to know whom you're depending on to get your job done and who is depending on you to get their job done.

The work breakdown structure (WBS) looks like the diagram in Figure 1.5.1.3.3. This example of structuring the work needed to build an outhouse was taken from *An Introduction to Project Planning* by Jack Gido (Industrial Press, Inc, 1985, p. 9.). The WBS is defined in the *Goddard Space Flight Center Handbook for Preparation and Implementation of Work Breakdown Structures*, "The WBS is a basic management technique which presents systematically subdivided blocks of work (program, project, contract, etc.) down to the point which represents the lowest level of controlled effort (i.e., the lowest level at which the project office plans to maintain routine surveillance). It is a product-oriented family tree composed of hardware, software, services, and other work tasks. It results from systems engineering and management planning processes and completely defines the program/project. A WBS displays and defines the products to be developed and relates the tasks to be accomplished to each other and to the end product. Blocks of related and consistent work effort form a branch of the structure." (Daniel D. Roman, *Managing Projects: A Systems Approach*, Elsevier, 1986, p. 131.)

You can use a WBS for any pursuit. Obviously, the WBS is better defined for those pursuits for which we know the end and therefore can better distinguish all tasks needed to manage the pursuit. For uncertain pursuits, the tasks in the WBS become assumptions to be adjusted as work on the pursuit progresses. Notice that two of the pursuits—programs and projects—are called out in the Goddard definition. A program has only a qualitative fix for the end, whereas, the process has a well defined end. Therefore, expect the WBS to work well for a process too.

Harold Kerzner specifies the hierarchical levels in the WBS. In his definition of WBS, Kerzner stresses the idea that the WBS helps us cover gaps and overlaps in task identification and responsibility by accounting for every task. “The work breakdown structure acts as a vehicle for breaking the work down into smaller elements, thus providing a greater probability that every major and minor activity will be accounted for. Although a variety of work breakdown structures exist, the most common is the six-level indentured structure shown below:

Level	*Description*
1	Total program
2	Project
3	Task
4	Subtask
5	Work package
6	Level of effort

Level 1 is the total program and is composed of a set of projects. The summation of the activities and costs associated with each project must equal the total program. Each project, however, can be broken down into tasks, where the summation of all tasks equals the summation of all projects, which, in turn, comprises the total program. The reason for this subdivision of effort is simply ease of control. Program management therefore becomes synonymous with the integration of activities, and the project manager acts as the integrator, using the work breakdown structure as the common framework.” (Harold Kerzner, *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, Van Nostrand Reinhold, 1984, pp. 553-554.)

Some structures break things down, others add things up. The WBS breaks the work down into smaller elements. The WBS is analytic, like the diagram in Figure 1.1.16.1.1. A chart of accounts—another structure, which shows relationships among the financial accounts in an organization—tends to add things up. The chart of accounts reflects synthesis like the diagram in Figure 1.1.16.1.2. However, in the chart of accounts, we break accounts down so we can add them up. The work flow diagram also looks like it breaks things down so we can add them up also. However, the work flow diagram is more holistic than just a combination of analysis and synthesis. That’s why Deming would prefer a work flow chart for an organization chart.

The WBS looks like a typical hierarchical organization chart—a structure we’re all more familiar with. The hierarchical organization chart links people through an hierarchy in the organization showing accountability and reporting. We can link people for decision making by using a data flow diagram. For computer specialists, we use the data flow diagram more to link conversion processes in the organization. We can also use the data dictionary to link data and information for decision making.

I do goal-oriented WBS to promote problem solving (making a connected series of related decisions). The goal-oriented WBS links organizational goals and objectives to the organization’s aim. The goal-oriented WBS also links activities and tasks to goals and objectives. In this way, the WBS can be used for any pursuit or for any domain of responsibility containing a spectrum of pursuits.

I’ve mentioned a large number of management tools in the category of relationships and structures. I’ve only described one in some detail—the WBS. You’re familiar with the hierarchical organization chart. I’ll describe the other tools in later modules.

To summarize, we need to link many elements in our domain, including people, tasks and activities, decisions, data and information, financial accounts, products and services, customers, and many more. These relationships guide us in how a decision about one element affects another element. The structures help us account for everything we need to keep track of. I can think of at least five types of functional linkages: 1) precedence, like a flow chart; 2) hierarchy, like the WBS; 3) partition for showing and relating the parts of a whole; 4) holistic relationships, like similar beliefs and aims; and 5) demographic, like similar gender, job description, material requirements and so on.

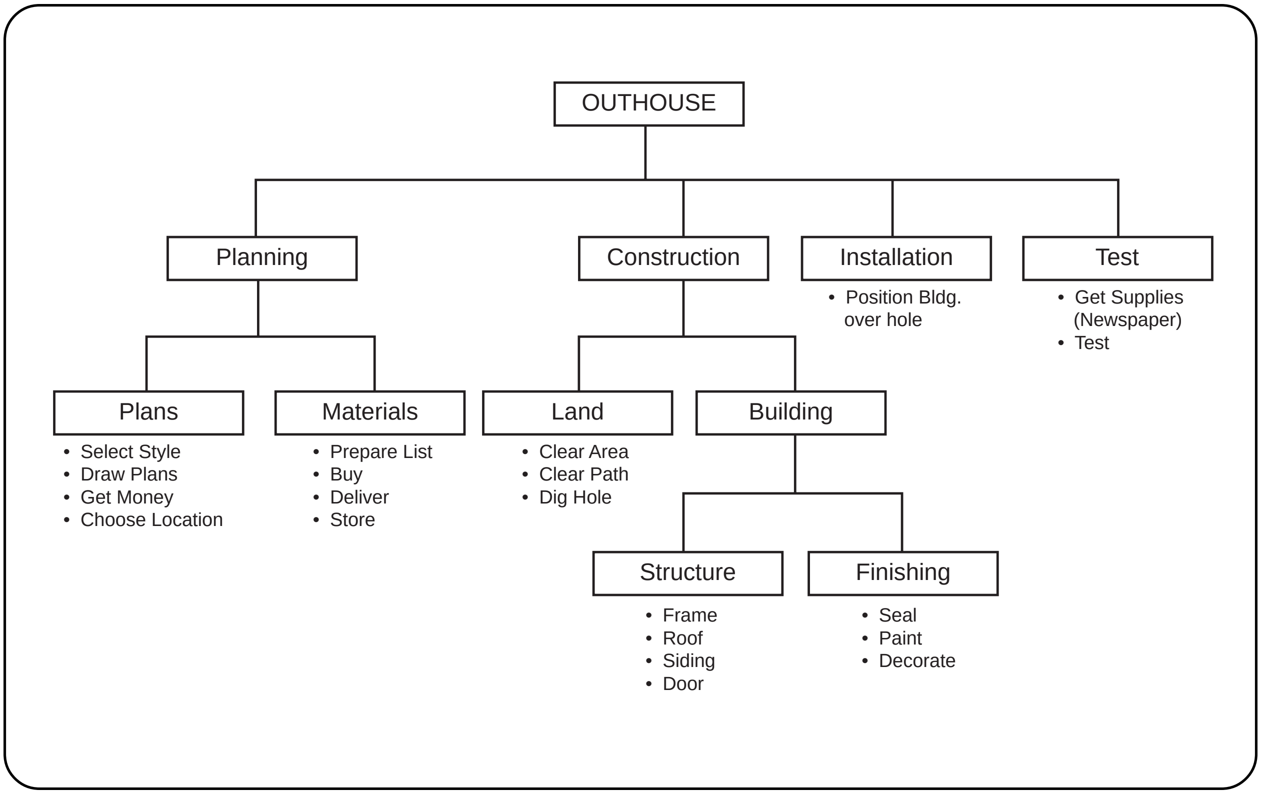

Figure 1.5.1.3.3. *The work breakdown structure is a graphic technique for dividing the project into related tasks. (taken from Jack Gido).*

1.5.1.3.4. Methods Suggest Solutions for the Decision Maker to Consider.

As a method, even the expert system can only develop a solution for consideration by the decision maker.

Whether the method you use to manage is a quantitative model, paperwork, rule of thumb, or expert system, you look to the method for a suggested solution based on the assumptions and limitations inherent in the method. As a manager, you compare your intuitive solutions (based on your mental model) and judgment to the method and either agree with the method's solution, adjust your intuitive solution, or question the method by adjusting constraints or quizzing alternatives.

Operations Research (OR) models are methods tools. An expert system (ES) is another one of the methods tools. I'll describe the expert system as an example of the methods category of management tools. In the management tools classification, an ES is in the methods category and the management information system (MIS) is in the data-to-information chain category. With other tools and other categories of tools, ES and MIS can work together to provide a decision support system (DSS). The manager selects the best combination of management tools from available alternatives to make up a DSS.

I've taken much of what I say in this module from a paper in an international conference comparing expert systems to operations research tools. Operations research tools are another type of management tool in the methods category (Kurstedt, H.A. Jr., "Responsive Decision Support Systems: A Broad View Illustrates When to Include Expert Systems," *Expert Systems & Artificial Intelligence in Decision Support Systems of the Second Mini Euro Conference*, 1985, pp. 53-77.)

The expert system bridges the gap between heuristics and quantitative models. Once the line of reasoning can be structured and automated, the knowledge engineers feel the system no longer is classed as an expert system. Thus, what is called expert system is continually changing, and describing what constitutes an expert system is difficult.

The standard definition for an ES places the ES within the body of a computer. I don't. An ES replicates an expert's knowledge of facts and rules for generating new facts or hypotheses from what is known. For an ES, the facts and rules are applied to a limited, well-defined domain of responsibility. The ES is structured so it can lead a machine or clerical person toward intelligent advice or an intelligent decision about the operation of the domain. The ES allows the user to repeat and identify the line of reasoning by which the advice or decision was reached.

The domain of responsibility can be considered relatively either a closed or open system wherein the closed system has little or no interaction with its surroundings (environment). Expert systems are not appropriate for open systems and should not be applied where models work. Quantitative models bridge the closed-system/open-system gap, and heuristics are most valuable in open systems. Heuristics are redundant to more precise methods in closed systems.

I frequently use a deterministic logic chart as an ES to capture an emergency manager's line of reasoning and action in responding to an unusual occurrence. The logic chart details the flow of response actions that the emergency plan elaborates. By documenting the step-by-step progression described by a person who is an expert in responding to a particular type of emergency, I enhance training, employ intelligent automation, and clarify the place each tool occupies within the emergency management system. Each logic chart is designed to identify potential gaps and overlaps in emergency responsibilities and response actions.

The ES is different from the other methods in that it replicates an "expert" and can regurgitate its inferences and line of reasoning. The ES includes and is the natural extension of automation techniques developed since the beginning of the century. A speller and a manufacturing line operator are expert at more operational-level endeavors. A physician and crisis manager are expert at tactical- or strategic-level endeavors. However, all these examples develop their expertise through learning, experience, and habit learned through repetition. The examples also apply that expertise using intuition and judgment. The ES includes both a problem-solving ability and the ability to adapt to the situation. The problem-solving ability achieves high levels of performance on problems that normally require years of special education and training for human beings to solve.

The ES may or may not employ reasoning based on probability. Without probability, the chain of reasoning has the force of logic. With probability, we can't guarantee that the conclusions are repeatable or are necessarily true.

Within the methods category of the "what is used to manage" component of the MSM, I include (in sequence of decreasing definition and repeatability and increasing requirement for the manager's judgment) quantitative models, expert systems, and heuristics. If any algorithmic solution will work, expert systems are inappropriate.

What's the difference between OR, ES, MIS, DSS? OR and ES are methods. MIS is the data-to-information chain. DSS is all categories of tools working together. Which is more inclusive? DSS.

AS A METHODS TOOL, EXPERT SYSTEMS SUGGEST SOLUTIONS TO MANAGERS.

- Can be housed on a piece of paper, in a file cabinet, in a computer, etc.
- Starts with assumptions, constraints, and/or boundary conditions.
- Replicates an expert's knowledge of facts and rules.
- Applies facts and rules to limited domain.
- Leads the user (audience) toward advice or solution alternatives.
- Is able to replicate the line of reasoning.
- Suggests a repeatable, knowledgeable solution to the decision maker.

Figure 1.5.1.3.4. *By tracing logic based on facts and rules, we can derive good advice and solutions depending on the appropriateness of the constraints in the facts, rules, and logic, and of the fit to the limited domain.*

1.5.1.3.5. Guides and Rules Even Support Other Management Tools.

Guides and rules guide or direct you in doing your work and management process.

I'll first separate guides from rules. Webster defines a guide as "one who leads or directs another in his way." A guide tells us what to do, either in general or in specific terms, as we work to accomplish something. A guide implies that somebody has either conceptually (as in planning) or physically been this way before and they have the map in their mind on where to go and what to watch out for. Guides include tools like policies, plans, procedures, and instructions.

We use a guide when we open up the box with our new VCR in it. There's a user's manual in there that tells us what to do. The user's manual may be as important as the VCR. If the manufacturer didn't work so hard to make the VCR fool proof, those people who never read their user's manual before using the VCR would at best break the VCR and at worst kill themselves. One thing we haven't made foolproof is how to set the clock on the VCR. Only those that use a guide like the user's manual or a friend who knows what they're doing can figure out how to set the clock. Unfortunately, not all guides are well made; and some of us can't figure out how to set the clock even with the user's manual.

Keep in mind the importance of the guide for any tool. When we build a management tool, we'll always need to build a guide to go with the tool to lead or direct the user of both the operations tool mechanization for the management tool (if the management tool is mechanized) and for the management tool itself. The success of a management tool is directly tied to the quality of the guide.

Webster defines rule as "a prescribed guide for conduct or action," as "a usually valid generalization ..... a regulating principle," and as "the exercise of authority or control." A rule is like a guide but is more conceptual, more directive, and broader. Rules include laws, orders, directives, and norms. Norms are unwritten rules, like "Don't belch at the dinner table." Norms, by the way, tend to be culture driven.

Rules tell us how to build or use a management tool. One rule I'll stress in my discussion of using management tools is to pay attention to detail. Another rule is don't lose the forest for the trees. Both rules are important. You'd expect to follow each of the statements in a guide carefully. Rules point you in the right direction. Since rules aren't specific and are sometimes conflicting, you have to figure out how to balance the rules.

Figure 1.5.1.3.5.1. shows where each of the guides I listed earlier (policies, plans, procedures, and instructions) apply. Policies give general direction and allow a lot of discretion so the manager can use their experience and intuition to deal with broad endeavors. Figure 1.5.1.3.5.2. highlights the difference between a policy and an instruction. The executive at the desk has a previously-developed corporate communications policy to guide the communications systems throughout all plants, geographic locations, and divisions of the company. The policy is written so the plant manager, area executive, and division head each can meet the communications needs of their domains and also can be consistent with the corporate needs. But, in Figure 1.5.1.3.5.2., the executive is faced with a clerical endeavor.

He has to dial his phone and the new phone system was installed just a few hours ago. The executive doesn't have time for the user's manual for the phone system. He needs a list of detailed steps to carry him through making a phone call. He needs instructions. The corporate policy or the procedure in the user's manual isn't the right tool. From Figure 1.5.1.3.5.2., we can see there's a connection between type of guide and the endeavor we're doing. We want instructions for doing a clerical endeavor. We want policy for doing a strategic endeavor. Notice that the president (often referred to as a strategic-level position) is doing a clerical endeavor. The tool he needs isn't a function of position; it's a function of endeavor.

In Figure 1.5.1.3.5.1., I show instructions as the right guide to help a manager accomplish a specific job (like call home) through direct action (like dial the telephone) in a clerical endeavor. Unlike a policy for general direction, instructions are a guide designed to make sure that no matter who follows the instructions, they'll end up with exactly the same effort leading to exactly the same result.

I've shown my favorite example of a rather ineffective set of instructions in Figure 1.5.1.3.5.3. Those of us who have children know that when you give your child a bicycle for the holidays, you don't buy a bicycle, you buy a box of parts and a set of instructions. In theory, no matter who follows the instructions, he or she will assemble the parts in exactly the same way, use each and every part properly, and end up with the exact same result. The humor in the figure is that instructions in boxes of parts for children's toys never seem to give you any result at all let alone the same result as anyone else, especially if you follow the instructions exactly.

Writing good instructions is harder than you think. Try to write instructions for how to tie your shoe. Then give the instructions to a friend and have him or her follow the instructions to the letter and see what you get. Consider the fact that if you were writing instructions for a robot to tie shoes, each of your steps in the instructions would have to be perfect and the steps would have to work together perfectly. Your friend may not follow your shoe tying instructions exactly because they have intelligence and they probably knew how to tie their shoes before you tried your experiment.

Tying your shoes isn't so critical a job that bad instructions spell disaster. Consider instructions for the guard at the road intersection during an evacuation from the scene of an emergency. As different guards stand their shifts, each must do exactly the same thing and get the same result and the result must be what is needed.

Figure 1.5.1.3.5.4. shows the top manager at a government facility coming to an emergency exercise. An emergency exercise is a methods management tool to simulate a real emergency to see if the emergency organization, plans, communications, and so on work. The top manager has brought with him the guides he's worked so hard and spent so much money to develop. I was the person who helped that manager build the guides he has under his arm. They are the emergency preparedness policies and the emergency response plans for the government site. The problem he and I faced that day was that the guides he brought didn't work. On that day, I figured out Figure 1.5.1.3.5.1.

The emergency exercise is largely an operational endeavor, or better stated, the manager did mostly operational endeavors during the exercise. Or even better stated, the endeavors the manager did for which we could preprepare management tools were mostly operational endeavors.

The manager had to figure out what the problem was almost instantly. So much for strategic endeavors. When he figured out the problem, he used his instinct, experience, intuition, and the emergency preparedness policy. Since he was the strategic-level manager, he knew the policy he needed by memory. (The larger value of the policy comes later.)

The resources either were available or they weren't that day. So much for tactical endeavors. The emergency response plan had long ago seen to it that the needed resources either were or were not ready.

What that manager in Figure 1.5.1.3.5.4. needed most and didn't have was a set of procedures. Procedures for notifying people. Procedures for moving people into and out of buildings and areas. Procedures for public information. Procedures for medical assistance. Who would ever have thought that the top manager would need mostly tools for doing operational endeavors? That's why we have exercises—to find out what we thought wrong.

An interesting point in the emergency preparedness story is that you can't develop good procedures until you have a good policy and good plans. That's the value of having a good policy. You need the policy to get good plans and procedures. We had done good first steps in preparing policies and plans. We just hadn't finished the job. We needed good procedures. In Figure 1.5.1.3.5.1., I show policies as the appropriate guide for strategic endeavors, plans as appropriate for tactical endeavors, and procedures as appropriate for operational endeavors.

In the right hand column of Figure 1.5.1.3.5.1, I show how we should evaluate the guides. If you will, the policy is a mechanism that relates the plans. In my emergency management example, we needed plans that carried the emergency preparedness policy toward specific responses. The plans needed to work together within the policy and we needed plans for all aspects of the policy. Likewise, the plan is a framework for procedures. Often in plans that deal with objectives and resources, the procedures are in an appendix.

My second column in Figure 1.5.1.3.5.1. is also important. I show goals as qualitative accomplishments. There should be any number of ways to accomplish a goal, and the goal is a broad result. Objectives are quantitative. We can specify an objective and what's needed to reach the objective. Webster defines mission as "a specific task with which a person or a group is charged; a definite military, naval, or aerospace task." I see a mission as task oriented. We meet a mission successfully when we solve a problem. However, in meeting our mission, we may not have reached either our goal or our objective. We may not have solved the exact problem or used our resources right in solving the problem

I know you can find references showing the words in the second column of Figure 1.5.1.3.5.1. in other sequences. Some people like to have objectives as more general than goals. Other people see the mission as the overarching umbrella above everything. I'm not as concerned about the words as I am the concepts. Call what is met or accomplished a duck, chicken, and turkey. What's important is that at the strategic level, we need qualitative direction; and, at the operational level, we need specific, task-oriented direction.

The third column in Figure 1.5.1.3.5.1. ties the endeavors and guides to the types of effort we work on. We need policies for whatever pursuit we engage in. We need policies for processes just as we do for perplexities. Plans help us with activities.

The word plan is both a noun and a verb. In Figure 1.5.1.3.5.1., the word plan is a noun. We plan (the verb) when we develop policies, procedures, and instructions just like we plan when we develop plans.

THE RIGHT GUIDE LEADS THE RIGHT ENDEAVOR TO THE RIGHT ACCOMPLISHMENTS.

Level of Endeavor	What is Met or Accomplished	Type of Effort	Guide	Evaluation for Guide
Strategic	Goals	Pursuits	Policies	Relationships of Plans
Tactical	Objectives	Activities	Plans	Framework for Procedures
Operational	Missions	Tasks	Procedures	Value of Instructions
Clerical	Jobs	Actions	Instructions	Yes-No on Steps

Figure 1.5.1.3.5.1. *If you build and use the guide best suited to the endeavors you're doing, you get to where you want to go. Otherwise, the management tool will work against your best efforts.*

Figure 1.5.1.3.5.2. *"Don't give me guidance. Tell me how the damned thing works!"*

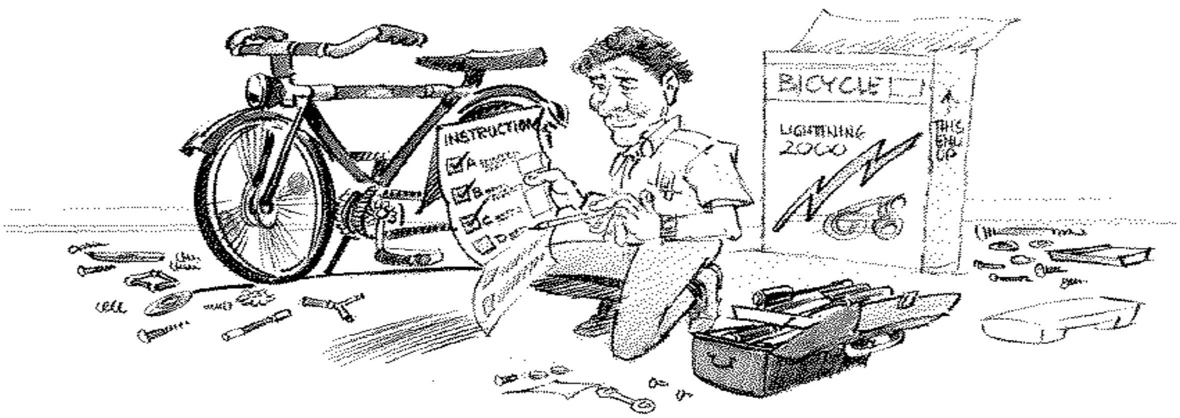

Figure 1.5.1.3.5.3. *"Why do I have all these parts left over? I hope the wheel doesn't fall off at the wrong time."*

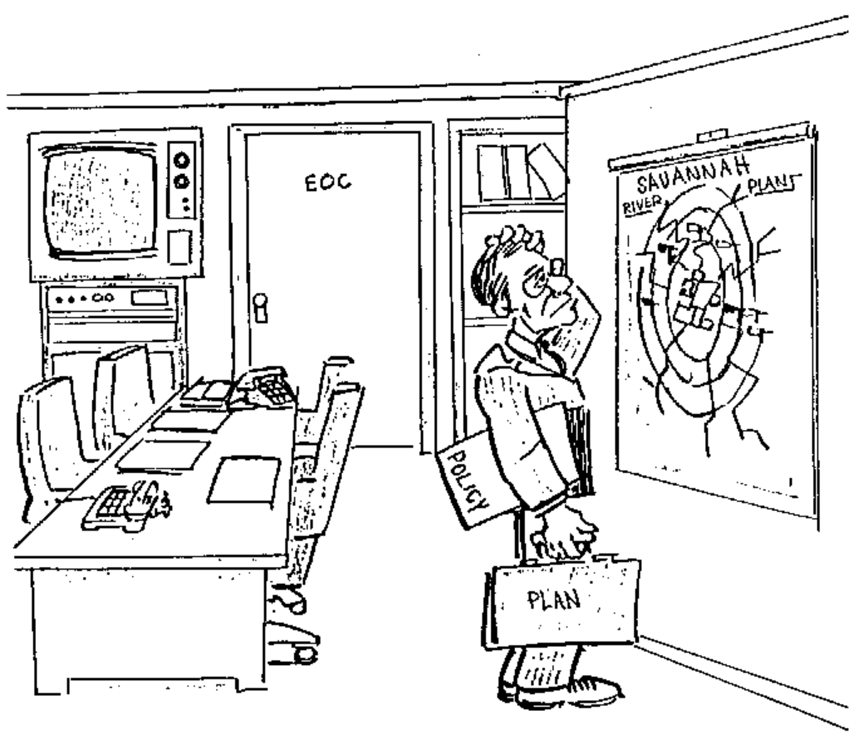

Figure 1.5.1.3.5.4. *"What's wrong with my policy and plan!?" Nothing. It's just that what you need here are procedures.*

1.5.1.3.6. Precedents Affect the Inner Person More than Other Tools.

Precedents tools help us set up the stability and consistency we depend on to manage ambiguity.

Webster defines precedent as "an earlier occurrence of something similar; something done or said that may serve as an example or rule to authorize or justify a subsequent act of the same or an analogous kind; the convention established by such a precedent or by long practice." A good manager uses the organization's history and culture to help him or her manage. Much of an organization is below the surface—only partially visible. A manager must manage not only what's on the surface but what's below the surface. Like an iceberg, most of the organization is below the surface.

What sorts of things are below the surface? Where we came from. Who we are. What we believe. Whom we trust. What we need to know. How we do things around here. How to behave. The people who know what's going on. What we stand for. What else counts? Not much. If these things are the important part of the organization, you can't ignore them. You have to make decisions about the precedents and you need tools to help you. Those tools are the precedents tools. These tools include legends and stories, symbols, heroes, values, mission-vision-principles (MVP) statements, rites and rituals, celebrations, and many more. These under-the-surface factors should affect other tools and processes, like the hiring process, the promotion process, and the retirement process.

When you come to a company, you're socialized to the new culture. While frightening to many people who put individualism over group action and competition over cooperation, socialization highlights the precedents management tools. Richard Pascale says socialization is "the systematic means by which firms bring new members into their culture. ..... It encompasses the process of being made a member of a group, learning the ropes, and being taught how one must communicate and interact to get things done." (Richard Pascale, *The Paradox of "Corporate Culture": Reconciling Ourselves to Socialization*, California Management Review, Winter 1985, p. 27.)

I learned about socialization during my four years at the Virginia Military Institute. The idea of socialization was to bring everyone to the same level and to remove any preconceived notions about life and your importance in it. The same level everyone is brought to is the level of a rat. Whether you came from wealth or poverty, city or country, aristocracy or immigrant, you were immediately rendered to a being equal exactly to everyone else. In this way, the Institute could implant its values, beliefs, and traditions into everyone in a consistent fashion. The brotherhood of graduates from the Virginia Military Institute is renowned. My advice is to make sure your personal values coincide with those of a strong-culture organization before you join.

Other organizations practice similar activities of socialization. According to Pascale, companies with strong cultures, like IBM, Proctor and Gamble, and AT&T, generally undertake seven key steps of socialization and, as a result, have sustained themselves over generations. Pascale lists the steps as: 1) "Careful selection of entry-level candidates." 2) "Humility-inducing experiences in the first months on the job precipitate self-questioning of prior behavior, beliefs, and values. A lowering of individual self-comfort and self-complacency promotes openness toward accepting the organization's norms and values." 3) "In-the-trenches training leads to mastery of one of the core disciplines of the business." 4) "Meticulous attention is given to systems measuring operational results and rewarding individual performance." 5) "Careful adherence to the firm's transcendent values. Identification with common values enables employees to reconcile personal sacrifices necessitated by their membership in the organization." 6) "Reinforcing folklore provides legends and interpretations of watershed events in the organization's history that validate the firm's culture and its aims. Folklore reinforces a code of conduct for 'how we do things around here.'" 7) "Consistent role models and consistent traits are associated with those recognized as on the fast track." (pp. 29-33.)

All organizations will attempt to socialize its new members to some extent. The various tools for socialization are precedents tools. Some scholars feel culture is ingrained in a group and can't be managed. Others (most popularly, Peters and Waterman in *In Search of Excellence*) feel that the excellent companies are the ones with strong cultures; and if you want your organization to be excellent, you need to manage your culture. You don't just use precedents tools for managing new hires, you use them for everyone in the organization.

Pascale argues in favor of effective socialization. "Organizations that socialize effectively manage a lot of internal ambiguity. This tends to free up time and energy; more goes toward getting the job done and focusing on external things like the competition and the customer. ..... When social roles are unclear, no one is speaking the same language; communication and trust break down. Remember, the power to get things done in corporations seldom depends on formal titles and formal authority alone. In great measure, it depends on a person's track record and reputation, knowledge, and a network of relationships. In effect, the power to implement change and execute effectively relies heavily on one's social currency, something a person accumulates over time. Strong culture firms empower employees helping them build this social currency by providing continuity and clarity. ..... The aim of socialization is to establish a base of attitudes, habits, and values that foster cooperation, integrity, and communication. The most frequently advanced objection is that the companies who do so will lose innovativeness over the long haul. The record does not bear this out." (pp. 34-37.) My personal experience from the time of attending high school at the Christian Brothers College in Memphis through the Virginia Military Institute until now supports Pascale's evaluation.

1.5.1.3.7. The Data-to-Information Chain Is a Map to Industrial Engineering Disciplines.

Industrial engineering methods and techniques are applicable to MIS development.

The data-to-information chain is shown in Figure 1.5.1.3.7. as the links that obtain data (through measurement of indicators) about the operation (what is managed), process those data, compare them to setpoints, or reference points, to generate information, and present that information to an intelligent decision maker. The decision maker then acts on the decision based on the information, all of which meets the objective, to affect the operation in such a way as to improve or adjust its condition—ready for measurement to assess the impact of what has gone before.

The illusory link distinguished by the dotted line in Figure 1.5.1.3.7. is really who manages, which is the connection between information and the operation. Obviously, this figure is similar to the Management System Model (MSM), wherein only the data-to-information chain takes the place of the what is used to manage component. All management tools convert data to information and take the place of the what is used to manage component. The data-to-information chain includes the links of the chain for the day-in, day-out acquisition, storage, retrieval, and manipulation of data to make information. The other management tools don't reflect the frequent and regular links of the chain.

Each Link Represents a Technical Specialty.

Each of the links shown in Figure 1.5.1.3.7. represents a technical specialty and is the domain of a highly-trained specialist. As a supervisor, you'll manage these specialists and be responsible for the outcome when the links are connected and working; however your obligation is what you know best—the dotted management intelligence link (who manages) and the operation (what is managed).

Figure 1.5.1.3.7. requires more attention. Consider each link a process, in which data are the raw materials. As industrial engineers, haven't we developed expertise in storing materials (inventory), lining up the materials for processing (queuing), retrieving and manipulating the materials according to procedure (materials handling), converting or assembling the materials into another form (manufacturing processes), interfacing the materials, their conversion, and their processes to the human element (human factors), and overviewing the materials, their conversion, and their processes (economics)?

Conceptual Fundamentals of the Specialty Lead to Transference of Techniques.

Of course there are differences between the specialized techniques of the industrial engineering disciplines and the generic purview of each discipline—much like the difference between minimum slack time (specialized technique) and critical path (generic concept) discussed earlier in module 1.4.5.2.2. An example of this difference involves inventory techniques. With hammers, we have similar objects with a few different prices by purchase sequence, and with data we have similar less-physical objects each one with a different makeup (characters for narrative data and numbers for quantitative data). However, concepts such as the A-B-C theory (80-20) and age of inventory clearly apply. However, I suspect the concepts never have been applied because the specialists dealing with the links in Figure 1.5.1.3.7. either don't have the industrial engineer's training or are only interested in the computer science aspects of the link in question. Considering all the links together and the industrial engineering disciplines they represent, we have a specialized (data) but universal application (data and information overlay everything we do) of all these disciplines integrated to meet a common objective--if you will, the capstone design (synthesis) effort which brings all our disciplines together.

The data-to-information chain emphasizes the process for converting data to information. Each of the components of the MSM involve a process. The who manages component involves the decision process for converting information into action. (Remember Forrester.) The what is managed component involves the work process. Information systems are about the process in the what is used to manage component. Boland says, “Data becoming information is what information systems are. Data becomes information in the consciousness of a human subject, and that is where we must look if we are to understand information systems.” (Richard J. Boland, Jr., *Phenomenology: A Preferred Approach to Research and Information Systems*, Research Methods in Information Systems, Elsevier Science Publishers, 1985, p. 200.)

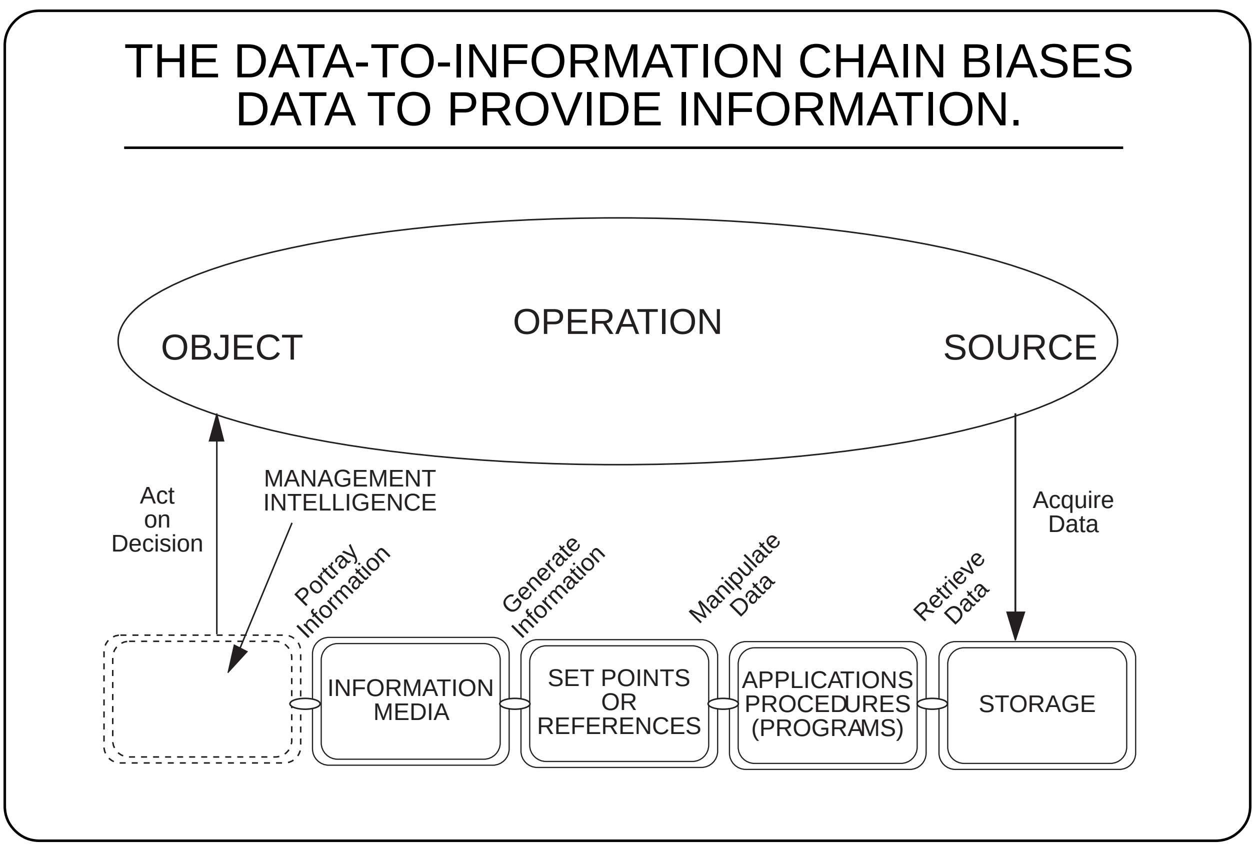

Figure 1.5.1.3.7. *The data-to-information chain includes links to make information from data.*

1.5.1.4. ORIGIN OF THE TOOL CLASSIFICATION

1.5.1.5. DSS VIS-A-VIS EDP, MIS, AOSS, AND MSS

Systems to support decision making include many tools, of which computer-based tools identify but one type of container for tools.

The functional groups of tools, singly or together, can be manual, automated, or computer-based. Standard definitions for concepts like management information systems include an embodiment in a computer. In contrast, I consider these concepts broadly enough to include manual embodiments and place the concepts within the framework of the Management System Model (MSM) so you can get a fixed, repeatable scope of the meaning of each concept. Figure 1.4.2.6.3. illustrates my view of what a decision support system (DSS) is, a view in terms of supporting decisions rather than a level or generation of hardware or software for a computer system. In Figure 1.4.2.6.3., the five functional groups of tools comprise a DSS when they are interrelated so they work together based on the same data and leading toward the same objective. I view other similar concepts (e.g., management information system, electronic data processing, and management support system) from the same perspective—tools, not necessarily computer-based, that we use to manage with.

The phrase "decision support" first appeared in a landmark paper by Gorry and Scott Morton in 1971. (*A Framework for Management Information Systems,* Sloan Management Review, Fall 1971, pp. 55-70.) Since then the term has come to be a "warmed over" and more palatable term for management information system, all of which has come to inherently include the concept of computer based. I agree generally with John D.C. Little in his TIMS Letter from the President in the April 1985 where he said "A certain amount of confusion has occasionally occurred about whether DSS is just OR/MS [Operations Research/Management Science]. Who cares? The business of management science is decision support. The computer is our chief delivery vehicle." I don't agree that the computer is now the chief delivery vehicle, but it will be.

I draw attention to how each such concept fits distinctly within the Management System Model; that is , the role each plays in helping us manage. Figures 1.5.1.5.1. and 1.5.1.5.2. show five such concepts in two diagrams, both representing an overlay of the concepts in the MSM.

Figure 1.5.1.5.1. includes data-information-related concepts and compares electronic data processing (EDP), management information system (MIS), and automated office support systems (AOSS). Figure 1.5.1.5.2 includes decision-related concepts and compares decision support systems (DSS) and management support systems (MSS). Within both diagrams, all concepts are defined and contrasted. My definitions are top-down, management-related concepts. They don't agree with computer-oriented definitions but are naturally distinguishable one from the other.

EDP Deals Only with Data.

Electronic data processing (EDP) is the first of several links of the data-to-information chain, shown in Figure 1.5.1.3.7. With EDP we merely access, store, retrieve, and manipulate data, a function well suited to clerical-level and operational-level endeavors. Before computers, we did the data processing function well using hand-generated spreadsheets for manipulation and notebooks or file cabinets for storage. Computers are able to duplicate this function faster and more consistently. One disadvantage is that since we now can do data processing so much faster, we can do so much more of it. So we produce the same data, manipulated into dozens or hundreds of different spreadsheets or tables.

I consider narrative to be data. Therefore, word processors are computer-based EDP devices. When you think about it, state-of-the-art networking, spreadsheeting, and windowing practices are nothing more than manipulating data, since moving data from place to place is a form of manipulation. EDP is important to consider because that is most of what we are really doing under the guise of MIS or DSS.

MIS Is More Than Manipulating Data.
When I look at the technological advances we are so excited about today, I see us manipulating data, not making information. Networking is moving data from place to place, windowing is displaying data, and spreadsheeting is aggregating data. Either by moving it, showing it, or tallying it, we are getting better and better at just manipulating raw data, not enhancing its value or truly supporting management.

The management information system (MIS) was coined to represent a more-useful, higher-level form of management support using information rather than just data. Unfortunately, when MIS was required to do much more than EDP (as I define it), MIS failed. That is, MIS may have been a new term, but it did little else than raise managers' expectations and sell a lot of computers. (Those of us in the information business will pay for that.)

MIS, as shown in Figure 1.5.1.5.1., is the entire data-to-information chain and includes not only the EDP links, but the links for forming and presenting information. MIS never has adequately addressed the measurement/data and the information portrayal/information perception interfaces. In terms of the individual links in the chain, we've developed the hardware and software specialties far beyond the ability or need of most of us to fully use them. We've recognized the garbage-in/garbage-out syndrome at the data-to-measurement interface, but the operational aspects of this interface (e.g., data administration and corporate data sharing) are still quite primitive.

I believe the area for greatest contribution lies at the information-portrayal-to-information-perception interface and learning how to portray information with purpose rather than at random. Since information can be portrayed in four different formats (table, graphic, checklist, and text), the right format can be selected depending on the data and information structure and the desired conclusion. In very few cases have we ever achieved a successful MIS as defined here.

An MIS is much more than a computer. As we become involved with microcomputers we learn how true this is. In our work, we focus on getting hardware and software and, as shown in Figure 1.5.1.5.3., celebrate its arrival. Then we realize the need for training, documentation, back up, security and the host of other operational needs that together make up an MIS.

AOSS Includes Part of the What Is Managed Component.
In that an automated office support system (AOSS) is generally considered to include office tools (part of what is managed), my concept of AOSS includes MIS, most if not all of the methods, and the office tools. As opposed to including only word processing, scheduling, and teleconferencing, many of us see AOSS as the automation of all office-related efforts typically under the jurisdiction of a single office environment. There's no need to quibble about whether rolodexes or lighted slide cabinets are part of automation,

but these tools along with models, paperwork, and the like and the office's MIS all support office decisions based on information.

The DSS Comprises all Management Tools through their Interrelatedness.

I believe decision support systems (DSS) arose as a response to bad feelings about MIS. Given that MIS hasn't progressed much from EDP, why should DSS suddenly be able to accomplish more than what was originally expected of MIS? What is the difference between information for managers and support for decisions in the real world where we are doing neither? By my definition, DSS is quite different from MIS and includes all the tools of the what is used to manage component; and DSS does address the measurement-to-data and the information-portrayal-to-information-perception interfaces.

The key to DSS is the synergism that results from the tools working well together. Thus, DSS focuses on the interrelatedness of the tools. The methods category of management tools should affect the plans in the guides and rules category. The plans should be used as much as the data-to-information chain because these two tools should be used hand-in-glove in formulating the reference points so we can execute against them using our MIS. Often, in an effort to "obtain computerized decision support," managers gain such a good understanding of these interactions, the need for computerization (or automation) is lessened because the manager has systematized what he uses to manage.

The term DSS was first used by Gorry and Scott Morton in 1971. DSS was to support Gorry and Scott Morton's semi-structured and unstructured decisions, which are described in Module 1.4.5.5.1.

Gorry and Scott Morton say, "We shall call the information systems that support [decisions that are largely structured] 'Structured Decision Systems' (SDS). Decisions [that] are largely unstructured, and their supporting information systems are 'Decision Support Systems' (DSS). The SDS area encompasses almost all of what *has* been called Management Information System (MIS) in the literature—an area that has had almost nothing to do with real managers or information but has been largely routine data processing. We exclude from consideration here all of the *information handling* activities in an organization. A large percentage of computer time in many organizations is spent on straightforward data handling with no decisions, however structured, involved. The payroll application, for example, is a data handling operation." (p. 61.) In terms of semi-structured and unstructured decisions, we haven't come very far in 15 years.

MSS Includes The Who Manages Component.

My definition of management support systems (MSS), a concept introduced by Katzan in 1984, is different from Katzan's. Katzan's definition of MSS and my definition of DSS are nearly equivalent. I define MSS as a system that combines the who manages and what is used to manage components of the MSM, thereby including everything from the measurement-to-data interface to the decision-to-action interface.

In short, the DSS supports who manages, or the decision maker, and MSS supports what is managed, or the operation. Since who manages is considered to be a human decision-maker, with his or her cognitive style, experience, and capability and such human traits as emotions, ambitions, unpredictability, and sense of humor, an MSS, by definition is not easily *fully* automated. My view of an MSS explicitly recognizes that a manager is more than a decision-maker; he or she is a person, above all.

Consider, for example, a system where the entire process, from measurement to data to information portrayal and perception, and, finally, decision-making and action is automated. Computer-based systems such as these exist—for example, we have systems which keep track of inventories and if the level falls below a prescribed minimum, automatically place an order for more items. Should we consider such a system to be a fully automated MSS? No. Note that the computer doesn't replace the "who manages;" it only automates routine actions permitting the who manages to attend to the non-routine tasks. Therefore, the system is a management tool. If anything were to upset the routine, the system described above would need the intervention of a human manager. At least until computers can perform a broad range of routine and non-routine decision-making and be endowed with human characteristics, we'll stick with my definition.

Whether we use the above definitions or the somewhat blurred definitions commonly used, EDP, MIS, AOSS, DSS, and MSS are all portions of a management system. The MSM includes all components and interfaces to close the loop.

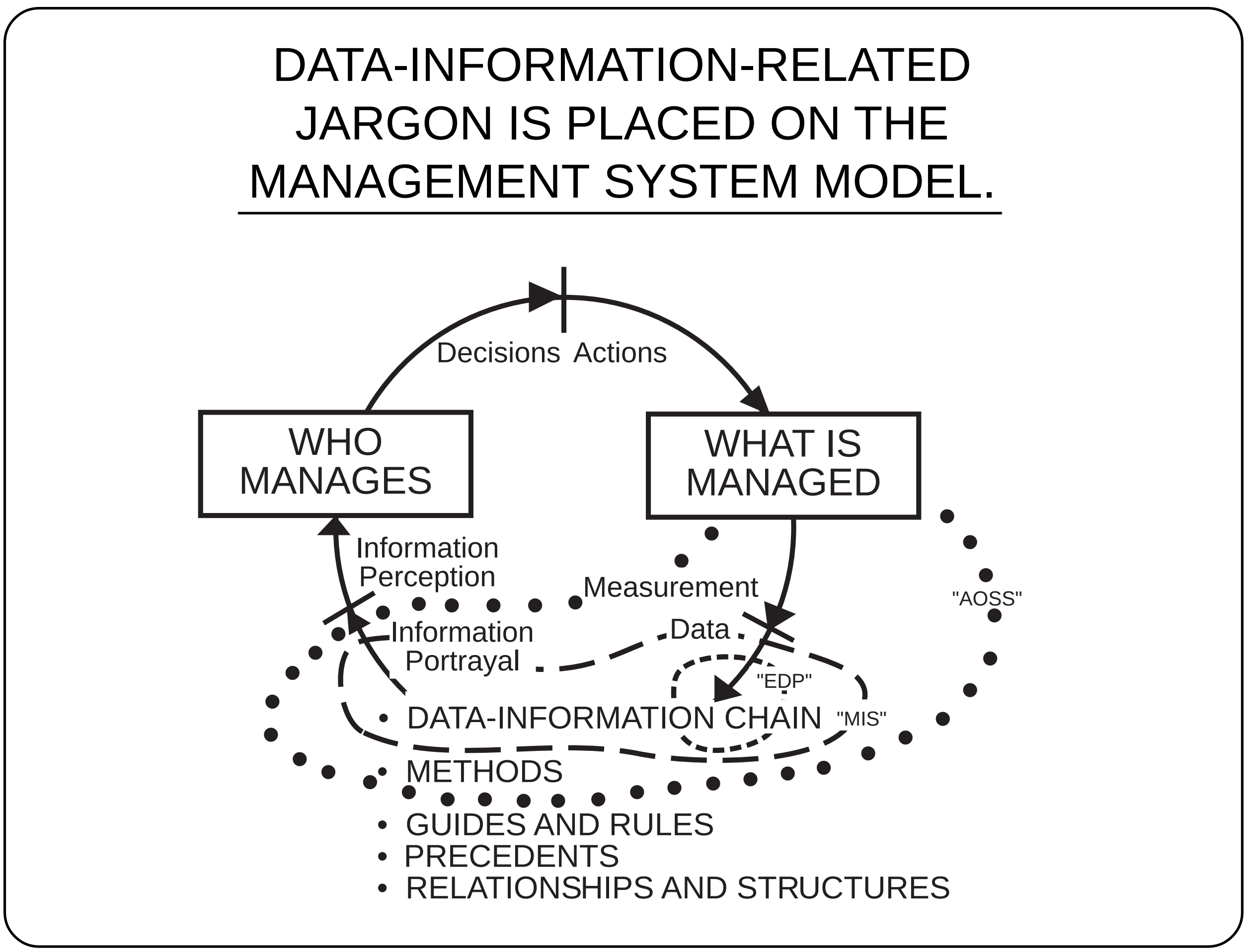

Figure 1.5.1.5.1. *Data-and-information-related concepts are easily defined using the Management System Model.*

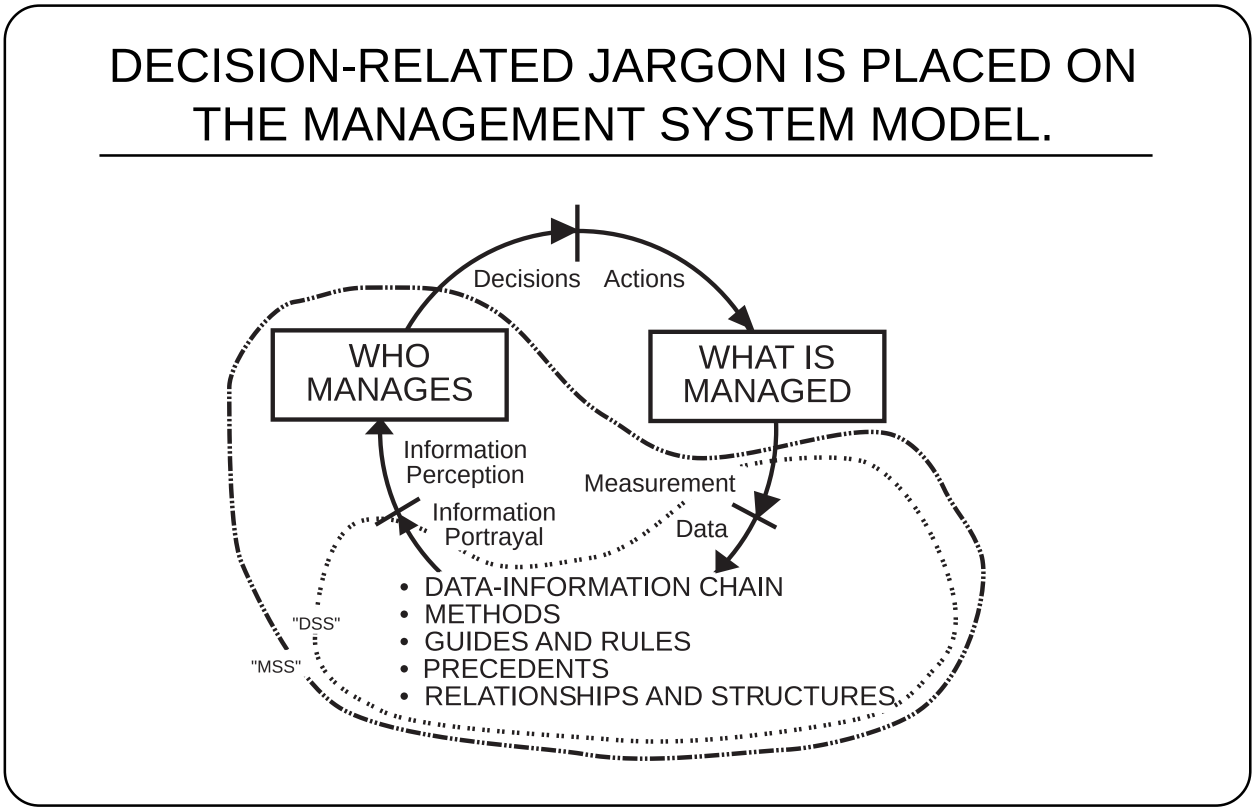

Figure 1.5.1.5.2. *Decision-related concepts are easily defined using the Management System Model.*

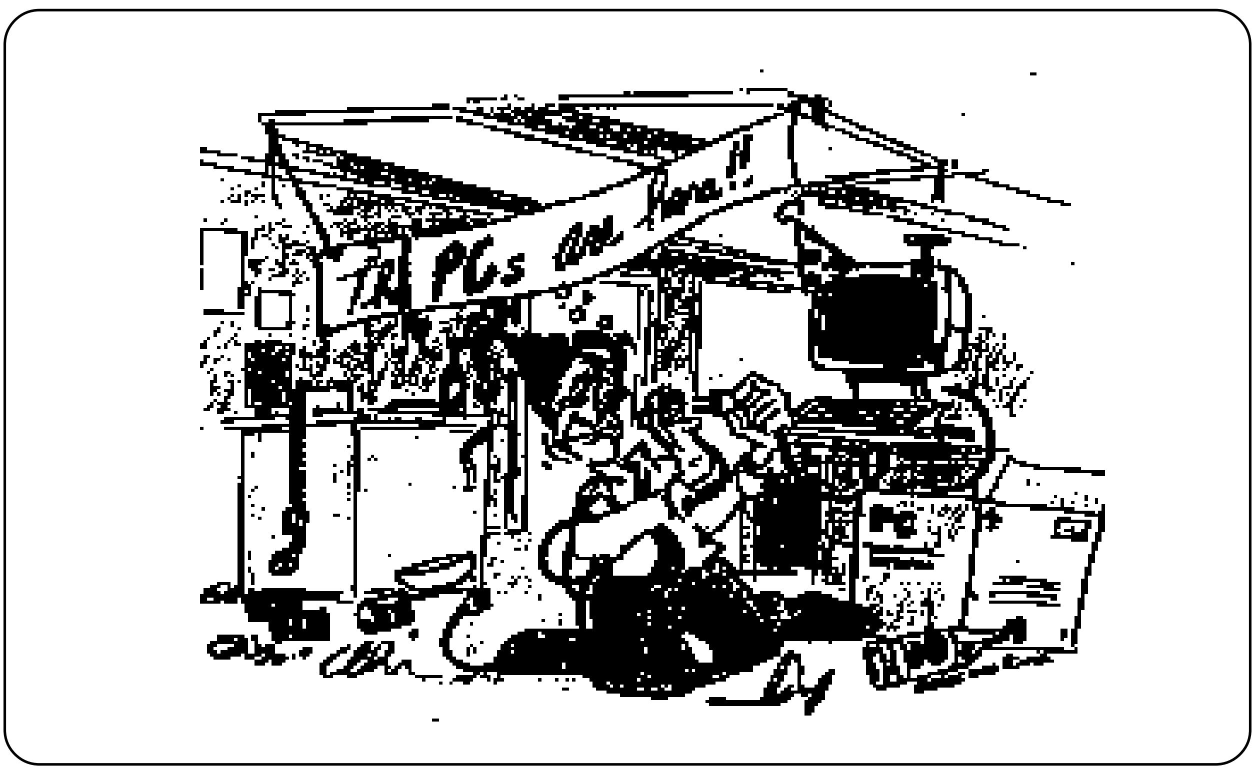

Figure 1.5.1.5.3. *"The PC's have come, the PC's have come."*

1.5.1.6. What Types of MIS Really Help You?

Make sure you know what an MIS gives you in supporting your decision making and takes from you in time and effort.

With office automation, a professional secretary working for a manager with mostly strategic-level or tactical-level endeavors is set free from clerical chores to do more judgmental work, and the resource pool isn't needed. At judgmental levels, automation makes the job more demanding. At the perfunctory levels, automation makes the job less demanding. If your work is more judgmental, you will end up with a new kind of office assistant. This person will be able to use office automation tools more deftly and will provide you the information you need when you need it, much as your secretary does now, only the new office assistant will require much more expertise.

Many of you may think that as you integrate automation into your offices, one or more secretaries will leave. That is an illusion.

At Virginia Tech we have a university-wide information system designed and developed by accountants for accountants. That system is useless to people like department heads and principal investigators in research because currency is sacrificed for preciseness and the outputs are intelligible only to accountants. Therefore, we decided to plan a system to satisfy everyone's needs. What a wonderful system it is supposed to be.

In a committee meeting after hearing about the depth and the breadth of the new system, an associate dean asked the question, "Do we have any idea how much this is going to cost?" Among the startled people who had been dreaming of the promised land, one said, "However, we must balance the cost by the savings this system will bring." I laughed because I knew in the university the savings that count are in reducing people, space, or equipment and that ultimately the system would require more (but different) people, space, and equipment.

Has the copy machine reduced the work for the secretary or increased it? Automation doesn't mean you do the same things with fewer people—it means you do more or different things. Given a resource pool with a word processor, you write more letters. In your offices, you probably won't replace people—you'll replace functions.

I've often said that strategic-level managers won't have computers on their desks. I say this for emphasis. What I mean is strategic-level managers will not program computers (including LOTUS 123) or manipulate programs. They'll bring up displays, review them, input notes or comments, and do simple "what-if" analyses. Without the new kind of office assistant, this will be very difficult.

As stated earlier, a successful computer-based management information system (MIS) can help satisfy the need for balance in the management system model (MSM). Computer-based MIS failures include any combination of those that aren't finished in time, involve turnover of key participants, exceed reasonable cost before any return, lack follow-through, become obsolete through obsolete requirements or obsolete technology, have an improper fit, or have not had their performance evaluated. I claim that we're only 30% successful.

I helped design and develop a milestone tracking system for one of our government sponsors. A rousing success, the computer-based package provided reports used monthly for milestone meetings and annually for performance evaluation. The package was quick, easy, and comprehensive. The manager had exactly what he liked and his organization grew to depend on the package. After a year, the manager was on the package. After a another year, the manager was transferred across the country, his deputy took his place, and the organization happily continued with the familiar practices.

A new person was brought into the organization to replace the deputy and he was given responsibility for milestones. The "successful" system didn't suit his preferences. From the management system perspective, that tool failed. It didn't do what it was supposed to do for as long as the user expected the package to do it. Successful software, hardware, and experience doesn't make a successful system. A generic package would not suit the first who manages, the original manager. The custom-tailored package did not suit the third who manages, the second deputy manager. Both ultimately failed in fit.

We designed and developed a research project financial management system for one of our department heads in engineering. His department, with 40-50 research contracts, had long been suffering from overruns due to late or faulty information from the university system. His new system worked well. His secretary, who was afraid of computers, had no trouble using this computer-based system, and overruns were eliminated for four years. Then one day I got a call from the department head. He had overruns everywhere. What had happened to this "successful" package?

After four years, the computing center had made a change in the operating system that affected our package. When the secretary tried to update her database, the terminal screen went "into bozo-land." Discretion being the better part of valor, she decided that she would worry about the problem after her vacation, which began in a couple of weeks. Of course, her vacation didn't improve the package and she had the same problem when she returned. However, this time she could put off the inevitable until after she returned from her surgery, which would take place in a few weeks. Again, upon her return she found no improvement in the package. She finally called my system designer, who would fix the problem very soon. But—he was hired away by another contract sponsor and didn't transfer information to co-workers either in the problem or its solution.

To show the length of the long story, the problem was nine months old when the department head called me. Even the data in the database were so old we no longer had an updating problem but a reinitiation problem on top of the simple programming solution. A classic failure. No follow-through. Good hardware, software, training, and documentation. But no procedures to identify, notify and resolve a simple operational problem.

Some MIS's Do Succeed.

By hiding from our failures, we aren't able to discover reasons for our successes. If an MIS fails because the new concept of the management systems isn't understood and the system components aren't balanced, then why do the few MIS's succeed?

An examination of successful MIS's reveals three commonly used development strategies that balance the MSM components. I'll also discuss a fourth strategy, which results in illusory success.

First, a computer-based MIS can be successfully implemented by merely automating an existing successful manual system. In developing and using the manual system, the manager has intuitively balanced the management system components. The manual system generates the information he or she wants for making decisions affecting what he or she manages. However, manual systems limit the manager's ability to get and frequently change large amounts of data. Automating the manual system removes its limitation, thereby improving the management system balance. Most MIS successes are of this type.

Second, a manager can get so excited about MIS development that he or she devotes inordinate amounts of his or her time and energy working with the systems designers to insure a custom-fit between the MIS and his or her needs. In this case, the manager demands what he or she likes and persists until the management system components come into balance. This strategy is effective, but inefficient because managers usually have limited knowledge of the features and benefits of automation techniques.

Third, for some common specific needs involving structured decisions, a range of computer-based MIS packages has been developed. These packages have broad application and markets. Accounts receivable packages are an example. Often, a package can be found which fits the manager's specific need well enough that the MSM components are *nearly* balanced. However, failure is almost certain if, lured by the apparent potential for a perfect fit, a package with near-fit is obtained and attempts are made to customize the package.

Sometimes, in an effort to get aboard the computer bandwagon or to shore up management inadequacies, some managers will force the components of their management system to fit an improperly developed MIS or an off-the-shelf MIS package. The new management system, forced to fit the MIS, may appear to be balanced, giving an illusion of success. However, because of the forced fit, the new management system probably no longer addresses the original management system goals and objectives. The computer-based MIS may appear successful while the entire management system fails. Such an illusory success portends dire long-term consequences for real MIS success.

As shown in Figure 1.5.1.6., automated airline reservation systems provide an interesting example of force-fitting who manages into a computer-based MIS, that may (or may not) fit what is managed. The reservationists are forced onto the system, and they either adjust or terminate their employment. Often, poor fits causes poor performance.

At a minimum, people with management tools that don't fit are frustrated. In Figure 1.5.1.6., I've shown two of the three reservationists as upset. By chance the automated airline reservation system fits the experience, ability, and cognitive style of one of the reservationists. The figure reflects my proposition that 70% of all MIS's fail. Check my proposition out the next time you're in an airport.

Airlines have determined that the relative costs warrant the trade-off between improved speed or responsiveness to the customer, and loss in personnel. They haven't learned about quality. This trade-off may be considered reasonable for reservationists performing clerical, or at best operational, endeavors. But we certainly cannot make similar trade-offs where tactical-level or strategic-level managers are concerned. You won't successfully tell your boss to adjust to the system or leave.

The what is managed component of management systems changes mostly in terms of maturity, either with new technology or through improved decisions and actions. Therefore, the operation changes relatively less frequently.

The who manages component changes more often since frequent personnel changes are common in most organizations.

Given the low MIS success rate and little inclination to reduce the frequency of personnel changes, can we expect the MIS success rate to improve? Not soon! If we confine our efforts to automating manual systems, we may slightly improve the success rate. But this solution is impractical in light of the ever-pressing need for managers to deal with more rapidly changing data.

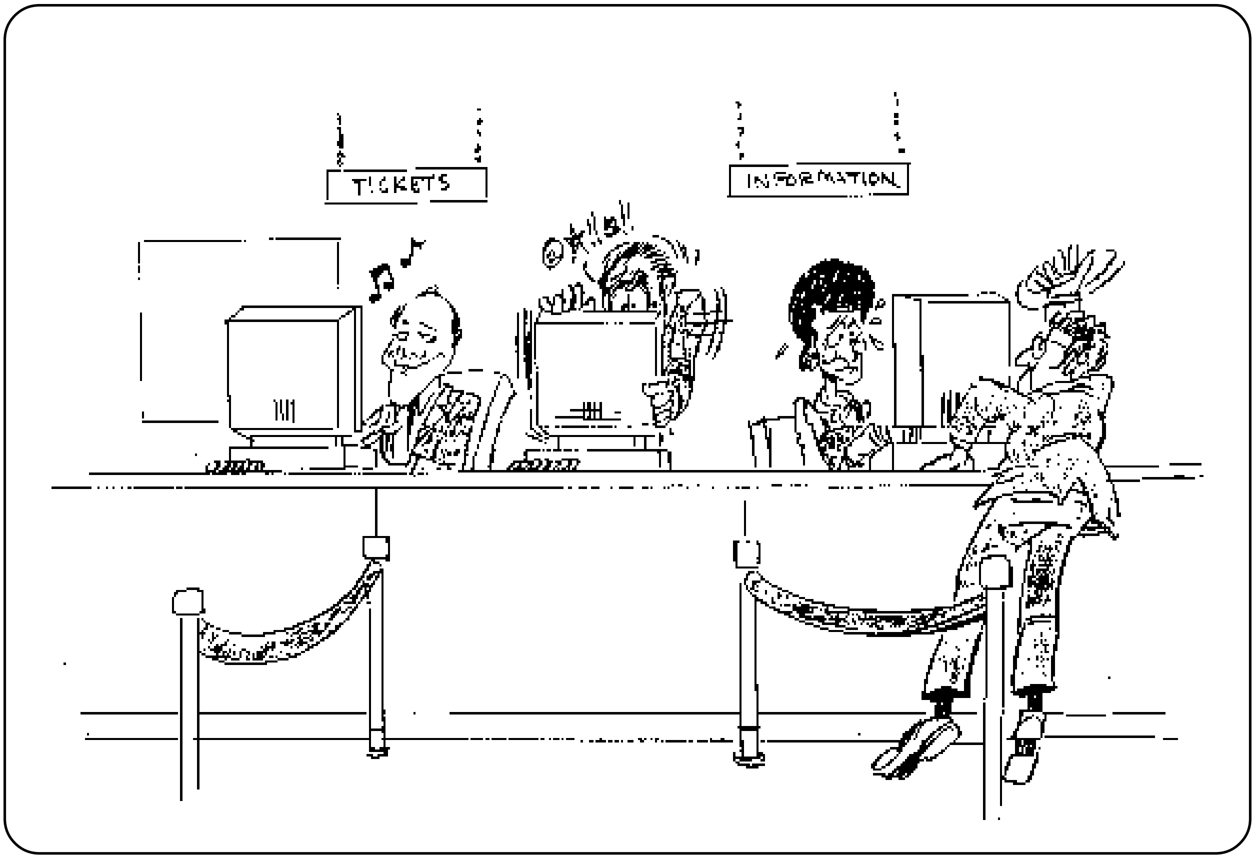

Figure 1.5.1.6. *"I have some reservations about this new computer system."*

1.5.1.7. WE NEED RESPONSIVE SYSTEMS.

We need systems that can understand what we need and give us just that.

I want to present a thought-provoking concern. Personnel changes are more than likely going to bring an existing MIS out of balance and cause it to fail. Therefore, to significantly increase the rate of MIS success, we must develop *adaptive* systems. To understand the profundity of this thought, I'll categorize successful systems as adaptive, adaptable, flexible, and, of course, custom-fit systems.

Adaptive Systems Are Self-Molding.
As in the bean-bag chair in Figure 1.5.1.7.1., *adaptive* systems are self-molding and adjust to who manages without being told. They will sense the user characteristics and adjust automatically. When a user touches the keyboard or just approaches in the vicinity of the management tool, it senses who is there and what he or she wants and then instinctively adapts to provide exactly what is needed (a very futuristic idea). The first glimmer of adaptiveness will be systems that adjust their menus and help-routines based on the user's knowledge or experience as monitored or sensed by the system.

Adaptable Systems Adjust When They're Told.
As in the electric car-seat in Figure 1.5.1.7.2., *adaptable* systems are less sophisticated; they adjust to who manages when they're told. System designers will determine what to tell the system and how to measure needed characteristics of the user.

An example of an adaptable feature in one of my systems (not an adaptable system) is a feature that we designed into a microcomputer-based simulation package. As the simulation is running and the numbers are changing on the screen for the manager to watch to determine trends and effects, the operator can change the speed of the presentation of the simulation. He or she can have the simulation proceed faster to get past slowly changing occurrences or slower to watch rapidly changing occurrences. He or she controls simulation speed by repeatedly using the greater-than or less-than key. Hitting the greater-than key speeds up the presentation of information; and hitting the less-than key slows down the presentation. He or she also can stop the simulation, change variables, or add processes and proceed.

Flexible Systems Have a Number of Options.
While we work toward these futuristic concepts we'll build *flexible* systems as illustrated with the lawn mower wheel adjustment in Figure 1.5.1.7.3. The lawn mower has several levels at which you can set the wheels. You get to pick one. Have you ever tried to set a wheel in between the choices? It doesn't work. Flexible systems provide a series (large or small) of fixed alternatives from which the user can choose. For instance, the user may select a graphical or a tabular format to view his or her information.

Custom-tailored Systems Fit A Specific Situation.
As in the tailor illustration in Figure 1.5.1.7.4., a system can fit the user if it is *custom-tailored* for him or her—even if he or she has a funny shape. The modern concept of windowing is a feature of a flexible system, not of an adaptive or adaptable one.

Responsive Systems Employ Artificial Intelligence.
The examples in the figures are responsive

systems not expert systems. A responsive system is an intelligent system, although not expert. We say a dog is intelligent if the dog performs routine tricks based on habit (See H.A. Simon.) learned though repetition. Responsiveness includes three characteristics: 1) timeliness—computer-based systems have shown this characteristic for years, 2) ability to observe and understand who manages and/or what is managed—the manager and the operation collectively constituting the user, and 3) the ability to interpret the user and eagerly and willingly carry out the user's wishes.

Responsiveness implies reasoning power and the ability to monitor and interpret; those are measures of artificial intelligence. The characteristic we call *user friendly* is the facade of responsiveness. The user *sees* user friendly but *experiences* responsiveness. Not only should people be responsive, but the decision support tools we use should be responsive to both who manages and what is managed.

All part of artificial intelligence, expert systems replicate an expert, responsive systems suit the user. Key features of expert systems include the abilities to make inferences and judgments, to deal with ambiguous and incomplete information, and to justify their conclusions with detailed explanation of their *reasoning* process. Expert systems won't do much for strategic-level endeavors, but responsive systems will. "The more expert the expert, the less logical his reasoning and the less he's able to describe how he works." (Robert Bernhard, Sr., Technology Editor, Systems and Software, July 1984).

Mike Sallada in my management systems engineering class connected the categories of systems to the endeavors framework described in Module 1.4.5.4.1. He wrote, "I think we are in a number of places on the evolutionary chain. Certainly we currently have and continue to develop custom-tailored systems. I think this is especially apparent in large main frame systems. I know the main frame was supposed to be dead, but just look at IBM's financial reports and it becomes apparent that the prognosticators were wrong. In smaller client server environments we frequently waiver between flexible and custom fit systems. Many times the off the shelf system has to be modified to fit the environment. Much of our development is currently in two areas, object oriented code and reusable code. Together they allow a system to be both flexible enough to be used in more than one organization, for more than one purpose; and the custom fit desired for each system. Adaptable systems seem to be the highest level we have currently approached for the mass market. With Windows 95 you can have the machine adapt to your preset requirements by your sign in password. I am not aware of any adaptive systems currently available, although we have discussed them in class. I think it is interesting that the further up the clerical-operational-tactical-strategic spectrum of the system; the lower we are in the range of custom-tailored, flexible, adaptable, adaptive spectrum."

In conclusion, we note that the cost of successful (adaptive, adaptable, flexible, or custom-fit) systems increases with sophistication and decreases as technology advances. Given the state of the art, the required sophistication, and short economic life caused by dynamic technology, right now we can't afford to be as successful as television commercials and computer zealots would have us believe.

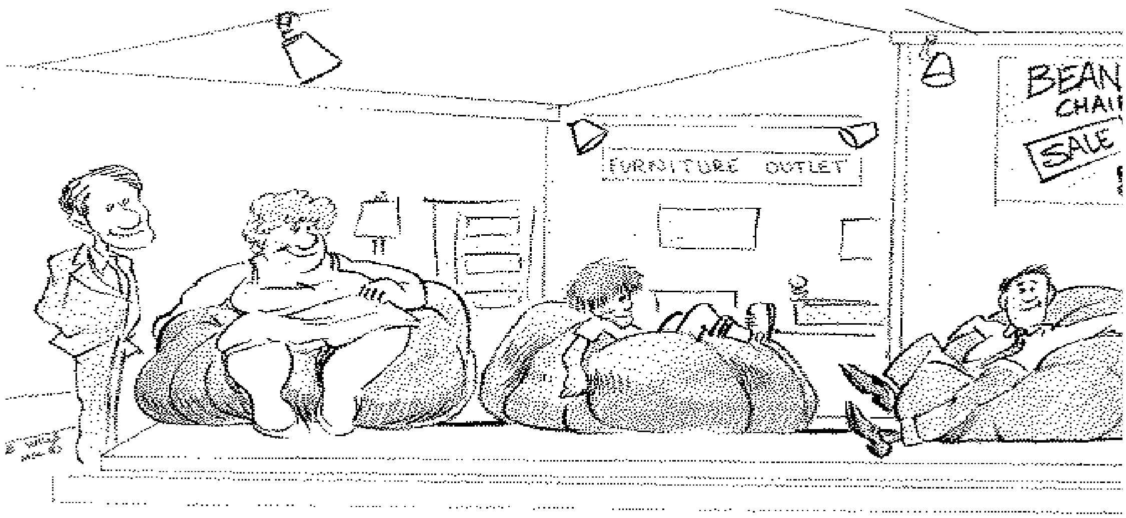

Figure 1.5.1.7.1. *The bean-bag chair inherently adapts to your body.*

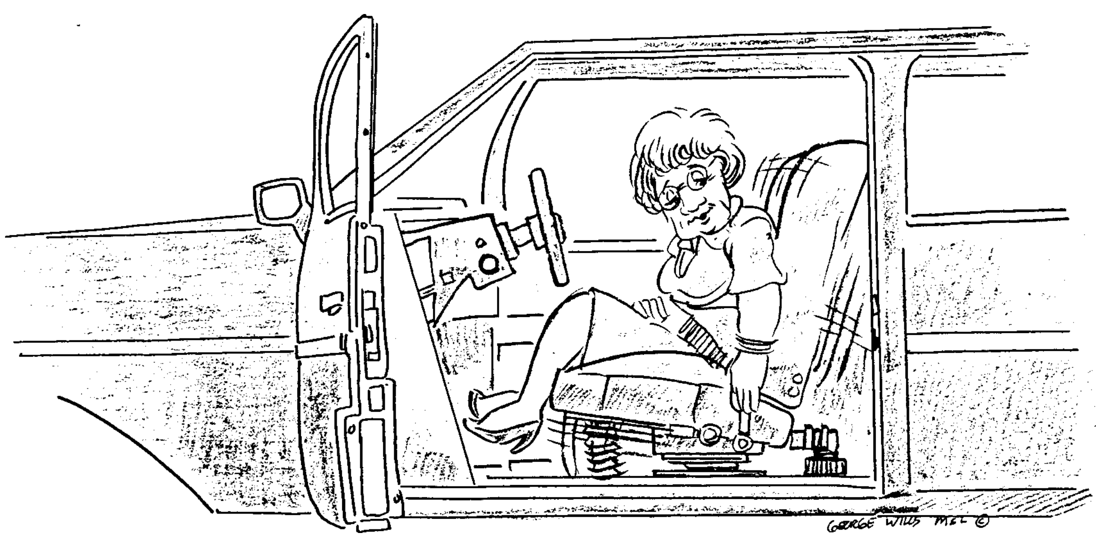

Figure 1.5.1.7.2. *The electric car-seat does exactly what you tell it to do.*

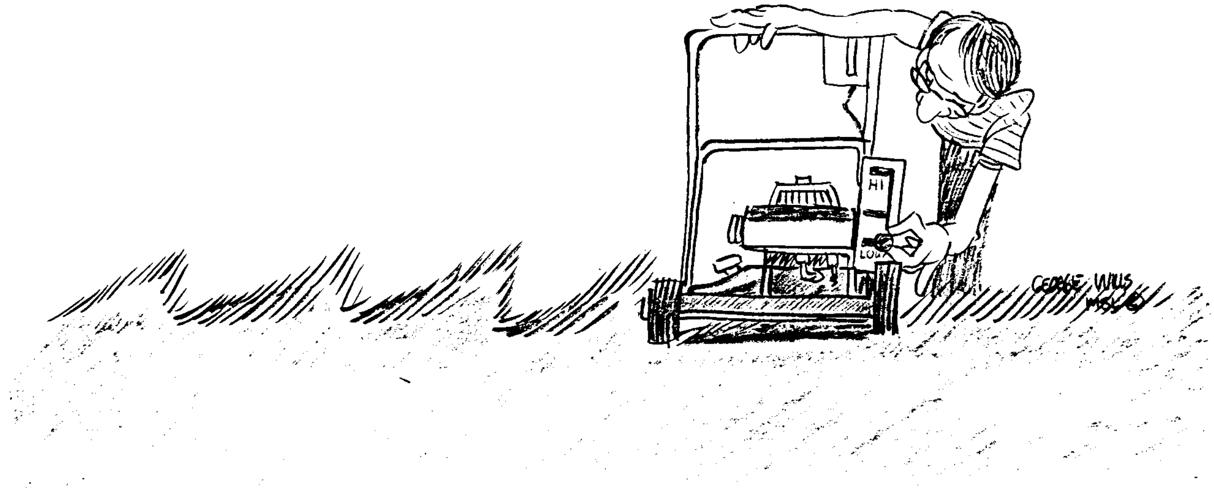

Figure 1.5.1.7.3. *You can choose from one of several options for lawn mower height.*

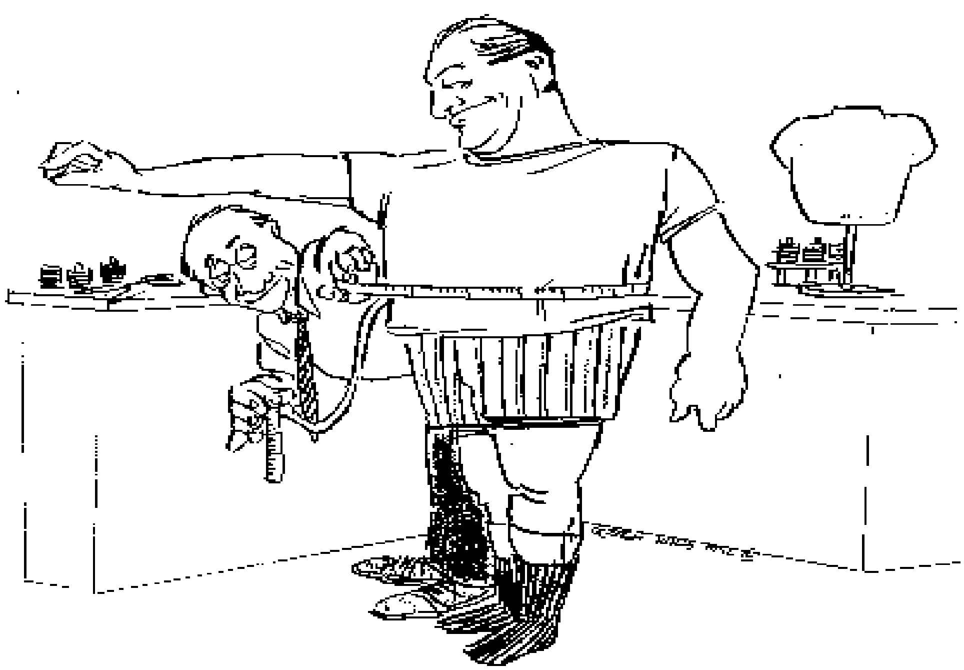

Figure 1.5.1.7.4. *The tailor finds the fit that's just right for you at the time he or she measures you.*

1.5.1.8. Exercise on Management Tools

To improve management tools, you must first figure out what tools are being used and how well they work; then you can determine what tools are needed.

Situation Description
Did you ever wonder where your electric bill went when you sent it to a post office box number? And why your check cleared your bank so fast? Your bill, with check, often goes directly to a bank. The bank sells a service called lockbox. The bank 1) receives the checks directly from the post office (picked up several times a day), 2) processes the checks (in just a few hours), and 3) deposits the money directly in their customer's account (in my example, the electric company). The bank charges the customer by the check processed and the information gathered (activity by date, financial information, etc.). The great advantage to the bank's customer (the electric company) is that lockbox gets your money into their account fast.

The lockbox unit in the bank employs 1) a management team; 2) many image scanning, letter opening, and other processing people; and 3) temporary workers for peak loads. Each worker has detailed procedures for operating their workstation. The management team sets yearly goals and objectives for the unit in an annual operating plan and for the individual in MBO (management by objectives) worksheets. Frequently during the day, at each station in the lockbox process, workers meticulously log work in, work out, and backlog. At the end of the day, the logs are collected and the data are transferred to a computer-based management information system (MIS). Management reviews the MIS first thing each morning with each worker individually. They recognize improved performance through monthly and annual celebrations. Once a year, management meets with each employee individually to appraise their performance against the MBO worksheets.

When a new management associate comes to work, he or she typically reviews and updates workflow charts and tally sheets that model the process. Based on these updates, they can verify they're measuring the right things at the right times and in the right ways.

Exercise
You've been hired to review the lockbox service with the objective of improving management tools. First, you must identify what the management tools are. Then, you must figure out how well the management tools are performing. Prepare a summary of what you expect to find and do.

1.5.2. Performance and Tool Performance

1.5.3. Tool List with Module References

1.5.4. Simplicity and Skill—Paul Gauguin

1. Background

1.5. Tools and Skills Categories

1.5.5. Skills

1.5.5.1. Sorting out Skills to Build and Use Management Tools.

We need a range of skills to manage our domain of responsibility and to build the management tools we need and use the tools well.

Webster defines skill as "the ability to use one's knowledge effectively and readily in execution or performance." (*Webster's Ninth New Collegiate Dictionary*) I won't distinguish carefully among the concepts of knowledge, skill, and ability at this time. Clearly, from the definition, knowledge, skill, and ability work together to help us reach a goal. There must be intellectual skills for performing mental and conceptual tasks and operational skills for performing physical tasks. In the intellectual category, I'll include concepts I've discussed like holistic thinking and being a generalist. In the operational category, I'll include tasks like diagramming organization charts and designing a calendar.

Some skills must be subordinate to others, such as the skill of constructing a Gantt chart being part of the skill of project management. Project management may be more than a skill; it may be a discipline. But, for now, I'll treat project management like a skill. Also, there's probably human-relations skills for performing emotional tasks. How about putting people at ease or promoting a sense of confidence in others as examples of human relations skills?

I'm interested in management tools. Many management tools are implemented using an associated operations tool. For example, we implement the data-to-information chain as a conceptual management tool usually with an associated computer, file cabinet, notebook, or other operations tool acting as a container.

A management tool or operations tool has potential. We exercise the potential (like converting potential energy into kinetic energy) through the guide for the tool, our skill in using the tool and the guide for the skill (in itself a management tool), and the fit of the tool to the situation. For a management tool, we often need an associated operations tool to live up to the management tool's potential. I use the word mechanism for the combination of a tool with its associated guide, the necessary user and operator skills; the fit of the tool to the application; and, if appropriate, the associated operations tool.

A mechanism by itself doesn't guarantee the desired result. We have to consider the systems approach and rules for integrating the mechanism into the system we're working on. In short, using a tool well includes not only the science behind the tool and its use; using a tool well includes art. If we didn't need art, we could consider the illustrative model in Figure 1.1.29.1. to be a map, develop a spreadsheet or procedure for walking through the illustrative model, put the whole thing into a computer, and let the computer automatically manage the domain of responsibility.

We have to fold in art through the skills. As I discuss skills, we'll work on folding in the art of management. Conversely, we can't manage well using art alone. We need to understand the science behind management and the tools we need to manage with. I assume that if we learn, practice, and develop skill for using a management tool, we'll develop technique.

I've discussed a few of the skills we need in management systems engineering in earlier modules. Recall skills like system, holistic, and generalist thinking (skill in the systems approach); personality typing; design; delimiting a domain of responsibility; analysis and synthesis; and writing, reading, speaking, and listening (skill in communicating). In the next module, I'll develop six categories for skills. We can use the categories to sort out the many skills we can think of into generic groups to help us use and understand the skills and watch out for skills we can't think of. When considering management tools, we can think of hundreds of specific tools, like time management tools. We're better off understanding categories of tools and using the specific tools as examples of the categories. The same approach helps us with the many specific skills we can think of.

After developing skills categories, I'll concentrate on systems analysis skills for building management tools. Later, I'll discuss skills for using management tools, especially in regard to the rules that help gain skill in using the management tools synergistically together. Figure 1.5.5.1. lists a number of the skills I'll discuss in this book. I've neither distinguished importance nor signified emphasis in the book among the skills.

EXAMPLE SKILLS ILLUSTRATE THE BREADTH OF ABILITY MANAGEMENT SYSTEMS ENGINEERS NEED.

- Systems approach
  - System perspective
  - Holistic perspective
  - Generalist perspective
- Systems integration
- Capturing the work process and charting
- Understanding life cycles
  - Framework for the engineering process
  - System development life cycle
  - Project management life cycle
- Information gathering
- Analytical thinking
- Analyzing information flow
- Evaluating systems
- Consensus and group dynamics
- Communication
- Information sharing
- Modeling systems
- Diagnosing problems and solutions
- Relationship building
  - Typing personality
  - Diagnosing interpersonal cycles
  - Resolving conflict
  - Coaching
- Information portrayal (Output design)
- Distinguishing data and information
- Imaging
- Input design
- Storing data
- Measuring performance
- Control for quality
- Dealing with change
- Leadership
- Project management
- Crisis management
- Iteration and recursion
- Hierarchical decomposition
- Using charts and graphs
- Using models
- Balancing analysis and synthesis
- Problem solving
- Facilitation
  - Building consensus
  - Building effective teams
  - Supporting empowerment

Figure 1.5.5.1. *I'll discuss skills for building and using management tools in upcoming modules.*

1.5.5.2. MANAGEMENT SYSTEMS ENGINEERING SKILLS CATEGORIES—SHOWING INTERRELATIONSHIPS.

You need a synergistic set of skills to help you play various roles for management, for leadership, and for management systems engineering.

We know we need to develop skills to be successful in managing our domain of responsibility. During a work day, the number of different skills we use is huge. Some of the skills are simple motor skills, like penmanship. (I mean the fundamental motor skill of making letters on a page.) Others are complex intellectual skills, like writing for thinking (writing things down) and writing for communication (writing things up). Editing is another complex skill we tend to overlook but is extremely important in our work. Typing is a skill all of us will need more and more as we deal with computers. I'm now composing at a keyboard. I can think faster than I can type. The better I am at typing, the less I forget as I think through this module. Spelling and punctuation are skills we can get help with from new office automation tools. My word processing package has a speller.

As we consider one important skill in applying both the engineering and the management processes—communication—we realize we're dealing with hundreds of associated skills. I just listed a number of simple and complex skills for writing. What about skills for reading, speaking, listening, interpreting body language, and so on?

To help get a grip on the many skills we can apply to improve our work, I'll develop a set of categories, like I did for management tools. I show these categories in Figure 1.5.5.2. For each category, I've included representative skills. I've included six categories, one for skills that cross-cut the other five categories. As we can see from the description of skills I just made, many of the skills work together. Typing helps me write things down. Spelling and punctuation help me write things up in that if people are distracted as they read through my spelling errors, they won't receive what I send very well. I won't communicate well. Since communication is but one of the important skills for engineering and management, we can see that we need a huge number of skills to work together synergistically to be a good management systems engineer.

In Figure 1.5.5.2., I took the first three categories of skills from Mintzberg's categories for things managers do. Mintzberg says "The classical view says that the manager organizes, coordinates, plans, and controls; the facts suggest otherwise." To Mintzberg, the facts suggest that "....formal authority gives rise to the three interpersonal roles, which in turn give rise to the three informational roles; these two sets of roles enable the manager to play the four decisional roles." (Henry Mintzberg, *The Manager's Job: Folklore and Fact*, Harvard Business Review, 53:4, 1975, pp. 45-61.) I described these roles in Module 1.3.1. You need skills to perform these roles. I've shown three categories of skills to include interpersonal, informational, and decisional skills.

Since the idea of a process is so fundamental to what we do as management systems engineers, I believe we have to develop skills attuned to the understanding, construction, and operation of a process. The management system, or organization, includes a number of processes, including the work process and the management process. I therefore include a category for organizational, or process, skills. Some skills are very conceptual and require a way of thinking or a way of looking at the world. I call those attitudinal skills. Ultimately, attitudinal skills may include the attitudes for human relations skills we act out through our interpersonal skills.

Just as you need to know what tool fits what situation in management, you need to know what skills apply to the situation. The classification in Figure 1.5.5.2. gives you a structure to think about and sort out the skills you need. If your skills are strong in one category and weak in another, you run the risk of not having a balanced approach to your work. For example, if you're strong at interpersonal skills, but weak at decisional skills, your people will want to work with you but will be frustrated because you have trouble closing the loop in the management process.

I believe you can learn all skills mentioned in this book. Simon speaks directly to learning management skills. He says, "...the important skills of [a manager] are decision-making skills. It is generally believed that good decision makers, like good athletes, are born, not made. The belief is about as true in the one case as it is in the other...A good [manager] is born when a [person] with some natural endowment (intelligence and some capacity for interacting with his fellow men) by dint of proactive, learning, and experience develops his endowment into a mature skill. The skills involved in intelligence, design, and choosing activities are as learnable and trainable as the skills involved in driving, recovering, and putting a golf ball." (Herbert A. Simon, *The New Science of Management Decision*, p. 4.)

Likewise, Flesch contrasts a special talent with an acquired skill. When talking about how hard people find imagining an audience when sitting down to write, Flesch says, "But it isn't a special talent you're born with—it's an acquired skill. You can learn it—just as thousands and thousands of ordinary tongue-tied people have learned to stand up before an audience and talk to them for five or ten minutes without making a complete mess of it." (Rudolf Flesch, *On Business Communications*, Barnes and Noble Books, 1974, p. 4.) I have yet to figure out something we truly have a special talent we're born with. However, I do notice some people tend to acquire some skills faster than other people. I think this acquisition is easier for people with a predisposition for certain abilities. Perhaps if you are tall and have a strong voice, you'll acquire a public speaking skill easier. However, I believe you can work to strengthen your voice—but not grow taller, yet.

You can't be perfect at everything you do. But you need to know your strengths and weaknesses and work for balance in applying skills to the workplace. You have two options for covering your weaknesses. One option is to learn new skills and improve old ones. You can, in fact, make a weakness a strength by learning new skills. I believe you can improve your skills at anything, including holistic thinking, leadership, and communication. These skills take time and effort to improve, but the result is worth the effort. An interesting aside is that for skills like these, you can improve in many different ways. You can improve leadership skills by independent study of leadership and of recognized leaders, by taking a course, or by gaining experience through volunteer efforts in the community.

Your second option is to recognize and then cover your weakness by working with someone skilled in areas you aren't. I've found I have to balance my options at covering weaknesses. I've decided to learn how to write better and I've decided not to learn how to deal with bureaucrats better. I study and practice writing skills. I hire people into my organization who are good at dealing with the bureaucracy.

The bottom line is that you should continually assess your skills. You need to determine your skill levels as accurately as possible. Then you can figure out where you want to improve. Every day you're not improving one or more of your skills is a day you slip behind in being an effective engineer or manager. Do you know which skills you're improving today? Are they the skills you need for balance?

CATEGORIES HELP SCRUTINIZE OUR SKILLS
TO DETERMINE HOW TO IMPROVE.

Interpersonal
Leadership, consensus/NGT, communication, MBTI

Informational
Information gathering (monitor), information dissemination/information sharing, data dictionary, information portrayal, distinguishing data and information, images, modeling the system, input design, file design, storing data

Decisional
Evaluating systems (cost/benefit), measuring performance, control for quality, crisis management

Organizational/Process
Understanding life cycles, information flow (DFD), records management, process definition and scope, integrator role, project management

Attitudinal
Holistic thinking, generalist thinking, analytic thinking, dealing with change, integrating

General skills—cross-cut the others
Iteration and recursion; hierarchical decomposition; use of charts, graphs, and diagrams; use of models; balancing analysis and synthesis; creative skills; problem solving

Figure 1.5.5.2. *For effective management, you need a closed set of skills, working together synergistically to support your decision making process.*

1.5.5.3. Skills for Understanding and Building a Management Tool

You need specific skills to carry you through the system life cycle for building a management tool.

I'll overlay skills for building management tools on the system life cycle discussed in Module 1.1.20.1. I call these skills analysis skills because we're analyzing what we're doing. I call the skills *system* analysis skills because that's what management information system (MIS) developers call them and what they're analyzing is a system. I'm as interested in describing system analysis skills as I am in describing the details of the functions of the management-tool-building process. The data-to-information chain is very analyzable. The functions of the MIS and the steps for its development are relatively easy to describe and to evaluate. I believe the skills we need for MIS development are also the skills we need for developing any management tool. Therefore, I'll have MIS development in mind as I continue through this module.

We must look at the life cycle of the project, product, or process we're building. Assume we're building an MIS. We must consider MIS development starting with recognizing the need and continuing through to the MIS's obsolescence, retirement, and disposal. We must think about the resources, like cost and people, the MIS will require. We also must think about the contribution (positive and negative) the MIS will make for its entire life. Most of our consideration for the MIS life cycle will focus on the system life cycle. My discussion of the system life cycle constitutes something perhaps larger than a skill—at least a group of skills. However, I'll consider understanding the life cycle to be a skill. You can apply this life cycle analysis skill to more than just MIS development. You can apply it to any service or product you're responsible for.

We'll start with understanding the life cycle for system development. How do other system analysis skills relate to the framework for the engineering process shown in Figure 1.1.11.7. Start with the five categories of functions: analysis, design, implementation, follow-up, and follow-through. Realize the skills can't be neatly directed to only one of the categories shown in Figure 1.1.11.7. I identify fifteen of the most important skills and overlay them where they best fit in the five MIS development categories of functions. You can expect to use the skills I've shown in relation to functions of one category when you're doing functions of the other categories. Here are the fifteen skills I discuss as system analysis skills:

1. Communicating to get information about and to give information to stakeholders of the management tool and recognizing the importance of documentation for traceability, maintainability, and accountability;

2. Interacting in groups for participation, consensus, and ownership;

3. Understanding the engineering process framework, or the system life cycle, for developing the management tool;

4. Understanding the work process (what is managed) to be reflected in the management tool;

5. Understanding the decision maker (who

manages) who'll be using the information produced by the management tool;

6. Gathering information or collecting data about the work process or the decision maker;

7. Analyzing the information flow overlaying the work process and modeling the operation, or manipulating and analyzing data about the layout of the work process;

8. Modeling the management system;

9. Getting data into the management tool, (or what is used to manage), or input design;

10. Storing, verifying, and updating data within the management tool, or logical data analysis;

11. Organizing and accessing data within the management tool, or file design;

12. Portraying information from the management tool, or output design;

13. Controlling for quality, including reliability design;

14. Evaluating the system, including cost/benefit analysis; and

15. Managing a project.

In the next modules, I'll review the role of people who practice system analysis skills and the general skills they use for sequencing and integrating the system analysis skills I've listed here. I'll re-emphasize the systems approach as a cross-cutting skill for building management tools. Then, I'll focus on the first and most important of all the skills—communication. I'll expand upon sending information by discussing the writing skill in some detail and showing parallels with speaking. Then I'll discuss listening as the crucial skill for communication. After straightforward communication, I'll address the second skill of interacting in groups. After the first two skills, the following skills become more tangible.

1. Background

1.5. Tools and Skills Categories

1.5.5. Skills

1.5.5.4. System Analysis

1.5.5.4.1. Role of System Analysis

The role of the system analyst is to use systems understanding and problem solving skills to build management tools to meet the needs of the decision maker in his or her domain of responsibility.

Why am I discussing the role of a system analyst in the middle of outlining skills we need to build and use management tools? We play roles to meet responsibilities. We use skills to carry out our roles. Roles are vehicles your skills ride on as you journey toward accomplishing your responsibilities. (See Figure 1.5.5.4.1.)

The who manages component in the MSM uses decision making, problem solving, and other skills as they play leadership, administrative, liaison, and other roles. I discuss the system analyst role in regard to building management tools; but the role and the associated skills are applicable to making good decisions.

The who manages and the information specialist coordinate efforts at the information portrayal/information perception interface and the measurement/data interface. In participating in this coordination, the information specialist needs to play the role of system analysis. And, so does the manager. The role of system analysis is traditionally discussed in reference to developing computer systems. I expand the role to building any management tool and to managing any domain of responsibility.

The system analyst is a problem solver. The idea of a system analyst and the role of system analysis comes from developing computer systems. Computer system analysts focus on building computer systems more so than using computer systems. Therefore, the role of system analysis is more an analysis role than an holistic or a synthesis role. In computer systems, we leave the integration or synthesis to the user. To build any management tool, you'll need to apply system analysis skills.

Often discussed in books on developing computer systems, skills for system analysis work together to solve the problem of getting the right information to the right people in the right place at the right time. These system analysis skills apply to developing any management tool. We can extrapolate the use of these skills even further. If you're going to analyze any system, you need system analysis skills. As management systems engineers, we must have skills both in analysis and in synthesis. I'll discuss the role of system analysis here. I'll discuss the problem solving process in Module 1.5.5.6.

In their handbook of systems analysis, Miser and Quade rightfully describe the nature of system analysis as being quite complicated. They first list a number of difficulties in carrying out the role of system analysis. Their list includes: 1) inadequate knowledge and data, 2) the involvement of many different disciplines, 3) unclear goals and shifting objectives, 4) pluralistic responsibilities, 5) resistance to change in social systems, and 6) complexity. (Hugh J. Miser and Edwards S. Quade, *Handbook of Systems Analysis: Overview of Uses, Procedures, Applications, and Practice,* Elsevier Science Publishing Co, New York, 1985, pp. 14 - 15.) The system analyst then must be a quick learn, have vision, be an integrator, be adaptable to change, and be skilled at human interaction.

Miser and Quade approach system analysis generically, not only as a computer development role. They argue that a system analyst approaches a problem in terms of these elements: 1) Setting the framework for systems analysis (defining objectives and generating and ranking alternatives for reaching objectives by involving iteration and feedback); 2) Formulating the problem (stating the objectives and constraints); 3) Generating and selecting alternatives; 4) Forecasting future states for the system; 5) Identifying the consequences, or outcomes, including the use of models; 6) Comparing and ranking alternatives, using criteria and including value and utility; and 7) Documenting the analysis and results. (pp. 119 - 145.) The value to you in seeing their approach is to compare their approach to the engineering method I'll describe in the next module and to the steps of problem solving I'll describe in Module 1.5.5.6. You'll notice that the process and skills of system analysis are essentially the process and skills of solving system problems.

The system analyst must combine both technical skill for developing the components and the relationships of the components into a working management tool and interpersonal skill for working with the user of the management tool, or the decision maker. The system analyst must have imagination, flexibility, and adaptability to develop the management tool to meet the needs of an unique domain of responsibility, regardless of the resource available to him or her. For building management tools, the system analyst must be able to identify the needs of the user and to have the knowledge and experience to overcome barriers and create pathways to meet those needs.

To begin developing a management tool, the system analyst must be able to delimit, learn, and diagnose the domain of responsibility and understand the user of the management tool. Our previous discussions on delimiting domains of responsibility, the information portrayal to information perception interface of the MSM, and the frameworks for diagnosing a domain of responsibility provide a starting point for developing the management tool. Now, we must figure out more about the work process and the aim of the domain of responsibility for which we're developing the tool.

In the next module, I'll describe the role of the system analyst through an example. I'll use the example of a small country inn because I've owned and operated a country inn and am familiar with the management needs.

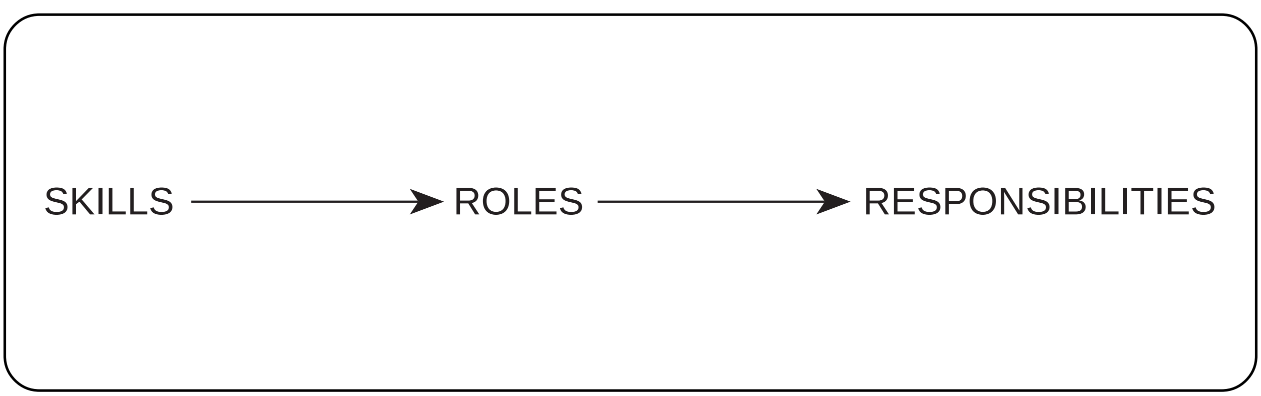

Figure 1.5.5.4.1. *Roles are vehicles your skills ride on as you journey toward accomplishing your responsibilities.*

1.5.5.4.2. An Example System Analysis Effort

By considering how a system analyst can help the business of a small country inn, we can see the use of the steps Where We Are, Where We Want To Be, and How To Get There—a form of the engineering method.

I'll describe the need for system analysis to build a detailed understanding of the work process and the aim of the organization through an example. The example I choose is one of a family-owned country inn. As I describe tasks of system analysis, note that these considerations don't contain any definition of computer processing.

First, as a system analyst, you must delimit, learn, and diagnose the domain of responsibility. You must find out how the innkeeper and the owner of the inn are getting information now and learn what's working well. Make sure what you do preserves the characteristics of the successful parts of the existing system for getting information. In this role, you're figuring out the situation in the domain. I say you're looking at Where We Are. You must know Where We Are (WWA) and Where We Want To Be (WWWTB) before you can begin to know How To Get There (HTGT).

Many system analysts focus on what's wrong with the existing system for converting data to information. A good system analyst focuses on what's right with the existing system. To understand what's right, the system analyst should walk through the work process and the information overlay to the work process. In the country inn, experience the work process from the point of view of the traveler. Experience the work process from the point of view of a worker. Experience the work process from the point of view of the innkeeper. Learn the reservation process. Learn the other parts of the work process.

How are data gathered and recorded? If data gathered last week must be retrieved to change a reservation, how well can the innkeeper find and use the data? What's happening is that the system analyst is experiencing the physical reality of the innkeeping system. Then, the system analyst must translate the physical reality into a logical model of the inn and its process. The model should emphasize the handling of data and the conversion of those data into information that will be perceived by the decision maker for making decisions and taking action.

As part of WWA, you must understand the needs and forces that both the innkeeper and the owner have for the management tool being developed. They won't express these needs and forces in terms of tool characteristics. Rather, they'll have needs in terms of occupancy rate, cash flow, and absenteeism of workers.

As part of WWWTB, you must understand the expectations and vision of the innkeeper and owner. Can you translate those expectations into functions a management tool can serve? Determine what the expectations of the innkeeper and of the owner of the inn (different people) are for what the management tools will provide in the way of information to support decision making.

One of the bigger skills a system analyst must have is to translate physical issues of the workplace into logical counterparts for management tool design. In the country inn, where will the management tool be housed? Is the tool easily accessible? Can those who need to use the tool understand what the tool can do? Then, can they use the tool? Can you build the management tool for a cost a small country inn can afford? When you add in a computer to house the data to information conversion process, the cost can become prohibitive. Do you know inexpensive ways to house the tool, such as a rolodex, notebook, or marker board? In addition to being able to function in terms of data, information, and mechanisms for converting data to information, the system analyst must understand business issues and how to translate those issues into tool characteristics. The system analyst must be able to judge quickly to what extent the mechanization of the needed data to information conversion needs to be.

After the system analyst knows what's right with the existing system and what's needed in the future system, then the system analyst can look for ways to improve the system. Now we're looking at HTGT. The system analyst will find opportunities for improvement at two levels: physical and logical. Consider an example of translating a physical issue into a logical one for a computer-based management tool as described by Powers, Adams, and Mills. "...suppose a hotel does a considerable part of its business with tours. Under the existing reservation system, tours are booked as a unit. When reservations are reported to the local hotel, however, cards are broken out in the names of individual guests. The fact that these guests are tied to a single tour is lost, creating a gap in information that might be useful to management. For example, suppose a hotel in southern Florida learns that a snowstorm has caused cancellation of all flights from Pittsburgh. Suppose further that the hotel had 20 guests in a single tour scheduled to arrive from Pittsburgh. If the card had already been broken out by guest name, it would be difficult to locate the unavoidable cancellations. However, a computer system could quickly search for and report the names of all guests who would not be arriving. The added dimension of information made available to management represents a system improvement achieved at a logical level. Timely information about business problems makes it possible to understand, anticipate, and react to situations that would not come to light under present methods. The ability to get information into a computer immediately represents a substantial improvement at the physical level. Rooms status is more current, by hours, than was possible under the manual system." (Powers, Adams, and Mills, *Computer Information Systems Development: Analysis and Design*, South-Western Publishing Co., 1984, p. 36.) My recent experience with a hotel and its computer-based management tool runs in the opposite direction. The desk clerk enters information from the registration card into the computer when the rush slows down. In the meantime, those people trying to call me on the phone are told I'm not at that hotel. The system analyst can never lose the translation between the physical and the logical.

Opportunities for improvement in management tools come from closing gaps. When we look at WWA, we want to close performance gaps. Are we doing what we know we should be doing? If not, we have a performance gap. When we look at WWWTB, we want to close expectation gaps. Are we doing what we want to do to improve. If not, we have an expectation gap.

When we introduce a new management tool into the country inn, we'll affect their work process at a physical level. The innkeeper will adjust how he or she takes reservations to reflect the abilities of the management tool. When we introduce the new tool, we'll affect the information flow at a logical level. The management tool can link information not easily done before.

Before any management tool can be designed and implemented by a system analyst, the innkeeper and the owner must be able to see what the resulting effect will be on their business. If they don't see a worthwhile return on their investment in time, money, and frustration of changing their work rituals to fit the new management tool, they'll not agree to developing the tool. We can always find hardware (tool container) and software (data to information conversion procedure) that exceed the ability of the innkeeper and the owner. Can we find the operations, the work procedure, and the information portrayal to come close to the ability of the innkeeper and the owner? If we can, we'll probably succeed as system analysts.

As we consider the role of computers in management tools, consider two needed considerations. One is to figure out how soon and how well the computer (the associated operations tool) fits into the solution of the country inn needs. Computers certainly don't fit into figuring out the problem. The other consideration is to figure out the solution not based on computers—then fit computers into the solution, if appropriate.

1.5.5.5. General Skills of System Analysis

You need certain general skills to do the system analysis to build a management tool.

In Figure 1.5.5.2., I identified a category of general skills for cross-cutting the other categories of skills. These general skills are extremely important for supporting the role of system analysis. Those who discuss building management tools and especially those who discuss building computer-based management information systems (MIS) promote the process of system analysis. Some people prefer the structured system analysis process of Edward Yourdon. (I'll show you some of Yourdon's ideas later.)

I've discussed the importance of balancing synthesis with analysis and of balancing holistic thinking with analytic thinking. I accept the need for balance, but will focus on general skills for system analysis here. You can imagine that a structured system analysis would be the height of analytical thinking.

I've also discussed the parts of the Management System Model (MSM) the manager (tool user) and the information specialist (tool builder) know best and the interfaces at which their expertise overlaps. I'll emphasize the view of the information specialist, or system analyst, here. (We have to be careful to recognize that information specialists aren't the only people who analyze systems. However, as a job title, system analyst often designates the analyzing of information systems.) Don't forget that the general skills are valuable for much more than system analysis. However, if we're going to focus on building management tools, system analysis for building an MIS is a good place to focus. The MIS tends to be the more structured of the management tools and makes a tangible example for considering the general skills.

Information specialists, or system analysts, should consider all management tools and how they together convert data into information to support the decision maker. However, I'll emphasize the analysis of the data-to-information chain here because that type of tool is both structured and representative. The MIS is exercised as a tool more frequently than a plan, for example, even though the data from the plan (what you intend to do) and from the MIS (what you did do) should be compared frequently (to see how well you did what you intended to do).

The skills of system analysis go beyond building management tools. Analysis of a system goes hand in hand with synthesis of a system. There's no sense in doing synthesis if there's no analysis. For example, can you use a management tool if you don't build one? As I described in Module 1.5.5.2., one of the categories of skills we need in management system engineering is the general skills that cross-cut the other categories. These general skills include iteration and recursion; hierarchical decomposition; use of charts, graphs, and diagrams; use of models; balancing analysis and synthesis; creative skills; and problem solving.

The system analyst provides a service function to support a user. A system analyst is a professional. Service professionals serve clients. Clients depend on those services. The system analyst role is an important one.

As we apply these general skills to help provide the decision maker with the information he or she needs, we can thoughtfully ask: Why the decision maker doesn't use these skills to provide his or her own information? Why doesn't the decision maker use their knowledge of their own decision making style and their operation to develop the best tools to meet their needs? The answer is that the management tool builder has several advantages over the decision maker. First, the tool builder deals with many different domains of responsibility. If the tool builder is a generalist, he or she can transfer many lessons learned from one domain to another. The tool builder is better able to understand the frameworks for diagnosing the domain based on using the frameworks for a large number of domains. Second, the decision maker often can't see the forest for the trees. He or she is so involved with the details of the domain and the decisions, he or she lacks the objectivity of seeing the total system and seeing that system from a fresh perspective. Third, the tool builder has developed experience in effectively and efficiently developing management tools. However, the tool builder, and anyone practicing system analysis, needs a set of general skills to apply to any situation.

Iteration and Recursion

In analysis, we decompose the whole into its component parts. We'll learn a number of skills and techniques for looking at the details of a system. We can repeatedly apply the techniques to look deeper and deeper into the system. We repeat the techniques iteratively or recursively. When we use iteration, we recycle through a closed-loop process. In the case of skills, we reapply the skill in the same way over and over to the increasingly detailed understanding of the system. For example, we can look at information flows across the boundaries of a domain of responsibility like we did in developing context diagrams. We can reapply the technique of developing information flows by treating the partitions of the domain as individual context diagrams. When we use recursion, we go back or forward in a closed-loop process by skipping steps in the process. We can repeat all of the steps or only the last few. We can skip ahead to future steps of the process. We saw this recursion when we looked at conducting management system analysis and management system synthesis together.

Later I'll describe a partitioning process you can use to determine the subdomains in your domain of responsibility. You'll repeat the partitioning activity again and again until you can distinguish the fundamental information flows within your domain. You took the first step in this iteration when you scoped a domain of responsibility in Module 1.1.18.8. Clearly the idea of partitioning is hierarchical decomposition and is analytic, not holistic.

Hierarchical Decomposition

In hierarchical decomposition, we decompose the whole into its component parts and those components into their component parts. We are dividing, or partitioning, each system or process into its subsystems or subprocesses repeatedly until we reach what we believe are manageable pieces. We'll use hierarchical decomposition when we look at information flows inside the domain of responsibility. If we partition the context diagram, or the management system, into its subdomains or subsystems, we can look at the information flows between these subdomains. Then, we can partition the subdomain further and further until we have no need to decompose any more. At that point, we believe we have all the information flows in the organization and can then identify the data set that makes up all the information used in the organization. We abandon the decomposition when we clearly understand the fundamental parts of the system.

Use of Graphs, Charts, and Diagrams

We'll use diagrams to help us iterate through hierarchical decomposition to find the fundamental information flows. Graphs and charts help us see the entire system. Since to touch a system anywhere is to touch the system everywhere, we need to see the entire system to decide where to touch it. We need to diagram, or chart, the work flow to see where we want to measure. We need to diagram the entire organization to see the individual information flows to determine the set of data from which we make all the information. We need to graph the total effect of an impact on a system to see the effect of an individual force, as in the example of a force field analysis or a cause and effect diagram.

Graphs and charts are very effective as communication tools. System analysts use graphs, charts, and diagrams to describe the organization for the user to confirm. I've shown a relatively simple data flow diagram, describing the processing involved in a student registration system, in Figure 1.5.5.5. We can use Figure 1.5.5.5. to communicate with people responsible for registration or for students who register to make sure we've captured what really goes on in the system.

Charting is an important tool for both the manager and the information specialist. The manager does a work flow chart to understand and improve his or her operation, or work flow. I'll discuss work flow charts in detail when I talk about using management tools. The system analyst does a data flow diagram (DFD) to understand and improve the data and information provided to the manager. I believe a DFD is really an information flow diagram, in that the DFD captures the information flows in the organization. Another tool, the data dictionary, identifies what data are carried along with the information flows.

Recall the diagram for the framework of the engineering process in Figures 1.1.20.1.1.a., and 1.1.20.1.1.b. Those figures are much like a data flow diagram, in that the arrows symbolize information flows between functions of the engineering process. You should see some similarity between the DFD in Figure 1.5.5.5. and Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. Figure 1.5.5.5. shows three sided boxes for data stores. Data stores are where you store data for later access, like a computer data base or a file cabinet. (Figure 1.1.20.1.3. is much like a work flow diagram in that the figure includes both decisions and actions.)

Use of Models

We've seen how we use models for showing the organization and for showing performance criteria in the illustrative model. We've discussed the types of models. Here, we're interested in modelling as a general skill and the use of models to help build management tools. We can use equations or diagrams as a model. An organization diagram models how people interact in an organization. A data flow diagram models how information moves in an organization. A work flow diagram models how the activities of the operation fit together. We use models as graphic, written, or visual representations of the system we're analyzing.

Balancing Analysis and Synthesis

I discussed the meaning and importance of analysis and synthesis in a general definition module. The issue here is that we can't do one effectively without the other. Just as we combined management system analysis and management system synthesis, we get more out of doing one of these skills when we're able to do the other.

Consider an analogy from Powers, Adams, and Mills. "When an architect develops a home for a client, a process takes place that begins with a description of the life-style to be supported and special features desired. From this description, the architect visualizes a way to meet the client's needs. Before breaking ground to construct a building, however, some modeling must take place. This is done with blueprints, detailed drawings, and, in cases, actual miniature models of the buildings. In the same way, data flow diagrams and the supporting data dictionary model a system conceived in the mind of a systems analyst for a user. Models, then, are tools for communication and understanding." (Powers, Adams, and Mills, *Computer Information Systems Development: Analysis and Design*, South-Western Publishing Co., 1984, pp. 53-54.)

Creative Skills

The system analyst must strive for ultimate understanding of the workings, needs, and issues in the existing system (WWA) and for creative, visionary thinking for the workings in the future system (WWWTB). Using creative skills, the system analyst can figure out the best way to transform the existing system into the future system. This transformation is partly content and structure of management tools and partly communication with and support of the people who will be affected by the transformation and will be threatened by the change.

One of the biggest problems facing a system analyst is sorting out what's right with a system and what needs to be changed. This problem requires the builder to put aside his or her desire to be creative and make sure he or she doesn't propose change for change sake. Once the system analyst knows a change is clearly needed, then he or she can use creative skills to make the change without undoing what's working well. He or she must know when the change is necessary and have the imagination to develop the process and content of the change without being inhibited by what's now in place. The system analyst faces an interesting paradox: Respect the value in what exists and improve the system.

To illustrate the level of creative thinking required in deciding the types of changes needed, consider the situation in many government oversight agencies. A government oversight agency is one that's close to the legislative body they serve. The government oversight agency is usually called the headquarters for the many local government implementation agencies located where the work is being done.

I'll use a state department of transportation as an example of a government oversight agency. The government oversight agency is the state department of transportation (headquarters) which is located in the state capitol where the legislative body is. The local government implementation agency is the county highway department that maintains the roads and clears the snow during winter storms. I've found that many government oversight agencies design their organization structure as a management tool to reflect the work that's being done locally. That is, headquarters has divisions for each of the functions implemented at the local level; in the case of the state department of transportation, a division for maintenance, a division for bridges, a division for snow removal, a division for construction projects, and so on. However, nobody at the state level ever maintains anything, constructs anything, or removes any snow. What the government oversight agency does do is broker information. They interpret the desires of the state legislature regarding transportation and make adjustments to the resources allocated to the local agencies to support their interpretation. They interpret the needs and problems of the local highway departments and make adjustments to their proposals and issue statements (usually in the form of budgets) to the legislature to reflect those needs and problems. The government oversight agency brokers information in two directions. But, they are organized as bridge builders and highway construction people, not as information brokers.

Here's where the creativity comes in. How does the system analyst ensure that he or she puts aside his or her view of what's needed to ferret out what's working well in the government oversight agency's organization structure that moves information up and down the state hierarchy? How do you get the agency's decision makers to see the advantages of changing their tried and true organization structure so they can be more effective in their work? Once the decision makers agree to a new organization, how fast and in what way do you transform the organization from its existing structure to its new structure? As the organization goes through the throes of change, how do you encourage, support, and resolve real concerns over the problems caused by the change? To work out the answers to these questions, the system analyst needs incredible understanding of the work process, the management process, and the people being affected. The system analyst must be visionary in seeing and holding onto the vision of what should be and how that future state will work. The system analyst must be creative in not only suggesting how to make the change but in working with the people and resources during the change to support the fear that accompanies any change in job description and in interagency relationships.

Problem Solving

I described problem solving as a general concept in Module 1.1.14.1. and highlighted problem solving as a fundamental of the engineering process in Module 1.1.11.6.4. I'll describe problem solving as a general skill in Module 1.5.5.6.

The system analysis process supports the needs of the system analyst for creativity and for problem solving. The use of models begins with diagramming the physical existing and future system. The system analyst uses the physical model to gather information from those who know the system and communicate the future to those who will be affected by the change in the system. The system analyst must be able to translate the physical model into a logical model needed by those who will build the management tool based on the logical relationship between data and information, not on the physical operation in the workplace. As the transformation takes place, the physical and logical models continue to play important roles for the system analyst.

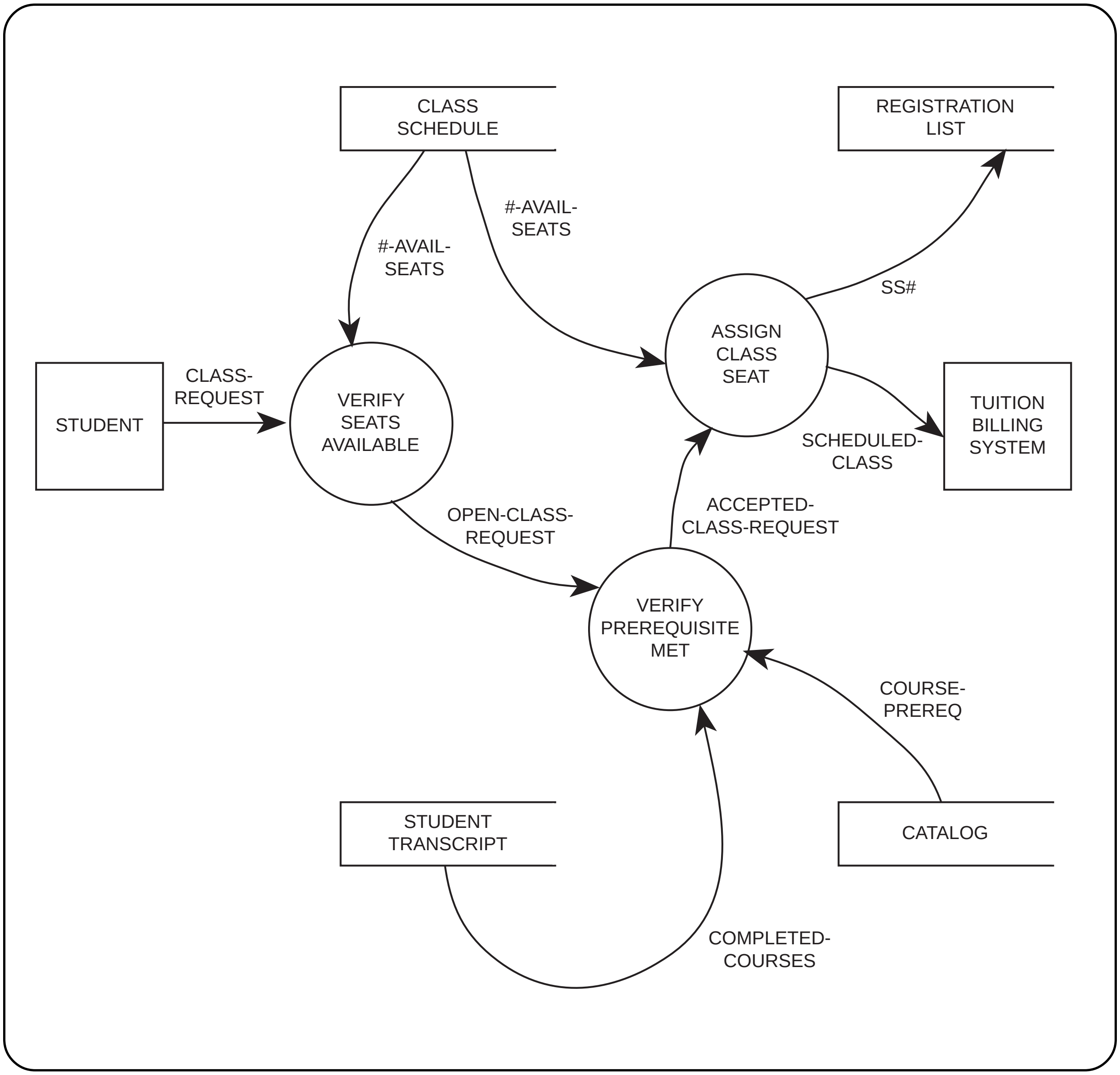

Figure 1.5.5.5. *The data flow diagram for a simplified student registration system illustrates how system analysts model information flows. (taken from Powers, Adams, and Mills, p. 54)* .

1.5.5.6. Skills for Problem Solving

As a fundamental for the engineering process, problem solving is a skill that involves a large number of interpersonal, informational, decisional, process, and attitudinal skills. The steps for problem solving show where the skills fit together.

Problem solving involves making a number of connected decisions, often in a group setting, all aimed at a specific objective. Recall that the decision making process includes the steps of investigation (get the facts), design (develop alternatives), and choice (pick an alternative). The problem solving process involving skills, as well as tools, will follow a similar path to the one for decision making. I've shown ten steps for problem solving in Figure 1.5.5.6.

The first step has to be to figure out what the problem is. This step requires an open mind, a quick learn, and an understanding or experience with other problems and their characteristics. From here on out in the process, be sure not to lose sight of what you decided the problem was. If you made a mistake, redefine the problem. All diagnosing skills are important here.

The second step is to determine the goals (qualitative) and objectives (quantitative) for what a solution means for that problem. Make sure everyone preparing and implementing the solution understands the same goals and objectives. Holistic skills are important here.

The third step is to study the problem. Where did the problem come from? What's its root cause? What are the characteristics of the problem relative to the goals and objectives you determined? What assumptions do you have to make to consider the problem? Analyze the problem. Can the problem be divided into subproblems such that solving all the subproblems solves the problem and achieves your goals and objectives? This question involves the general skill of hierarchical decomposition. What are the consequences of not solving all the subproblems or partially solving some or all of them? Recall that the do-nothing alternative is an alternative. Therefore, you must know the consequences (both good and bad) of solving the problem as well as not solving it. Analysis skills are important here.

The first three steps parallel Simon's intelligence phase of decision making. In the case of problem solving, we're cycling through any number of decisions and the early phases of the decision making process for a number of decisions.

The fourth step is to develop alternatives for solving the problem. For each alternative, consider a strategy for how you'll implement the solution. Many of your alternatives will be part of the solution as opposed to the complete solution. By that I mean one alternative for solving the problem may have a clear beginning but then have a number of alternatives for what to do next. The idea of strategy carries with it the ideas of priorities and contingencies. Which is the highest priority goal? Which alternative has the most or best fall-back position. This step is almost as important as the first step for identifying the right problem to solve. If you overlook a good alternative, you only have sub-par alternatives to choose from. All creative skills are most important here.

The fifth step is to evaluate the alternatives. Develop a consistent set of criteria to measure the alternatives against. Apply your understanding of priorities and contingencies to the alternatives. Identify the resources you'll need for each alternative. Consider the method and its difficulty for applying the resources to the problem. Consider the risks and threats to the organization and its people for each alternative. Procedural and appraisal skills are important here.

The fourth and fifth steps parallel Simon's design phase of decision making. You need to design not one but many good alternatives to choose from. You need enough of a plan for implementation for each alternative that you haven't overlooked a risk or a barrier that will set you back when it rears up after you've chosen a particular alternative.

The sixth step is to choose one of the alternatives. By considering the advantages and disadvantages of each alternative in terms of the method, priorities, contingencies, and consequences of implementing the alternative, you must select the alternative to carry forward as the solution to the problem. Group choice requires an understanding of information sharing and consensus gathering. I discuss those concepts shortly. Decisional skills are important here.

The sixth step parallels Simon's choice phase of decision making. Now you must continue on from your choice and make sure the choice is implemented. In essence, you're following the choice phase with an action phase.

The seventh step is to formalize the action plan for implementing the solution. Through the action plan, you assign responsibilities, dedicate resources, and lay out the method and contingencies for implementation. Part of your action plan must include points to test the choice and the progress of the implementation. You must ensure all those affected by the method for solution have bought in to the need (There is a real problem.) and the solution (The method will work.). Interpersonal and informational skills are important for this step and the next few steps.

The eighth step is to implement the solution. We learned from the Management System Model that every decision requires an attendant action. Now is the time to act. And you must monitor the progress of the solution. Evaluate the solution to determine if you chose the right alternative.

The ninth step is to follow up on the solution. You want to formalize the solution, especially if the problem is recurring. If possible, you want to go to the root cause of the problem and make sure the problem doesn't come up again. If not, you want to ensure you identify the next occurrence of the problem early and apply what you learned from solving the problem before. You don't want to go to all the trouble to figure out how to solve a problem and not have your solution formalized and at the ready to solve the problem again.

The tenth step is to iterate on the solution for continuous improvement. Your skills for iteration and recursion help you know when to apply what you learned in earlier steps to improve the steps next time through. The resemblance to the Plan-Do-Study-Act (PDSA) Cycle occurs because both the PDSA Cycle and problem solving stem from the scientific method.

Clearly, problem solving is an opportunity to integrate your skills. As an integrator, problem solving cross-cuts all the categories of skills.

THE TEN STEPS FOR PROBLEM SOLVING CROSS-CUT THE SKILLS CATEGORIES.

- Identify the problem
- Determine goals and objectives
- Study the problem
- Develop solution alternatives
- Evaluate the alternatives
- Choose an alternative
- Formalize an action plan
- Implement the solution
- Follow-up on the solution
- Iterate for continuous improvement

Figure 1.5.5.6. *The ten problem solving steps reflect the scientific method leading to a resemblance with the PDSA Cycle.*

1.5.5.7. THE SKILL OF UNDERSTANDING THE SYSTEM LIFE CYCLE.

Understanding the system life cycle puts the other skills of the management system engineer into context.

The system life cycle is the framework for the engineering process, the process by which we improve organizations and build, select, or change management tools. As such the functions of the life cycle discussed in Module 1.1.20.1. tell us where each of the skills highlighted in Module 1.5.5.2. fit into the engineering process. Even though the skills described can be effectively used in the management process, I've highlighted them here to indicate their importance in carrying out the engineering process. I'm not surprised by the effectiveness of these skills in both the management and the engineering processes because both processes have the same root: the scientific method.

The understanding and use of the system life cycle, either for the engineering process or for the organization life, is a skill in and of itself. I might call the role needed for exercising this skill that of a system synthesist. Of course, I believe the management system engineer must be able to play both roles and to find the right balance between the roles. The skills may be the same or similar for playing both analyst and synthesist roles, but each role dictates how the skills will be used. Even the ability to make such a balance indicates an associated skill.

Developing a management tool isn't a simple process. We recognized that problem when we saw the complexity in the system life cycle in Figure 1.1.20.1. To develop a management tool, the management system engineer must be able to 1) identify the information requirements of the decision maker (Recall management system analysis.), 2) design the management tool to convert the needed data into the information to meet the requirements, 3) build the management tool to carry out the design, 4) make sure the designing and building of the management are conducive to the dismantling and replacement of the tool when the tool becomes obsolete, and 5) prepare the needed documentation, training, and project management to support the design, building, and use of the tool. Recall that these five activities are the analysis, design, implementation, follow-up, and follow-through groups of functions of the framework of the engineering process.

The way in which the framework of the engineering process is applied differs from situation to situation. The skills required to carry out the framework are broadly transferable. The skills for identifying needs and solving problems transcend any methodology or any discipline. These skills are needed for addressing any problem and building any solution.

1.5.5.8. An Information System Needs the Systems Approach.

Systems analysts can do more good than harm, if they and you practice the systems approach.

Everyone has some form of information system. Some information systems are primitive, but they are indeed information systems. The information system may be misunderstood or poorly suited to the organization. Such failings put managers and their system at cross purposes.

The way you manage can result from the state-of-the-art in establishing an information system. For example, in the Roman Empire, it took weeks or months to transfer information to and from the outposts. Therefore, the territories were given a great deal of autonomy to set policy and make decisions. With better information systems, authority can be focused better.

The existence of an information system does not imply the existence of the systems approach. You are familiar with your information system and it has worked to some degree. It reflects history and the real world. As suggested in Figure 1.5.5.6., don't abandon or abuse your existing information system. There are reasons why you have the information system you do—they probably are good reasons. You must know these reasons before turning to a new information system. Your existing information system is the first iteration in the process to develop your new information system.

Know Your Domain and Your Role Within It.

Microcomputer or no microcomputer, mainframe or no mainframe, you should analyze what it is you manage. The reason you must do that for computers is that they only do automatically what we tell them to do—we have to tell them things to do that will be helpful to us and work toward our mission. Otherwise they will do something, and a random selection will result in much harm.

I remember a day when I needed to assemble a number of notebooks for a prototype workshop on office automation. The 500 pages were to be divided by tabs; but, because of the last minute rush, the decision had been made not to number the pages. I knew very well where each page belonged; but, to get ready to leave for the workshop, I wanted my own workers, who are intelligent, logical, and know my idiosyncrasies, to assemble the books for me. If I led the process and the workers through the assembly we could assemble the books, otherwise for that one afternoon the job couldn't be done.

The bottom line is that even though I knew very well what I was doing and could do it myself, I could not in that short time tell my workers well enough how to do the job by themselves. (Later we numbered the pages and had the time for the workers to learn how to assemble the books.) Most importantly, if I didn't know the process well enough to tell my people how to do the job, surely I didn't know the process well enough to tell the computer how to do it.

For this reason, most of us have experience with automation specialists who repeatedly fail us. If we don't know what we manage well enough, surely the automation specialist doesn't. To deal with computer systems analysis you must balance a thorough understanding of your information needs and the availability and characteristics of automation.

Systems Analysts Will Help, If You Know Your Stuff.

Computer and information or automation organizations are service organizations. I learned a rule from being such a service organization. That is, "Never mess with the guy's operation." Do not ask him to change "what is managed" or "who manages" to make it easier to develop tools for him. Otherwise, you'll throw the management system out of balance or cause it to fail to meet its' objectives. You must insist that the service organization leave your operation alone. I have seen automation drive companies to bankruptcy—these were not hardware or software problems; they always were a fit problem.

Both you and the information specialist should recognize each other's responsibilities. The information specialist provides a service or support function to you. Without knowledge of your information needs, the information specialist can do nothing more than tell you the wonderful things automation is capable of accomplishing.

Figure 1.5.5.8. *"Good-by, Junior. We're tired of you."*

1.5.6. Skill List with Module References

1.5.7. Exercise on Skills

If you know which of your skills are transferable and what they're transferrable to, you can determine your perceived value by a person who needs someone with skill to contribute to their organization.

Explanation

You've been developing skills since you were born. Some skills you learned at home and in the community and others you learned at school and in the workplace. Many of your skills seem personal but are applicable to your work responsibilities. Learning to cross stitch well teaches you paying attention to detail. Skill at putting together large jigsaw puzzles implies you are good at seeing a long, tedious effort through to its end. Skill derived in high school geometry indicates you can develop a logical solution to a problem.

You can transfer some of your skills to a large number of different situations. The skill of cross stitching is limited to situations where you want to do decorative needle work. The skill of paying attention to detail is broadly applicable to figuring out and solving a host of different problems and to doing a complete and thorough job in any line of work. What you learned from your life's experiences and how you understand the range of applicability of what you learned affect your skills and their transferability.

Exercise

Make a list of skills you believe you've developed. After each skill, briefly identify (with a phrase, if possible) a situation where you've displayed that skill. You want a situation that would convince a stranger that you indeed have that skill. Don't be limited by my lists of skills in earlier modules.

Group the skills into three groups: high, medium, and low transferability. As you think of transferability, think of using your skills in different work situations. Make sure you have at least a few skills in each group.

Which of your skills do you think are most valuable to a prospective employer? How do you show those skills to a prospective employer? Where did you get the skills most valuable to a prospective employer?

1. Background

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.1. The Message Isn't in the Words—Francois Boucher

1.5.8.2. Communication Skills for System Analysts

Communication is probably one of the two most important skills you can develop for your professional advancement. The other important skill is information gathering.

Often total strangers will need to coordinate and integrate their efforts to produce a responsive management tool to support a manager in his or her domain of responsibility. For example, a project for developing a management tool requires the participation of people with many different interests and backgrounds and from different disciplines. To coordinate these diverse people, this project needs effective communication programs directed to the specific information requirements of all the people involved. Some of these people are users, computer professionals, and top-level managers. The project leader must create a communication structure for delivering the information people need to do their jobs. A good system analyst should be at the center of this communication network. A system analyst must be able to speak the language of most, if not all, of the people working on or interested in the tool.

Who's Your Audience?

A primary responsibility of the system analyst in any project is to identify the audiences of their communications and the needs of those audiences. Rudolf Flesch says you should imagine yourself talking about *this* subject to *this* person at lunch. In other words, think about your audience before you begin writing. The needs of the audience must determine the context and purpose of the message. A simple approach to effective communication in any systems development project implies you must know your audience, understand their interests or motivation, and their information needs. Three formal communication activities of management tool development projects include: problem solving work sessions, technical reviews, and reports (written and oral presentations). These activities represent situations in building management tools where you'll need to exercise your communication skills.

Problem Solving Work Sessions

Let's begin with problem solving work sessions as an example of a setting a system analyst would find where he or she would need to practice communication skills. System analysis is problem solving. The overall problem being solved is made up of hundreds of smaller subproblems. Members of the project team will address one or more of these subproblems each day. According to Powers, Adams, and Mills, the best problem solving model involves *objectivity* when looking at a problem. They define five simple and direct steps to objectivity in problem solving. (Powers, Adams, and Mills, *Computer Information Systems Development: Analysis and Design*, South-Western Publishing Co., 1984, p. 218.)

Step 1: State the problem clearly, separating large problems into individual smaller ones.

Step 2: Analyze the problem for its probable cause.

Step 3: Identify alternatives for eliminating the cause.

Step 4: Consider the consequences of these alternatives.

Step 5: Choose the best alternative.

Compare these problem solving steps with the steps in Module 1.5.5.6. Any problem solving process emulates the scientific method. Effective problem solving is done using groups of people, some of whom know the problem and some of whom have expertise in solution alternatives. The key to bringing the right solution together with the right problem is our communication skills.

Technical Reviews

The second category of communication activities is technical reviews. You can participate in formal or informal technical reviews. Engineers tend to think of anything technical as having to be based on physical science. However, technical review is the review of the content of a system or its associated processes (WWA or WWWTB) or projects (HTGT) as opposed to the review of the management or progress of changes in the process or project. Therefore, you can conduct a technical review of any process, including those based on life science or social science as well as physical science.

A formal review includes the preparation of, transfer of, and interpretation of technical documents and reports and oral briefings and briefing charts. An informal review includes walk-throughs, table tops, and observations of the process or project. The communication issues in formal technical reviews are similar to those issues in reports, which I'll discuss shortly.

To illustrate the communication issues in informal reviews, I'll discuss what happens in a walk-through. In emergency management, we formalize a walk through a bit and conduct a table top exercise. In a table top, the participants in a potential emergency response gather and review and test an emergency plan or a emergency operating center, both of which are management tools. They review and test the management tools by using the tools in an hypothetical emergency situation. They also review their roles and skills in following the procedures laid out in the plan and using the resources available in the room that makes up the emergency operating center.

People who do a walk-through simply identify the strengths and weaknesses in the intermediate products in the development of a management tool. Some example development products are data flow diagrams, program structure charts, collections of input or output documents, and test plans. These walk-through people aren't expected to act on what they find; they just find strengths and weaknesses.

A walk-through is just what it sounds like. People who'll use or develop the management tool and others who want the tool to work walk through the tool, its features, and its use. They pretend they're exercising the tool. They put the tool through its paces.

Walk-through is a term coined in the MIS business for testing and improving computer-based information systems. In planning (primarily emergency planning), this activity is called a table-top exercise. Those people with responsibilities defined in the plan sit around the table and pretend they're carrying out their responsibilities. As they play out their roles, they find problems in the plan. They fix the problems. Then, when the plan is needed "to do its thing," the glitches are out of it.

In developing a computer-based management tool, usually three to five people will be involved in reviewing any particular intermediate product. The author, or developer, of the product provides most of the information during the walk-through. For large projects, one or more experienced system analysts will be appointed as administrator of walk-throughs. The administrator resolves any conflicts or disputes and has authority to cut off any unproductive discussion. Each walk-through administrator should also appoint a secretary who has a thorough understanding of the product being examined. In table tops, we include people who observe the exercise and critique not only the management tool but those people participating in the table top.

A walk-through should be conducted in a businesslike way with all parties participating equally. Each member of the review team should receive an advance copy of the product they're reviewing. Additional walk-throughs may be scheduled if they find rework requirements during an earlier walk-through.

There are two end-product documents to a walk-through. One is a walk-through report, which is a brief, factual document identifying the product, author, date, names of participants, and outcomes. Another end-product document of a walk-through is the management report. This report summarizes the walk-through report but doesn't give a detailed list of errors found during the walk-through. If the participants accept the product, in full or in part, they sign the management report. The participants who sign this document share responsibility for the quality of the product.

Walk-throughs have some problems no matter how expertly and professionally they're conducted. One potential problem is when the product to be reviewed is too large, which results in a session taking too long. Another problem occurs if participants aren't given enough time to review the document and prepare themselves. Often in walk-throughs, we rush to give the participants review documents at the last minute and the participants don't have time to prepare properly for the walk-through.

Reports (Written and Oral Presentations)
The third category of communication activities is reporting (written reports or oral presentations). Reports deliver messages to identified audiences. Powers, Adams, and Mills (pp. 225-226) list five steps to be used in organizing a message. The five steps are:

Step 1: Identify audience needs and set priorities.

Step 2: Collect all relevant information.

Step 3: Start the presentation (message) with the most important item, then support this initial statement.

Step 4: Analyze and critique the content of the message.

Step 5: Use only enough time or words to deliver a message that meets the information needs of the audience.

This approach works equally well with written reports and oral presentations. I'll discuss the skills needed for both written reports and oral presentations shortly. Now, I'll highlight the communication activities management tool developers participate in.

Examples of written reports include management summaries, progress reports, procedures manuals, training manuals, and many others. We use graphic information portrayal, such as data flow diagrams and structure charts, in written reports. Management summaries are used as a basis for decision making and therefore should include recommendations for solutions and for actions. The management summary should be limited to a one-page to two-page typewritten presentation. Often the management summary is written in "bullet" form. We'll practice doing management summaries when we discuss the management process function, organizing and presenting information.

Procedures manuals should do for people what programs do for computers. The guiding principle in developing a manual should be that people are in the system because they're able to apply judgment. Procedures manuals should emphasize the importance of the results and contain items to help build human understanding and interest.

Training manuals should be designed as easy-to-use references. No trainer can teach everything needed for smooth, continuous operation of a computer information system or any other management tool. This kind of skill and experience can only be built on the job. Effective training programs teach operators to learn.

Another type of report is an oral presentation, which may fall into at least three categories: project management reviews, status reviews, and acceptance reviews. Project management reviews include reports of progress during the current week, completion of tasks, time remaining for tasks in process, reviews of particular problems encountered, or tasks about to begin. I'll outline a set of ten simple tools for project management shortly. You'll use these tools to prepare the content of the project management review.

We give status reviews to keep user management current on the progress of the project. They are information sessions, not sales meetings.

Acceptance reviews consist of formal documents prepared in advance and provided to the decision makers. The purpose of an acceptance review is to get approval for recommendations made.

Most guidelines for preparing written reports apply equally to oral presentations. However, several special considerations also apply to oral presentations. An oral presentation should be supported by visual aids that focus the attention of the participants on the topics being discussed. Members of the audience should be encouraged to ask questions and participate actively in the discussion.

1. Background

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.3. Written Communication I

1.5.8.3.1. Audience Plus Purpose Equals Design.

When you communicate you must match the purpose of the information sender to the purpose of the information receiver.

How do we design an information portrayal so we can effectively work the information portrayal to information perception interface in the Management System Model? Lou Middleman has the most valuable answer to that question in his simple equation: Audience plus purpose equals design. Whether you're planning what to say or what to write, always consider: Audience plus purpose equals design. You design the oral or written portrayal by considering in similar measure both the purpose of your communication and the audience to whom you're aiming the information.

When discussing the skill of communication, I choose first to look at written communication, because the written form is more tangible, is easier to look at again, and is useful for discussing both written communication and communication in general. The two best pieces to read to learn how to communicate in writing effectively are Lou Middleman's *In Short* (Louis I. Middleman, *In Short: A Concise Guide to Good Writing*, St. Martin's Press, Inc, New York, 1981) and Rudolf Flesch's *On Business Communications* (Rudolf Flesch, *On business Communications: How to Say What You Mean in Plain English*, Barnes and Noble Books, New York, 1972).

Both books speak to the way to write effectively and what to consider in writing so you'll hold your audience's attention. Neither spends much time on grammer, punctuation, or sentence structure. What we want in writing is to effectively transfer the information we want to get from us to some audience. Lou Middleman puts it well when he indicates that the issue in spelling or grammer is that if we do it wrong, we distract the reader. The reader can usually figure out what word we mean or what the grammer should be. But, why ask the reader to do that much work? The reader won't. If the reader has too much (really not much at all) trouble in finding out what he or she might want from what we've written, the reader will abandon what we've written.

When we set aside the issues of punctuation and spelling and so on, what's left? How do we communicate so the audience will stick with our communication long enough to get our message? How do we communicate so the audience will get the message we intend? Middleman and Flesch get into the specifics of issues like writing like you speak, spilling the beans, getting to the point, writing for thinking versus writing for communicating, using short sentences, and more. Middleman tends to be more intuitive and Flesch tends to be more sensing. Probably, your personality type will dictate which you like best.

One of Middleman's issues is knowing the audience of what you write. Later, I'll talk about matching the reader's and writer's purpose. Now, let's think about how important or urgent what you write will be to the audience. Stephen Covey urges us to focus on what's both urgent and important rather than just what's urgent. He also argues that the important should come before the urgent. Consider importance and urgency when you decide to write. In business writing, we often write memos. Do you expect the reader to read everything you write? Of course, you do. Otherwise, you wouldn't write it. Do you read every word of what people write to you? Of course, you don't. You don't have time. The age of information has gotten out of hand. We can't read everything every writer has labored so hard to put in front of us. So, we choose.

When I look at my in-box material I stand over the trash can. Most of what I get I never open. I use the return address on the envelope or the subject heading on the memo to decide whether to trash the document. Sometimes I lose time because I throw away something I should have read at least the first sentence of. Then, I have to use some of the time I saved by throwing most of my in-box away. What do you want me to do with what you write? Consider how important or urgent I'll feel your document is based on at most the first sentence. Figure 1.5.8.3.1. is a scale for the importance and urgency of memoranda. What I consider 1 through 7 on the scale, I never get to. You want me to consider what you write a 10. In Figure 1.5.8.3.1., Middleman indicates that a 10 on the scale requires a reason (because) for reading a memorandum immediately. You must know the because before you write the document to have any chance for me to have a because to compel me to read what you wrote.

MIDDLEMAN'S IMPORTANCE/URGENCY
SCALE FOR MEMORANDA

	1	2 3 4	5 6	7 8	9 10	
No rush; read only if infinitely curious or paranoid; File		Read on the john if you're bored.	Read during insomnia.	Read first thing this a.m. or tomorrow a.m.	Stop whatever you're doing! Read and respond at once.	Read immediately because_______.

(An I/U number should follow each name on the distribution list; the number may differ for different recipients.)

Note: A "9" or "10" must be accompanied by a "because."

- In a memo, you have at most two sentences to grab your reader.
- No reader should have to ask, "Why is so-and-so telling me this?" It's discourteous to waste someone's time. Actually, it's murder, stealing life, because all we have is time.

Figure 1.5.8.3.1. *What is the reason (because) for me to read your document immediately?*

1.5.8.3.2. Scoping Your Audience

If you expect your audience to read what you write, you must know your audience well before you write.

How do you figure out your audience when you write a memorandum? The first hard question is: Who's the audience? Often, you don't know exactly who's going to read what you write. Often, more than one person will read your writing, and the people are quite different one from the other. When you write a love letter, it's easier. You're writing to one person that you've spent some time trying to figure out what's important to him or her, why he or she should hear what you have to say, what he or she wants to hear, and how he or she wants to hear it.

It's almost impossible to write a document that's equally effective for two or more people. I don't suggest using the same letter for two or more lovers. Tailor each letter to each lover. Likewise, don't send the same memo to two or more bosses. Consider the following issues when you scope out the reader of your memorandum. I'll include issues for a primary reader and a secondary reader. If you're writing to a bunch of people, I suggest you pick out one person to focus on and try to make that person the one who is most important to you in the bunch. Then try to group all the rest as the secondary reader.

1. When did you determine that you need to write the document?
2. When does the document have to be delivered?
3. What is the subject of the document?
4. If you need a title, what title reflects what you want the reader to conclude from reading the document?
5. Consider the following issues first for the primary reader and then for the secondary reader.

   a. What is his or her communication level (education, understanding of terms, experience, knowledge of the topic or field, etc.)?

   b. What is his or her position relative to acting on what you propose or discuss in your document (position, relationship to you, responsibility, etc.)?

   c. What is his or her attitude toward the subject (interest, history, motivation, concern, issues, etc.) before reading your document?

   d. Why would he or she want to read your document (need, importance, urgency, etc.)?

   e. What do you want him or her to do after he or she reads your document (action, response, etc.)?

   f. What do you need to say to get him or her to do that?

   g. What attitude do you want him or her to have toward the subject after reading your document?

   h. What attitude do you want him or her to have toward you after reading your document?

   i. What do you need to say to get him or her to feel that way?

6. Why (motivation, purpose, outcome, etc.) are you writing your document?

7. What do you want to accomplish in your career or financial position as a result of writing your document?

8. What resources (library, people, documents, etc.) do you need to prepare your document?

9. What information (facts, data, information) do you need to prepare your document?

10. What visuals (graphs, photographs, drawings, etc.) do you need to include in your document?

11. What constraints do you have on the document (style, length, etc.)?

12. What form (letterhead, binding, color, etc.) do you want to put the document in?

13. How many copies will you need to make of the document and where will they go?

I suggest that before you write a document you carefully answer these questions. Based on the answers, you can write down what you're thinking. Middleman says that we use writing to help us think through what we want to communicate. When we write to think, we're writing things down. He says that we use writing to help us transfer information. When we write to communicate, we're writing things up.

What we write down is good for thinking and lousy for communication. When we think, we make wrong turns, say the same thing in different ways, put extraneous information in to remind us of something else, and so many other cumbersome and messy techniques. This extra structure, or scaffolding, gets in the way when we try to communicate. Before writing things up, we have to identify and tear away the scaffolding so we can see the creation we worked so hard to build. Now, we want to communicate what we've exposed by removing the extraneous stuff and crisply stating the important stuff.

1.5.8.3.3. Guides For Writing

To write effectively, keep it simple, spill the beans, consider your audience, and be active.

Guides for writing are legion. Here are a few from Lou Middleman.

1. Writing is an highly idiosyncratic, nonlinear, recursive process of inventing and rehearsing, drafting, revising, and rewriting. Writing begins anywhere between "Oh, Oh!" and "Aha!" and ends when the written product is abandoned. Writing begins before the first word and ends before the last.

2. Write first to find your thoughts, then to please yourself, finally to shape the message to the reader's needs.

3. All effective writing is persuasive: it must persuade a reader to go on.

4. Audience plus purpose equals design.

5. Trust your sense of simplicity, clarity, and conciseness. It is easier to muddy a clear statement than to rescue clarity from gobbledygook or drivel. When appropriate, inform your audience, up front, that for the sake of clarity you have deliberately departed from its formal expectations of style and word choice (specify), so he or she won't respond to your writing as an accident, a mistake from which you must be saved.

You abandon any communication. When I speak, I can see people shift their attention. Then I know I have to do something to get them back. You abandon any written document. Your eyes may look at the words, but your mind has gone somewhere else. To transfer information, I need your mind, not your eyes. When you write, do so knowing that your audience will mentally and then physically abandon what you write. The question is : How long can you keep his or her attention?

Crispness is a guiding rule for the management process. Crispness means simplicity, clarity, and conciseness and also means strength. I'll discuss crispness at length when I discuss the guiding rules for the management process.

One way to be unclear is to write in the passive voice. I suggest you write in the active voice. When you want to be obtuse or unclear (and, unfortunately, you'll want to do that sometime), you can go back and change the wording. If you write clearly, you can be unclear on purpose. If you write unclearly, you can't be clear on purpose.

You can write about your writing or speak about your speaking. You can write that you're using a certain kind of jargon or that you're writing in a very personal style for a purpose.

Lou Middleman likes to list six rules to help us write better. I've included the six rules in Figure 1.5.8.3.3.

SIX “RULES THAT ONE CAN RELY ON WHEN INSTINCT FAILS”*

- Never use a metaphor, simile, or other figure of speech which you are used to seeing in print.
- Never use a long word where a short one will do.
- If it is possible to cut a word out, always cut it out.
- Never use the passive where you can use the active.
- Never use a foreign phrase, a scientific word, or a jargon word if you can think of an everyday English equivalent.
- Break any of these rules sooner than say anything outright barbarous.

*from George Orwell’s “Politics and the English Language”

Figure 1.5.8.3.3. *These six rules will help you write better.*

1.5.8.3.4. Usage of the Passive Voice

Read Kent Porter, "Usage of the Passive Voice," *Technical Communication*, First Quarter 1991, Vol. 33, pp. 87-88.

1.5.8.3.5. TO BE OR NOT

Read DeWitt Scott, "To Be or Not," *Journal of Management Consulting*, Spring 1992, pp. 50-51.

1.5.8.4. Communication in Bits—George Seurat

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.5. Oral Communication

1.5.8.5.1. How to Say What You Mean and Mean What You Say.

For effective oral presentations you must move your audience toward the conclusion you mean for them to come to; and you have to prepare your information portrayal so your audience will know what you mean.

You have to prepare if you want to give an effective oral presentation. When you prepare, you set up the purpose of the presentation and determine the conclusion you want to move your audience toward. In figuring out how to meet your purpose and move your audience, you design your presentation and set up the visual information portrayal to support your presentation. This thinking reflects Lou Middleman's equation for writing: audience plus purpose equals design.

In these nine modules, I'll lay out a set of exercises to follow for preparing an oral presentation. The first three modules set up a set of six exercises. The following six modules describe each of the six exercises. I developed this set of exercises to aid a team of people who were preparing an important briefing as a group. I suggest that you can use these same exercises when you prepare your briefing. You may be preparing an oral presentation on your own for you to present. Or, you may be a part of a group of people who are preparing a presentation for one of the group to present or to present in sequence as a team. In many ways, a participative group presentation is more difficult to do because the participants aren't coordinated in what they think or what they do. These exercises are especially good for group presentations. I expect you to review the exercises and reflect on the text supporting each exercise. When you have a presentation to prepare, you'll work out the exercises.

The purpose of the set of exercises is to come up with drafts of charts to use as visual aids for the oral presentation and for everyone involved in the presentation to know and influence the contents of the charts. You should work step-by-step through your briefing and iterate as necessary. The result of the set of exercises will be a coherent and agreed-upon basis for anyone to use to prepare a professional-quality briefing.

Many of the ideas in the exercise worksheets were taken from a workshop by Robert Perry and from texts by Louis Middleman and Rudolf Flesch.

I designed the exercises as a two-hour participative session for a group of a dozen people. The group was a team of people who worked together and were working on a briefing to be presented by the team leader. Working as a group brought in the added dimension of getting the team members aimed in a common direction toward a common conclusion without gaps or overlaps. Preparing an information portrayal as a team is a common situation. We'll see the situation again in a team-writing exercise later.

What often happens in team preparation of an information portrayal is that the briefing or document is disjointed because of the different approaches, conclusions, biases, styles, and perspectives of the team members. In this case, the team leader often throws away the work (or at least most of it) of the team members and does the briefing or document himself or herself. Then, the team leader, by disregarding the work of the team, disempowers the team members.

Many of us do team briefings and documents when we work on a team project even when we're in school working on design projects.

1.5.8.5.2. Preparing to Prepare.

Before we can effectively design an oral presentation information portrayal as a team, we each need to do our homework on the purpose and the audience of the presentation. In this way, we're preparing to come together to prepare the presentation.

The purpose of the oral presentation worksheet in this module is preparing to prepare. When we bring the team together, we need for each of the members to do some thinking about the briefing before they get together and influence each other. We'll want the team members to influence each other shortly. However, at this point, we want to collect their independent thoughts. The worksheet focuses on five issues: 1) Who is the audience? 2) What is the purpose of the presentation? 3) To what conclusion do we want to move the audience? 4) What are the preferences of the audience? and 5) What's the size of the presentation?

Figure 1.5.8.5.2. contains a leader's review sheet. The purpose of the review sheet is for the leader to see and to share with the team members the amount of consensus the team has even before they come together in terms of the purpose and desired conclusion of the presentation. If you will, this exercise including the worksheet and the review sheet is the homework the team should do before they come together to share their thoughts about the presentation.

ORAL PRESENTATION WORKSHEET

1. Write one sentence naming and describing the one person to whom you're speaking. [For very large audiences, you may be speaking primarily to a group or category of people (e.g., budget analysts, congressional staff).]

____

____

____

2. What is the single overall purpose for making this presentation? Write a sentence describing why you're making this presentation.

____

____

____

3. What single conclusion do you want your audience to come to as a result of your presentation? Write a sentence clearly stating your conclusion.

____

____

____

4. What three or four important points do you want to make in your presentation? Each one must be written as a sentence.

1) ____

____

____

2) ____

____

____

3) ____

____

____

4) ____

____

____

5. If you know any, list your audience's preferences for presentation style, information formats, or content topics.

1) ____

2) ____

3) ____

6. How many minutes are you considering for this presentation? And for questions?

Presentation:________minutes Questions:________minutes

Total:________minutes

LEADER’S REVIEW SHEET

If you’re planning more than one presentation in a single sitting, you want the presentations to work together to meet a common purpose. To keep the presentations from working against each other, review each purpose and conclusion of all presenters. Make sure they agree with or support your central purpose and conclusion. If they don’t agree, you must adjust theirs or yours.

Presenter	Purpose Agrees	Conclusion Agrees	Adjustments
__________	_________	___________	_____________________________________
__________	_________	___________	_____________________________________
__________	_________	___________	_____________________________________
__________	_________	___________	_____________________________________
__________	_________	___________	_____________________________________

Unless the total presentation is extremely long—several hours to several days—you shouldn’t have more than five presenters.

Of secondary importance, review the important presentation points and audience’s preferences from the worksheets. You may gain some additional insight for yourself or have the opportunity to redirect presentations obviously in trouble. Aside from consistent conclusions and purposes, be sure to allow presenters freedom in preparing their presentations. They’ll speak their own words best.

Figure 1.5.8.5.2. *The leader should see and then share the independent thoughts of the team members before the team develops their collective thoughts.*

1.5.8.5.3. Organize the Presentation.

We'll use a set of six exercises to prepare a worthy message and hold your audience's attention. A solid purpose, a good conclusion, a worthy message, and holding the audience will give us a successful presentation.

Figure 1.5.8.5.3. includes the topics for the set of six exercises and shows the relative amounts of time a group should spend on each exercise and on each step within that exercise so the group can complete a good draft of the presentation in two hours. As we organize our presentation, we'll work through the steps to build an effective result.

Both oral and written presentations are formal communications. Communication is a means for transferring information. If you go to the trouble of preparing and presenting a formal communication, you must have a purpose.

A presentation is a device for securing a *predetermined* audience response. You use a time-constrained spoken message. This set of exercises will help you produce a complete message to be cued by reinforcing visuals. Often we fool ourselves and refuse to admit we have anything to sell. Let's at least agree that you want to persuade someone of something. Sometimes you make a presentation because you're told to—but a smart person will identify a purpose anyhow.

Once you have a purpose, you need to know your audience and the object of your purpose: your conclusion. Otherwise, your presentation will fail.

Every presentation needs two things: 1) a worthy message and 2) entertainment. To entertain means to involve or to draw close. In short, you want both to draw your audience close with entertainment and to move him or her to a conclusion with your message. The important items in your presentation, in priority order, are:

1) know your audience and purpose,
2) define your conclusion,
3) develop your message, and
4) entertain.

Entertainment is what the definition says; and only in certain cases should entertainment be frivolous. The best entertainment reinforces your message. Variety will be your primary weapon in holding your audience's attention.

For a short presentation, you may have no time for entertainment, which is no problem. You'll hold the audience for several minutes just because of the difference in the audience's environment when you get up to speak.

For a presentation longer than five to ten minutes, we'll consider entertainment, but we'll work on the message first.

LIST OF EXERCISES AND STEPS

Exercise I	LAST THINGS FIRST. (40 minutes)
Step I (a)	Start with the title for your last chart. (13 minutes)
Step I (b)	Put your ideas into your conclusion chart. (17 minutes)
Step I (c)	Clean up your ideas. (3 minutes)
Step I (d)	Prepare your conclusion presentation chart. (7 minutes)
Exercise II	YOUR PURPOSE AIMS YOU AT YOUR CONCLUSION. (20 minutes)
Step II (a)	Say why you’re there. (9 minutes)
Step II (b)	Put your ideas into your purpose chart. (7 minutes)
Step II (c)	Prepare your purpose presentation chart. (4 minutes)
Exercise III	YOUR AUDIENCE CAN HANDLE NO MORE THAN FIVE CONTENT POINTS. (20 minutes)
Step III (a)	Prepare titles for the content points in your presentation. (6 minutes)
Step III (b)	Put your content ideas into your content charts. (10 minutes)
Step III (c)	Organize your presentation. (4 minutes)
Exercise IV	DETAIL CHARTS EXPAND CONTENT POINTS INTO MODULES. (15 minutes)
Step IV (a)	Develop titles for your ideas to expand one content point. (6 minutes)
Step IV (b)	Prepare detail charts for a content point. (6 minutes)
Step IV (c)	Organize your module. (3 minutes)
Exercise V	SUPPORTING CHARTS ADD LIFE AND EMPHASIS TO YOUR PRESENTATION. (24 minutes)
Step V (a)	Review your content points. (1 minute)
Step V (b)	Consider additional information. (7 minutes)
Step V (c)	Review your presentation for highlights and emphasis. (7 minutes)
Step V (d)	Plan for detailed data used in supporting charts. (2 minutes)
Step V (e)	Identify ideas for support. (6 minutes)
Step V (f)	Associate supporting charts. (1 minute)
Exercise VI	FIRST THINGS LAST. (1 minute)
Step VI (a)	Start with a formal title.
Step VI (b)	Consider an informal title.

Figure 1.5.8.5.3. *The six exercises and the detailed steps within those exercises will build a good draft for an effective presentation in two hours.*

1.5.8.5.4. Bring the Audience to Your Conclusion.

The hardest and most important part of preparing the oral presentation is working out the conclusion we want our audience to come to and the supporting points for coming to that conclusion. We'll do this chart, which is our presentation outline, first.

This is the first of the set of six exercises. Developing the conclusion we want the audience to come to is the hardest and most important part of constructing the oral presentation. Therefore, we'll spend most of our time on what turns out to be the first in importance and last in sequence of our briefing charts. Since the conclusion is what we want the audience to end up with, by doing this chart first and foremost, we're doing last things first. We'll do four steps in completing this exercise. I've identified the steps as Step I(a) through Step I(d).

Exercise I - LAST THINGS FIRST. (40 minutes)

Step I (a) - Start with the title for your last chart. (13 minutes)

You'll first prepare your conclusion and final briefing chart. All other charts will lead your audience to this chart. On your oral presentation worksheet in Module 1.5.8.5.2., you wrote the single conclusion you want your audience to come to as a result of your presentation.

Now work with this sentence until it has ten or fewer words and clearly makes your point. Keep the verb "to be" out of your sentence. You'll strive to include in your sentence the topic and what's in it for your audience.

____

____

____

Using a 4x6 card, write your short sentence at the top of the card. The sentence will be your chart title. (The reason for a 4x6 card is to limit the number of words you use and to set up your overheads.) (3 minutes)

Discuss conclusion titles together with others in your group. The objective is to be sure your sentences are active (not passive), make the points you want, and are easy to understand. (10 minutes)

Step I (b) - Put your ideas into your conclusion chart. (17 minutes)

Write no fewer than three and no more than seven ideas to expand, clarify, prove, justify, support, emphasize, or reinforce the chart title. If you want a push to get started or want help if you get stuck, read in Figure 1.5.8.5.4. about two concepts to develop and organize your ideas.

1) ____

____

2) ____

____

3) ____

____

4) ____

____

5) ____

____

6) ____

____

7) ____

____

If you believe there are more than seven ideas, pick the best seven (or fewer) and save the others for later. Research shows that any conclusion can be proved in six points. Any more points are simply diminishing returns. Your should anguish over any seventh idea. (7 minutes)

Discuss conclusion ideas together with others in your group. For the conclusion chart, your ideas start best as sentences. You want all the ideas to work together.

The order of these ideas in leading your audience to your conclusion is extremely important. Use an inverted pyramid style—the second concept described in Figure 1.5.8.5.4.

As you discuss the ideas, you'll want to mark through the numbers for the ideas and re-number them. (10 minutes)

Step I (c) - Clean up your ideas. (3 minutes)

Now review your ideas and combine, clarify, or eliminate as necessary. If an idea is good but doesn't strike you as supporting the title, eliminate that idea from this chart and save the idea for later. If two ideas are similar, combine them—not with the word "and" but by writing an idea including them both. Write each idea with as few words as possible. Eliminating words brings you to the "meat" of the idea and will clarify the idea.

One by one, evaluate whether each idea supports or leads the audience to your central conclusion. We suggest you look at each idea and ask yourself the question, "So what!" If you can't answer yourself, your idea needs work. Together, your ideas supporting your conclusion should say what and so what—what is the conclusion and why your audience cares.

As a functional part of your presentation, the conclusion chart is used to tell your audience what you told them. You want your conclusion to be a tangible stimulus to action.

Consider again the rank order of the ideas. Re-order and re-number them to clean up this, your most important, chart. (3 minutes)

Step I (d) - Prepare your conclusion presentation chart. (7 minutes)

Bullet Forms
Each of your ideas will become a bullet on your final chart. A bullet is a fast, accurately-directed missile. That's how you must fashion each of your ideas.

An advantage of the method you're now learning for preparing charts is that in addition to being effective for the audience, the charts are wonderful crutches for you. Since your title is the sentence that "says it all" for your chart, read the title to your audience. Your audience won't notice you're reading because they're reading the same thing. Seeing and hearing the same thing at the same time has been proven to be *ten times* as effective in remembering a point as in seeing or hearing by itself. The bullets for the audience become, for you, ticklers. The bullets remind you of your ideas during the stress of the presentation.

You may prepare each of your bullets in one of three forms: 1) words, 2) phrases, or 3) short sentences with periods. Your choice of form should be a combination of your preference and your audience's preference. The shorter form is generally better. If you're scared to death, a longer form may be the least of all evils. If your audience is going to review a hard-copy version (hand-out) of your presentation before you present the briefing, he or she may prefer a longer form. Write your bullets on the 4x6 card with your title from Step I (a). *Don't number the card yet!* (5 minutes)

Parallelism
Check for parallelism. If you chose the word or phrase form, make sure all bullets on the chart are either noun-based, adjective-based, or verb-based. Mixing bases is distracting. If you chose the sentence form, make sure your tenses are consistent. Sentences end with periods. Words and phrases don't. (2 minutes)

You've now completed the hardest and most important part of your presentation (at least in first draft form).

TWO JOURNALISM CONCEPTS WILL HELP DEVELOP AND ORGANIZE YOUR IDEAS.

Each briefing chart tells a story. All charts together tell a larger story. The news media uses a form of communication that both is effective and efficient and is familiar to your audience. I'll briefly describe two concepts taken from the news media to help you both in constructing a chart and in organizing your charts when preparing your presentation.

"AIDA" is an acronym used by journalists:

A - gain your audience's *Attention*;
I - arouse your audience's *Interest*;
D - bring your audience to *Desire* the benefit of what you offer; and
A - request an *Action*.

A good journalist uses AIDA in every piece he or she writes. It works. Try it!

The inverted Pyramid style of writing *does not* keep the audience in suspense. When competing for readership, newspapers found they had to "spill the beans" early.

Technical specialists have learned to write by beginning at the beginning and going on to the end. It's the obvious and easiest way to organize your material. The trouble is that what's easy for you is hard on the audience. Don't build your audience's impatience and subconscious resentment by holding him or her off.

Notice in your newspaper that the headlines are arranged with the broadest headline in the biggest type on top and successively narrower headlines with smaller type below. The news story itself follows the same principle. Start with a summary of the result. Follow this with important details. Continue with explanatory details and background. Each step fills in more and more details of less and less interest and importance.

Arrange your bullets with the most important and inclusive one on top. (People often forget to *have* such a bullet!) Follow with important details. The limit of seven (or fewer) bullets may force you to drop some details. Good! You don't read all of every newspaper article. You stop when you have the level of detail you want. Your audience will stop listening to you when he or she has the level of detail he or she wants. If necessary, you can abandon your chart part way down the bullets—if you use the inverted pyramid style. You abandon bullets when your audience's attention has obviously wandered. You and I have both experienced our audience's attention wandering. We used too many bullets. We must stop overdoing the amount we want to communicate. We always will want to tell the audience more than he or she will want to hear. We shouldn't do what we want to do, in this case.

Figure 1.5.8.5.4. *As you figure out the story you'll tell with each briefing chart and that you'll tell with all the charts together, you'll be wise to use two journalism concepts.*

1.5.8.5.5. KNOW YOUR PURPOSE.

The first thing our audience should see is the purpose for the oral presentation and that purpose should answer for the audience the questions: So what? and What do you want from me?

This is the second of the set of six exercises. This chart will come first in the briefing (after the title, of course). We'll do three steps in completing this exercise. I've identified the steps as Step II(a) through Step II(c).

Exercise II - YOUR PURPOSE AIMS YOU AT YOUR CONCLUSION. (20 minutes)

Step II (a) - Say why you're there. (9 minutes)

You'll now prepare the first chart after your title chart. You're going to tell your audience why you're there.

You'll prepare your title chart last. Forget about your title for now! Your title will be obvious when the time comes.

On your oral presentation worksheet, you wrote the single purpose for making the presentation. Now work with that sentence until it has ten or fewer words and clearly makes your point. The words "My purpose is" are not allowed in your sentence. Again, include the topic and what's in it for your audience.

Tell your audience why you're there. Aside from leading your audience to your conclusion, you're there for a reason. "I want to convince you to fund XYZ Project;" "I need you to support me on the DEF issue;" "You need to know about the ABC problem;" "I find that most people in your position believe RST." Answer your audience's question "What do you want from me?" right now.

Your audience suspects that they're there for a reason. Your audience won't relax and be open to you and what you're saying until they know that reason and what's expected of them. So, put your audience at ease and tell them up front why you're there and what you want from them. By the way, you *do* want something. Figure it out, and tell your audience up front.

Using another 4x6 card, write your short sentence at the top of the card. The sentence will be your chart title. (3 minutes)

Discuss purpose titles together with others in your group. The objective is to be sure your sentences are active (not passive), clear the air with your audience on what you expect of him or her, and are easy to understand. (4 minutes)

Step II (b) - Put your ideas into your purpose chart. (7 minutes)

Write no fewer than three and no more than seven ideas to expand, clarify, prove, justify, support, emphasize, or reinforce the chart title. Remember the news media ideas from Figure 1.5.8.5.4.

1) ____

2) ____

3) ____

4) ____

5) ____

6) ____

7) ____

If you believe there are more than seven ideas, pick the best seven (or fewer) and save the others for later. Remember, after six points you get diminishing returns. (5 minutes)

Combine, clarify, or eliminate those ideas that need improvement. One by one, evaluate whether each idea helps your audience see the importance of your being there and what you expect of them after your presentation.

Your audience may have biases on or objections to where your presentation is taking him or her. If you know the biases or objections, you must acknowledge them. You don't have to answer them now, but you can put your audience at ease by recognizing that he or she has concerns. Recognize them as soon as possible. Try your purpose chart.

When working in a group to prepare a presentation, review your purpose ideas together. Again, your ideas should start as sentences. You want all the ideas to work together. *The rank order of ideas is always important*. Based on the review, you'll want to reconsider your purpose ideas. (4 minutes)

Step II (c) - Prepare your purpose presentation chart. (4 minutes)

As you did for your conclusion chart, prepare a bullet for each idea in your purpose chart. Pick a form (word, phrase, or sentence) for your bullets and check for consistency and parallelism. Clean up your ideas. Ask yourself, "So what!" for each idea. Write your bullets on the 4x6 card containing your title from the purpose chart. Number the 4x6 card #2. This chart follows your title chart and is therefore your second chart. (4 minutes)

As a functional part of your presentation, this chart is used to tell your audience what you're going to tell them. Your purpose is a formal statement of why you are there. There are similarities between your purpose and conclusion charts. One similarity is that your purpose chart tells the audience what you're going to tell them, and your conclusion chart tells them what you've told them. The charts you'll develop in the next exercises will tell them.

If your presentation is five minutes or less, you're probably finished. You may want to add your title chart or one or two supporting charts—not content points. Later, we'll discuss illustrations, graphics, tables, photographs, and diagrams as supporting charts. Then we'll discuss title charts. If your presentation is five minutes or less, skip to supporting charts in Step V (a).

1.5.8.5.6. Content Points Contain the Meat of The Presentation.

We need to support our purpose and conclusion with facts, ideas, and examples. Our content points give the audience the reasons for coming to the conclusion we chose for them.

This is the third of the set of six exercises. These several charts follow the purpose chart. We'll do three steps in completing this exercise. I've identified the steps as Step III(a) through Step III(c).

Exercise III - YOUR AUDIENCE CAN HANDLE NO MORE THAN FIVE CONTENT POINTS. (20 minutes)

Step III (a) - Prepare titles for the content points in your presentation. (6 minutes)

The content of your presentation will present facts, ask questions, and review principles. Choose no more than five content points. Recall the important points you listed in the oral presentation worksheet in Module 1.5.8.5.2. Write each content point as a sentence. Remember the topic and what's in it for your audience.

1) ______________________________

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2) ______________________________

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3) ______________________________

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4) ______________________________

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5) ____

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One by one, evaluate whether each point supports or leads the audience to your conclusion. If one point doesn't, change or eliminate the point. Remember, rank order is always important. (4 minutes)

You may have selected as many as five content points. If so, together with your purpose and conclusion charts, you now have seven charts. The minds of your audience can hold no more. Psychologists have proven that with more information the brain accepts less than if you have seven or fewer ideas. (This fact affects the maximum of seven bullets we allowed on earlier charts.) To insist on more ideas will significantly reduce the effectiveness of your presentation.

My friends at Citibank tell me that to communicate something you must tell a person three times. I believe they expect some time between tellings. However, you told them what you told them in the conclusion chart, told them what you were going to tell them in the purpose chart, and now you'll tell them. That's three times.

Rewrite each of your content-point sentences in ten words or less. Write one of the sentences at the top of a 4x6 card, one for each point. The sentence is the title of your chart. (2 minutes)

Step III (b) - Put your content ideas into your content charts. (10 minutes)

For each 4x6 card, titled with a short sentence, prepare no more than seven bullets. Pick a form (word, phrase, or sentence) for your bullets and check for consistency and parallelism. Be very careful. Each bullet must clearly support the title of the chart. If it doesn't, consider discarding the bullet, combining it with another bullet and restating the new bullet, moving the bullet to another chart, or creating an entirely new chart to hold the bullet in question.

When creating a new chart, your total can't come to more than five content points. You may decide to combine two content points to keep from discarding the bullet. Also, when creating a new chart, you'll need more than the one (and really more than two) bullets. The bullet, in fact, might be an important content point deserving a series of bullets.

Now is a good time to consider the extra bullets you may have saved from your conclusion and purpose charts. If you can't find a place for the saved bullet on the content-point charts, you probably don't need the bullet.

Evaluate each content-point chart to be sure your point is clearly made. If you prepared the conclusion and purpose charts properly, each of the well-made points should draw your audience closer and closer to your conclusion. We'll check that now.

Step III (c) - Organize your presentation. (4 minutes)

Lay your seven (or fewer) 4x6 cards out on a table. Lean back and review and evaluate your entire presentation. With your #2 (purpose) card in first place and conclusion card in last place, arrange the content-point charts in the order to most effectively lead your audience to your conclusion. Remember the news media ideas from Figure 1.5.8.5.4. AIDA and the inverted pyramid style apply to organizing your content points within your presentation as well as ordering your bullets on a chart.

When you have the cards in order, number the cards following your #2 (purpose) card from card #3 to the conclusion card.

If your message isn't clear from the cards in front of you, you must re-think the presentation. Is your problem purpose, conclusion, content points, order of charts or bullets, or consistency? For a long presentation, you may produce many more charts (and 4x6 cards). If the charts you've already finished aren't effective, more charts won't help. Make the charts you've finished effective, and more charts can bring more information to your audience.

If your presentation is fifteen minutes or less, you're almost finished. In a presentation this long you'll want two to five supporting charts, and of course, a title. Making your presentation more detailed will get you into trouble. Everything we do from now on spices up the presentation.

Later, we'll discuss illustrations, graphics, tables, photographs, and diagrams as supporting charts. We'll also discuss your title chart. If your presentation is fifteen minutes or less, go to Exercise V.

Sometimes a photograph, illustration, table, graphic, or diagram can make your content point best. In this infrequent case, the chart makes the point of one of the five sentences that you began this exercise with. The short version of that sentence becomes the title of your chart and must appear as a title on that chart. For a photograph, you should precede the photograph with a title chart.

1.5.8.5.7. Develop Reinforcing Details.

We'll add a measure of clarity and reinforcement to our presentation through the way we handle our detail charts that expand on the content points of the presentation.

This is the fourth of the set of six exercises. These several charts make up a module to clarify and enhance one or more of your content points. With these reinforcing charts, we'll have the oral presentation laid out. We only have a need for adding excitement to our laid out presentation if we have time left in the presentation schedule. We'll do three steps in completing this exercise. I've identified the steps as Step IV(a) through Step IV(c).

Exercise IV - DETAIL CHARTS EXPAND CONTENT POINTS INTO MODULES. (15 minutes)

Step IV (a) - Develop titles for your ideas to expand one content point. (6 minutes)

After you've been preparing bullet charts for awhile, you'll find the best way to develop a bullet for any chart is to write a sentence first. Then choose the words for the bullet.

For a longer presentation, you don't want to make more content points. You want to expand on one or more of them. In expanding a chart, start with the bullets on the chart. The sentence form (ten words or less) of each bullet to be expanded becomes the title of a new chart.

Pick one content-point chart. Choose the ideas you want to expand and to drive home more forcefully. Write each idea as a sentence. Remember the topic and what's in it for your audience. (4 minutes)

1) ____

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2) ____

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3) ____

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4) ____

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5) ____

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6) ____

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7) ____

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You can have no more than seven sentences because seven is the maximum number of bullets on your content-point chart. Each of these detailed-chart sentences must support or lead the audience to the content point because you developed the bullets that way.

Write each of the detailed-chart sentences in ten words or less. Do so on one 4x6 card for each detail chart. (2 minutes)

Step IV (b) - Prepare detail charts for a content point. (6 minutes)

Pick a form for the bullets and check for consistency. Be very careful. Each bullet must clearly support the title of the chart. Otherwise, as before, you must do something with the bullet. Remember, rank order is important.

Visuals as Alternatives
Quite often, at this level of detail, you can communicate the title of the detailed chart best through illustration, table, diagram, graphic, or photograph. If so, remember the chart must be titled with your sentence. Most people in the world are sensing rather than intuitive. Illustrations, diagrams, graphics, or photographs don't clearly make the point for them. Your title will.

Step IV (c) - Organize your module. (3 minutes)

Lay the cards for your detail charts out on a table with the content-point chart they were derived from. Lean back and review and evaluate this module you've just created. Arrange the detail charts in the order that best supports the content point. If the order you choose is different from the order of the bullets on the content-point chart, change the content-point chart. When you have the cards in order, the content point has a number, let's say #4. Number the detailed chart cards #4-1, #4-2, and so on, in order. If you want, you can lay the entire presentation out before you to evaluate your presentation. The primary reason for using 4x6 cards is to offer you this benefit. The other reason is to reinforce your attention to the brevity needed in what you put on each chart.

Now you have a module in your presentation. You can choose to use the content-point chart alone or supported with its detail charts. The extra charts will add ten to fifteen minutes to your presentation. The rule of thumb is that seven charts should take from ten to fifteen minutes to present. Clearly, for each detail chart in bullet format, you can develop another level of detail. The procedure is the same as before. Always use a sentence as a title. Make sure each child chart supports its parent and all children are in the proper order. Number more-detailed charts with more-detailed numbers: e.g., #4-2-1, #4-2-2, and so on.

At this level, you'll be using more and more illustrations, etc. and must consider variety to hold the audience's attention. We'll do supporting charts next.

1.5.8.5.8. DEVELOP ENTERTAINING SUPPORT.

We'll add a little spice and excitement to our presentation through the way we handle our detail charts that expand on the content points of the presentation.

This is the fifth of the set of six exercises. These several charts make up a module to clarify and enhance one or more of your content points. With these entertaining charts, we'll add to the laid-out presentation by including entertainment. Our intent is to do more to bring the audience close to us so we can bring the audience to our conclusion. If we're giving a long presentation, we'll need a few charts to add spice and keep the audience's attention. We'll do six steps in completing this exercise. I've identified the steps as Step V(a) through Step V(f).

Exercise V - SUPPORTING CHARTS ADD LIFE AND EMPHASIS TO YOUR PRESENTATION. (24 minutes)

Step V (a) - Review your content points. (1 minute)

Before starting to develop supporting charts, review the important points you listed on your oral presentation worksheet in Module 1.5.8.5.2. Make sure you've made them in your message or that you've decided not to make them. Chances are slim you'll be able to work these points in now. Supporting charts generally add variety and emphasize a point already made. List these points now as sentences.

1) ____

____

____

2) ____

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Try to put the points into the primary part of your presentation and cross them off your list. We'll try to work the others into your supporting charts. (1 minute)

Supporting charts usually reinforce a point already made or add information to support a point. Sometimes they can effectively make the point by themselves. This happens mostly for detail charts.

You have many options for the form of your supporting charts. They include quotes, illustrations, photographs, diagrams, structures, matrices, graphics, and tables. We'll first find the additional information, the highlights, or break points needed in your presentation. Then we'll think about which form to use.

Step V (b) - Consider additional information. (7 minutes)

Write down ideas for additional information you believe generally will strengthen your presentation. You might want to highlight something or include facts or concepts you have in your documents or have seen that strike you as significant. An important issue or concern could be on your mind. Do you have a war story that will make an important point? Is there an aspect of your logic that is particularly intense, strange, or visual—from which humor or emotion might spring? Write these ideas now.

1) ____

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2) ____

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3) ____

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4) ____

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5) ____

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6) ____

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Step V (c) - Review your presentation for highlights and emphasis. (7 minutes)

Review your 4x6 cards representing your presentation. Look for points (titles, bullets, implications) that don't seem to stand out but should. Look for points you believe the audience may not buy without justification or explanation. Look for points that have subtle implications or impact. Do any of the points stimulate emotion in you? Anger, humor, concern? Write these ideas now.

8) ______________________________

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9) ______________________________

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10) ______________________________

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11) ______________________________

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12) ______________________________

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13) ______________________________

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14) ______________________________

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15) ____

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Step V (d) - Plan for detailed data used in supporting charts. (2 minutes)

Review the two sets of ideas from Steps V (b) and V (c) and indicate whether you can find any detailed numbers, tables, diagrams, or pictures you need to provide input to the ideas.

____________	1)	Yes ________	No ________
____________	2)	Yes ________	No ________
____________	3)	Yes ________	No ________
____________	4)	Yes ________	No ________
____________	5)	Yes ________	No ________
____________	6)	Yes ________	No ________
____________	7)	Yes ________	No ________
____________	8)	Yes ________	No ________
____________	9)	Yes ________	No ________
____________	10)	Yes ________	No ________
____________	11)	Yes ________	No ________
____________	12)	Yes ________	No ________
____________	13)	Yes ________	No ________
____________	14)	Yes ________	No ________
____________	15)	Yes ________	No ________

Step V (e) - Identify ideas for support. (6 minutes)

For each of the ideas you've listed, take a 4x6 card and write a ten-word or shorter sentence at the top of the card. The sentence is the title identifying what the idea says. *Don't write any bullets under the title yet*.

Place the 4x6 cards on a table in front of you; arrange and then number them in sequence. In the spaces for the other bullets, indicate any needed detailed data. Use your detailed data list from Step V (d).

Gather up your 4x6 cards. These cards represent your supporting charts. Deciding among illustration, diagram, table, photograph, or graphic is another concern and, for each chart, depends on the title and the detailed data available. You'll consider the best visual after you place each chart in your presentation.

Step V (f) - Associate supporting charts. (1 minute)

Place your 4x6 cards representing your primary presentation charts on a table in order in front of you. Take your 4x6 cards representing your supporting charts and match them to your primary presentation charts. Number each of the cards first with the number of the chart it supports and write an "S" after that number.

For each primary presentation chart with more than one supporting chart, figure out the sequence of the supporting charts. Write the number of the supporting chart in the sequence after the "S." For example, if you have three supporting charts for chart #4-2-3 and this is the second supporting chart in the sequence, write the number #4-2-3 S 2.

Lay your entire presentation out in front of you. Think your way through the presentation. If you see a place where the presentation drags, has too much detail, or just needs a break for relief, put a 4x6 card in that place. Write the word BREAK across the card. Consider that card a supporting chart and number it properly.

Your supporting charts will be more visual than your bullet charts. Consequently, many of them are lighter in attitude and will entertain. Primarily, the variety will help keep your presentation moving and give it life. Additional entertainment can help at these break points. At times being a little frivolous can help change pace, break the intensity, and relax the audience. Cartoons, illustrations, photographs, or quotes do this job best when used with war stories or examples to help make your point. Don't start or end your presentation with a war story, example, or joke unless it makes your entire point.

Work with your 4x6 cards to develop the best form for your supporting charts. Review the supporting cards together with all your other charts. (1 minute)

1.5.8.5.9. FINISH THE PRESENTATION WITH A TITLE.

We'll finally know what to title the presentation based on the purpose, conclusion, and content points we've worked so hard to develop and integrate into a tight package.

This is the sixth and final exercise of the set. This chart is what the audience will see first. We'll do two steps in completing this exercise. I've identified the steps as Step VI(a) through Step VI(b).

Exercise VI - FIRST THINGS LAST. (1 minute)

Your title is the lead to your persuasive story. The title should stick in your audience's mind and say everything. The bottom line is at the top.

Step VI (a) - Start with a formal title.

A formal title includes three, and maybe four, items. First, state who you are. This attitude seems assertive; but, in any presentation, you must identify yourself and establish your credibility first. Second, state your presentation statement. Your presentation statement should paraphrase your conclusion statement. Third, state who the audience is. Finally you can add the date and place of the presentation. Write the four items below.

1) WHO YOU ARE:____

2) PRESENTATION STATEMENT:________________________________

3) WHO THE AUDIENCE IS:_____________________________________

4) (optional) DATE AND PLACE:_________________________________

Step VI (b) - Consider an informal title.

Try to develop an informal alternative for your title. Decide which title to use.

This set of exercises has a formal title: An Oral Presentation Exercise. I added an informal title which could have stood by itself: How to Say What You Mean and Mean What You Say.

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.5. Oral Communication

1.5.8.5.10. Listening

1.5.8.5.10.1. Listening Is the Important Part of Communication.

We do more listening than any other communication skill, listening is the skill that makes or breaks the transfer of information (communication), and we don't receive instruction on effective empathic active listening.

To be good at communication, listening is the important skill. Why? Because even a poor sender (speaker) sends some message and a good receiver (listener) can pick up important information from that message. Because of all the time we spend communicating, by far the greatest is spent listening. Because, if we spend so much time listening, any amount of ineffectiveness is costly. Because listening is the most effective connection we can make with another person.

Everyone who discusses listening distinguishes between the physical act of hearing and the emotional or mental practice of listening. You may hear a sound or a word, but if you don't listen, you don't get the meaning or the message. Hearing is but one of a number of senses we can use as the first step in a listening process. I'll discuss communication and listening processes and models in the next module. Here, I want to highlight the extent to which we spend our lives listening—either well or poorly, mostly poorly.

Shortly, I'll list for you the facts about listening. Everyone who writes about listening reports these data. To give you an idea of the breadth of interest in the elusive listening skill, I'll list a number of places you can find these data. You can find the data in Leroy L. Lane, *By All Means Communicate*, Prentice Hall, Second Edition, 1991 p. 29; Deborah B. Strother, "On Listening," *Phi Delta Kappan*, 68, April 1987, pp. 625-628; Lyman K. Steil, et. al., *Listening, It Can Change Your Life—A Handbook for Scientists and Engineers*, John Wiley and Sons, 1983, pp. 2-3; Clare Sproston and Glenna E. Sutcliffe, *20 Training Workshops for Listening Skills,* Glower, Aldershot, 1989, Chapter 1, p. 11; Madelyn Burley-Allen, *Listening, The Forgotten Skill*, John Wiley and Sons, 1982, p. 2; Diane Bone, *The Business of Listening: A Practical Guide to Effective Listening*, Crisp Publications, Inc, 1988, p. 34; and Larry Barker, et. al., "An Investigation of Proportional Time Spent in Various Communication Activities by College Students," *Journal of Applied Communication Research*, 8, November 1980, pp. 101-109.

Here are the data. From studies done many years ago, we find that we spend 70 to 80 percent of our waking lives communicating. Of that time we spend 45 percent listening, 30 percent speaking, 16 percent reading, and 9 percent writing. (I believe these data are originally from studies summarized by Dr. Ralph Nichols in his book, *Are You Listening* published by McGraw Hill in 1957.) Listening is the skill we use most in learning. Consider how much you learn both inside and outside your school classes. Without good listening skills, you're a handicapped learner. Ironically, listening is the least understood communication skill. We assume that listening is understood instinctively from infancy, so we make little effort to improve our listening skill. When faced with the data, the numbers seem correct on the face of it.

Let's play with these numbers some. Consider which of the skills you spend most of your time in school learning. We receive instruction and assisted practice in inverse proportion to the need to use the skill. (Madelyn Burley-Allen reports 12 years formal training in writing, 6-8 years in reading, 1-2 years in speaking, and 0-1/2 years in listening. (p. 31.)) If we add the 45 percent of our communication time we use for listening to the 30 percent we use for speaking and consider approximately 80 percent of our time is spent communicating, then for 60 percent of our waking lives we're either listening to someone or hoping someone is listening to us. Most people average a 25 percent efficiency rate in oral communication. Then, we are wasting 45 percent of our waking lives.

The average speaker talks about 200 words per minute and the average listener can process about 300-500 per minute. So, it's easy to spend time thinking about something other than what you're hearing.

When we receive a message from listening to another person, we get 7 percent of the message from the words; 38 percent from vocal cues like tone, inflection, and so on; and 55 percent from facial expressions, posture, and gestures. (Albert Mehrabain quoted in the article, "Communication without Words," *Psychology Today*, September, 1968, p. 53.) The 55 percent is commonly called body language. Then, most of receiving a message from a sender lies in something we see rather than hear.

Listening comes before reading. Both are the receiving part of information transfer, or communication. The ability to listen affects our ability to read. (Robert Watson and Henry Clay Lindgren, *Psychology of the Child*, John Wiley and Sons, 1973.) Language is instrumental to communication and to our culture. We initially acquire our language from our ability to listen, before we have the ability to speak.

The content of what we communicate is relatively insignificant in oral communication when compared to the tones we hear and the body language we see. Then, listening to a person face-to-face has as much to do with the sense of sight as it does the sense of hearing. (However, we can't today see the person we're listening to on the telephone.) So, listening is something more than hearing. Listening includes sensing what the other person is communicating, and hearing is one of the senses we use. We know we use sight. How about smell? I understand animals can smell fear, anger, or friendliness. Can you recognize those feelings in another person without hearing or seeing them? Can you feel positive or negative energy around a person you're dealing with? When you hug someone you haven't seen in a long time, do you receive a message? Perhaps the sixth sense is most important when listening. In short, listening has to do with recognizing a message from someone and requires that we're tuned in to the message they're sending. I'll talk about models for listening that include more levels or stages in the listening process than sensing in the next module.

What is listening? From "The Human Use of Human Beings," Norbert Weiner says, "Speech is a joint game between the talker and the listener against the forces of confusion. Unless both make the effort, interpersonal communication is quite hopeless." (Madelyn Burley-Allen, *Listening, The Forgotten Skill*, John Wiley and Sons, 1982, p. 1.) Madelyn Burley-Allen says, "Listening is (a) taking in information from speakers, other people or ourselves, while remaining nonjudgmental and empathic; (b) acknowledging the speakers in a way that invites the communication to continue; and (c) providing limited, but encouraging input to the talker's response, carrying the person's idea one step forward. This definition stresses the listener's responsibility in the communication process. While listening is one of the most demanding aspects of communication, it is also one of the most rewarding." (pp. 2-3.) Burley-Allen's definition expands

Weiner's to describe effective listening.

According to Sproston and Sutcliffe, "Listening is to hear and to consider with thoughtful attention: a complex procedure involving interpretation and understanding." (p. 13.) I believe this definition of listening is good for telephone listening, where the hearing sense is all we have to go on. I believe that listening face-to-face whether geographically face-to-face or in cyberspace involves a sense of recognition and awareness, leading to understanding and acknowledgment, in the context of interpreting, evaluating, remembering, and responding to support the communication leading to meeting the speakers needs. Perhaps I've defined listening, but I believe the models in the next module will help with our definition.

Listening is much more than hearing. Listening has to do with how you handle what you perceive and how you interpret and respond. Imagine that you go to a car dealer and ask for a particular model in green. The salesperson takes you across the lot to look at that model in black. "We believe black is best for you and that particular model doesn't come in green because there's not enough interest in that color." How would you feel? The salesperson obviously heard you say which model and the color green. By not listening to your need or intent, the salesperson first ignored and then insulted you. Would you go back to that car dealer? Whether you're selling cars or ideas, coats or yourself, effective listening is crucial to your success.

Listening is a learned skill. For effective listening, the listener must be active and engaged, not passive and distant. Empathic listening is more than listening for facts like we often do in the classroom when we are bored by the instructor. Listening includes listening for comparisons between what you're sensing and what you sensed yesterday or somewhere else. Listening includes listening for meaning and listening for feelings, which requires that we be empathic and tuned in. Listening includes sensing what's not present as well as what is. Just as we must read between the lines, we must listen to the silence. Sometimes, the kind and length of silence tells us more than the sound. Listening for the silence is an example of the holistic perspective in communication.

Here's a story commonly used to help define listening (e.g., Lyman K. Steil, JoAnne Summerfield, and George deMare, *Listening, It Can Change Your Life: A Handbook for Scientists and Engineers*, John Wiley and Sons, 1983, p.9.) " Two men were walking along a crowded sidewalk in a downtown business area. Suddenly one exclaimed, 'Listen to the lovely sound of that cricket!' But the other could not hear. He asked his companion how he could detect the sound of a cricket amidst the din of people and traffic. The first man, who was a zoologist, had trained himself to listen to the voices of nature, but he did not explain. He simply took a coin out of his pocket and dropped it on the sidewalk, whereupon a dozen people began to look about them. 'We hear," he said, 'what we listen for.' Bhagwan Shree Rajneesh, The Discipline of Transcendence." (Madelyn Burley-Allen, *Listening: the Forgotten Skill*, John Wiley and Sons, 1982, p. 112.)

1.5.8.5.10.2. The Elements of Listening

Listening is more than sensing the content of what a speaker is sending; it means supporting, interpreting, and being responsive and responsible.

Listening is a process. In fact, effective listening is a closed-loop process. We've learned that closed-loop processes bring continual improvement, learning, and empowerment. In Figure 1.5.8.5.10.2., I've shown a closed-loop process model of listening as a oral communication model. You can replace the speaker with a writer and the listener with a reader and have a written communication model. The model has six elements: 1) speaker (sender), 2) message (information to be transferred), 3) channel (means of information transfer), 4) noise (barriers to transfer), 5) listener (receiver), and 6) feedback (verification that what was received was what was sent). Leroy Lane leads up to the presentation of this model by saying, "The need to analyze and understand oral communication has inspired many models of human communication. In 1960, David K. Berlo, in his book *The Process of Communication* [Holt, Rinehart, and Winston, 1960, p. 32.], published one of the most influential of these models. It has six ingredients: (1) the *communication source*, (2) the *encoder*, (3) the *message*, (4) the *channel*, (5) the *decoder*, and (6) the *communication receiver*. He applied his model to various practical situations. As his title suggested, Berlo viewed communication as a *process*, one that he saw as 'ongoing, ever-changing, continuous,' and without beginning or end.

Berlo's words remind us that linear models—which show a source sending to a receiver—cannot adequately represent a dynamic communication process. They can, however, sharpen our awareness of the essential elements that contribute to that process. Furthermore, they can help us to perceive speech communication in concrete, practical terms rather than in abstract, theoretical ones; thus, we can apply them to our speaking and evaluate our performance. Models help us to identify and connect the elements of speech communication and use them consciously." (Leroy L. Lane, *By All Means Communicate*, Prentice Hall, 1991, pp. 2-3.)

If you put information portrayal in place of the sender and information perception in place of the receiver in Lane's model or in Berlo's description, you can see the complexity of matching the information portrayal to information perception interface of the Management System Model. The Management System Model has three components and three interfaces, each of which is a process. The result of this process, the communication process, is a change in state of the receiver. When you listen, do you recognize that you have been changed as a result of the communication process? In what ways are you changed?

In Figure 1.5.8.5.10.2., you'll see two additional boxes. The encoder box consists of selecting and arranging symbols to develop a message of appropriate content for the listener. You combine words, vocal cues, tones, and body language to symbolize the message. The decoder box reverses the process. Noise is any disturbance that influences the transfer of information.

Lane makes another interesting point when considering the context of information transfer within the communication process in Figure 1.5.8.5.10.2. He discusses the context of communication as including intrapersonal communication (inner dialogue or inner feedback), interpersonal communication (two people exchanging messages), small-group communication (gaining consensus), and public speaking (sharing information). For individual decisions, listening is only important in listening to yourself. Effective listening includes not only listening to others, but tuning in to ourselves. Listening effectively to what we say to ourselves and how we say these things tells us a lot about ourselves. (Next time you talk to yourself, silently or aloud, pay close attention and try to figure out what you really mean.) However, as we move to matched decisions, consensus, and teams, listening to others becomes the crucial skill.

Madelyn Burley-Allen sets up a framework for listening. She uses three levels of listening. She indicates that we listen at different levels at different times and in different circumstances. We listen better in some situations than in others. We may listen better to our friends than to our family or to our colleagues at work. Her argument is that we should control our level of listening and not fall into an ineffective level by default. Each successive level requires more concentration and sensitivity. The levels approximate a continuous variable of effective listening as three discrete levels, with level 3 being the least effective. As you consider the three levels, consider your personal listening style. (Burley-Allen adapted these levels from Dr. Anthony J. Alessandra's article, "How Do You Rate as a Listener?" in *San Diego Realtor*, February, 1980. Effective listening is crucial to effective sales. I've adapted the levels from Burley-Allen, *Listening: The Forgotten Skill*, John Wiley and Sons, 1982, pp. 10-11.)

Level 3 includes listening in spurts, tuning in and out, focusing on yourself, half-listening, keeping up mostly to interject your thoughts, passive listening without encouraging or acknowledging the speaker, faking attention, and being more interested in talking than in listening.

Level 2 includes hearing sounds and words; not really listening; staying at the surface without listening for meaning or feeling; tracking what the speaker is saying but not really understanding; not sensing the deeper meaning or intent of the speaker; listening logically to the content, not for feelings; and remaining emotionally detached from the discussion and not participating in the interaction.

Level 1 is active listening; showing empathy with the speaker; seeing things from the speaker's point of view; acknowledging and responding; paying attention with all senses; putting aside your ego; not judging the speaker's words, intent, or meaning; and listening for intent, meaning, and feelings.

Level 2 is dangerous because the inattention in level 3 is more obvious than in level 2 and the speaker can get a false sense of connection in level 2. Most of us listen at each level at one time or another. Sometimes level 2 or 3 listening is appropriate for a given situation. However, most of us aren't able to control the level.

We want to learn where each level is appropriate. Most of all we want to learn how to spend more time at level 1. To listen at level 1, you have to recognize and eliminate physical, emotional, and semantic barriers between the speaker and the listener. Burley-Allen suggests that you avoid being critical and judgmental; be attentive; be interested in the speaker's needs; listen to the underlying meaning of what is said, empathetically and nonjudgmentally; be a mirror or sounding board; don't ask a lot of questions and hold your questions until you've listened empathetically a level 1; don't discount the speaker's feelings; don't solve the speaker's problem or do his or her thinking for him or her; don't let the speaker get you angry, hurt, or upset; don't jump to conclusions; be encouraging and acknowledging by using brief expressions of acknowledgment and body motions of encouragement; and don't interrupt, take the discussion on a tangent, interrogate, teach, or give advice. She says, "Keep two important ideas in mind when interacting with others: (1) people prefer talking to listening, and (2) the listener actually controls the conversation. To listen effectively and be in control of what is being said, check your understanding regularly by summarizing what the other has said. Then, wait for feedback—either confirmation that your understanding is correct, or clarification of what the speaker intended." (p. 101.)

Burley-Allen introduces another listening framework based on the concepts of attention, reception, and perception. She says, "Listening is a highly selective, subjective experience. Information that conflicts with the listener's present ideas and beliefs may simply be tuned out. When we expect to hear certain things, we don't listen to what is really said. Present in each situation is attention, reception, and perception. Depending on the situation and the listener's motives, different mental interactions between these three and the listener may be activated. For example, we sometimes pay attention only to what interests us or what we like about the talker. On the other hand, the more we are receptive to people or to their point of view, the more we will pay attention to what they say. .... These factors—attention, reception, perception—happen unconsciously. Often, people aren't aware of the internal process that distracts them from listening at Level 1. Once we pay attention to something the speaker is saying, our feelings about it and the way it sounds to us will influence our perceptions. When you feel good about what is said and it makes sense to you or sounds right, you are receiving the information through your five senses. Using your five senses allows you to get fully involved with the information and be open to listening at Level 1. Even smell and taste affect how and what we listen to. For example, have you ever tried to listen to someone with bad breath or body odor, or while eating something you find really delicious or distasteful?" (pp. 40-41.) My interest in this framework is the emphasis on perception and the relationship of perception to the information portrayal to information perception interface of the Management System Model. Also, note that the framework is influenced by all our senses. So, once again, we confront listening as using more than the hearing sense. Listening is more an holistic blend of the senses into a sense of recognition.

Steil, et. al. and Bone offer what Steil calls the SIER model. Steil et. al. say, "The model we have developed here describes the four main aspects of listening: first, the ability to *sense* (in this case to hear, in some cases to get a reading through facial expression of body language) what is being communicated; second, the ability to *interpret* to understand what is being communicated; third, the ability to *evaluate* what is being communicated, to decide its relevance to us and its validity within the context of what we know; and fourth, to *respond*, to complete the cycle of communication by indicating in an appropriate way that we have sensed." (Lyman K. Steil, et. al., *Listening: It Can Change Your Life*, John Wiley and Sons, 1983, pp. 11-12.)

As result-oriented people, we tend to want to skip the first three steps and respond immediately. By skipping sense, interpret, and evaluate, we ensure our response is at best irrelevant or inappropriate, even though the response may be correct. Bone suggest the three keys to sensing the message as paying attention, choosing the important features, and recognizing the emotional messages.

Interpretation has to do with matching your meaning with my meaning, that is to understand, to grasp, to comprehend, to recognize—a step that has been the cause of more trouble in our lives than any other. Interpreting is the most mysterious and difficult of all the listening faculties because we really don't know how we understand something. We can't analyze how to understand something. To validate interpretation, Covey and others suggest that in dialog we strike a bargain. You can talk after I've talked if you can tell me to my satisfaction what I've just said. And I can talk after you've talked when I can tell you to your satisfaction what you've just said. Covey claims he can resolve the most bitter conflicts with this simple method for ensuring the interpretation step in listening. Bone asks the difference between the following two statements. "When I look at you, time stands still." "You have a face that would stop a clock." (p. 16.) She says the three keys to interpreting the message are knowing yourself, wanting to understand, and asking for clarification.

Evaluating is assessing or appraising what we've sensed and interpreted. Of course, wrong sensing or interpreting leads to faulty evaluation. Evaluation puts value or utility on what we've sensed and interpreted. One of the critical evaluations is whether we're listening to the right person about the right issue. The way the issue is presented will affect the evaluation. We're back to the concern over who should bias the information. The way the information is biased and portrayed will dictate the decision. Bone's three keys to evaluating the message are: ask questions, analyze the evidence, and don't jump to conclusions.

Responding is the fourth step in listening. Responding completes the cycle. We usually think of response in terms of action. However, response can be simply in the form of acknowledgment. No response is offensive. No response means that the speaker and the speaker's message are of no value. Being offensive affects the relationship between the speaker and the listener. Being responsive means paying complete attention; supporting the presentation of information, meaning, and feelings; and being nonjudgmental and ensuring that the speaker feels as though he or she has had his or her say. Bone suggests effective response depends on the desire to reach a common understanding (not necessarily agreement) between speaker and listener, giving feedback in some way, and avoiding confusing messages.

Steil, et. al. also describe five purposes for communicating orally: the binding purpose, the cathartic purpose, the informing purpose, the persuading purpose, and the entertainment purpose. The two least obvious purposes are the binding purpose and the cathartic purpose. In the binding purpose, we use phatic speech, which is also known as chitchat or passing the time. The primary result of phatic speech is to establish or evolve a relationship with another person. Phatic speech recognizes a person as a human and is therefore more important than the other purposes. Busy people tend to look at phatic speech as a waste of time. Nothing could be further from the truth. The relationships you build now will save problems and time later. The trick, of course, is to know how much phatic speech to engage in. Cathartic speech is for venting emotions. The sooner emotions are out and resolved, the fewer problems the emotions will cause. Even though we may prefer to have anger, frustration, or hurt feelings submerged, they will eventually be seen as sick days, time spent complaining, or just plain non-productivity.

Knowing what to do to be an effective listener isn't obvious. The various models or frameworks that help define effective listening give us a foundation for what to do but don't necessarily lay out the procedure. I'll set up a procedure in the next module.

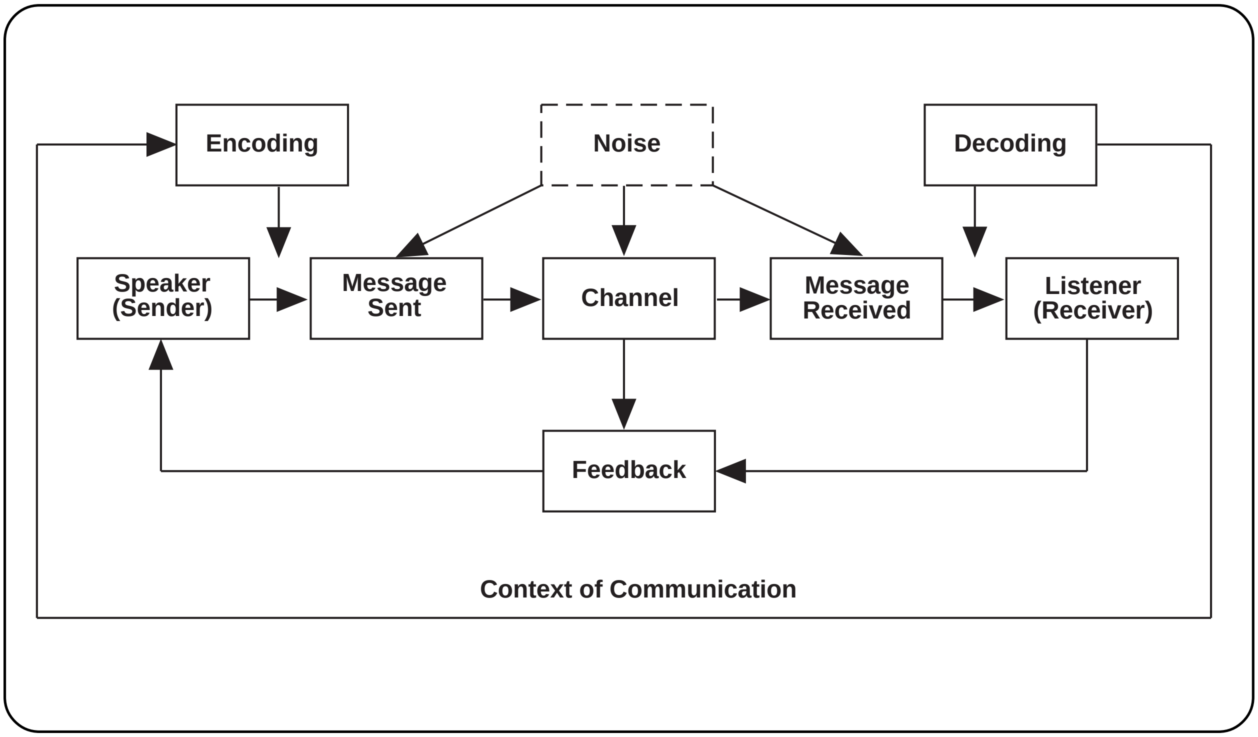

Figure 1.5.8.5.10.2. *The model for oral communication is a closed-loop process in which the listening process plays the role of the receiver, or in the standard control loop, the role of the plant.* (taken from Leroy L. Lane, *By All Means Communicate,* p. 3)

1.5.8.5.10.3. Sequential Actions for Effective Listening

To be an effective empathic active listener, you need to open yourself up, set aside your ego, and connect with the speaker.

I've constructed a procedure to follow in implementing the several models and the advice given by those who understand effective listening. The key to remembering the procedure is that each skill or action begins with the letters *Re*. I've grouped the actions into five broad categories: *Re*late, *Re*member, *Re*flect, *Re*spond, and *Re*act.

RELATE

As an active listener, you must first and foremost open yourself up and connect or *RELATE* to the speaker. If you're not accepting of what the speaker has to offer, the speaker will feel less confident and more anxious and will try too hard to find your hot button. As the listener, you'll be controlling the dialogue, which is always the case. However, not being alert or involved in the exchange will control the dialogue in nonproductive ways. I include a number of actions and related skills to the idea of relating to the speaker. These actions condition the receiver of the exchange to stimulate and enhance the information transfer to follow.

The first action is to *Receive*. Be in a receptive mode. Be *open* to the speaker. Put aside your bias for the moment and try not to have your personal filters working to select out the information you may not prefer to receive. Show him or her, you're in an *accepting* frame of mind—to accept both the speaker and the content of the message. Being receptive doesn't mean you have to agree. Being receptive means you're willing to try the ideas on for size. You want to *absorb* what the speaker has to offer and are eager to receive his or her issues, concerns, creative ideas, or plans as a gift. In being receptive, you're *alert* and *attentive*. The speaker knows that if you act tired, bored, or distracted, you're not receptive. You want to connect with the speaker and get *involved* in the exchange. You want to be *focused* on the speaker and the message and indicate that you're *nonjudgmental* of the information and are willing to receive the information for your thoughtful and fair *consideration*. (I've italicized the words that describe the conditions of the action to *Receive*.)

The second action is to *Request.* Draw out the speaker. *Encourage* him or her to express himself or herself without hesitation or concern. Show your *interest* in the speaker and the message. *Acknowledge* the speaker, the exchange, and his or her content, intent, and feelings. *Invite* the speaker to continue. Willingly *permit* the speaker to communicate whatever is on his or her mind or in his or her heart. Eagerly *anticipate* the value, importance, and usefulness of the message. Be *inquisitive* with encouraging and clarifying questions without interrogating or quizzing the speaker.

The third action is to *Relax*. Allow yourself to receive the message. Be at your peak of performance because listening takes effort—your best effort. *Concentrate* on being just at the interface between anxious and bored where you're *excited and relaxed*. That interface is where you maximize your performance or your concentration. Being too eager or anxious makes you nonobservant and more self-oriented. Being too laid back makes you nonobservant and disconnected. You want to be *tuned in* and *not distracted*.

The fourth action is to *Relate*. Develop the bridges between you and the speaker and between you and the message. Keep your *perspective* in the connection between you and the speaker. *Internalize* the message for thorough and even-handed consideration. Be *unselfish* and *introspective*. Look for what the speaker most wants to get across to you. Seek out the speaker's *needs* over your own. Make sure you *perceive* the information, meaning, motives, and feelings in the message. *Connect* the needs and the message to your life—your experiences that *nurture* the ideas and your interests that *celebrate* the ideas. Identify the value to you and help the speaker recognize the value and your *appreciation*. Perhaps not all the message is what you need, but in there somewhere is value to you, at least in your relationship with the speaker, or the speaker wouldn't have offered his or her thoughts to you.

The fifth action is to *Recognize*. Show your *awareness* of the speaker, the message, and the value of both. The speaker is *worthy* of your consideration. The message is intended for you. If the speaker knows that he or she has your *acceptance*, he or she will expose more of himself or herself and his or her deeper thoughts. Disclosing ideas on the edge of your understanding is threatening; and your awareness and acceptance provides a level of *safety* and *comfort* for the speaker to disclose ideas and feelings that are sensitive or aren't fully germinated. If you and the speaker didn't have a relationship before this exchange, you do now. Show the speaker that you recognize the relationship. Be aware of the *speaker's* body language. Tune in to what isn't said to identify what's missing. You'll want to better understand the gaps and absences to fully *appreciate* the importance and meaning of the message.

The sixth action is to *Reciprocate*. *Return* some of the thought process offered by the speaker by interpreting the message and the speaker. Ask questions to *clarify* and *reinforce* the message. Use sounds and body motion to show your *interest* and *desire* to receive more. You really don't want the speaker to hold back. If you worry about what you want to say or do, you may want the speaker to stop and let you get on with your own interests. When you do that, you close the door before the speaker discloses the idea he or she is most concerned or sensitive about. Then, you haven't received what the speaker set out to send. Make sure the speaker feels a *sense of give and take* over his or her issues, concerns, information, and feelings. Stay away from cross talk. Watch for the quizzical look or the tilt of the head or the tone of voice that communicates a need for *recognition*, *reinforcement*, and *continuation*. Your desire is to secure the message well enough so you can reciprocate with a statement that shows you've understood the message to the speaker's *satisfaction*. At this point, you can check to clarify what you heard, gather additional ideas or information for completeness, explore the ideas further, or make sure you understand the assumptions and delimitations on what you're receiving. Your questions seek to find out more about what, how, or when for information you've already received.

The key to the *RELATE* category of skills and actions is that they lay the groundwork for sensing and interpreting the speaker and the message. If you sense or interpret wrong, the *foundation* for evaluation and response is weak or misplaced. From here on out, you're wasting your time and the time of the speaker. If you do these skills and actions correctly, you have a chance to make the 60 percent of your time you spend listening or being listened to productive for you and for the speaker. The concentration, effort, and personal change required to do these skills and actions is large, but the payoff is much higher.

REMEMBER

Once you've set up a fertile relationship between you and the speaker and are receiving unobstructed ideas, information, and feelings, then you need to store what you receive in your memory. You want to *REMEMBER* the ideas, information, and feelings. You'll need to access your short-term memory to respond when your turn comes. You'll need to access your long-term memory to carry out the parts of the message that are important in your life. The primary problem with your memory in listening is your shifting of attention to what you want to say. Always remember that the other person will never know what you forgot to tell him or her. You'll gain more from the exchange if you know you received what was important than if you know you sent what was important. In this case, you'll get more than you give. Isn't it interesting that our conversations with other people may be the one place where we typically try to give more than we get and is the one place where we should get more than we give?

The seventh action is to *Retain*. Without retention of what the speaker has sent to you, there is to be no exchange. You may speak your piece; but, without retention, your piece doesn't relate and the discussion isn't an exchange. You may be two or more people speaking at each other or past each other, but there's no connection or relationship. To retain what you receive, you must *connect* the ideas, information, and feelings to what else you know about the speaker or the message. You must develop *mental images* of what you're receiving.

REFLECT

If you're open to the speaker and have remembered what you received, you need to return to the speaker what you received so the speaker knows whether or not he or she was successful in transferring the ideas, information, or feelings. This return to the speaker verifies his or her part of the transfer process. You and the speaker can check out whether you've accurately and completely received the message and whether you understand what you received. You can *REFLECT* the speaker's feelings and restate the basic ideas, emphasizing the facts. In mirroring what you received, you acknowledge that you were involved with and connected to the speaker.

The eighth action is to *Reflect.* You want to present an *unbiased*, *nonjudgmental*, and *accurate reflection* and *feedback* of what the speaker sent to you. This kind of reflection comes from a mirror. One of the gifts you can *return* to the speaker is to be a *faithful* and *kind mirror*. We seldom get to see ourselves accurately. Reflect the speaker's feelings to ensure accurate communication of his or her feelings by *matching* your understanding of the meaning of the message to the speaker's meaning. You can reflect by starting statements with words like, "You feel that ....," "It seems to me that ....," or "I sense that ...."

The ninth action is to *Restate*. Try to *repeat* what you received. You'll receive more than words. Your job is to restate the message in different words, using a different tone and facial expressions, with different feelings and capture the meaning of the message to the speaker's satisfaction. *Ask*, "Did I capture your meaning?" "Do I understand how you feel on this matter?" Chances are, the speaker will restate the message more crisply in different words with different nuances from the original communication. Don't worry if the words and expressions change. You want the *meaning*. You're being offered that same meaning from a different *perspective*. The more perspectives you get of the same meaning, the better you'll understand the message and the message behind the message. *Paraphrase* in your own words what the speaker sent to you. When both you and the speaker are comfortable that you've received what the speaker intended to send, then you've been successful. To restate is not to state your ideas in relation to those of the speaker. To restate is to *verify* you received the message. When you *rephrase* the message and capture the meaning, you'll *reinforce* the speaker and the message.

The tenth action is to *Recap*. To recap means to *recapitulate*, *review*, or *summarize*. When you summarize, you cut through all the explanation, background, and justification to focus on the real message. To be successful at summarizing, you'll have to *evaluate* what you've received. You'll need to evaluate, not based on your own assumptions and premises but based on the premises and delimitations of the speaker. You'll summarize the major ideas and feelings of the speaker. Then, you'll not only verify that you heard the message, but you'll verify that you listened to the message and understood. Based on your summary of the message, the speaker can determine if he or she is satisfied with what you got out of the message.

When you REFLECT, be careful that you never recite (even though recite is another word beginning with Re). You don't want to be able to mouth the speaker's words. You want to be able to reflect back to the speaker what he or she intended to send.

RESPOND

We have to complete a cycle for effective listening. The closing of the loop occurs when the speaker receives a response to his or her message. Sometimes the return on the investment of exposing himself or herself is a sense of relief. Sometimes the return is more tangible in the form of emotional or physical action. The response is not a retort or argument. The response is an acknowledgment or support. When we *RESPOND*, we ensure a closed-loop process for continual improvement, learning, and empowerment.

The eleventh action is to *Relieve*. By responding *empathically*, You've allowed the speaker to get off his or her chest what he or she brought to the table. Because the speaker has an opportunity to vent his or her feelings, his or her emotional level is *relaxed* and his or her concerns are relieved. Often, communication is initiated over a problem. Most problems are best *answered* by the person who raises the problem and usually the problems are exacerbated by lack of effective communication. Merely by listening openly and reflecting the ideas, information, and feelings of the speaker, you can *reduce* the problems, support the speaker as he or she figures our his or her own solution, and relieve the feeling level in the relationship between you and the speaker. If you are a good listener, more people will *remember* you. The speaker remembers you because of the sense of *comfort*, *satisfaction*, and *relief* he or she feels about the exchange. Listening to the speaker tells him or her that his or her feelings and ideas are *legitimate* and *worthy*. Most people worry about being worthy and legitimate. Listening relieves these worries. Relief is an immediate result of your response of listening well to the speaker's message.

The twelfth action is *Respond*. Respond is what we, in our culture, tend to default to. Even when the time has come for response, we respond poorly. Our response is not a retort or argument. Listening does not include the message we want to send. We'll get our chance to send our message later, after we've completed the listening process. Therefore, the response here relates to the speaker and his or her message. How can we respond to *support* the speaker and the message? We can *acknowledge* the legitimacy of the idea, information, or feeling. We can *reflect* that we've received and understood the message. We can indicate some level of support, such as further consideration, providing resources, or action. Often the need for response is *resolved* by the speaker himself or herself as he or she talks through and figures out his or her own issue or problem. This *result* comes as a form of relief. Sometimes, however, the listener needs to follow through and follow up on the message. Now is the time to commit to that follow through and follow up.

REACT

Throughout the listening process, you not only need to do things, you need to be. How you are as you listen reflects how you *REACT* to the speaker and the message. You'll notice that the thirteenth and fourteenth actions include the words *to be* along with the Re word. You need *to be Responsive* and *to be Responsible*. As with any powerful tool, when used well, you do great good and when used poorly you do great harm. You must use the powerful listening tool well and must recognize when another person isn't using the listening tool well. When another person is using the powerful tool poorly, you must protect yourself for your own safety. Use the listening tool well so the speaker won't have to spend his or her energy protecting himself or herself from you. Few people listen well. Therefore, when you listen well, you'll find that people will seek you out as a listener. Since, the process of listening places you in *control* of interactions and people are the key resource in a domain of responsibility, you'll find great *influence* and *power* in your group. Handle that influence and power well.

The thirteenth action is to be *Responsive*. Throughout the actions and skills of effective listening, you need to show that you're *eager* to receive the speaker's message, you're *willing* to be open and work to understand the message, and are *enthusiastic* about following through and following up from the message. Often, responsiveness is related to timeliness. Although you need to be there for the speaker at the time the speaker is sending his or her message, I see responsiveness as much more than timeliness. Responsiveness has more to do with an attitude of encouragement, excitement, and support.

The fourteenth action is to be *Responsible*. If you've done a good job of the listening skills up to this point, the speaker has quite possibly exposed himself or herself and his or her sensitive issues. You must handle that *exposure* and *vulnerability* with great *care*. You must be *kind* with feelings. You must be *gracious* with ideas. You may be carrying a creation of the speaker in your hands. You must be careful not to abuse or damage the creation or the speaker. When you handle exposure and vulnerability with care and kindness, you'll support the speaker so he or she can empower himself or herself.

Bone provides a checklist for evaluating your attitude for listening. Consider these: I'm interested in most topics and wouldn't tune out anything knowingly. I listen carefully for your main point and supporting points. I take notes when appropriate so I don't miss something important. I'm not easily distracted. I keep my biases, emotions, concerns, and issues under control. I concentrate and don't fake attention. I wait for you to finish before evaluating your message. I respond appropriately with a smile, nod or word of acknowledgment or encouragement during your message. I'm aware of and put aside distracting mannerisms, whether yours or mine. I don't interrupt. I maintain eye contact about 70 percent of the time. I often restate, paraphrase, or summarize what you send to make sure I have the meaning you intend. I listen for feelings and meaning as well as words. I ask clarification and encouragement questions. I don't finish your sentences or ideas. I attempt to set aside my ego and focus on you. I don't judge you whether or not I agree with your message. I'm patient and caring for you, your message, and our relationship. (Diane Bone, *The Business of Listening: A Practical Guide to Effective Listening,* Crisp

Publications, Inc, 1988, pp.30-31.)

In Figure 1.5.8.5.10.3., I've restated the fourteen Re words and grouped the words into the five broad action categories. By reading the statements an active listener would make to a speaker, I expect you to get an understanding of the attitude of active listening. Even though listening is a process, to do the process effectively, you need to have a certain attitude, or be in a certain state. The state is unselfish, inquisitive, caring, open, and helpful. As I'll discuss later, when you're in this state and a speaker sincerely wants to send you a message, you'll set up conditions where you'll support the speaker as he or she empowers himself or herself. Notice in the explanation of the fourteen Re words in this module the introduction of even more Re words, such as reinforce, review, resolve, result, and reduce. Not all Re words fit effective listening, but one way to recognize and remember the skills and actions for effective listening is to think of Re words.

RELATE

Receive	I want to listen to what you have to send to me.
Request	I want you to send me everything on your mind and in your heart.
Relax	I'm ready and able to receive what you are sending to me.
Relate	I'm connected with you and relate your message to my experience and my interests.
Recognize	I'm well aware of you, our relationship, your message, and your desire that I accept you and your message.
Reciprocate	I'll return energy to you to renew and re-energize your desire for me to understand your thoughts.

REMEMBER

Retain	I'll hold on to what I received so I can support you.

REFLECT

Reflect	I'll be a mirror for you to view what you've sent.
Restate	I'll return to you in words what you sent.
Recap	I'll summarize the ideas so you can decide if you're satisfied with what I got out of your message.

RESPOND

Relieve	I want to share your concerns and issues and will relieve you of some of the burden of carrying them around.
Respond	I'll do something to support you and your message.

REACT

Responsive	I'm eager to receive your message and will willingly and enthusiastically reflect and respond to your message.
Responsible	I'll care for you, your message, and your feelings with kindness.

Figure 1.5.8.5.10.3. *If you had a message you wanted to send to me and I convinced you I believed the statements in this list, how would you feel about my receptivity and probability I would understand what you intended for me to learn from your message?*

1.5.8.5.10.4. Listening Styles

Just as we have different personality types, we have different styles we exercise as we listen to a speaker. We can characterize and diagnose those different styles.

A number of people have developed instruments for measuring your listening style. The instruments consist of questions or checklists for you to offer your perceptions of yourself. Based on your answers, you are placed in one of a number of categories.

Bone identifies five categories: Vacant Vincent who is a daydreamer, impatient, pencil or toe tapper, easily distracted, and pretty much missing in action; Critical Carrie who finds fault, concentrates on specific words and details of the message, asks threatening questions, and misses the meaning or intent; Compliant Curtis who is passive, is interested in getting along, reacts little, fakes attention, and generally doesn't contribute to the exchange; Arlo Active who is involved and committed to good communication, participative and listens for meaning and intent, and actively encourages and acknowledges the speaker; and Lisette Listener who listens carefully, pays close attention, and asks clarifying questions to accurately interpret the message. (Diane Bone, *The Business of Listening: A Practical Guide to Effective Listening*, Crisp Publications, Inc, 1988, pp.30-31.)

A more-serious version of listening test is Watson's and Barker's listener preference profile. (Kittie W. Watson and Larry L. Barker, *Guide to Using the Listener Preference Profile: Tips for Trainers and Facilitators*, Spectra, Inc, 1993, pp.5-16.) They identify listeners who are people-oriented, action-oriented, content-oriented, time-oriented, multiple preferenced, and listening avoiders. "Listeners demonstrate people-oriented preferences when they: show care and concern for others' feelings, identify the emotional states of others, internalize/adopt emotional states of other, or try to find areas of common interest. .... Listeners demonstrate content-oriented preferences when they: test or evaluate facts and evidence, welcome complex and challenging information, listen to facts before forming judgments and opinion, or favor listening to technical information. .... Listeners demonstrate action-oriented preferences when they; jump ahead and finish thoughts of speakers, get frustrated by unorganized speakers, focus on inconsistencies and errors in messages, or show impatience when speakers ramble. .... Listeners demonstrate time-oriented preferences when they: let others know how much time they have to listen or tell others how long they have to meet. Individuals with multiple preferences may switch back and forth among preferences in different situations and/or with different people. Listening avoiders show no clear listening preference(s). Listening avoidance can come from disinterest or listening burnout. Each of the types have advantages and disadvantages. (pp. 4-5.) Watson and Barker report research findings that suggest the female listener is people-oriented and primarily relational rather than task oriented. Male listeners are more content-oriented or action-oriented and thus task oriented.

Madelyn Burley-Allen describes five listening styles: the faker, the dependent listener, the interrupter, the self-conscious listener, and the intellectual or logical listener. (Madelyn Burley-Allen, *Listening: the Forgotten Skill*, John Wiley and Sons, 1982, pp. 48-51.) The faker is a listener who fakes attention and pretends to listen while he or she is thinking about his or her own interests. The dependent listener is a listener who is highly dependent and lives vicariously through the ideas, opinions, beliefs, wishes, and feelings of other people. The interrupter is a listener who won't let the speaker finish offering the message, usually because he or she is afraid he or she will forget what he or she wanted to say. The self-conscious listener is a listener who is so concerned about how well the conversation is going or how well he or she is coming across that he or she loses track or spontaneity and becomes involved with his or her own issues instead of being open to the message. The intellectual or logical listener is a listener who receives the message mostly with his or her head and receives only what he or she wants to hear and blots out feelings and meanings.

Woody Ashton and Harold Gilbert of Virginia Tech's Training and Development Division include a communication style worksheet in their *Improving Communication Effectiveness* workbook. This set of styles is from James H. Brewer (1989) and includes the bold listener (assertive, likes bottom line, goal oriented), the expressive listener (persuasive, talkative, optimistic), the sympathetic listener (people-oriented, patient, team player, cautious), and the technical listener (controlled, precise, rule-oriented, logical). Ashton and Gilbert include a Norbert Weiner quote from "The Human Use of Human Beings:" "The good Lord blessed us with two ears and only one mouth. This should serve as a constant reminder that we need to listen twice as much as we talk."

As with all tests that look for preferences, we have to be very careful with the results and not to pigeonhole people. You may prefer one style but be very competent in another. The value of considering the different categories is to note your own preferences and to know that other people could approach listening differently than you do. So, if you notice a style that seems strange to you, the difference may be style or preference and not being right or wrong or an issue of competence.

1.5.8.5.10.5. PRACTICAL EFFECTIVE LISTENING HINTS

In everyday life, practicing effective listening includes a multitude of little thoughts or acts that implement the fourteen actions or steps in the effective listening procedure.

I've made a numbered list of helpful hints for effective listening. I've numbered the list so you can identify a hint for your discussion. You may want to add some of your own ideas to the list.

1. Practice listening skills by listening to yourself.

2. Don't mentally abandon the speaker by daydreaming, going on mental tangents, or forming a rebuttal or questions to confuse the speaker.

3. Don't tune out the speaker if you don't agree or aren't interested.

4. Don't assume you know what the speaker is going to say and stop listening.

5. Repeat in your own words and summarize what the speaker has said and ask for verification before you begin on what you want to say.

6. Make sure you know what the speaker means when he or she uses words that could have multiple meanings.

7. Don't fake listening. If you can't listen, apologize and reschedule.

8. Listen for the main idea, the meaning, or the real issue, rather than just words or facts.

9. Make eye contact about 70 percent of the time.

10. Know which words and phrases have emotional impact on both you and the speaker.

11. Take notes when appropriate.

12. Don't judge or criticize the speaker or the message.

13. Restate instructions and messages to ensure you understand.

14. Be aware of your listening filters (values, assumptions, beliefs, memories, prejudices, expectations).

15. When someone says, "Yes, but ......", he or she isn't listening.

16. Don't attempt an important dialogue when the speaker or listener is tired or the energy level is low.

17. Eliminate external distractions, such as room conditions, noise, acoustics, interruptions and phone calls, and time and work pressures.

18. Don't fidget, blink, yawn, doodle, bite your lip, frown deeply, play with your hair, look at your watch, tap your foot or a pencil, read, jingle money, slouch in your chair, or talk to someone else.

19. Listen for pitch, rate, timbre, and subtle variations in the tone of voice.

20. Don't give advice to the speaker unless in response to a direct request.

21. Face the speaker with an open, relaxed posture.

22. Acknowledge the speaker and the message by nodding your head, leaning forward, or making facial expressions that match the speaker's feelings.

23. Summarize what the speaker says by using your own words and then ask if the speaker is satisfied that you've captured the meaning.

24. Don't ask why questions.

25. Listen for new ideas everywhere.

26. Become personally involved with what the speaker is saying.

27. Listen for the essence of the message (the holistic perspective).

28. Search for an idea you can use.

29. Use encouraging, noncommittal acknowledgments to stimulate the speaker, such as "Hmm," Uh-huh," I see," "Right," "Gee," "Oh," and "Interesting." (People prefer vocal stroking to silence. But don't overdo it.)

30. Invite the speaker to say more by saying things like "Tell me more," "I'd like to hear what you're thinking," "How do you feel about that," "Would you like to talk about it?" "Let's talk about it," and "I'm interested in your ideas about that."

31. The listener should take responsibility for at least 51 percent of the total communication process.

32. Listen to the speaker on his or her own terms.

33. People who listen well spot the "value moment," which is the information or the part of listening that proves most relevant to the listener.

34. In a conversation, balance speaking and listening, where balance means the right mix.

35. Wait for the speaker to finish before finally evaluating the message.

36. Don't finish the speaker's sentences.

37. Build rapport and pace the speaker by imitating or mirroring his or her gestures, breathing, voice rate, vocabulary, favorite phrases, and facial expressions. (Don't mimic, however.)

38. Stick to the speaker's subject.

39. Keep an appropriate distance.

40. Don't interrogate, teach, or give advice.

41. Overlook a poor speaking technique to get at the message.

1.5.8.5.10.6. Exercise on Effective Listening

To understand the fourteen actions of the effective listening procedure better, you can identify which of the actions is best served by each of the helpful hints for effective listening.

On the form below, list the helpful hints for effective listening (You can use the numbers.) under the action where the hint fits best.

RELATE

Receive

Request

Relax

Relate

Recognize

Reciprocate

REMEMBER

Retain

REFLECT

Reflect

Restate

Recap

RESPOND

Relieve

Respond

REACT

Responsive

Responsible

1.5.8.5.10.7. Practice in Good Listening

By doing one or two group exercises, you can gain practice in the principles, skills, and acts of good listening.

The first and easiest exercise to try is to play the game of gossip. Gather four or more people together. Find a short paragraph of about 50 words of facts. Have one person read the paragraph to the second. Then the second must repeat the message to the third person without benefit of the written paragraph or any input from the first person. The third person tells their understanding of the message as faithfully as possible to the fourth and so on. When the last person has received the message, he or she should repeat the message as faithfully as possible and the first person should compare that version of the message with the written paragraph. Usually the last version of the message is so different from the written version that the two aren't comparable. You can try the exercise again with a very short story based on general ideas and feelings rather that facts and see what happens.

I'll describe another exercise you can try in your mind or with a few friends. The objective of the exercise is to illustrate some of the skills for active listening. The exercise needs three or more participants. One person is the monitor. The other people converse with one another on a controversial topic the group agrees to discuss. The job of the monitor is to remain out of the discussion and focus on the skills for active listening.

In the typical discussion, we concentrate on what we intend to say next and don't really listen. In this exercise, before any person can speak, he or she must summarize the essence of the previous speaker's statement to the satisfaction of the previous speaker. The monitor will make sure people don't speak until they have satisfied this requirement.

Here's an example discussion.

George: ...... and that's why I favor the quarter system over the semester system in our university.

Sally: Okay. You're saying you favor the quarter system because you can take more electives and the students and teachers won't get so drug out in the five weeks of the semester after the quarter would be over. Do I have that right?

George: Yes. I also like the idea of the late quarter system so I get to include ....

Paul: But that's ridiculous. Why would you want ......

Monitor: Hold it, Paul. You didn't let George finish his point. You shouldn't make value judgments about his point. You need to summarize or restate George's message before you can make your point.

George: Well, my point is that I want to include the beautiful month of September in my summer vacation.

Paul: How can you care about when your summer vacation ends. The beginning of the summer vacation is more important.

Monitor: Stop, Paul. You again didn't restate George's point.

Paul: Okay, okay. George is worried that he won't be home for his birthday in early September.

Monitor: Let's see if George is satisfied that Paul understands his point.

George: Paul doesn't understand my point at all; and I'm not sure Sally fully understands my point either.

Monitor: Paul, do you want to try again to reflect George's point of view to him? Or do you want George to repeat his point?

This exercise can last as long as the group wants. As the discussion continues, other skills for effective listening will arise. The more people who enter the discussion, the more complicated the monitor's job becomes. One way to keep the monitor's job in bounds and give a number of people a chance to participate is for the monitor to let different people play the discussant roles as the discussion continues.

I'll discuss listening three more times. First, I'll discuss listening as an important ingredient in group interaction and decision making. Second, I'll discuss the importance of listening in being an effective leader. Third, I'll discuss active listening as an important ingredient in supporting people as they empower themselves.

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.6. Written Communication II

1.5.8.6.1. Removing Clutter—Henri Emile Matisse.

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.6. Written Communication

1.5.8.6.2. STOP

1.5.8.6.2.1. The Idea Behind STOP.

Once you've written 500-700 words, you've changed topics and should show the change by separating topics into modular presentations.

The STOP Method (Sequential Thematic Organization of Publications) produces a topical presentation of material. Based on the idea that if you write more than a 500-700 word reasonably-crisp text, you've changed topics, STOP sets out to organize your topics sequentially. If you organize what you have to say topically and you state the thesis of each topic, your audience will be able to find and follow what he or she needs more easily. Multiple writers can coordinate their thinking through topics and theses so their writings don't conflict, overlap, or leave gaps in a multi-author document.

Lou Middleman describes your thesis as the leading idea of your writing. Your thesis specifies "The connections you will have perceived and subsequently intend to make clear to your reader." Lou distinguishes topics and theses by saying, "Topic comes from a Greek noun meaning 'places' and *thesis* from a Greek verb meaning 'to put into place' or 'organize' so your topic is 'where you go' to look for your thesis, and your thesis is 'what you do when you get there' in order to make sense—your sense—of that place. The topics provide the subjects of the thesis sentences, and the predicates, with verbs and their objects, say something about the topics that specifies the nature of the connections to be developed in [the writing]." (p. 18-20.)

The thesis relating to each topic becomes paramount in writing and reading in STOP. Lou says, "Because the thesis is your 'point'—that is, it marks the point on the reader's mental map toward which you intend your essay to lead him or her—it contains, implicitly or explicitly, both the route to be followed and the sights along the way." (p. 22.) If you've organized your topics and subtopics, have a thesis for each one, and have a list of the important sights along the way, you can storyboard your writing. By storyboarding, I mean you can lay out what needs to be written to make the point of the topic in such a way that anyone can write the text to support your thesis. Each topic contributes to the point of the document you're writing. The topic, thesis statement, associated 500-700 words of text of describing sights along the way and, if useful, a figure highlighting a landmark of the thesis are combined in a two-page format. When read, the two pages of a topical module should be facing pages, so the reader has the entire topical exposition in vision all at once.

If a group of people are working together on writing a document and they develop the storyboards together, each person can write up any one of the topics in harmony with others writing other topics. If one person is writing the document, he or she can clearly make points through theses and associated text and can connect points logically through the structure of the topics.

Not only are the thesis statements valuable, but the list of topics becomes the map to the document. The reader can look at the map of topics (organized topic list) and read from the beginning, middle, or end of the document. The writer can write according to what moves him or her in a creative moment and connect creative moments through the map. I've found that people will read more of a STOP document than the traditional alternative. With STOP writing, the reader starts with the topic of greatest interest to him or her and moves through the document from topic to topic until they have all they need.

The classical alternative is called river raft to indicate a river of words interrupted randomly by rafts (figures). With river-raft writing, the reader starts at the beginning searching for topics of interest, never sure where he or she is in a sea of often-overlapping topics, and quit when he or she decides he or she can't find what he or she needs after all.

I've attached a set of briefing charts about STOP. The charts describe the procedure for writing in STOP and the advantages of STOP. I've also attached a storyboard form and hints for writing topic headings and thesis statements.

I first heard about STOP in 1985 from Frank Falci, a Department of Energy (DOE) manager, who had discovered STOP years earlier when working with Hughes Aircraft Company. Frank had recently been introduced to the Perry Method for oral presentations and saw the connections to STOP. Much later I was told (I don't remember by whom) that Robert Perry was part of the team that started STOP. I brought copies of Frank's notes back to MSL for our people to study.

In 1988, Lou Middleman revived STOP when he was responsible to bring the writing of dozens of people together covering hundreds of topics for the DOE's first environmental management Five-Year Plan. Lou's job was to coordinate the writing of the large team of people writing new material all in a couple of months. Lou realized the job was impossible without STOP. The resulting document was praised by the National Academy of Sciences as one of the best written documents they had encountered. As a result, many other government documents have recently been written in STOP.

1.5.8.6.2.2. Starting to STOP.

STOP ORGANIZES DOCUMENTS INTO TWO-PAGE TEXT-AND-FIGURE MODULES.

- Topical rather than categorical outline precludes “river-raft” documents
- Spoon-feeds reader in bite-size chunks
- Turning page means changing topic
- Permits group organization and review before writing or redrafting
- Can be applied “from scratch” or to “quantize” a river-raft document

AN UNDERLINED THESIS SENTENCE BEGINS EACH TOPICAL MODULE.

- A specific, arguable point or contention
- Contains key words and premises
- Module paragraphs and figures demonstrate thesis
- Line of argument always evident
- Prevents reader (and writer) from wandering
- Reader can skim or scan without confusion

THE OVERALL STOP PROCEDURE HAS FIVE STAGES.

- Making a subject list
- Storyboarding
- Group review of storyboards
- Writing the modules
- Converting river-raft material

FOUR RULES OF THEMATIC UNITY GUIDE MODULE FORMULATION.

- Have a point and get to it.
- Treat it completely.
- Keep out extraneous matter.
- Relate figures to text.

TOPICIZING RIVER-RAFT MATERIAL IS A SIX-STAGE PROCESS.

- Spread out manuscript pages
- Mark figure/table reference to define art/topic relationships
- Obtain copies of figures
- Locate true topic boundaries
- Cut manuscript on topic lines and reassemble as mock-up modules
- STOP Critique
  - Write new topic headings
  - Extract or create thesis sentences
  - Check modules for thematic unity and copy fit
  - Identify gaps and overlaps; add, delete, combine, separate, substitute, transpose

STOP PROVIDES THREE UNAMBIGUOUS LEVELS OF CONTENT EMPHASIS.

- Less important content occurs within a topic module.
- More important content occupies a whole module.
- Most important content occupies multiple modules.

HOW TO WRITE TOPIC HEADINGS

1) Since they are not written to, Section and Subsection headings are OK as plain noun groups:

   - System Tradeoff Analysis

   - Data Processing Equipment Description

2) But, the author, reviewer and reader all need to know "what about?" the Topic Heading:

   - "Receiver Design"—what about it?
     TRANSISTORIZATION OF RECEIVER DESIGN

   - "Target Tracking"—what about it?
     NEED FOR REALISM IN TARGET UPDATING

3) Hence, the Topic Heading should be a phrase (a sentence fragment of 4 to 8 words) containing prepositions:

   - DESIGN OF TOW CABLE FOR LOW DRAG
     (not "Tow Cable Design")

   - REDUCTION OF NONSYSTEMATIC ERRORS
     (not "Nonsystematic Errors")

or infinitives:

   - THREE WAYS TO SIMPLIFY ANTENNA DESIGN
     (not "Antenna Design")

or "ing" verbs:

   - CONTROLLING CHARACTERISTIC IMPEDANCE
     (not "Characteristic Impedance")

4) If you can take a position, show your attitude with qualitative words:

   - ADVANTAGES OF INTERLACING INSTRUCTIONS

   - LIMITATIONS OF ANALOG AZIMUTH CONVERSION

   - PITFALLS IN PROGRAM SCHEDULE CONCURRENCIES

5) If at first you don't know "what about?" the topic heading, go back and revise it for greater pertinence after you have written out the Story board (or rough draft).

(taken from Hughes Aircraft Company document, 1965)

HOW TO WRITE THESIS SENTENCES

1) The Thesis Sentence should state your proposition concisely, and it must boil down the theme body to 25-30 most informative words, showing the whole proposition and proof (or substance otherwise) at a glance.

2) Make the Thesis Sentence an argument, or arguable hypothesis:

   - irrefutable, weak: "TRL gating circuits have been designed to meet the requirements."

   - Refutable, strong: "TRL gating design has been adopted because active circuits are the best way to achieve increased fan out at the required speeds."

3) There is a "design thesis" behind every block diagram or circuit write-up. So, no matter how low the level of detail, you never have to write equipment descriptions that merely describe. Contemporary proposal evaluators consider straight descriptions tedious and nonpertinent. Since important technical detail must be included, find the original design issue, or invent a point (even if it's "advantages of using a conventional and proven design").

4) The purpose of a unit, especially if difficult, makes a good thesis sentence for some block-diagram discussions because it reveals why the unit is organized the way it is:

   - "The telemetry system must be capable of multiplexing the outputs of 20 hydrophones and transmitting the information without degradation in a form suitable for time-compressed signal processing."

5) If the topic merely embraces a collection of ideas or items unrelated by a single, definite proposition, then either summarize all the facts, or call attention to one or two most important and noteworthy ideas. Go back and check the Thesis Sentence for its summarizing function after you have filled in the Story Board (or written the draft).

6) Tests for a good Thesis Sentence:

   - Does it state an issue that can be refuted?

   - Does it repeat the key words of the theme body?

   - Does it embrace the major substance of any accompanying figure?

   - Does it contain adverbial conjunctions which show a train of reasoning (because, since, so, therefore, however, but, moreover, etc.)?

   - Does it contain comparative adverbs and adjectives which show attitude and conclusions (more, least, highly, almost, too, very, good, better, only, etc.)?

(taken from Hughes Aircraft Company document , 1965)

1.5.8.6.3. DISCLOSING PROGRESS

When disclosing progress, start with the end (the bottom line), then disclose what led up to the end.

Put the bottom line on top. If your objective is to communicate, you'll need to change some of your old thinking. You'll need to concentrate more on information portrayal and information perception. You'll need to perfect your ability to design your information portrayals to meet your purpose and suit your audience. If you're a senior in the Industrial and Systems Engineering Department, one information portrayal you'll soon deal with is your first senior design progress report. I'll use this senior design requirement of yours as a vehicle to emphasize and demonstrate a way of thinking about clear communication for decision making.

As an engineer, you're taught to start at the beginning and end at finish—all logical and in the proper sequence. Not here. I'll try to convince you to spill the beans. Say it and then explain it. Not vice versa.

What's the purpose of the senior design progress report? The purpose is to communicate your progress. Your progress is the difference between where you are and where you were based on what you've done since then. Where you were is your situation that last time your audience reviewed your project.

For your audience—whether faculty or corporate sponsor, your statement of progress should have more to do with results than with activities. That is, your purpose in the progress report should be to show accomplishments, not effort. You really want to communicate more about your output than your input because output is what your audience expects to see. Input is nice, yet is necessary but not sufficient for output. You'll be tempted to focus on input because input reflects all the effort you've spent on the project. Don't give in to the temptation. Step back from your effort, critique your results, and state your progress. Use discussions of your effort, represented by activities involved in getting your results, to build confidence in your audience that your results are valid.

Distinguish between your means and ends. Your activities are your means and your results are your ends.

"But," you may ask, "I'm not finished; what results do I have?" You have interim results, milestones along the way to your final results. The relationships of your interim results to where you started and to your final results show your progress. Before you know those relationships, you must know what your interim results are.

If this is your first progress report, anything you understand about your company, anything you know about your project, and anything you've accomplished is progress. Remember, you started with nothing. But, after the first report, progress is only what you understand, know, or have accomplished since the last report.

Your progress report has a different purpose from your proposal, for example. Your proposal talks about what you plan or want to do. You talk about what you will do. Your progress report talks about what you accomplished. You talk about what you did do. If your progress report sounds like what you will do sometime in the future, your audience won't believe you've accomplished anything. Be sure to modify what you've written when you copy material from your proposal. Change the material to clearly show you've completed something. I've seen progress reports I knew were copied over in part from the proposal. Everything was in the future tense. Don't do that. The purposes of the two information portrayals are different. You did a proposal written about what you were going to do; now you should change it for your progress report written about what you did do.

I've just talked about the purpose part of the equation for designing information portrayals. Now, let's talk about the audience part. You have several audiences, and each audience is different from the others. To explain my point, I'll discuss three audiences: your faculty advisor, your company contact, and the senior design faculty coordinator.

Consider first your faculty advisor. If he or she expects a stereotype, bland, stilted, long, pompous report, that's exactly what you should give him or her. This particular audience may know what you've done because they meet with you every day. They may look at the report as documenting the steps they already know you've taken to get the results they already know you've obtained. Their purpose is documentation. Then give them that documentation. They aren't finding out for the first time what you've done. They just want a hard copy data base to store what you've done in a logical sequence.

Consider next your company contact. They may want a crisp, clear, easy-to-read business report. Then you should give them what they want.

Finally, your senior design faculty coordinator may want to know what you've done compared to other design groups. They may want to know what you've done compared to their list of things they want you to do and learn in this course. Then you should help them find what they want in your report. You should highlight what they want to see so they can fill in their check sheet.

Your audience (or in this case, audiences) will have unique personality types, interests, capabilities, experiences, and expectations. As a specific example, recognize the difference between detail and bulk. Three-fourths of the people in the world are sensors. They like detail. Detail gives them confidence they have all the information they need for decision-making. Detail allows them to dig in wherever they feel they need more information. Many of us don't like to go to the trouble to give all the details and we also have trouble sorting and organizing all the details. Some of us are intuitive and don't see any value in all that detail anyway. Give the sensing person the detail they want.

Be careful! Don't bulk your audience. Don't pad your report with pages of some documents you found laying around the company on your last visit. A detail person wants to know how many visits you've made. When did you make them? Who on your team went? Whom did you meet with? What did you do while you were there? How did that help? And so on. My point is these details are germane. They're important to a detail person. Give them what they want.

But details will bore an intuitive person to death. An intuitive person will skip over the details. If the bottom line of what you've accomplished is buried either at the end of the detail or randomly imbedded deep in the detail, the intuitive person will mentally (or physically) abandon your report long before they get to the bottom line. I've been known to flip pages of seemingly detailed information (physically abandon the report) and miss bottom lines. The detail person will abandon your report too. They'll just spend more time on the details.

How do you know what your audience is so you can factor that into your information portrayal design? Ask them. Your audience will be happy to tell you what they want. And if you spend the time to figure out and ask the right questions, they'll tell you all you need to know about their unique traits as information perceivers and decision makers.

My recommendations are purpose and audience dependent. However, I'll make the following recommendations. Write a "users manual" for your document. Call it an executive summary, a foreword, a prologue, or even an abstract. (I personally wouldn't call it an abstract.) Title a section "Developments Since the Last Report." Title subsections 1) What we accomplished since October 10, 1988 (or whatever the date of the last report was), 2) How this report was improved, 3) What has happened at the company, and 4) What has changed in project management. Then put specific items of tangible progress in "bullet" form under each of the subsections. For each bullet identify the page in the progress report where the audience can find the discussion, background, and justification for the bullet.

As you discuss each accomplishment, improvement, or change, remember you want to state two things. First, state what you did or what changed. Second, state the usefulness or significance of what you did or what changed. You're not only telling the "what" you're also telling the "so what."

Notice how what you've written is actually a user's manual for using the progress report. That is, you've shown the audience how to use the report. For the senior design faculty coordinator, they can fill in their check list right from your executive summary. If they're not sure they want to take your word you've accomplished what you said in a short bullet, they can check out the appropriate pages in the progress report. After they've tried several times and found your report substantiates several of your bullets' claims, they'll probably stop checking. They'll love you for saving them time.

For the company contact, they can see the differences between where you were and where you are at a glance. They can easily check an item out more closely if they wish by flipping to the pages you've identified for that item.

For your faculty advisor, by using your executive summary containing a "map" of the locations of accomplishments in the report, they can distinguish what they haven't yet reviewed from what they already reviewed. As a faculty advisor, I get tired of reading the company description again in the fourth progress report—unless, that is, you've changed or added something; and if you have, you told me in the executive summary what you changed or added.

As an aside, any time you have someone review a long document several times, be sure to tell them what changes you made. If you tell them what the changes are and where they are, the reviewer only has to find and review the changes. If they don't know the changes you made, they have to check every word of the long document to make sure it's right.

Your faculty advisor and/or senior design faculty coordinator probably have an evaluation matrix either on paper or in their mind. The matrix lists the design groups on one axis and their evaluation criteria (and maybe the relative weights of the criteria) on another axis. You shouldn't care about the other design groups, but you should care about what the evaluation criteria (and weights) are.

I'm saying here that if you want a high evaluation, knowing what the criteria are comes before (and in that sense is more important than) putting the substance into the report to be evaluated against those criteria. You can usually figure out the evaluation criteria from the assignment document or class discussion (both information portrayals) about the progress report. Your faculty advisor or senior design faculty coordinator most likely will go to those information portrayals to figure out which criteria to use for their matrix. If you're not confident you know what those criteria are, I'd ask.

Now, put yourself in the shoes of your faculty advisor or senior design faculty coordinator. How well does your progress report satisfy the criteria you guessed? What I'm telling you is that you can figure out the criteria and look at your report without bias and come close to determining the grade you'll get. The reason you might get different grades from the two people is that they have different criteria or weights. After guessing (maybe by just listening or asking) the different criteria, you can determine the different grades. Try it. Hopefully, in trying this technique you'll want to fix your report when your report has nothing in it to meet, or is weak in meeting, a particular criterion. Now you're affecting your own grade before the fact.

Often, when a decision maker is making a qualitative evaluation or comparison among candidates, they use a matrix. Your senior design project is such a case. Your application for a job is another. Your prospective employers won't compare your height and weight or other quantitative measures. They'll generate some criteria like "communicates well" or "is poised" and give you a score of, say, four out of ten. I advise you to find out what the criteria are before you're evaluated. The same thing holds true after you go to work. Your supervisor will evaluate you. That's how they decide whether to fire you or to give you a raise. Ask your supervisor what the criteria are! Most people don't want to ask about the criteria because people don't like to think about being evaluated. Also, your supervisor won't offer the criteria without being asked because people don't like to evaluate others.

My midterms and exam are qualitative. So, I use a matrix to grade them. You can guess the matrix from the statement of the midterm or from criteria I think are important based on what I've said in class. You can also guess the number of criteria. Let's guess ten. Now try to guess what they are. Since you don't know for sure, you may come up with a few more than ten. Try it. You won't come up with many more. If you came up with, say twelve, why not write your midterm to provide substance for meeting all twelve. Chances are, the effort won't be wasted. Figuring out the matrix helps you not only get a good evaluation (grade) but it also helps you think through what constitutes a comprehensive, clear, and complete midterm.

I've discussed how to figure out the evaluation criteria so you can get a good grade. How crass! Let's look at the situation more idealistically. The evaluation criteria are your advisor's understandings of what makes a good report (or a good project). Do you want to do a good job? Then by definition, you want to address all the criteria in your report. If you think about and find out what your audience wants and thinks is important before you prepare your report (or even before you do the work you're reporting on), you can write your report (and do your work) on the right things.

Research proposals are evaluated qualitatively. Usually there's a formal matrix and that matrix is spelled out when the proposals are requested. Most faculty write proposals to suit their own interest in a technical approach. In their proposals, they ignore the matrix. Most proposals fail. One technique to succeed is to figure out the matrix, identify the criteria on one or more cover sheets or foreword, state clearly you've met the criteria, and identify where the substance is in the proposal to substantiate you meet the criteria. Now, the person evaluating the proposals can easily give you high scores on his or her matrix. Other proposals may have better content. But the evaluator never sees the content and never sees that the proposal meets a given criterion because their mind wanders at exactly the wrong time when reading dozens of proposals. I've gone so far as to use different color paper for the pages when I state I've met their criteria and when I show where to find the supporting information. I want to make it easy for the evaluator to put high marks in his or her matrix.

The senior design faculty coordinator also reads dozens of rather long documents. What can you do to make sure your document has the substance to meet every criterion the evaluator is diligently searching to find?

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.7. Information Portrayal

1.5.8.7.1. Communicating is Difficult—Grant Wood

1.5.8.7.2. How We Portray Information.

When you portray information, you want to bring forth an image in the mind of your audience that matches the image you have in your mind.

When you portray something—an idea you have, a description of something, directions, etc.—you're representing it. You're portraying information and representing something. You portray information to bridge the information portrayal/information perception interface in the Management System Model (MSM). You're trying to communicate, or transfer information, across that interface. Why is portrayal so important in understanding information and using information for decision making (management)?

Except perhaps in mathematics, every portrayal involves a betrayal—that is, you omit or add something. The idea of betrayal involves the principle of identity. Nothing ever consents to be anything other than it is. But you override this lack of consent and you bias and interpret what you see or feel or understand. If we start with x, that which is to be portrayed (the percept), and go to y, the portrayal, we must go through z, the action of abstracting the essence of x and translating it into y.

Think about a red vase. You see a red vase because whatever color you see you call red. Another person may see something extremely different—but they also have learned to call it red. And as long as we consistently see the same thing and can distinguish between different colors, we'll agree the vase is red. So, we need nomenclature or definitions of what we're trying to represent so we can transfer the information—which brings us to the idea of format.

Format is the organization, plan, style, or type of what we're portraying, or its appearance. And we end up finally dealing with our senses. We portray information in visual, auditory, tactile, etc. formats.

Of course we can portray information by combining senses. For example, if you're giving an oral presentation and using visual aids, you're combining visual and auditory senses. If you speak the words (auditory) on a visual aid as the audience reads it (visual), the senses are working together and the information transfer (communication) is far greater than double that for using only one sense. (We've gotten synergy.)

You can see ("see"?) that this generalized idea of information portrayal is tough for most engineers to handle. Most of us don't spend as much time as some other people thinking about art (visual), music (auditory), sculpture (tactile and visual), and other ways of expressing ourselves—especially in terms of what we're feeling or thinking. (Thank goodness, these days many engineers do spend a lot of time in these ways of expression.)

Much of our informal information portrayal or informal communication uses more of our senses than our formal information portrayal. Consider gestures and body language, for example. Since information is biased, we need to get a look ("look"?) at the bias of the person portraying the information. How helpful body language is in doing that.

Formal information portrayal is easiest to deal with because it's more tangible. So, the information portrayal formats we understand best and can talk the most about are written formats. The written formats are visual. We can use illustrations, photographs, maps, logic diagrams, data flow diagrams, and other visual formats. But the most common are text, checklist, table, and graphic. And simply because they're most common, I'll talk mostly about them. You can, however, extrapolate in your mind to other formats the ideas of logic and structure that I'll present for these common formats.

A management information system (MIS) can portray any of these more common written formats. So we'll consider the role the MIS plays in portraying information and then concentrate on the different common written formats.

1.5.8.7.3. PORTRAYALS FROM MANAGEMENT TOOLS.

Like all management tools, the output from a management information system portrays information to be used by a decision maker depending on how they perceive that information.

We can classify MIS information portrayals several ways. Normally, we emphasize end-user information use—the information portrayals on the management tool side of the information portrayal/ information perception interface in the MSM. We also produce information in the form of reports and query responses we use in the operation of the management tool or to tie management tools together.

Perhaps the best way to classify the outputs of an MIS is by how we use the output. MIS outputs serve three main purposes:

1) Delivering Information. We use an MIS primarily to communicate information to users on a timely and accurate basis.

2) Storing Information. A computer-based MIS can store information in forms and formats to be retrieved later. We can keep some archival information in the computer for ready access, and we can put most of it on tape or other long-term media storage for access when needed. The MIS can hold archival information for a long time in a very small space.

3) Transferring Information. Computers can produce information for other computers. Computers can produce specially encoded outputs so we can enter data into computers as transactions are completed.

The first purpose (delivering information) crosses the information portrayal/information perception interface of the MSM. The other two purposes remain inside the what is used to manage component.

Delivering Information

The first function of MIS outputs is delivering information. We portray information so we can communicate data and information to people who need it. We produce this output in human-readable form. We can present human-readable output in a variety of formats using different types of media.

We can classify information from outputs of information systems in the form of l) a comprehensive document, 2) a short answer to a query, and 3) a transaction report.

A comprehensive document is a report predesigned to give a comprehensive closed set of information to managers. I'll classify comprehensive documents by content and group them in three general categories:

l) Detail reports present all or nearly all of the data content of one or more files from a database. Managers use detail reports to monitor their day-to-day activities. Staff people use detail reports to respond to specific inquiries. Detail reports can be produced weekly or daily to give the manager operational-level information needed to formulate and execute work effort for their operational endeavors. In some organizations, managers get a daily MIS report. Many managers close to the work flow want detail reports, specifically relating to problem areas they're watching.

2) Summary reports show accumulated totals from detail reports—rather than complete file contents. Managers use these reports for reviewing tactical and sometimes stra-

tegic-level endeavors. When managing these endeavors, we must be careful not to depend solely on summary reports. Aggregations (being integration as opposed to differentiation) can lose or obscure as much or more information as they surface or highlight. Summary reports show information for a current time period, with projections and figures for that time period along with projections and figures for other time periods. With this information, the manager can compare current operating results with expected results and with prior operations. Managers use discrepancies between actual and expected results to determine corrective action to bring the operation back on course.

3) Exception reports call attention to conditions outside normal operating limits. For example, we can scan a customer status file to find overdue accounts. Rather than a detail report listing all accounts and the action dates or a summary report giving the total sales by sales region, an exception report would list only those long overdue accounts so managers can take action on them. With an exception report, we try to identify the crucial data and trends to readily differentiate the points for managerial attention. Exception reports can be more effective than detail reports for day-to-day control of operational endeavors.

A short answer to a query is like a report in its data content. However, a short answer to a query is dramatically different in its presentation method, data currency, and delivery cost.

A comprehensive document is printed, uses one or more files, and presents a snapshot of a part of the organization as it was when the report was run. On the other hand, a short answer to a query involves a real-time output presenting up-to-date information for immediate use. Query response capabilities respond to managers with current and detailed information. So, the source files for queries must be updated frequently. Query responses normally report at a detail level. However, query responses can also access summary and exception reports.

A transaction is an act of doing business. A transaction moves something of value (product, money, information, resources, etc.) from one place to another. An order is a transaction. Transactions represent both input to and output from a system. Transactions play a central role in many computer information systems.

When doing business, an organization generates data representing their transactions. Data provide evidence of transactions, and, by capturing transaction data, the organization maintains records of business activity. The data about transactions go to company files as documentation on the organization's operations. We use the comprehensive documents containing these data to provide management with the information needed to control the organization's activity.

We can capture transaction data using source documents or we can put the data directly into the computer. However we capture the data, transactions serve other purposes besides collection of data for historical files. One of the most important uses of transaction reports is to help work flow through the production and distribution processes of the system. A transaction is either a physical document or a computer record and transmits information between people. So the transaction is a process control device. Transactions trigger activities—and are controlled by the information contained on them.

Consider the following example. In a manufacturing and sales operation, work begins when a customer orders something. This order transaction triggers the preparation of a production order transaction requesting a manufactured product. Then we produce several other transactions to gather the material to produce the item, to specify work orders, and to integrate the materials, people, machines, and manufacturing processes to produce the item. In the meantime, we use the sales order transaction to prepare invoices and statements requesting payment from the customer. These transactions enter the accounting system and are maintained as historical records for reporting and control purposes. Documents sent to customers request and provide evidence of payment for the products. These transactions, in turn, enter the accounting system to be balanced against production and distribution costs and expenses.

As this scenario suggests, transaction records are part of many systems. They provide mechanisms for getting the work done. They represent the key data flows in a system, activating and controlling system processes.

Storing Information

The second function of MIS outputs is archival storage. Archival records are permanent documents. Sometimes archival records are business reports and transaction documents. Sometimes we copy these reports and documents in either human or machine readable form and use the right materials for long-term retention and use.

We have three reasons for archival storage. First, we're legally required to retain certain business transactions. Second, business records give us an historical commentary on business activity. Long-term trends contained in this information can be used to project and plan for future activity. Third, archival records give us backup security. If we destroy active records through fire or other disaster, we can restore business files, reports, and turnaround documents from archival files. So we must be able to easily access archival records.

Transferring Information

The third function of MIS outputs is turnaround documents. Turnaround documents are computer output documents we use as input documents to a follow-up processing activity. In its output form, a transaction document triggers some action on the part of its recipient. Usually the action is then indicated on the document itself or accompanies the document on its return. The returned document activates the next processing step in the system.

Some years ago, we used turnaround documents for college class registration. In those days, the outputs were punched cards representing individual seats available for each class. A student registering for a particular class was given a card identifying a taken seat. Those class cards, together with cards containing student identification information, were collected and reprocessed through the computer to produce registration records and lists of students enrolled in particular classes.

A turnaround document triggers a transaction and produces an output document. A returned output document is evidence of the transaction and becomes input to the next processing phase. Turnaround documents can take physical forms besides punched cards.

A turnaround document helps automate data entry. In the class registration example, class cards were punched with identification information already in input form. We didn't have to keyboard those data. We only had to enter the student identification numbers, saving time and reducing the possibility for error.

Turnaround documents help collect data. For example, in a billing system for an electric utility, meter reading books serve as turnaround documents. The computer can print the books so the pages are ordered by the sequence in which the meters will be read and can contain meter location and other information helpful to the meter reader. Usage data are then collected by meter readers who record the data in these books.

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.7. Information Portrayal

1.5.8.7.4. Portrayal Design

1.5.8.7.4.1. WRITTEN FORMATS.

In written formats, we must make meaning for our audience.

Many system analysts design information systems by first considering the design of the output formats. They come at the information specialist part of the MSM for the information portrayal/information perception interface.

We design output documents or displays by first establishing data content. The system analyst works with the user to identify the information needed to support certain decisions. Then he or she can figure out the list of data elements to be included in each of the outputs for the system. This listing leads toward the creation of a data dictionary for the new system. The user must be involved in generating this list. Before you start designing forms, display screens, or report layouts, you must know what the content requirements will be.

Once content is established, analyze and formulate output requirements. The user and the analyst together should consider questions such as these:

- What is the business purpose of the output?
- Who will use the output and how will they use it?
- What decisions will the manager make using the output?
- Is each data element in the output essential?
- Are any data elements missing, given the intended use?
- Is the same information to be included in other outputs?
- How often should the output be produced?
- How many copies are needed?
- What is the best form and format for presentation of the data?

Answers to these and other, similar questions will help the analyst establish a business understanding of the problems the system will solve. By specifying content, format, and scheduling for output documents, users indicated how important the reports will be and the role they will play in the new system.

Common Written Formats

Recall the MSM and focus on the information portrayal/information perception interface. I'll discuss the distinction between data and information and explain logical ways to determine which of the four portrayal formats—graphics, checklists, tables and text—is appropriate for the various characteristics of the data that must become information to be useful.

The model has three components: who manages, what is managed, and what is used to manage; and three interfaces: the decision/action interface, the measurement/data interface, and the information portrayal/information perception interface. The manager, the who, is the forcing function, driving the system through decisions that lead to actions that affect what is managed. Measurements of what is managed become the data that feed what is used to manage: plans, policies, procedures, reports, and briefings, supported by the people and machines that collect, store, retrieve, manipulate, and portray these data, which the manager perceives in various formats and uses to make decisions.

What do I mean by data becoming information? Aren't data and information the same thing? I just happen to have here 18 volumes of census data for Czechoslovakia, by province, for the years 1920 - 1932. So what? But suppose I was studying Czech demographics over that period to determine the effects of increased industrialization on farmers' migrations to urban areas.

It's like clues in a mystery. Until some Sherlock perceives a *pattern* of meaning, in which a bunch of things that-are-the-case add up to something that tells whodunnit, a clue isn't a clue at all. It doesn't *have* meaning all by itself but must be *made* meaningful by someone who figures out how to ask the question to which the clue becomes part of the answer. "Data," after all, means "what is given." Data are the mere results of measurements, either by instruments or by the inventor of all instruments, the human mind. Whereas "information," or in-formation, is an internal pattern, a schema into which data are incorporated by an organizing principle that selects data that fit and rejects as noise those that don't. Depending on the schema, that in turn depends upon the schematizer's reason for having or wanting or needing it, the data's pattern and therefore meaning will differ. In short, data are a matter of what is given, and information is a matter of what is received, or perceived, or conceived—all three words coming from a root signifying "to gather."

Nothing counts as information unless it responds to someone's question and therefore fulfills a purpose. For purposes of management, information is anything that helps a manager make decisions and take actions that affect what is managed. Data become information—or rather, managers use data to generate information—when they apply a bias or slant or interpretation to a set of data. I can make the best decisions—that is, the most informed decisions in the shortest time—when the information comes to me the way I want it: when it answers all the questions I need to have answered, none that I don't need to have answered, and in a format that is as easy and pleasant to understand as possible.

Part of managing is measuring what is managed; these measurements yield data that a variety of people and machines working on operational endeavors will store, access, manipulate, and portray for strategic-level decisions. To manage effectively, the manager must see to it that the format(s) generated by these people and machines—by what we call the data-to-information chain, answer his or her needs for making the best decisions (down the line) and the best presentations (up the line). In other words, a manager of hardware inventories is not simply in charge of quantities of nuts and bolts on hand and on order. This manager is also in charge (or should be if he or she isn't) of the formats in which the data-to-information chain converts data to information for his or her use.

The characteristics of information portrayal depend on the characteristics of the data. Data characteristics differ along two dimensions: purity and volume. On the purity dimension, data may be seen as isolated from everything except that which was measured, the means of measurement, and (though this last is usually overlooked or lumped in with the means), the agency of measurement, i.e., the measurer. Data lose rawness (if they ever have it!). After all, to measure anything is to distort it, as Heisenberg showed; so even measurement as measurement, as well as the decision to measure *this* and not *that*, constitutes interpretation and yields the quantitative equivalent of a metaphor.

A datum, which is a straightforward quantitative physical measurement—for example, the millimeters of mercury in a thermometer—is impure in proportion as the device itself is imperfect. If the thermometer is read by a second device, then the original impurity, or limit of error, is increased by that of the device. If the thermometer is read by a human, then the impurity grows by at least the imperfection inherent in the best human perception. In short, though objectivity is in principle impossible since it always involves a human subject's perception of an object, the bias in physical measurement is the lowest attainable and grows less as instruments mitigate human perceptual limitations.

At the other end of the purity scale are subjective, qualitative, conceptual data, as in William Blake's perception of the sun as "an innumerable company of the heavenly host shouting 'holy, holy, holy is the Lord God Almighty.'" Between these poles come subjective responses given within an objective and therefore quantifiable scale or framework, like grades A to F or the response to

> I like meatballs. (circle one number.)
> DISLIKE 1 2 3 4 5 6 7 8 9 10 LIKE

The data-volume dimension is simple: data can be few or many.

These characteristics and their combinations (many/pure, many/biased, few/pure, few/biased—with all possible gradations) help us logically to determine the appropriate portrayal format. They only *help* us, because portrayal logic is one thing, but perceptual preference, or cognitive style, may be quite another. No vendor has ever succeeded in selling Proctor and Gamble graphics packages for their computers because the company wants and hires managers who love tables—detail people, not visualizers.

Strictly speaking, converting data to information is always a matter of losing something and gaining something else. What you lose is some purity, by the very process of selection (which, you recall, is already a form of interpretation); what you gain is a point of view, a bias—which means a cut or an angle. So, portraying data into information isn't "lying" in the sense of deception with intent to protect oneself and/or harm another. It is, rather, deciding what *part* of the whole truth to tell, for a particular purpose, to a particular audience, for a particular occasion.

1.5. Tools and Skills Categories

1.5.8. The Communication Skill

1.5.8.7. Information Portrayal

1.5.8.7.4. Portrayal Design

1.5.8.7.4.2. Graphics

1.5.8.7.4.2.1. What Graphics Do.

A graphic provides a pictorial representation of data with implied comparisons for making information. The question is: Which representation implies a particular type of comparison best?

All presentation formats begin with raw data and add the perspective or goal of the individual who creates information from the data. The form closest to the raw data, which includes greatest purity and least perspective, is the table. The arrangement of data for a table allows the presenter to choose titles, rows, and columns, and arrangement of rows and columns. The data in the table can carry as much precision as available. The graphic is the next most pure representation of the data. In the transition from table to graphic, much precision is lost and much perspective or bias is added. Within this hierarchy of presentation formats, the checklist follows; and the final form is the narrative or text. The narrative includes little precision and much perspective, opinion, and conclusion. An important point is the danger in producing a format from a higher-ordered format. That is, a graphic would not be produced from a checklist or narrative because there doesn't exist sufficient purity in those forms. Rather, a graphic should be produced from a table or from the raw data.

Figure 1.5.8.7.4.2.1.a., the presentation formats flowchart, allows the manager to choose the appropriate presentation format. By looking at the data characteristics, the manager will be logically moved to select text, tables, checklists, or graphics.

Graphics

Some managers, perhaps intuitive managers, should receive the best decision-oriented information from graphics. In support of these graphics, a management document may contain tables of data, checklists, and narrative, explanatory, or analytical text. The key to a good document is that the graphics will display the crucial points of information, while the tables, checklists, and text will provide the backup data and information the manager would want when more specific analysis and interpretation are required.

While graphics can be a concise way to communicate information in a book, paper, report, briefing, or management information document, they can also be confusing or misleading when improperly designed. The increased availability of computer-generated graphics has led to a proliferation of charts and graphs. Graphics should simplify, not confuse. They must focus, not distract. Some managers dislike a particular type of chart; and while preferences are to be expected, given various cognitive styles, chances are that much of this dislike comes not from the chart type itself but from experience with the misuse of that chart type.

Each graphic should be designed to communicate one idea or point. Once the point is defined, a logical, structured procedure can be followed to design an appropriate graphic. While the following approach contains certain specific guidelines for graphic design, it also incorporates considerable flexibility. Since the selection of points to be made depends upon the manager's personal approach and style, this design flexibility is one of the strengths of the presentation format procedure. My approach is to structure the process of designing graphics through a set of logic diagrams. These diagrams provide guidelines whereby anyone can address vast amounts of data and render effective graphics.

The general principles for the design of graphics arise from two basic criteria. The graphic must be easy to read (i.e., clear). And the graphic must strongly make the desired point about the data, or conclusion from the data. The steps described below are intended to create graphics that satisfy these criteria.

The first and most important step in graphic design is to determine the main idea to be communicated. Then an appropriate graphic can be selected to communicate this idea. Since the number of points or ideas successfully communicated by a graphic is inversely proportional to the number of ideas or points exhibited on the chart, it is important to minimize this number, ideally to one.

Graphics display five different types of comparisons:

1. Component comparison—shows the relative importance of the component parts of a whole.

2. Item comparison—shows the relative importance, ranking, or performance of related items.

3. Time-series comparison—shows the distribution of an item over time.

4. Frequency distribution—shows the distribution of an item over several categories or classifications.

5. Co-relationship comparison—shows how two variables relate to one another.

We must determine the main idea to be communicated before we can select the type of comparison we want. Then we can identify the type of comparison that will best communicate this idea. The third step in the graphic design is to select the appropriate chart type. The final step is to create the graphic following the design principles for the chart type selected.

There are seven basic types of charts. Figure 1.5.8.7.4.2.1.b. [from *Choosing & Using Charts* by Zelanzny and Roche] shows how each of these chart types applies to the five types of comparisons. Figure 1.5.8.7.4.2.1.b. is the basic tool for selecting a chart type.

There are many possible variations and combinations of these seven basic chart types. For example, bar and column charts can be subdivided into components that make up each bar or column; several curves can be superimposed on the same chart with varying scales. The best general guideline is to design the simplest chart that will communicate the main point. A graphic with two curves is not necessarily twice as good as a chart with one. Each of the seven chart types and a few of the individual design rules are given in the following sections.

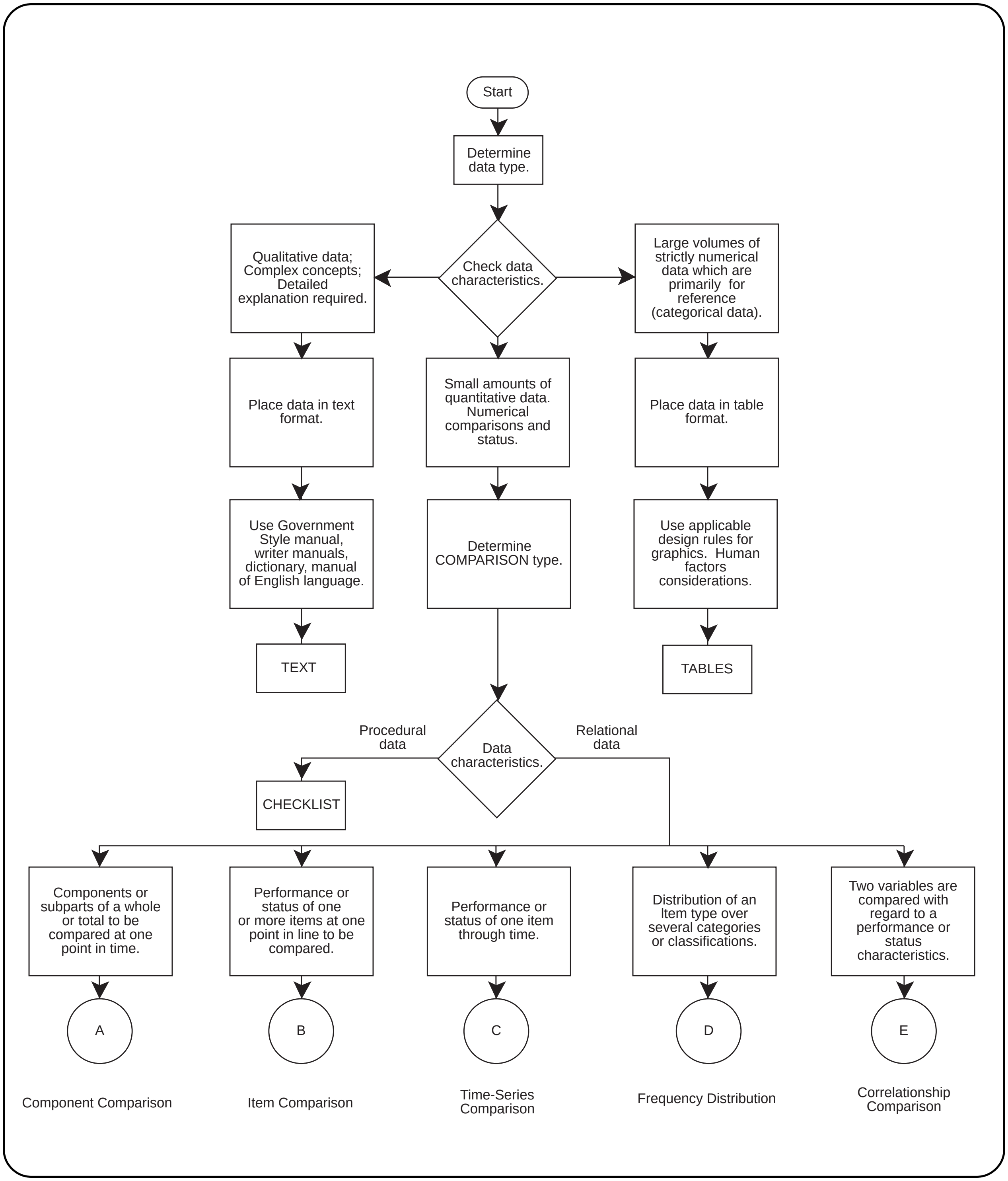

Figure 1.5.8.7.4.2.1.a. *We can flowchart presentation formats to help us logically choose the presentation format most suitable to the data and to the conclusion we're trying to make.*

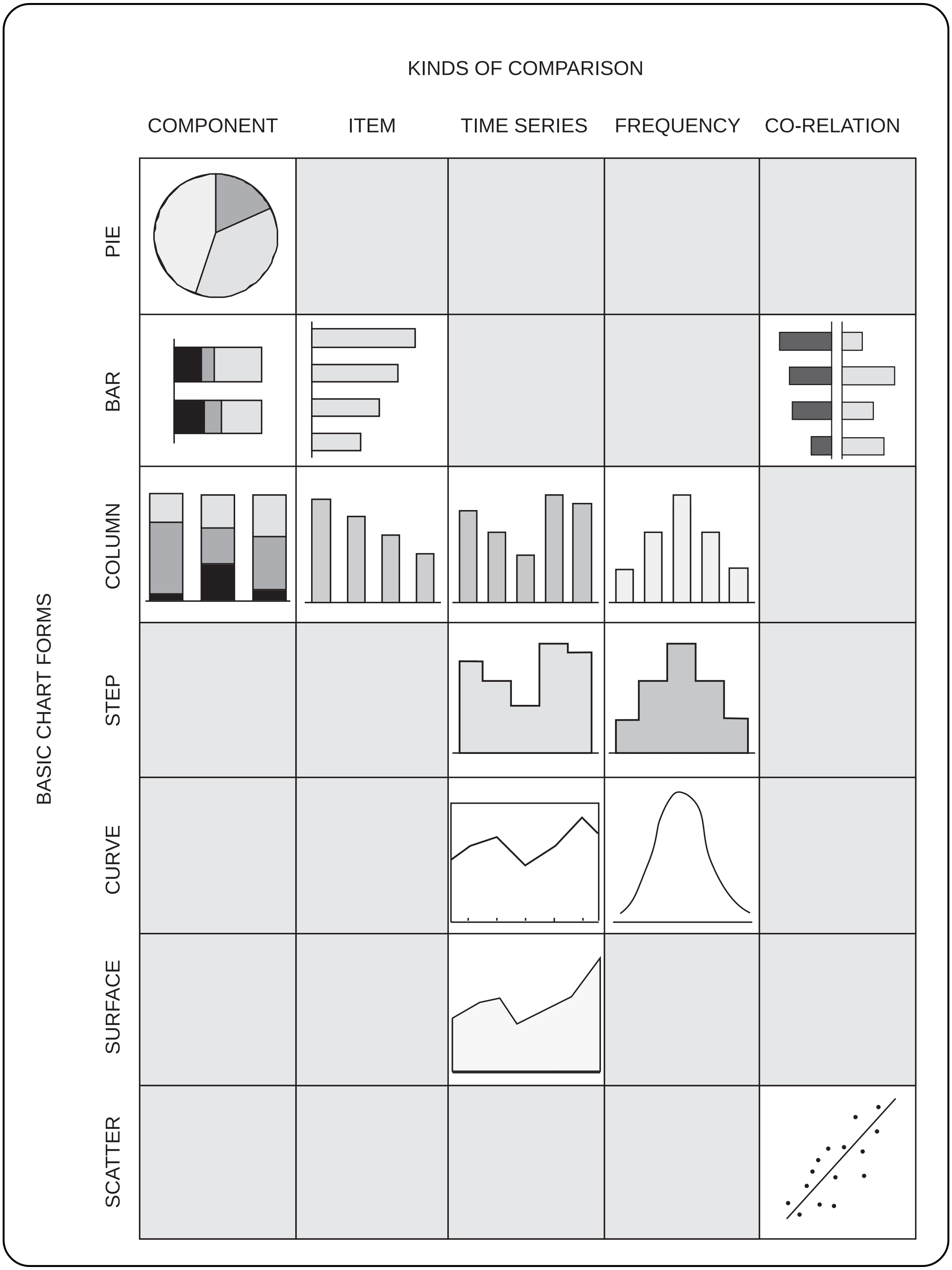

Figure 1.5.8.7.4.2.1.b. *Several types of graphical presentation formats show the different types of comparison for data.*

1.5.8.7.4.2.2. Component Comparison.

We use component comparison when the main point of the graph is to show the relative importance of the component parts of a whole.

The logic diagram for component comparisons is displayed in Figure1.5.8.7.4.2.2. We use component comparisons when the main point of the graph is to show the relative size of component parts of a whole. A component comparison is often described using words such as "percent of total," "contribution," "portion," or "share." Three types of charts are best for graphically portraying this type of information: pie charts, 100% bar charts, and 100% column charts.

As the first decision node of the logic diagram in Figure 1.5.8.7.4.2.2. indicates, component comparison is only appropriate when the number of components is less than five. The next decision node concerns the number of totals or wholes involved. When information is to be given concerning one total, the pie chart is best. If a particular component of a pie chart requires emphasis or if the components can be ranked by importance, then the component receiving emphasis should be placed in the pie starting at the 12 o'clock position and proceeding clockwise. Darker and denser colors should be used for the most important components and for those components that need emphasis.

The logic diagram in Figure 1.5.8.7.4.2.2. shows that when the components of several different totals are to be portrayed on a single chart, the 100% bar chart or the 100% column chart is indicated. If there is a time orientation to the components, the column chart is indicated. Time is normally displayed on the abscissa. When there is no time orientation to the components, the bar chart is most appropriate. The bars are easier to label, fit in less space, and make comparisons between separate totals easier than two or more pie charts placed side by side.

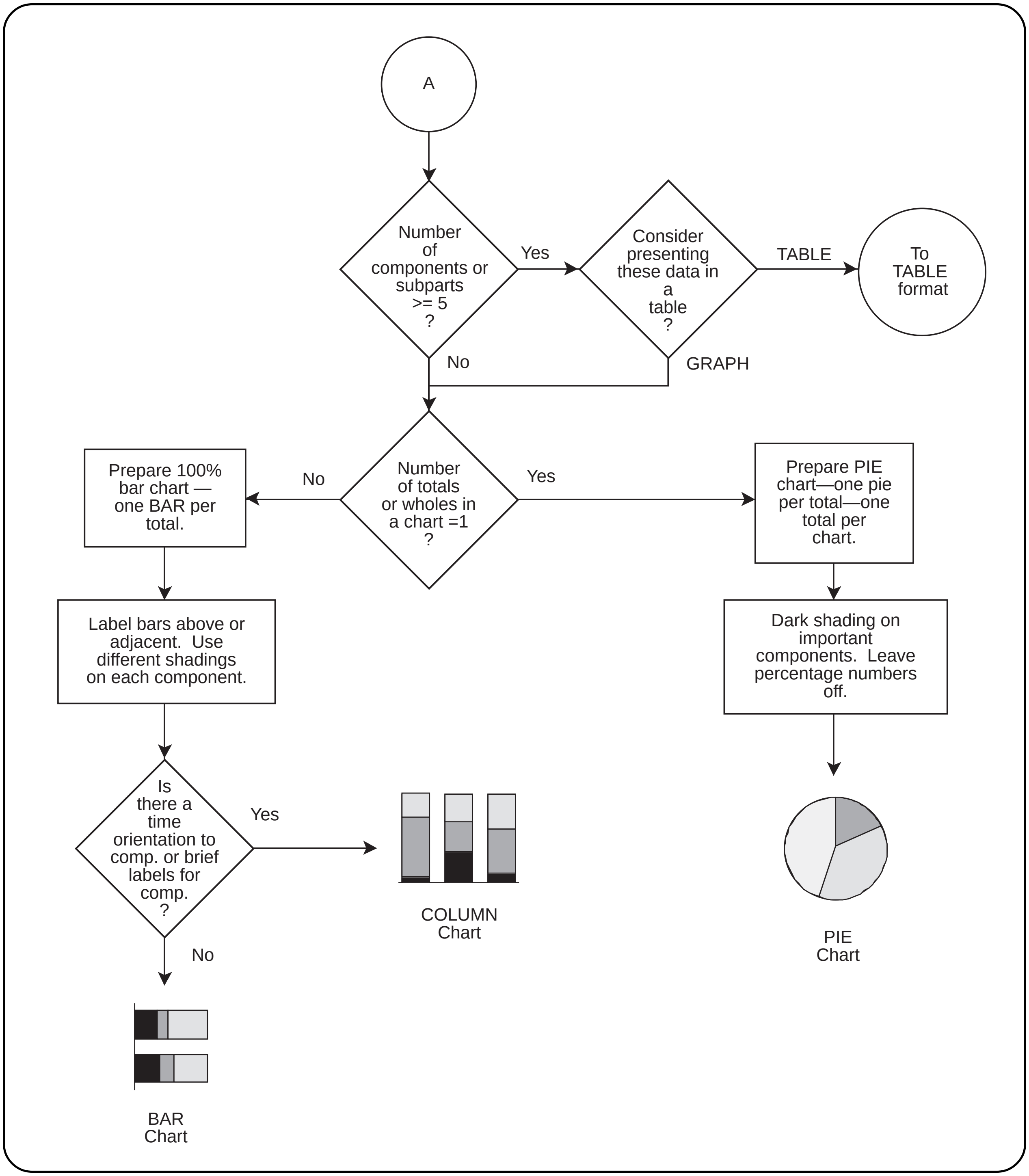

Figure 1.5.8.7.4.2.2. *We use component comparison when the main point of the graph is to show the relative importance of the component parts of a whole.*

1.5.8.7.4.2.3. Item Comparison.

We use item comparison when we want to show the relative importance, ranking, or performance of related items.

The logic diagram for item comparison is displayed in Figure 1.5.8.7.4.2.3. Item comparison differs from component comparison in that related items are compared on a scale which is labeled with absolute units. As the first decision node of Figure 1.5.8.7.4.2.3. indicates, if the items aren't on the same scale, a text or table should be used, or the items should be placed on the same scale and the bar chart used. These units may be any physical or monetary scale or a percentage. When the scale is a percentage, the 100% mark doesn't represent the sum of the items graphed.

Each item in an item comparison is shown with a value for the characteristic being displayed in the graphic. For example, a chart showing a year's production (in pounds) of various chocolate bars made by one company would be an item comparison. The focus of item comparisons is to show the sizes of, or quantities achieved by, each item.

Although either the horizontal-bar or vertical-bar chart can be used, current thinking in the field of graphic art recommends that the primary tool for item comparisons should be the horizontal-bar chart. The horizontal-bar chart allows sufficient room for a textual description or name for each item in the comparison. Thus the vertical scale in such a chart is not really a scale at all. Item names may be arranged alphabetically, randomly, or by some other criteria. A major advantage of the horizontal-bar chart is that it will not be mistaken for a time-series chart. A horizontal-bar chart is a "snapshot" of the status of the items involved at a single point in time.

In a bar chart, the main point of the graphic affects the order of the items. For example, the order may be randomized to emphasize the unevenness of performance among items. On the other hand, items may be ordered by increasing or decreasing value of the characteristic being displayed. This is often done to show where particular items lie in the ranking.

There are several variations of the horizontal-bar chart. These include range bar charts, which show a range of performance on the characteristic scale, and deviation bar charts, in which bars may extend in either direction from a vertical base line. Horizontal-bar charts may even have bars split into several components. While this practice may make the chart appear similar to a component-comparison chart, the difference lies in the emphasis on the comparison between items rather than among components of a single item.

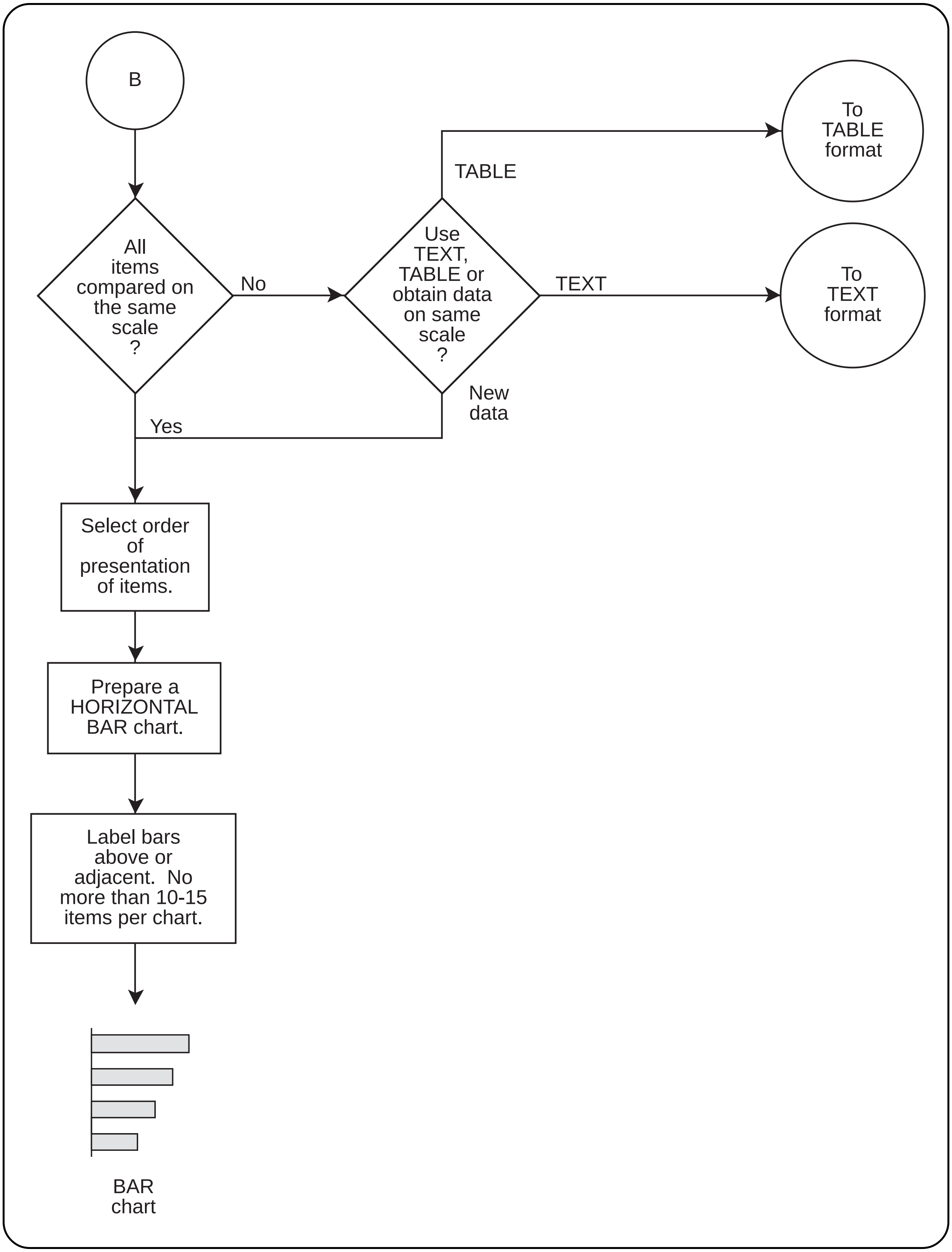

Figure 1.5.8.7.4.2.3. *We use item comparison when we want to show the relative importance, ranking, or performance of related items.*

1.5.8.7.4.2.4. Time-Series Comparison.

We use time-series comparison when we want to show the distribution of an item over time.

The logic diagram for time-series comparison is displayed in Figure 1.5.8.7.4.2.4. A time-series comparison shows how the performance of a single item changes through time. It highlights fluctuations or trends and exposes patterns. Figure 1.5.8.7.4.2.4. requires two key decisions that narrow the choice among the four chart types. The first question is whether or not the data have been kept on the same scale over the time period. If yes, the next decision is whether the data are discrete or continuous. If they're continuous, the surface chart or curve chart is most appropriate. We select the surface chart if the emphasis is on magnitude, the curve chart if the emphasis is on trends or changes.

If the data are discrete, the column or step chart is indicated. The key question for selection between these two types is whether or not the number of time periods is fifteen or fewer. If the number is less than fifteen, proceed to the column chart; if it's greater than fifteen, proceed to the step chart.

Customarily, time is placed on the horizontal axis in all time-series comparisons. The vertical axis represents the scale of the characteristic that is being measured for the item.

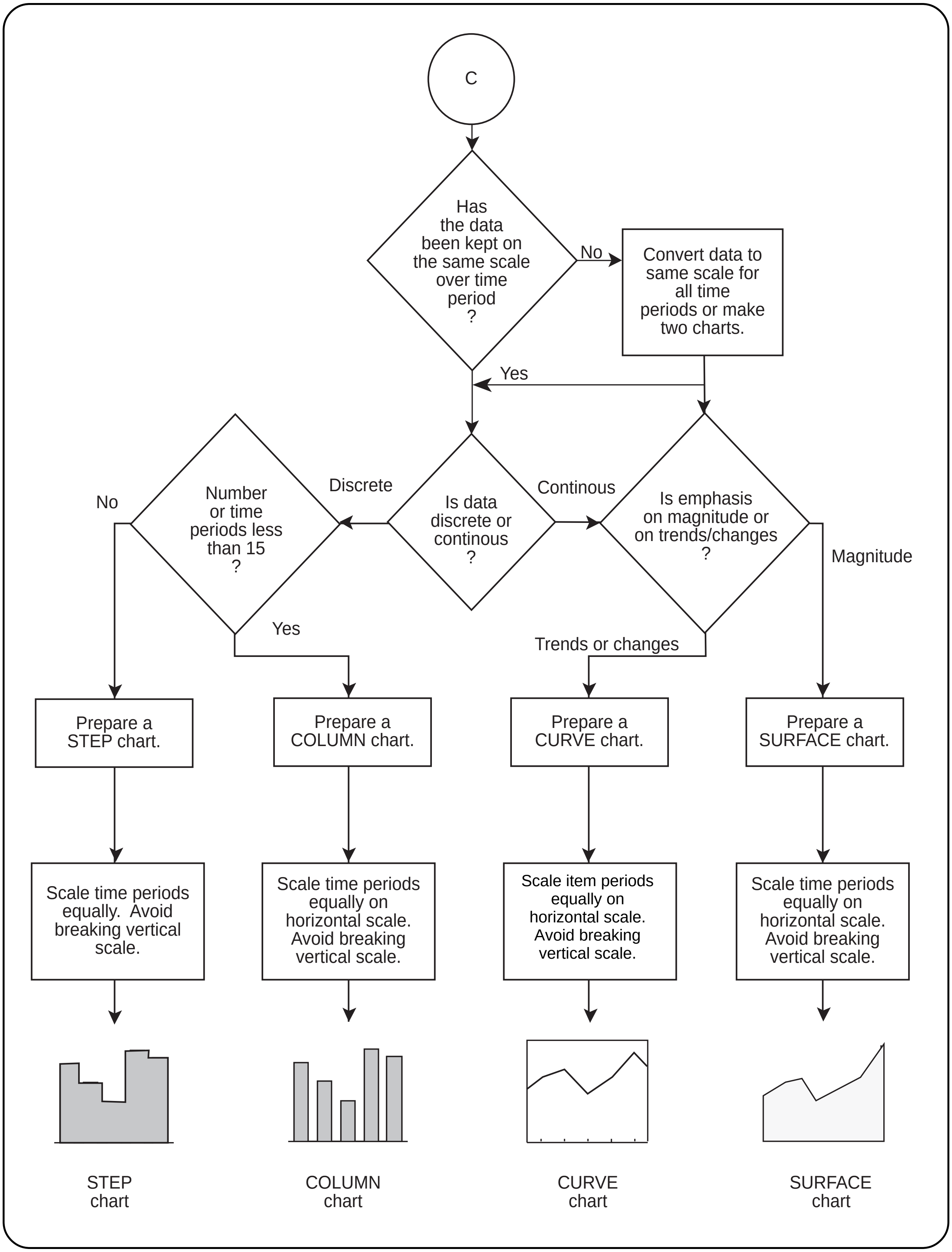

Figure 1.5.8.7.4.2.4. *We use time-series comparison when we want to show the distribution of an item over time.*

1.5.8.7.4.2.5. Frequency Distribution

We use frequency distribution when we want to show the distribution of an item over several categories or classifications.

The logic diagram for frequency distribution is displayed in Figure 1.5.8.7.4.2.5. A frequency distribution comparison shows the number of occurrences or events in each of several ranges along a scale that measures a particular characteristic. Suppose, for example, you wish to understand something about the patterns of service calls for various brands of microcomputers in August 1992. A frequency distribution could be created from daily service call reports from that month.

Column, step, and curve charts can be used to display a frequency distribution. Generally-accepted practice is to place the scale that measures the characteristic of interest along the horizontal axis in these charts. The vertical axis in all of these charts is either a simple frequency count or a percentage of the total number of occurrences.

As the first decision node of Figure 1.5.8.7.4.2.5. indicates, the key decision for selection of graph type is whether the data are discrete or continuous. If the data are discrete and we have more than ten valid points and more than fifteen class intervals, we select the step chart. If we have fewer than fifteen class intervals, we select the column chart (or histogram).

As indicated in the first decision node in Figure 1.5.8.7.4.2.5., if the data are continuous, the curve chart (or frequency distribution) is indicated. The curve chart will show continuous data where differences between intervals are infinitesimally small and the number of intervals is large.

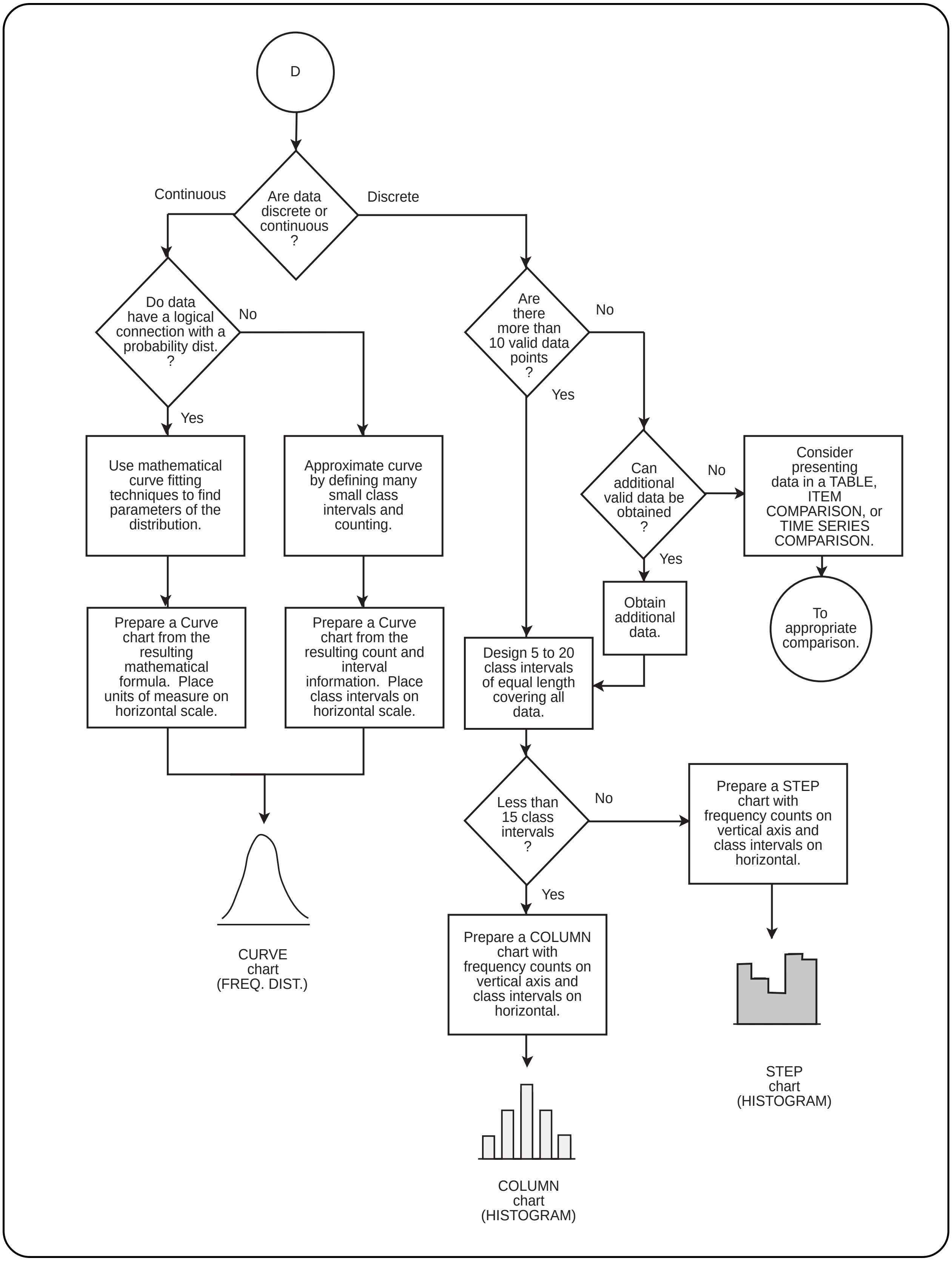

Figure 1.5.8.7.4.2.5. *We use frequency distribution when we want to show the distribution of an item over several categories or classifications.*

1.5.8.7.4.2.6. Co-Relationship Comparison

We use co-relationship comparison when we relate variables to each other.

The logic diagram for the co-relationship comparison is displayed in Figure 1.5.8.7.4.2.6. Co-relationship comparisons relate two variables to each other in a manner similar to the way variables are examined in regression and correlation analysis. The typical purpose of a chart of this type is to expose a relationship between the two variables. For example, we may want the relationship between the output from a particular nuclear reactor and the amount of energy consumed by that reactor.

There are two chart types used to graphically portray co-relationship comparisons: the dot chart, also known as a scatter diagram; and the paired bar chart. As Figure 1.5.8.7.4.2.6. indicates, the key decision node for selecting chart type is whether data points must be individually labeled.

Labeling each dot in a dot chart is difficult to do so that the reader may easily understand the source of each data point. The paired bar chart solves this problem by using a pair of bars (one bar for each variable) to represent each data point. This type of chart provides the reader with more confidence in apparent relationships by clearly indicating the source of each data point.

The scatter diagram contains data in the form of dots, each of which represents a pair of variable values, usually obtained from historical data. Data for the comparison between reactor output and energy consumption could be collected on an annual basis for ten years, which would result in ten data points (dots).

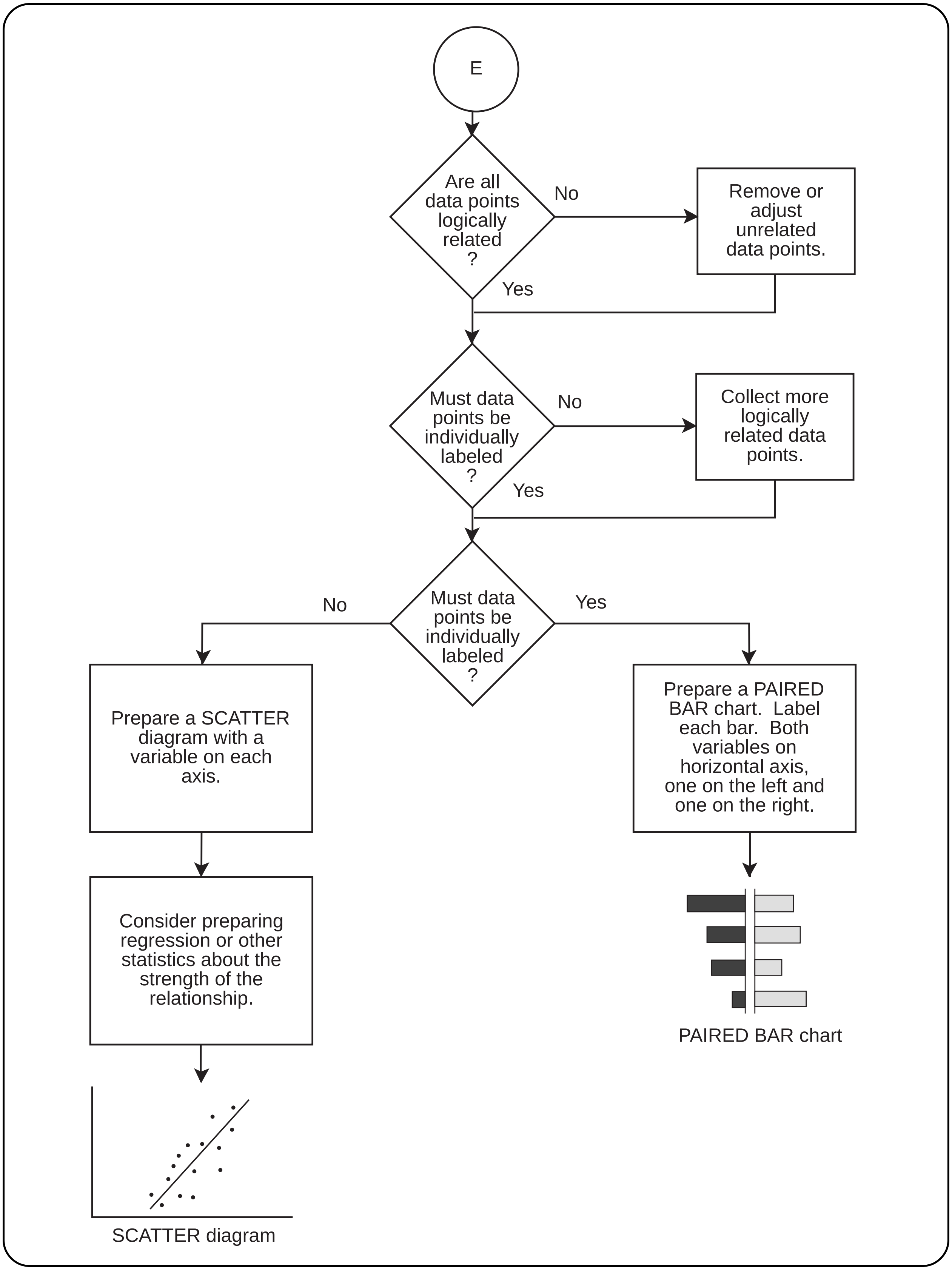

Figure 1.5.8.7.4.2.6. *We use co-relationship comparison when we relate variables to each other.*

1.5.8.7.4.3. TABLES

Tables provide the most unbiased format for data.

Tables
A table is rectangular array of usually numerical data, designed to show relationships between the horizontal and vertical categories. A table is a container for data points; each cell of a table is a point specified by two coordinates. Thus, and in accordance with the dictum that a purer format can be used to generate an exhibit in a less pure format, a table can yield a set of one or more graphics, checklists, texts, or a combination of these. The table, on the purity dimension, is one step removed from raw data. Raw data are in principle infinite in quantity, and even the longest table is finite and therefore a *selection* of data; to select is to bias. Further, the table is selective in the relationship(s) it portrays through the table maker's choice of categories.

The purpose of a table is to provide easy access to a (usually) relatively large number of reference data. Thus, unlike a graphic, a checklist, and (usually) a text, a table is a randomly accessible database, used primarily only in part or parts—a table of logarithms or English/metric conversions or even a telephone book.

Table Design
The logic diagram for constructing tables is shown in Figure 1.5.8.7.4.3. First, the preparer must, as with all portrayal formats, name the table, i.e., choose what shall be portrayed for what purpose. The title or name should indicate the precision and the relative completeness or incompleteness of the data presented. When possible, the title or name should be given as a complete sentence, preferably no longer than 10 words. This recommendation, which follows the central criterion of the Perry Method for constructing briefing charts, is apt because a sentence, unlike a word or a phrase, expresses a complete thought. The table maker can thereby unequivocally establish his or her slant on the data by making clear who's doing what to whom (or what's doing what to whom, or what's doing what to what). The normal pattern of an English sentence—subject, verb, object—is also (and probably for deep reasons that neurophysiologists may never understand) the pattern, the heuristic, that makes data into information.

Beyond naming, the aim is to make the table as easy to use as possible. Given that a user will look down (or up) and across to find each data point, this task should be easy on the eye, with possibly a network of orthogonal lines boxing in the points if there are many and they're physically close together.

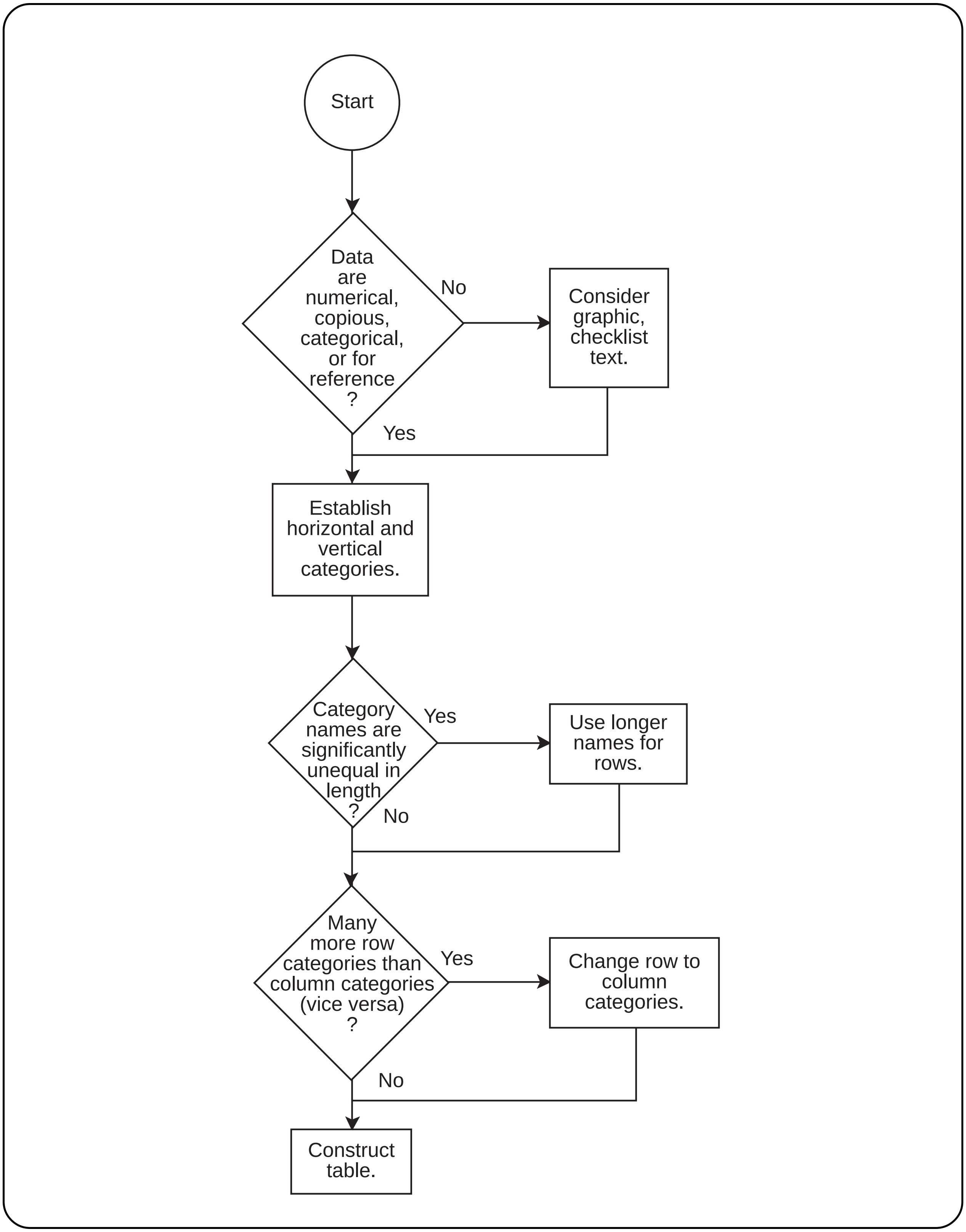

Figure 1.5.8.7.4.3. *The construction flowchart for a table starts with the number and type of data.*

1.5.8.7.4.4. CHECKLISTS

The checklist guides your thinking in a predetermined direction.

Checklists

A checklist is a mnemonic, a set or sequence of procedural steps, sometimes appearing as just a list of items of any sort, for example, a grocery list. In fact, the grocery list *is* a set of procedures, for the verb "buy" [or in some neighborhoods, "steal"] must be understood, as must the verb "mix" or "combine": for the items in another species of checklist, the recipe.

The checklist *may* be randomly arranged—like a grocery list of items in the order in which they came to mind—but the most effective list will be in *some* logical order. For shopping, the order might be that of related items (meat, milk, cereal, etc.) or of location, classifying items by aisle; it might equally be in order of importance: if money runs out, buy the first items first. In short, the checklist must carry some bias and direct the user to follow the simplest path to the desired goal. Normally, unlike a table, which is used for reference and in part, a checklist is meant to be completed.

The purpose of a checklist is to move a user through a process to achieve a specific goal. The user is not to argue with or interpret or make selections from the list; he or she is to be controlled by it. All interpretation—the purpose of the process, the selection and ordering of the steps—is done beforehand by the preparer. Sometimes the order will matter little, when for example one is to buy eggs and milk; it's no great question whether to pick up one or the other first. But say a spouse makes a morning checklist containing the items

wake up
kiss husband/wife
brush teeth

In this case, the order is everything. If the purpose of the procedure is to celebrate and prolong the marriage, the brush precedes the kiss; if, however, the goal is to show contempt or slowly to poison the union, then the kiss should come first. The distinction is thus between necessary and conditional constraints.

Checklists Design

The logic diagram for constructing checklists is given in Figure 1.5.8.7.4.4. As with graphics and tables, the checklist must be easy to read and follow. Ease will partly be a function of layout—size of type, spacing, etc.—and partly of length. The general rule here is that fewer is better. The preparer must not, however, sacrifice clarity for brevity by combining into one step two or more sub-steps that the user may not recognize as indicating more than one action. The preparer will do well to keep in mind, if not always to practice, the rule concerning what has been called "the magic number 7 plus or minus 2." Human short-term memory, researchers have found, can store only between five and nine bits. To remember many more than nine bits, an individual must "chunk" bits into larger units—as we do with telephone numbers, the three-digit prefix becoming not three separate pieces but one single chunk. Thus, if a checklist contains many more than nine items, the preparer should try to organize these items into a smaller number of groups or categories.

The ease-of-use criterion applies more or less strongly in proportion to "what's in it" for the user. Someone using a checklist for bomb disposal is likely to pay the fullest possible attention to each step. An experienced pilot, however, is likely occasionally to neglect—or wish to neglect—steps in the start checklist and must be persuaded, insofar as possible, by the very simplicity of the format, to follow it through. In some instances, the preparer may find it advisable to make what must necessarily be a long procedure into a series of shorter ones—two or three separate checklists, perhaps, instead of one.

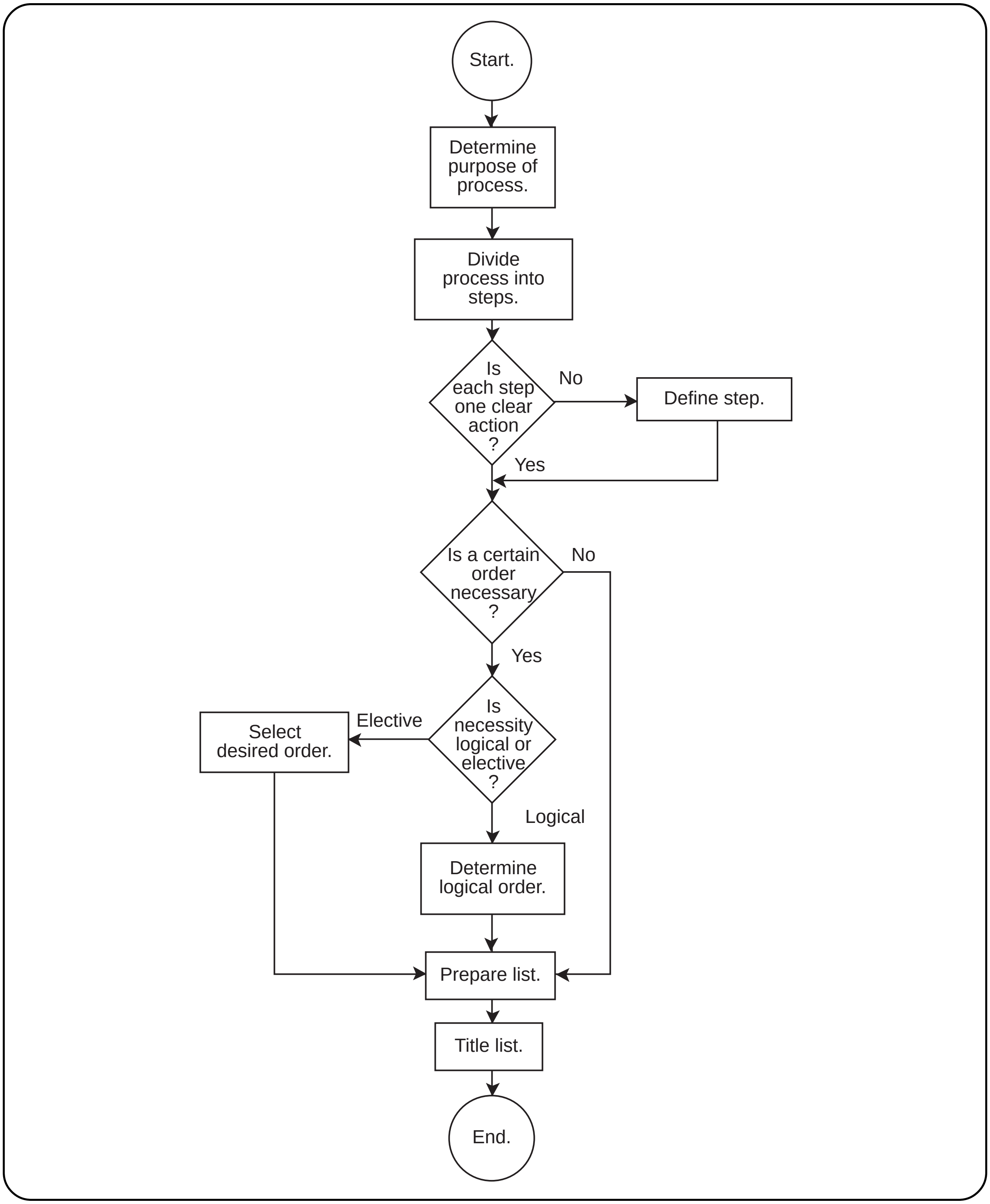

Figure 1.5.8.7.4.4. *The checklist construction flowchart focuses on clarity and usefulness of the checklist.*

1.5.8.7.4.5. TEXT

With text, we can portray our bias easily and we can interpret the meaning in many different ways. Text carries the maximum richness, biasedness, and opportunity of ambiguity.

Text
Text (discourse) permits the presenter the most control or bias, for the rules and constraints governing text production exist only at the most formal levels (use of conventional letters, numerals, and other symbols; and accepted standards for spelling, grammar, and syntax), leaving more to the producer's choice than any other medium (except music and visual art, which is not to the point here).

Textual presentation is appropriate when data are primarily or entirely qualitative, abstract, or conceptual, and when the producer must supply detailed explanation, description, narration, or argument. Text is also the only format that can have a voice—that is, call clearly to mind a *persona*, a character behind the words.

Text may be made randomly accessible by the use of tiles, headings, and other symbols, but the smallest unit of text is the sentence, whether fully represented or elliptical. The text producer must, like the producer of any other format, take into account both the purpose of the text and the needs and desires of the audience. Given that text communicates both objective information (facts and hypotheses) and subjective information (attitudes and feelings), the writer must decide in advance what he or she wants the reader

a) to know or know how to do as the result of reading the text, and

b) what attitude toward this knowledge or ability he or she wishes to elicit.

The schema in Figure 1.5.8.7.4.5. shows the priorities and subtasks of the process of text production, moving from matters of choice at the top to matters of convention at the bottom.

Text Design
So much attention has been paid in recent years to the cognitive processes underlying the production of text that even the briefest summary would occupy many pages. For my purposes, let it suffice to highlight those assumptions shared by all theorists and researchers. Instead of providing a flowchart in this section, I'll highlight the salient premises, comment on them, and suggest useful applications.

1. Writing is not merely the transcription of already-formed thought; it is, more, a technology for knowing, thinking on paper (or monitor!).

   Comment:
   In *Rhetoric, Romance, and Technology*, Walter Ong observes that writing makes possible not only the *storing* of information outside the mind (this storing refers equally to any presentation format, any set of marks on paper); more importantly, writing, discourse, makes it possible *to have thought* that would be impossible in a strictly oral culture.

   Every writer surprises himself or herself by thinking something unexpected. E. M. Forrester's "How do I know what I think till I see what I say?" jibes with B. F. Skinner's assertion that "It is strictly impossible for a person to see all one's verbal behavior until he emits it."

APPLICATION:
Practically no writer "gets it right the first time." Few writers are what British poet Stephen Spender calls "Mozartian" composers—writers who do all the conception, generation, revision, and polishing in their heads so that when words meet paper they are fully formed, springing like Athena from the head of Zeus. Most of us are, rather, "Beethovenian"—explicitly messy in our composing, with all the stages in the production of a final draft exhibited. (Word-processing equipment makes it easier to forget this fact, since changes—additions, deletions, combinations, separations, substitutions, and transpositions—can be made without preserving the evidence.)

Therefore:
Write first to find your thoughts, second to please yourself, and finally to shape your message to the characteristics of your audience.

2. Writing, in the paradigm proposed by Murray, is a non-linear, iterative process of collecting, connecting, writing, and reading. That is, these four activities go on during the process that begins with the need or desire to write and terminates when a piece of text is transmitted to its intended audience. But though each activity may properly designate most of what the writer is doing at any one time, the stages continually overlap. In theory, a piece of writing is never finished; it is rather simply abandoned at some point because the writer has to get on with his or her life.

   Comment:
   The writer is the first reader of his or her text but should not be the only reader. It's too easy to overlook information or logic that, while plain to the writer, will be absolutely missed by the reader.

   APPLICATION:
   Get peer commentary on a document before sending it out. You won't have time to do this with everything you write, but for the most important documents, it's essential. Writing is always to some extent gambling, floating a trial balloon: there's simply no way to insure that a one-to-one correspondence exists between the writer's intentions and the reader's response. This difficulty is specific to the textual format because of the degree to which people can misunderstand by imposing on a set of words the interpretation they bring to them rather than being brought by the words to the interpretation the writer desires.

3. Every professional manager is also a professional writer and reader, and no manager has time to read all that comes into his or her mail slot.

   Comment:
   Every manager will agree with the premise given above as it applies to what he or she receives; few will realize that it applies also to what they send out. Somewhere in the mind of every manager lurks the erroneous assertion that "I know I get a lot of junk; thank goodness what I write gets read immediately and with pleasure by all receivers."

   APPLICATION:
   Write as simply, clearly, and briefly as possible. This is terribly difficult and takes practice. The harder the writer works, the easier it is for the reader.

Choices

Thematic (choice, unity, and development of topic)	Choose a subject and thematic design for generating and organizing ideas; select adequate points, details, or examples from observation, reading, or other sources of knowledge.
Rhetorical (audience and attitude)	Have specific readers in mind and their background and expectations regarding the subject and writer; maintain a consistent point of view, tone, and style.
Generic (genre or type of writing project)	Determine the kind of writing required for the subject, circumstances, and audience and the complexities involved—which may range from a simple personal note to the intracacies of a sonnet or a scientific explanation.
Formal (coherence)	Begin and end paragraphs at proper points. Use transitional devices, repetition of key words, and parallel sentence structure.
Syntactic (sentence structure)	Maintain logical word order, grammatical structure, coordination, subordination, and effective closure of independent or sentence units.
Lexical (diction or word choice)	Choose words that convey meaning and style accurately and effectively; keep a dictionary handy.
Grapholectical (standard written English)	Use the dialect and conventions of standard written discourse as distinguished from idiom to irregular patterns of speech.
Graphical (spelling and punctuation)	Use standard orthography and conventional graphic devices of mechanics and punctuation.
Scribal (handwriting or typing and proofreading)	Use legible handwriting or accurate typing, the motor skills of written composition.

Conventions

[*]Adapted from Ellen Nold's "Classification of Writing Subtasks" and Edward P.J. Corbett's *The Little English Handbook*

Figure 1.5.8.7.4.5. *Priorities and Subtasks of the Writing Process*[*]

1.5.8.7.5. Evaluating Portrayals

For the outputs of management tools, we evaluate information portrayals for performance criteria.

We evaluate outputs of management tools against criteria involving a number of trade-offs. Since information portrayals are the outputs of the data-to-information conversion processes within the management tools, we'll focus on these portrayals. The criteria for evaluation include:

1) Timing
2) Use
3) Volume
4) Quality
5) Cost

The age of information is driven by our need for the right information in the right form at the right place and the right time. We develop better computer tools because of the larger quantities of more-rapidly changing information. Timing has to do with the ability of data to rot. Data have shelf lives just like tomatoes do. And like running a grocery store, different kinds of data have different shelf lives. The problem is that data don't stink like food does when it rots. So, it's harder to sniff out rotten data. It's the decisions that stink when data rot. Is the information in the portrayal current? Is the information what is needed for this decision at this time? These are a couple of timing issues that affect the value of the information portrayal.

What will we use the information portrayal for? Is the use important? It's nice to have a birthday list of all our employees. It's more important to have a wage rate for all our employees. As we look at uses of information, we need to look at uses inside our domain of responsibility and uses outside our domain. In Module 1.6.1.1., I'll talk about information portrayals inside our domain as red-loop portrayals or information flows and information portrayals from our domain to another as blue-loop portrayals. We don't want people in other domains to necessarily see our internal information. We also want to make sure we address the audience when we prepare information portrayals for someone else.

Internally, we want to use information to help us manage better. This information is usually process-oriented information. We either want summaries and aggregations or details. When aggregating data, we get a bottom line or a trend. We're integrating data. When we look for details, we're differentiating data. We're looking for potential problems we can nip in the bud. All problems telegraph themselves first as small details. If we see the problem early enough, the problem is easy to fix. We may want standard reports, specialized responses to queries, work-process reports, or business transactions. If we look for the right details, we'll manage better. If we look for the wrong details, we'll manage poorly. Ultimately, we want to know if we're managing better as a result of having information available to us.

Externally, we tend to use information to show others what we're accomplishing for them or what we need from them. This information is usually result-oriented information. People in other domains of responsibility, if they're thinking total quality management, will want process-oriented information. Unfortunately, not many people have realized yet the value of looking at the supplier's or the customer's process rather than the results. For external domains, the valuable details are usually different than the best details for internal use. The information portrayals typically for those who want results are reports, invoices, shipping orders, and so on.

The volume of information we can produce is unlimited. So today, the measure of success is the least amount of information to get the job done. Throwing data at a problem is as inefficient as throwing money at a problem and about as expensive. With modern computer equipment and techniques, we can supply a vast amount of information in a small amount of space or time. Always remember the information portrayal to information perception interface and the equation audience plus purpose equals design. We have to carefully fit the amount of information to the needs of the audience. We can do great harm by producing large amounts of information to people who don't know where the details they need are or don't know how to use the information they get.

Quality of data and information and of the information portrayal depends on the ratios of bad, good, and relevant data and information discussed in Module 2.1.9.3. and on the fit of the portrayal format to the use of the information discussed in Module 1.5.8.7.4. The quality we need for an information portrayal depends on its use.

The cost of the information portrayal depends on the quality and quantity of the data and information, the process for accessing the data and information, and on the portrayal mechanism. The cost depends somewhat on the timing of the data and information, although today speed of delivery is so quick that seldom is timing a cost factor.

As with all sets of criteria, we have tradeoffs among them. Higher quality usually begets higher cost. Lower volumes usually mean lower costs.

1.5.8.7.6. Exercise on Designing Portrayals Student Registration

When we register for classes, we use many different portrayal formats, each needing improvement.

Scenario
The University Registrar manages academic information and some other personal information about students, like permanent and local addresses. We're only interested in academic information here. Most academic information deals with conducting classes, but some is regularly needed for things like graduation and some is sporadically needed for things like finding out how many classes are held in McBryde 100.

The Registrar's Office is the hub for data input and output on student registration. The users of the information are l) students; 2) faculty; 3) department heads; 4) college deans; and, of course, 5) the Registrar and the Student Systems organization that maintains the databases. The primary inputs to the system come from the students and the department heads. The assistant department heads (acting for the department heads) fill out course requests identifying for a course who teaches, class size, number of sections, requested time and room number, and other data. The Registrar produces the timetable (output format!). The students use the timetable to produce the other key input instrument to the Registrar—the registration op-scan sheets. The Registrar's Office is responsible for inputting to the Student Systems' database and for outputting class rolls and approved class tickets. The Student Systems organization maintains the databases for everyone to access. In addition to the users I've listed earlier, Student Housing, Student Affairs, the Office of Institutional Research, and others can access information. Both the Registrar and Student Systems report to the same Associate Provost.

I'll list the users of the information about registration and for each user. I'll identify documents they need by the name you're most familiar with.

Student
- timetable
- registration op scan sheet
- approved class ticket
- grade report
- graduation analysis
- drop/add form

Faculty
- class roll
  - initial—before first class
  - revised—after add deadline
  - final—after drop deadline
- individual student information—on request, for advising
- grade sheet
  - preliminary—for graduating seniors
  - final—for all students
- change of grade

Department Heads
- management report—showing class enrollment for all classes, no student names—used to assign faculty before classes begin
- class roll—the three versions listed for faculty
- grade sheet—copy from faculty—both versions
- student grade report—for student's file
- graduation analysis

College Deans
- grade report—for student's file
- graduation analysis

candidates for degree report—listing all students who applied for degree
any other report on request
special reports from STUCENFL (student census file), like those for all classes with more than 30% failures or all classes taught in McBryde 100

Registrar
requested course schedule—from department heads (to generate time tables)
registration op scan—from students
request for graduation analysis—from students application for degree—from students

Student Systems supports all this by maintaining the databases. They do no input. They code programs and maintain databases. They produce STUCENFL, which is a read-only file for archival use and is all data for all students. The data are frozen ten days into the semester. They also maintain a current file for up-to-date, live data for requests.

Another document all users need is the University Catalog (both undergraduate and graduate editions) written by each department and coordinated and published by the Registrar. Many departments update and extend the catalog by producing curriculum flow charts to help students schedule their classes in the right sequence.

Exercise
Your job is to pick three different information documents for three different users and develop student registration documents or output formats to help the users make their decisions. You can either improve in some significant way an existing document or you can design a new document. Show what you've done by drawing each format and stating the purpose of the improvement in the new document. (I've attached a few of the formats you're now familiar with.)

USE BALL POINT PEN ATTENTION PRINT CLEARLY PRESS FIRMLY

TO THE STUDENT: ENTER ALL NEEDED INFORMATION IN THE PROPER BLANKS. PRESENT THE ENTIRE FORM TO THE OPERATOR OF THE COMPUTER TERMINAL. THE OPERATOR WILL MARK CHANGES MADE, STAMP THE FORM AND RETURN THE CARBON COPY TO YOU. KEEP IT. YOU ARE REQUIRED TO SHOW IT ON REQUEST TO BE ADMITTED TO CLASS OR TO SUPPORT ANY REQUESTS FOR CORRECTIONS IN REGISTRATION YOU MAY NEED TO MAKE.

Student: I.D. number	last name	first	middle	major	academic level	sem	year

SCHEDULE COMPLETION STRATEGY **VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY**

DROP					ADD									COMMENTS
		course					course		cr hrs		add/change option			
operator use only	index number	dept	number	cr hrs	operator use only	index number	dept	number	#hrs	*CHNG?	A/F	P/F	AUD	
	00	Lunch	009											
						00	Lunch	009						

INSTRUCTIONS: List DROPS in any order. List ADDS in priority order, most important first. DROP and ADD same course if section change needed. BRACKET alternate elective ADDS and comment on number of courses wanted from group. Write "FROM" and "TO" in columns for option change. Dean's APPROVAL (Graduate Dean for graduate students) required for: 1. overloads. 2. ADDS and DROPS after "DEADLINES." Specify CORRECT TOTAL credit hours for all courses. To amend "CR ARR", write "YES" under "*CHNG" and NEW TOTAL for course under "#hrs."

Signed ______ student ______ date Signed ______ course adviser (optional) ______ date Signed ______ dean ______ date

DEAN/REGISTRAR

REV. 9/86

STUDENT CLASS TICKET

STUDENT NAME	STUDENT NUMBER	TERM		CLASS	CURR.	
		FS	93	30	FCD	17592

*	DEPARTMENT	COURSE NUMBER	INDEX NUMBER	COURSE DESCRIPTION	OPTION	CREDIT HOURS	MON	TUE	WED	THU	FRI	BEGINNING TIME	ENDING TIME	BUILDING & ROOM
	BICL	1005	4714	GENERAL BIOLOGY		30		T		H		3:30PM	4:45PM	MCB 100
F	BICL	1015	4752	GENERAL BIOLOGY LA										
	FCD	1004	6423	HUMAN DEVELOPMENT		30	M		W		F	12:00PM	12:50PM	SMYTH146
	FCD	3334	6441	PRIN HUMAN SERVICE		30		T		H		8:00AM	9:15AM	LITRV1760
	HIDM	2404	6774	CONSUMER PROBLEMS		30		T		H		9:30AM	10:45AM	LITRV1860
F	PSYC	3014	8266	ABNORMAL PSYCHOLOG										

CLASS SCHEDULE AS OF AUG 07, 1993. TOTAL HRS = 12.0 ADVISOR - ANDITTI
TERMINALS OPEN 8/20, 8/23-8/27, 8/30 CHEM 1025 AND 1045 PLEASE SEE OTHER SIDE FOR EXPLANATION

TO: 17592

1200 HUNT CLUB ROAD #37C
BLACKSBURG, VA 24060 0000

PLEASE SEE OTHER SIDE FOR EXPLANATION OF THIS CLASS TICKET AND SEE THE TIME TABLE OF CLASSES FOR DEADLINES.

OFFICE OF THE UNIVERSITY REGISTRAR
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY
BLACKSBURG, VIRGINIA 24061

PLEASE READ INSTRUCTIONS ON REVERSE SIDE

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

COURSE REQUEST FORM 11/87

STUDENT LAST NAME	FIRST NAME	MIDDLE INITIAL	MAJOR	ACA LVL

STUDENT I.D. NUMBER

0 1 2 3 4 5 6 7 8 9

PER	
Fall	1st Sum
Winter	2nd Sum
Spring	Ext Sum

DEPT ABBR | COURSE NO | VARIABLE CREDITS
INDEX NO | GRADE OPTION
0 1 2 3 4 5 6 7 8 9 — P/F OR AUD OR A-F

DEPT ABBR | COURSE NO | VARIABLE CREDITS
INDEX NO | GRADE OPTION
0 1 2 3 4 5 6 7 8 9 — P/F OR AUD OR A-F

DEPT ABBR | COURSE NO
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INDEX NO | GRADE OPTION
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LUNCH REQUEST

TUE THU					
11:00					
11:30					
12:30					
1:00					
	11:00	11:30	12:00	12:40	1:00
	MON. WED. FRI				

MUST BE ACCOMPANIED BY A FREE TIME LETTER

FREE TIME REQUEST

MTWTF 8 AM	MTWTF 9 AM	MTWTF 10 AM	MTWTF 11 AM	MTWTF 12 NOON	MTWTF 1 PM
MTWTF 2 PM	MTWTF 3 PM	MTWTF 4 PM	MTWTF 5 PM	MTWTF 6 PM	MTWTF 3-7 PM
MTWTF 4-7 PM	MTWTF 7-10 PM	M 7-10 PM	TUE 7-10 PM	W 7-10 PM	THUR 7-10 PM
F 7-10 PM	MWF 8 AM	MWF 9 AM	MWF 10 AM	MWF 11 AM	MWF 12 NOON
MWF 1 PM	MWF 2 PM	MWF 3 PM	MWF 4 PM	MWF 5 PM	MWF 6 PM
TT 8 AM	TT 9 AM	TT 10 AM	TT 11 AM	TT 12 NOON	TT 1 PM
TT 2 PM	TT 3 PM	TT 4 PM	TT 5 PM	TT 6 PM	

TOTAL HOURS REQUESTED

STUDENT SIGNATURE

COURSE ADVISOR SIGNATURE

SEE YOUR DEAN BEFORE THE END OF THIS REGISTRATION PERIOD TO REQUEST CORRECTIONS TO SCHEDULE BELOW

CP82-0836

APPLICATION FOR DEGREE / ANALYSIS

Name as it should appear on diploma (Print Clearly):

First Name ____ Middle Names ____ Last Name ____ Jr., III., etc. ____ Social Security Number ____

Degree ____ Major ____ Double Major (if any) ____

Minor(s)(if any) ____ Option (if any) ____ Expected term of completion ____

CURRENT MAILING ADDRESS

Street ____

City and State ____ Zip

HOME TOWN (For use in Commencement Bulletin and News Release)

City ____

County ____

State ____

Name and address of parents or guardians (For mailing President's Commencement invitation:)

____
List both if separated

____
Number and Street or Route and Box ____ List both if separated

____
City ____ State ____ Zip Code ____ List both if separated

____
Signature of Candidate ____ Date of Application

If degree requirements are not completed by the date indicated on this application, it is the responsibility of the student to notify the Office of the University Registrar of the change of completion date.

1.5. Tools and Skills Categories

1.5.9. The Gathering-Information Skill

1.5.9.1. Gathering Information–Jacques-Louis David

1.5.9.2. How and Where to Collect Data

If you don't know how to gather data and information, you won't be able to make management tools work or make good decisions.

Importance of Information Gathering

In the analysis stage of developing an information system or any management tool, you'll need to study and learn about specific portions of the domain of responsibility and about how information is now processed in that domain. Therefore, you must gather information before you can figure out how to build the management tool. Much of the pre-existing information you gather may be out of date, so you'll have to make contacts and observations and update the information you need. Gathering information about a domain of responsibility and its present activities isn't an easy task, but you must do it to build the management tool. For that matter, you must be good at gathering information to figure out any problem you'll solve as an engineer or as a manager.

Categories of Information

In building an information system, you'll search for four categories of information. The first category is information about the organization. Organizational information includes MVP (mission, vision, and guiding principles) and goals of the company; organizational structure; work flow charts and objectives and purposes of functional units; and policies, plans, and procedures.

The MVP and the goals and objectives of a company guide the organization and set the tone and direction for much of the systems analysis and development work. Policies are rules or guidelines for directing the objectives of the business. These policies should implement overall goals and objectives. Such long-term statements may be found in orientation brochures, procedures manuals, or in annual reports. Organizational structure indicates management's intentions and directions and should correspond with statements of the goals.

A good place to begin your search for information about the organization is to ask for organization charts, work flow charts, and procedures or production manuals. Each subdomain of the organization should have objectives and purposes stated for its functional units which network with those of the overall domain.

The second category of information you'll gather is information about the people in the domain of responsibility. This category should include information about authority and responsibility relationships, job duties, interpersonal relationships, and information needs. Authority and responsibility relationships may be presented by an organization chart, but actual working relationships may be very different. You must discover these actual working relationships, but this information may be sensitive and you'll have to keep it confidential in some work environments. Make sure the organization charts are up-to-date and be ready to draw up some of your own charts to show the lines of authority in the organization and other relationships among people (the who manages in separate domains) and their responsibilities.

Job duties are what each person does in connection with the ongoing operation of the existing system. This type of documentation may be found in manuals for task performance, but these formal, written procedures may be different from the way work is done. You can also find position descriptions in an organization to find out who's responsible for what. Remember that being able to determine what is occurring is the job of information gathering.

Gathering information about interpersonal relationships is another piece of information you'll need to learn about the people. This information will be used to confirm suspicions established by formal organization charts. As people do whatever they have to do to get the job done, the flow of information may differ both from organization charts and from systems designs. Finally, you should learn about people's information needs. You should find out what information each person needs and what information is received.

We'll learn about information flow diagrams. They're more popularly called data flow diagrams. These diagrams help us capture and organize how information flows in the organization. If we do the diagrams right, they also help us talk with people in the organization to make sure we know what's really going on. When we get this information, we usually have trouble distinguishing between *what the information flows are* from what the person we're talking to *would like for them to be.* For that reason, we get the best information about information flows from observing information flows.

The third category of information gathering is information about work which includes tasks and work flows, methods and procedures for performing the work, work schedules and volumes, performance criteria, and control mechanisms. Gathering information about tasks and work flows may begin by collecting flow charts for the work process and associated forms and logs that include entries made at each point in the system. You should look for processing steps that center around individual personalities, skills, or experience.

The best method for capturing work flow based on your observations is to use diagrams called work flow diagrams. These work flow diagrams look like computer programmers' flow charts. You should use these diagrams to discuss and verify the work flow with people in the domain. Your flow chart shows the relationships among all the processes in the domain.

A document flow chart (similar to a work flow chart) is one means of representing this type of information graphically. Methods and procedures for performing the work focus on the physical process. A system flow chart can often help supply this type of information. Work schedules and volumes include the amount of work to be accomplished in a given period of time. You should note the variations in work loads for the areas under study. Performance criteria are standards against which the work can be measured. These standards should apply to schedules and volumes, as well as, to quality, accuracy, and reliability of information processing work. Control mechanisms are checkpoints at which feedback from processing is evaluated according to specifically defined criteria.

I was working with an Office Director in the Department of Energy. On one of my visits he called me into his office and said, "Harold, I've noticed you're spending a lot of time helping my secretary make copies of documents. Why do you do that?" I said I not only helped make the copies but I helped distribute the copies. I told him my job was to gather information about information flow and use. If I asked him what the information flows were in his organization, he would tell me either what he thought they were or what he wanted them to be. Because I worked with the physical evidence, I knew what the information flows were. I also knew who put the information in their file cabinet or in the trash can or kept the information on their desk handy for use. I wasn't gathering information about information in his acquisition from interviews or questionnaires. I was gathering information through observation and direct experience.

The fourth category of information gathering is information about the work environment. This information includes physical arrangement of work areas and available resources. Physical arrangement of work areas may be illustrated in a diagram of desks and work positions, along with a series of arrows showing how data move in the course of processing. This information is essential when evaluating the efficiency, effectiveness, and degree of control within the existing system. Resources available focuses on the specific items of physical equipment in use, along with their costs. You should document the kinds of equipment and facilities available at each work station including available resources which are not being used in the existing system for this functional area.

Notice how much we can use diagrams and charts to help us capture, organize, understand, and discuss information about the domain of responsibility. Information overlays all the workings of the domain. The manager will use information about everything in the domain to make decisions. To get the right information to the right people at the right time, we must understand the workings and relationships of everything in the domain. Organization charts, document flow charts, work flow charts, information flow charts, and office layouts help us analyze the organization.

Sources of Information

One source of information is existing documentation which includes organization charts, policy manuals, methods and procedures manuals, job descriptions, forms and reports, document flow and work flow diagrams, systems flowcharts, computer program documentation, data dictionary listings, and computer operations manuals. You should evaluate these things before using other methods of information gathering. Another source of information is information gathered from people such as system users and managers. Finally you may have to gather information from external sources such as other companies, equipment and software vendors, and business publications, seminars, workshops, or visits to showrooms or other companies for demonstrations.

Methods for Gathering Information or Collecting Data

Data collection is an important component of any measurement system. And you'll use one or more of several methods to gather information as you analyze the situation you find in any organization you're developing an information system for. Six primary methods for acquiring facts are identified below. Each has its advantages and disadvantages, which are summarized in Figure 2.1.5.2. These methods are briefly described below.

1. Interview. Conducted face-to-face or over the phone.

2. Questionnaire. Can use a variety of response formats, such as multiple choice, open-ended answers, rating and ranking scales, and semantic differentials.

3. Observation. Conducted continuously over a time period (standard), or intermittently at different times (time sampling).

4. Document Analysis. Accomplished by analyzing documents such as MIS reports, appointment books, minutes of meetings, office memos, and customer correspondence.

5. Critical Incident Review. Focuses on events that interrupt business as usual. Only those things which are especially important, unique, or revealing are considered. According to Ruddock (1981) "much that is usual may have no obvious

explanation. To explain it may require analysis, reference to purposes, to common perceptions, to hidden interests and sometimes to theory." Critical incidents tend to expose reality often with uncommon clarity.

6. Work Sampling and Measurement. Involves statistical techniques for gathering information about a large work volume by studying a carefully selected portion of the total.

You can combine data-collection techniques. Charting is a most-effective method for gathering information and collecting data. If you do a workflow chart, for example, you observe, ask questions (interview), and evaluate documents to identify the activities and decision points in the work flow. The draft workflow chart becomes a good discussion point to determine what information you're missing and what information is wrong. Another method for gathering information is in a participative decision making or information sharing meeting. You surface ideas and capture information to be shared and evaluated. How could you use a panel discussion or gripe session to gather information? Are some meetings called only for the purpose of gathering or sharing information?

The choice of data collection method depends upon a number of factors, including the potential for embarrassment, sensitivity of information sought, number of people to be contacted, importance and possible impact of the evaluation, routineness and repeatability of procedures, degree of scrutiny to which the evaluation will be subjected, and personal preferences of the manager or evaluator. Often, you may use more than one method. The method you choose must be agreeable to the client and colleagues, must be technically sound (reliable, valid, and measure what it should), must be within the evaluation budget, and must allow sufficient time for gathering and interpreting the data.

When planning an interview, the first step is to identify the sources of information. As a rule, you should always interview from the top down. Another step in planning an interview is to define your objectives and prepare for the interview by writing down an outline of points to be covered in the interview. You should always advise the interview subjects about the objectives of the interview, the topics to be covered, and the types of documents that might be needed. When possible you should hold the interview in the subject's own office or department. The best interview is one in which the interviewer does most of the listening. Always follow up the interview by sending information collection summaries to interview subjects so they'll have a chance to edit them.

An effective questionnaire should have certain basic characteristics which include validity, reliability, face validity, and ease of administration and scoring. Validity means that the questionnaire measures what it's supposed to measure. One way to measure validity is to compare the tabulated results of the questionnaire with other measures such as interviews. Reliability means that the respondents answer redundant questions in the same way. Much of the same information is sought in different ways through the use of multiple questions. Face validity implies the respondent feels that items on the questionnaire have a valid purpose. Ease of administration and scoring means that the directions should be clear and easy to follow. When possible, the questionnaire should be structured for machine scoring. There are many things to consider when planning a questionnaire. You should refer to a good source before attempting to use a questionnaire.

An important characteristic of observation is that a highly-trained person must do the observing. These people usually have to be experienced systems analysts or industrial engineers.

All the data collection methods require a great deal of skill. You need to learn to look (observe), listen, and probe. You want information. You talk or ask questions only to get the best information you can. Your success as an engineer or manager will depend on your ability to ask questions or probe to get the information you need to make decisions with. Being able to collect data (ranging from technical situations to personnel situations) and to gather information is one of the most important things you'll ever learn. Think about it! Do something about it! Don't forget it!

SIX DATA COLLECTION METHODS ARE COMMONLY USED		
Method	**Advantage**	**Disadvantage**
Interview • Face-to-face • Phone	Permits in-depth probing. Permits discussion of sensitive issues. Good for eliciting new ideas.	Expensive and time-consuming Inter- and intra-rater reliability may be difficult to obtain.
Questionnaire • Multiple-choice • Short answers • Rating scales • Ranking scales • Semantic differential	Anonymity encourages truthful response to embarrassing questions. Can be administered to large groups at low cost. Reduces judgmental data into a manageable form.	May need follow-up to obtain adequate number of responses. May require respondents to draw distinctions that don't exist. May produce no response if poorly designed (complex instructions; lengthy; ambiguous).
Observation • Standard • Time-sampling	Permits first hand observation of events. Skilled observers can obtain insightful facts.	Observer can change the environment. Inter- and intra- observer reliability may be difficult to obtain.
Document Analysis • MIS reports • Correspondence • Financial records • Office memos • Timesheets	Unobtrusive. No new data collection required.	Documents may be disorganized, unavailable, or too voluminous. Can be expensive. Only formal communications are likely to be recorded.
Critical Incident • Internal events • External events	Exposes facets which are otherwise not obvious. Focuses only on particularly important or revealing events.	Can be difficult to interpret. Insiders may not notice situations which appear very unusual to an outsider.
Work Sampling and Measurement	Uses limited and specific results to make inferences about a large population.	Requires services of highly qualified individuals with experience in research design and statistics.

Figure 1.5.9.2. *Methods for data collection. (Sources: adapted from Koscoff and Fink, 1982: Figure 3 on pp. 117-119).*

1.5.9.3. Exercise on Gathering Information

Scenario:
Some years ago Virginia Tech decided to convert from the quarter system to the semester system. All courses had to change from thirty class periods to forty-five class periods. Also, so students could possibly finish an undergraduate degree in four years we had to decrease the number of courses required to graduate by one-third.

Each professor wanted to protect his or her course from elimination. Clearly we had to review all courses and determine what to eliminate, what to combine, and what to preserve. The ISE Department selected a curriculum transition committee to figure out what was best for the Department. The committee had to submit its new slate of courses for the semester calendar to the faculty for approval.

Exercise:
You're on the curriculum transition committee. Your committee has decided not only to convert to the semester calendar but to use this opportunity (make lemonade out of lemons) to review each course toward improving the ISE curriculum. Remember, over the years, the courses have evolved based on changes in technology, the latest emphasis in industrial engineering, or the professor who's teaching the class. It's time to look at each course and see if it's relevant to the curriculum and to determine how the course might fit into the curriculum objectives.

Your committee has assigned you the job of gathering all the information they might need to improve the ISE curriculum. You have three months to get the job done. Some data (or information) gathering techniques take time to implement, some techniques depend on the results of others. You need to develop a brief plan (about one page) to make sure you've thought of everything and can set priorities and schedules for gathering information.

Just for fun:
How might you gather information for completing this homework assignment?

1. Background

1.6. Group Decision Making

1.6.1. Matched Decisions (Two)

1.6.1.1. COMMUNICATING BETWEEN DOMAINS.

We communicate between two domains by linking information flows at the information-portrayal-to-information-perception interfaces of the two domains.

When we focus on the Management System Model (MSM), we're considering one domain with one decision maker (who manages.) Obviously we've made a simplifying assumption when we think the domain has no interactions with its environment. We assume our domain of responsibility is operating as an island of management, as a closed system.

Now we'll consider one type of interaction between one domain and another. The types we won't consider now are those where our domain sends information to another domain for their independent decision making or where our domain receives information from another domain for our independent decision making. The type we'll consider is the one where our domain and another must pass information back and forth so the decision makers of both domains can make decisions leading to a mutual outcome. This mutual outcome is a single action affecting both domains. Such decisions I call matched decisions because one without the other is necessary but isn't sufficient to achieve the desired mutual outcome.

You can think of a number of situations where you must receive a decision from another domain to match your own decision for you to get the result you want. Consider the situation of choosing a mate—the marriage problem. How about choosing a college? You'll soon be looking for a job. You'll want the company you most want to work for to want you most also. If you want them but they don't want you, you won't go to work for them. If they want you but you don't want them, you also won't go to work for them. So, for you to go to work for them, both you and the company must make a matched decision. And you must make your mutual decisions at exactly the same time. Timing is important. I've seen a situation where Sally wanted to marry Bill but Bill was marrying Paula. After Bill and Paula were divorced, Bill wanted to marry Sally, but Sally had married Harry. It's fascinating how matches are made. I'll add another example we at the university worry about all the time. Both the researcher and the sponsor must come to a mutual decision at the same time or we don't get a research contract.

Operations researchers study this problem mathematically. One specific application they consider is the secretary problem. The generalized problem is called optimal selection and assignment. Operations researchers look for situations to optimize numbers of applicants to numbers of selectors. They look for stable and optimal situations. In choosing a college, an assignment of applicants to colleges is called unstable if, for example, there are two applicants Mary and George who are accepted by the University of Virginia and Virginia Tech, respectively, although George prefers UVA and Mary prefers Tech. A stable assignment is called optimal if every applicant is at least as well off under it as under any other stable assignment. Believe it or not, the operations researchers find that there always exists a stable set of marriages. But they're looking at large numbers of applicants and selectors.

We're interested in individual pairs of domains. That is, given a company and a college graduate, what information must be passed in each direction and how do we pass the information to find a match, where the only match we want is a stable one. In Figure 1.6.1.1., I show two isolated domains sharing a hiring decision.

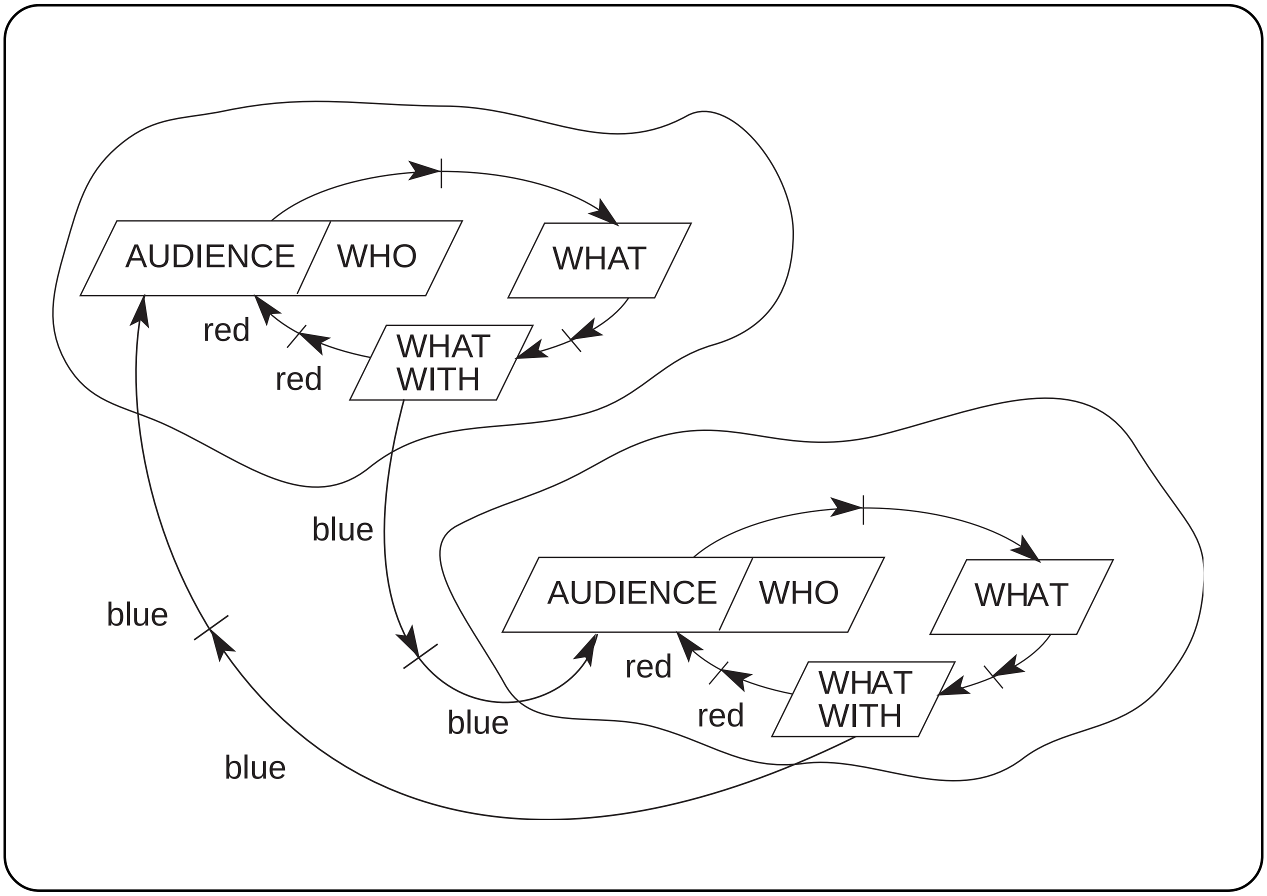

Figure 1.6.1.1. *Two domains are joined at their information portrayal/information perception interfaces.*

1.6.1.2. The Hiring Decision.

Like a marriage decision, when a hiring decision is made, two domains must exchange information and make a pair of compatible decisions.

Let's concentrate for a moment on the domain of responsibility of you, the student, in Figure 1.6.1.2. Of course, you use the management tools in your domain to portray information. But, portray information to whom? In this case, you can portray information either to you, the who manages of your domain, or to the recruiter, the who manages of XYZ company. Remember, we design information portrayals based on the equation: Purpose plus audience equals design. So, we want to portray information about our desires, needs, abilities, preferences, and transferrable skills to ourselves—within our own domain. We also want to portray similar information to the recruiter. Note, however, that the audiences (the different who manages of the two domains in the figure) are certainly different and the purpose could very likely be different. Therefore, the design should be different. I'll argue, by the way, that the purpose should be the same—that is, to make a stable match.

Since the portrayal design should be different for the two domains, should you design your resume to fit the audience represented by the recruiter? Yes. The recruiter is the person whom you want a given action from. What action? The appropriate action to want in the recruiting process is the setting up of another information portrayal. That is, you want the recruiter, based on the information in your resume, to decide to invite you to a job interview.

How about the other audience in Figure 1.6.1.2.—you. You use the resume to accurately display what you like to do, are good at doing, and want to do. I believe you should want your resume to honestly portray your transferrable skills you believe can help the company you've decided you really want to work for. You'll decide you want to work for that company based on an entirely different set of information portrayals. The information portrayals you'll use to decide you want to work for XYZ company are from the company, either directly designed for recruiting or indirectly from the library, a friend who works for the company, or other information.

Perhaps you need two resumes. One for the recruiter and one for you. Remember, the audiences are different.

Let's look at some separate information portrayals you might produce from your management tools to serve your desire to find the right company to work for. These separate information portrayals include the resume, interview, plant trip, letters, telephone calls, and potentially many others. Yes, letters and telephone calls are information portrayals, although often they include portrayals both by you and by the company. So, each portrayal should be designed by you to address the right audience and to meet the right purpose.

Don't forget, in addition to concentrating on information you portray to get the right decision from the recruiter, you must also concentrate on getting (having portrayed and perceiving) information from the company to get the right decision from you. Don't get caught up in the chase of getting the company to love you and make the mistake of going to work for a company you'll hate. (The parallel with getting a matched decision in choosing a mate as we discussed earlier is valid here also.)

Each information portrayal should have one and only one purpose. For example, single-purpose, decision-related information portrayals should help me make my point. The resume is an information portrayal designed to get a decision and action for an interview. The interview—at least the kind you'll have on campus—should have the single purpose of getting a plant trip. The plant trip includes almost all information portrayal, and focuses on the decision and action of a job offer. Even then, we won't have a match. Based on the information in the job offer (salary, benefits, and other information), you'll need to decide if, indeed, you have a match and will accept or decline the offer.

Be sure you focus on the purpose the portrayal should be designed to meet. Don't think your resume is designed to get the action of getting hired. If you did that, you'd be admitting it's all right if the company hires you sight unseen.

In addition to asking, "What information should I portray about myself?" another question you should ask is, "What information should I seek about the company?" The answer to the first question is: Portray information about the transferrable skills you have and the company needs, and use your experience and attributes to lend confidence to both you and the company you have these skills and the skills are transferrable. (The only reason for a long resume is to show you've repeatedly transferred the skills the company is hoping you'll transfer to them.)

We'll address the question of what to look for in a company when, later in the semester, we discuss organizational culture. Organizational culture is about shared values. Most of all, you'll want to know how your values match up with the company you're considering. That means you'll have to figure out what your values are and the importance of finding a company that shares your values.

Finally, I'll mention a key issue in designing an information portrayal after you've figured out the audience and the purpose. That issue is: When you know what the key information is you want to portray, put the information where the audience will find it immediately.

Think about the information portrayals you hear or see. How long do they hold your attention. I'll bet not very long. Soon after the sounds or sights of the information portrayal begin, your mind wanders. And not very long after that, you either put what you're reading down or walk away from whom you're listening to. But, wait a minute. The information portrayer is saving the best for last. Too late. You're either mentally or physically gone. If you do these things, you can bet your audience does too.

The bottom line is: Put the important stuff, all of it, where the audience (the perceiver—who manages) will see it first and condense that important stuff so the audience gets it before he or she abandons you. And one place people usually look or listen first is at the beginning. So, put the bottom line on top.

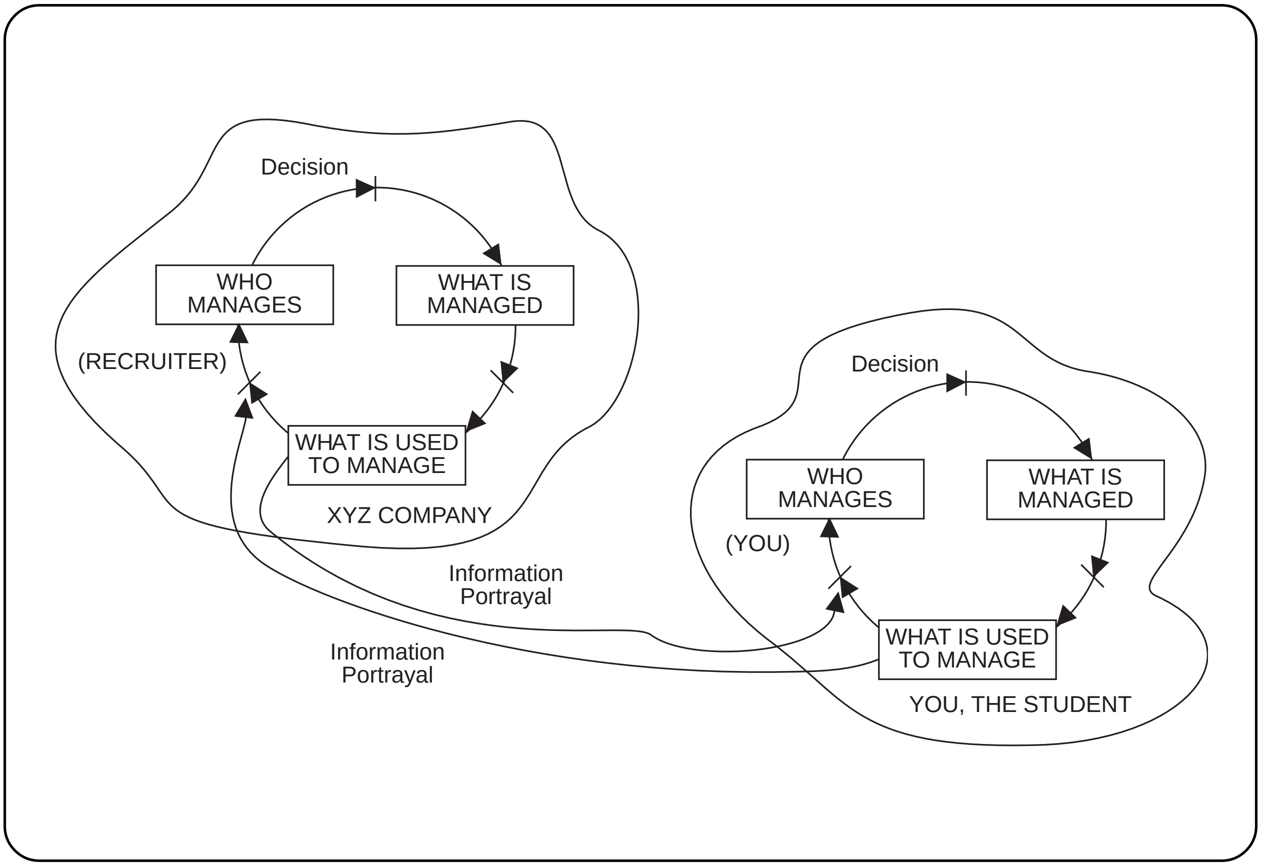

Figure 1.6.1.2. *To make a matched decision, you must exercise the red loop, blue loop information transfers extensively.*

1.6.1.3. THE LESSONS-LEARNED SHARING PROCESS.

When we share information between domains of responsibility about what we learn in one of the domains, we're linking the Management System Model and the Plan-Do-Study-Act Cycle.

When you make decisions (manage) about your work process (what is managed), you want to observe the effects of the action you take. Your observation is the information gathering part of the Plan-Do-Study-Act (PDSA) Cycle. After you act on what you plan to do, you study what happened to see the effect of that action. You can share your actions and the resulting effects with someone with a similar domain of responsibility.

A good example of similar domains is two different shifts in a manufacturing plant. Consider Domain A to be Shift I in a manufacturing plant and Domain B to be Shift II. The machines are usually the same between shifts, but are the work processes the same between shifts? No, because, by definition, the people involved in the work process change between shifts. Also the decision maker may change and so may the management tools.

In Figure 1.6.1.3.1., I show two different domains as two sequential shifts. I show each domain as a PDSA Cycle because I want to get at the lesson learned out of the Study step of the PDSA Cycle of shift I to share with shift II. The sharing process shares lessons learned from one cycle's Study step to the other cycle's Plan step. Each cycle can represent a work shift or a project, with the shift or project beginning with the Plan step.

In Figure 1.6.1.3.2., I show the two different domains as two Management System Models. I've shown the what is managed components as tasks and the what is used to manage components as organizational memory. As we convert data to information in the management tools, we have the opportunity to remember the information. Since the management tools gather data about the work process and the effects of the manager's decisions and actions on the work process, the memory is organizational.

In Figure 1.6.1.3.2., I use the notation {domain, cycle} to distinguish the components and interfaces of the two different domains and cycles. I'll illustrate the cycles in Figure 1.6.1.3.2. The first cycle begins with a decision in Domain A and ends with the update of the organizational memory in Domain A. The first who manages {A} during the first cycle {c1} makes a decision {A, c1} that leads to an action {A, c1} on a task {A, c1}, all within the first cycle {c1}. Measurement {A, c1} on the task performance produces data {A, c1}. The second cycle {c2} begins with the updating of organizational memory. Organizational memory is updated with a lesson learned.

The contents of organizational memory at the beginning of cycle {c2} are shared between management domains {A} and {B}. The information portrayal of both domains {A} and {B} at the beginning of the second cycle {c2} is a set of lessons learned in domain {A} to be shared with domain {B} and , therefore, is the same for each domain. The second cycle begins when the second who manages {B} uses this information {B, c2} to make a decision {B, c2} leading to an action {B, c2}. The action on task {B, c2} produces a lesson learned through measurement and data. Organizational memory is updated to represent its new state at the beginning of the third cycle {c3}.

The lessons-learned sharing process to support organizational learning is best seen in the sine-wave representation of the Management System Model described in Figure 1.1.18.3. The sine-wave representation is repeated in Figure 1.6.1.3.3. to emphasize the cycles illustrated in Figure 1.6.1.3.2. The functions of the lessons-learned sharing process are: 1) the problem-solving or learning experience, 2) the storage and refinement of data, 3) the conversion of data to information and the updating of the organizational memory, and 4) the retrieval and interpretation of information. One repetition on the lessons-learned sharing process overlays one loop from one learning experience to the next represented as sequential what is managed components of the Management System Model.

The understanding of the lessons-learned sharing process and the linkage between the Management System Model and the Plan-Do-Study-Act Cycle was developed during my collaboration with Tim Kotnour on his Ph.D. dissertation. (Timothy G. Kotnour, "The Effect of Lessons-learned Sharing Processes for Organizational Learning on Decision-making Performance," Unpublished Ph.D. dissertation, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, pp. 6-8.)

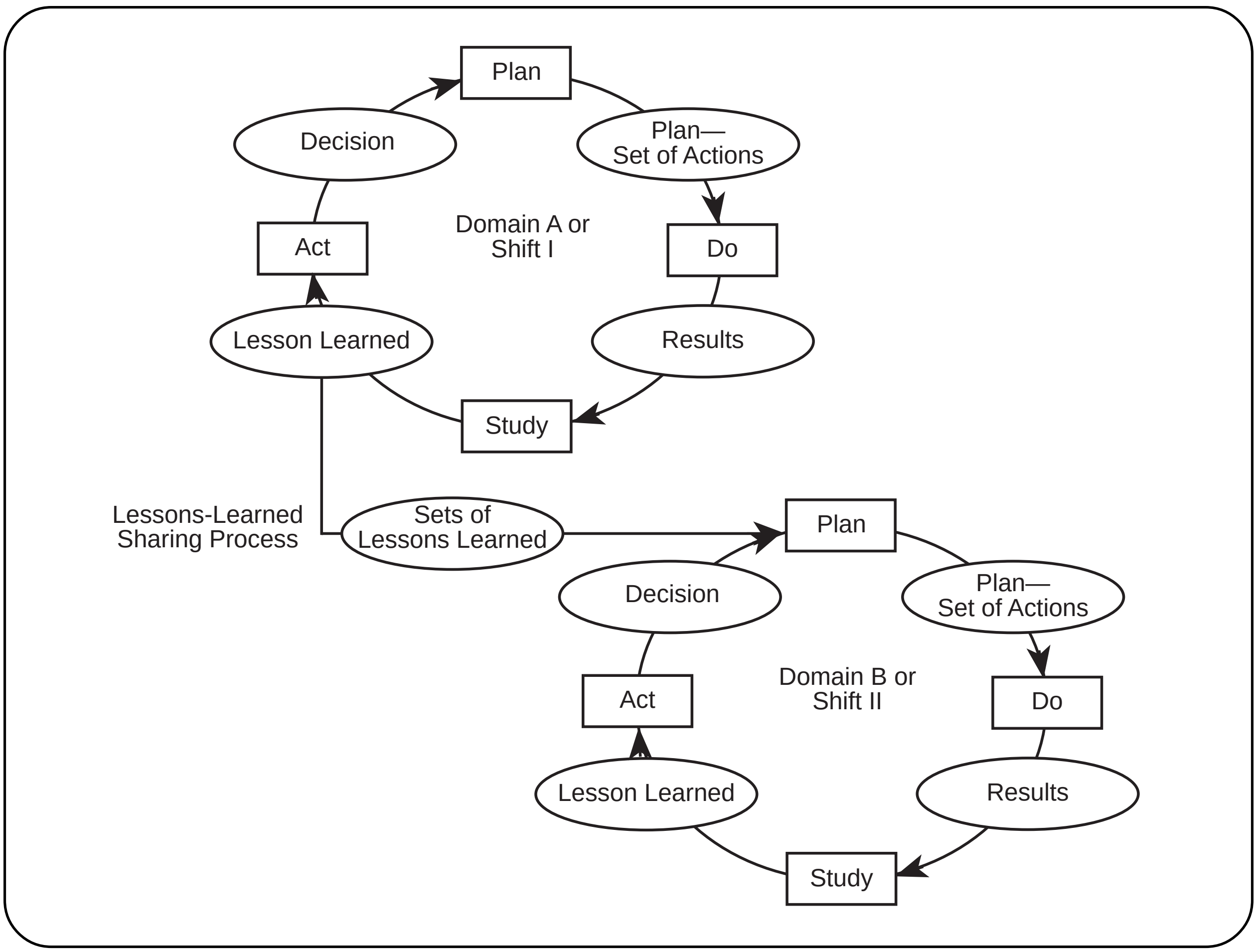

Figure 1.6.1.3.1. *One domain shares a lesson learned with another domain when information about the effects of an action is shared.*

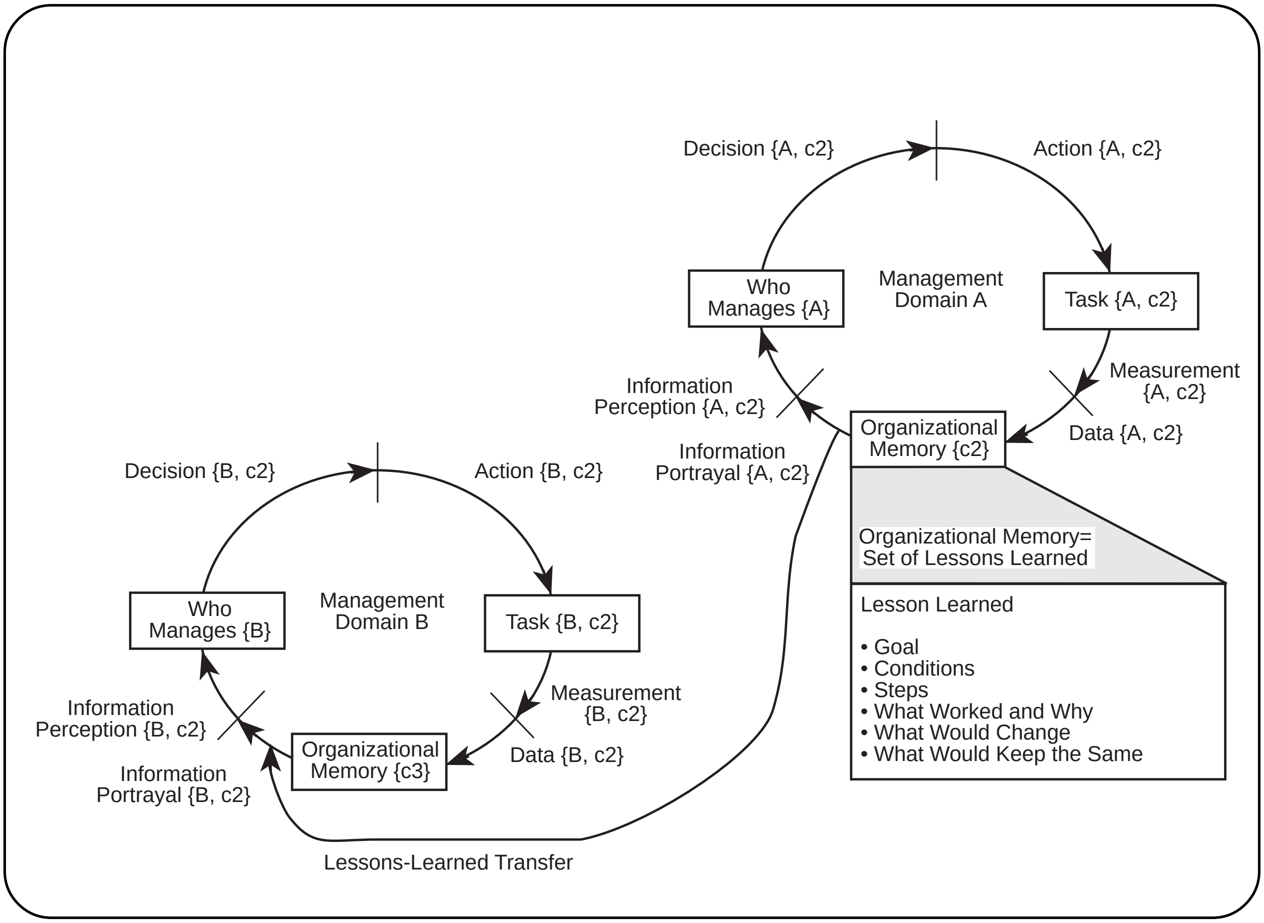

Figure 1.6.1.3.2. *The lesson learned is shared when the organizational memories of both domains are updated.*

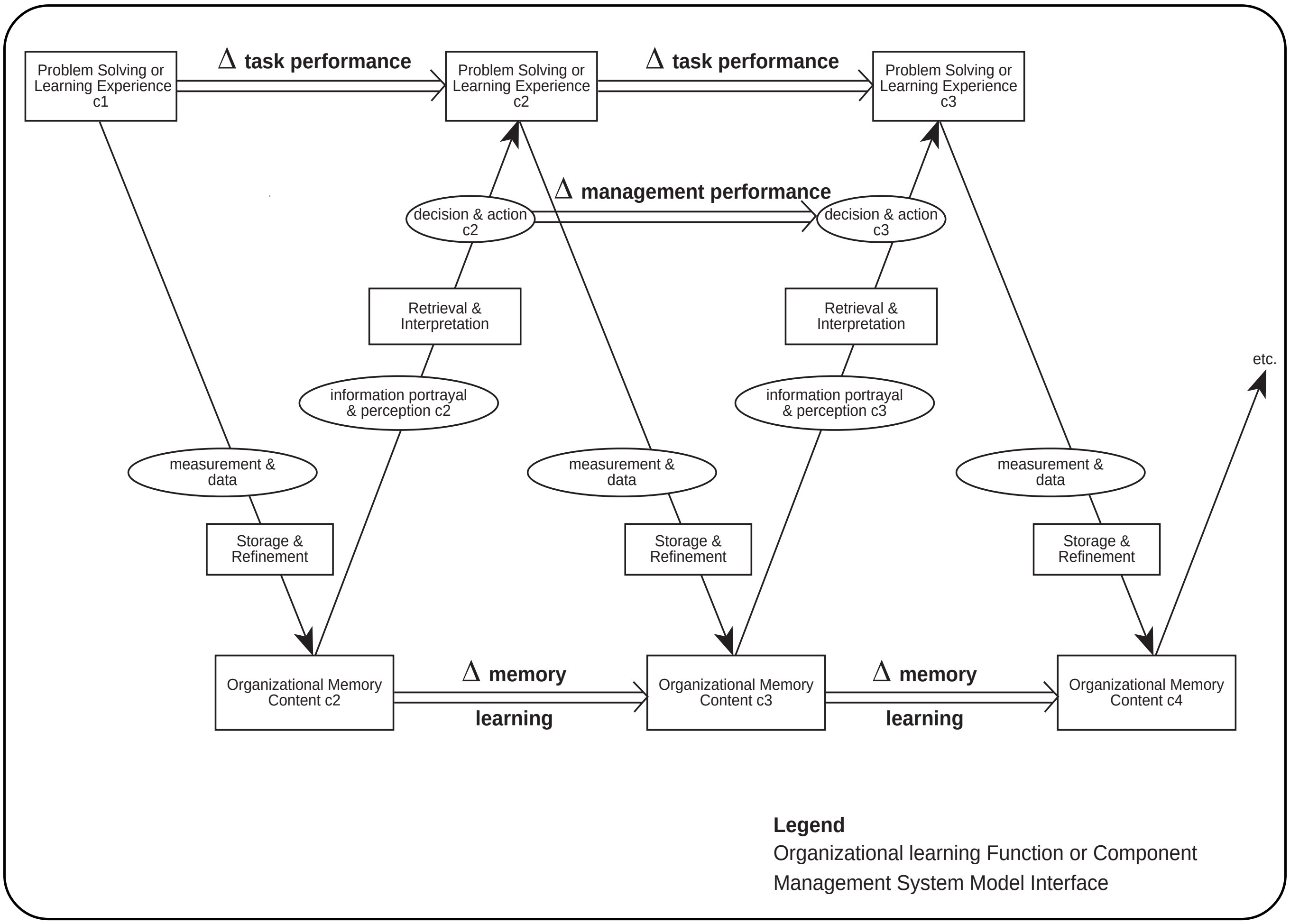

Figure 1.6.1.3.3. *The sine-wave representation of the Management System Model shows a number of sequential lessons-learned sharing process cycles.*

1. Background

1.6. Group Decision Making

1.6.2. Group Decisions (More than Two)

1.6.2.1. Information Sharing

1.6.2.1.1. Sharing Information—John Constable

1.6.2.1.2. Sharing Applied to Shared Information Processing

Sharing presents several dilemmas as we work with data and information.

How can informal communication be shared without turning it into formal communication? How do we prevent computer crime—or the unwarranted distribution of confidential data and information—without making it unreasonably hard on the people who should have access (Littman, 1984)? How do we deal with what we call the Dilemma of Protection: the problem of unnecessary *protection* of data versus counterproductive *hoarding*?

The word *share* comes from a root that means both to join and to separate. This paradox leads us to the correct assumption that understanding and dealing with sharing isn't simple. Sharing is borrowing, or taking from someone. Sharing is lending, or giving to someone. Sharing is dividing something that can be divided and then giving or lending part and keeping the rest. And then there's *not* sharing—deliberately protecting or hoarding data and information. We spoke of the Dilemma of Protection. Here we have a similar but distinct case—sharing with some while hoarding from others—which is the source of a second dilemma of shared information processing, the Dilemma of Hoarding: the harder you work to hoard what you want to hoard, the harder it is to share what you want to share.

Shared information processing can be good or bad. It's good when the result is everyone singing off the same sheet of music. It's bad when data and information are abused—stolen, for example, or incorrectly changed. We need to understand and implement shared information processing to maximize the good and minimize the bad.

Kreckel (1982) classifies communication as a form of sharing—sharing information. Lindenberg (1982) notes three dimensions of sharing. The first distinguishes whether the shared goods are public (parks, streets, communication lines) or private (lawn mowers, cars, terminals); the second whether the shared goods are instrumental (time, money, data) or directly usable (cookies, clothing, information); and the third whether the shared goods are divisible (candy, databases) or indivisible (books, printers).

Let's classify the sharing of corporate data, one factor of shared information processing, in terms of the three dimensions. Corporate data is a public good, as we define it, being shared by a group of people—the members of the organization. Since data are converted into information, and this information is processed for use in making decisions, corporate data are instrumental. More specifically, corporate data are instrumental when used for decision making. When they are used to gain or maintain power by being protected or hoarded, corporate data are used not instrumentally but against corporate empowerment goals. We generally treat corporate data as being indivisible, because access is given to groups of data, not to just the specific data items needed. (Although databases are often partitioned, the user sees a group of data, even though it may not be the full body of data.)

Corporate data, then are public, instrumental, and indivisible—at least among an organization's insider network. But corporate data carries a twist not exposed by our classification: while corporate data are generally indivisible, the data used can be changed without other sharers being aware of the change. When you share your lawn mower or your tuxedo with a neighbor, you can usually tell if it is returned in its original condition. But when you pull data out of a database, change them, and then replace the original data with the revised data, other users will not as easily notice the changes.

A third dilemma, the Commons Dilemma (Hardin, 1968), an example of sharing studied 25 years ago, is pertinent to shared information processing. This dilemma pits an individual's short-term consumption against a group's long-term conservation. The name of this dilemma comes from the New World settlers' designation of a common grazing area for their cattle, as had been the custom in England. The common resource was depleted as each farmer sought to increase his own herd. This dilemma appears in shared information processing. Managing the integrity of your own data that only you have access to is not particularly difficult. But problems arise when a group of people makes updates on the same database. How do we know if the data retrieved are accurate? How do we know whether or not they are ready for release?

1.6.2.1.3. The Forcing Function for Sharing

No matter how hard it is to do, we must share data, information, decision mechanisms, and information processors.

There are three forcing functions for sharing, and all three are related: rapidly accelerating technology, the rising popular emphasis on participative management (due to society's desire to be part of major decisions as the world becomes an electronic global village, shared through networks of computers, televisions, and radios), and the public's, as well as the Congress's demand that we run a tighter economic ship and work smarter and leaner. We must, now that we seem technologically capable of it, convert from slack management to effective management. No longer can we solve problems by throwing more money at them in hopes they'll go away. No longer can we let huge inventories of materials, people, and equipment mask—or rather, demonstrate—our collective national inability to manage.

We have technologized compatibility. We have higher processing speed, more users, more data and information to deal with. We have not only word processing but voice and image processing. We have networks—local, national, and international. And along with all this revolutionary hardware and software we have the manager's strong desire, even demand, that the technology add up to something big, something good: increased productivity for organizational units; improved performance for the organization as a whole.

More complex technologies lead to greater specialization within organizations. Therefore, these specialized groups need to coordinate and communicate with each other more than ever before. "Interdependence is a central characteristic of the modern, complex society. . . We have learned that we can have more of everything we want by specializing individually. However, the price of specialization is dependence on others" (McGregor, 1960). Our interdependence forces shared information processing.

Participative management is a further result of the interdependence McGregor underlines. Technology says we have no choice but to be interdependent. Once we listen to what technology says, and start to figure out how to manage our interdependence, we discover that we really *like* sharing: we discover that the more often we can be heard where it counts, the more we count, the more we matter.

Shared information processing is not a new concept. But because of the three forcing functions, as never before we need technologies for effectively managing this sharing. We don't restrict the concept of "technologies" to mean only computers, distributed databases, and other computer devices. We understand and use the term broadly, like anthropologists, who define technology as "controlling nature and taming it to human purposes" (Newman, 1971), or "how people use skills and knowledge to make things" (Howard, 1986). This broad definition includes but is not limited to technologies for sharing information in decision making, sharing data and information for strategic planning, and implementation technologies for shared information processing.

Problems with Shared Information Processing

Several researchers are working on the problems of distributed processing and the sharing of corporate data (Berstein et al., 1978; Garci-Molina, 1978; Kohler, 1981; Watson and

Fletcher, 1979). Walter Kohler, professor of computer and electrical engineering at the University of Massachusetts and pioneer researcher in distributed processing systems, voices the need for more research in shared information processing. He says information processing is in transition. "We haven't wrestled with the issue of shared systems." He claims researchers are using primitive sharing models. He further states the solutions generated are technical, but the problem of sharing data and information is general, therefore requiring more general research (Kohler, 1986). By including the sociological and psychological aspects of sharing, we can approach sharing data from precisely this broader shared-information-processing perspective. Following are three examples of shared-information-processing problems. These three are not the only ones (Rothnie et al. 1980). Attention must be paid to distributed query processing which corresponds to the "execute" phase of a distributed processing system.

Concurrency Control

Berstein and Goodman (1981) define concurrency control as "the activity of coordinating concurrent accesses to a database in a multiuser distributed DBMS. Concurrency control permits users to access a database in a multiprogrammed fashion while preserving the illusion that each user is executing alone on a dedicated system. The main technical difficulty in attaining this goal is to prevent database updates performed by one user from interfering with database retrievals and updates performed by another." Distributed Data Base Management Systems (DBMS's) create problems besides concurrency control since (1) in a distributed system, users may access data stored in many different computers, and (2) one computer's concurrency control mechanism cannot instantaneously know about interactions at other computers. Concurrency control in distributed DBMS's was and remains "in a state of extreme turbulence" (Bernstein and Goodman, 1981; Kohler, 1986).

Lack of Responsiveness

Solotruk and Kristofic (1980) say user adaptability should be built into information systems. They claim lack of adaptability will lead to lower information systems quality. Responsive systems (adaptive, adaptable, flexible, and custom-fit) deal with adaptability.

Data Security

Shared data poses an additional problem of security. Not all members of the organization owning the data should have access to all the data. There need to be procedures and techniques for managing data access. Roos (1981) suggests users in a data sharing environment should draw up a very clear set of agreements about data usage authority.

The security problem increases exponentially in an environment containing classified data and information. Most people in such environments need routine access to *both* classified and unclassified data and information. But the two kinds cannot be stored together for easy access, nor can they both be processed on the same equipment. Again we have the Dilemma of Protection: everything we do to make data more secure also makes it harder to share.

1.6.2.1.4. THE ALTERNATIVES FOR SHARING

We can share data and information better either by decreasing the need for it or by increasing our capacity for doing it.

Design of Responsive Systems

Consider four stages of responsiveness—adaptive, adaptable, flexible, and custom-fit . Adaptive systems are futuristic. They'll adjust their menus and help-routines based on the user's knowledge or experience as monitored or sensed by the system. Adaptable systems can adjust to who manages when they are told about who manages. Flexible systems provide a series (large or small) of fixed alternatives from which the user can select. Today's responsive systems are mostly custom-fit, at great cost both of time and money, and don't perform well in a shared information processing environment.

Organizational Design Strategies

Information processing can be managed through organizational design strategies. Galbraith (1973) notes that when an organization's hierarchy is overloaded because of the frequency of exceptions the "organization must employ new design strategies." Galbraith continues, "the organization can either act in two ways to reduce the amount of information that is processed, or it can act in two ways to increase its capacity to handle more information." The strategies obviously extrapolate to shared information processing, as shown in Figure 1.6.2.1.4.

The first two ways are "creation of slack resources" (reducing the required level of performance by increasing schedule time or person-hours) and "creation of self-contained tasks" (giving "each group...all the resources it needs to perform its task"). These two ways, Galbraith observes, "reduce the need for information processing." They also reduce the need for sharing, but at high (these days, prohibitively high) cost. Government organizations, for example, tend to decentralize into rather independent field offices meeting Galbraith's criteria for creating self-contained tasks. Government organizations also tend to achieve management "efficiency" by meeting Galbraith's criteria for creating slack resources. They create slack in the dimensions of time (slipped milestones or schedules rarely have dramatic negative consequences), material inventories (in-process inventories are the norm), personnel, dollars, and . . . information! Government organizations are so used to operating off slack, they produce extra information just for the sake of having it in case they need it. The result of this in-process information inventory is information overload and consequent muddling of decision processes. Government organizations act to reduce the need for shared information processing rather than increase the capacity for it.

The second two design strategies, "investment in vertical information systems" and the "creation of lateral relations," both "increase the capacity to process information" and also increase the capacity for sharing. Organizations that operate in environments characterized by high uncertainty must be prepared to make adjustments (decisions) continuously. They need on-line, real-time vertically-integrated information systems, and they need lateral relations.

Lateral relations, says Galbraith, "selectively employ lateral decision processes which cut across lines of authority. The strategy moves the level of decision making down to where the information exists rather than bringing it up to the points of decision." In a decision environment heavily reliant on lateral relations, the manager is in effect a manager of shared information processing, responsible "not to make the best decision but to see that the best decision gets made." Decentralization is truly effective only in the presence of strong lateral relations, or sharing; otherwise, hierarchical decision processes become overloaded, and the organization has to fall back on the costly alternatives of slack resources and self-contained tasks. Galbraith's second pair should be the route of choice.

An organization, Galbraith says in summary, "must adopt at least one of the four strategies when faced with greater uncertainty. If it does not consciously choose one of the four, then the first, reduced performance standards, will happen automatically. The task information requirements and the capacity of the organization to process information are always matched. If the organization does not consciously match them, reduced performance through budget overruns or schedule overruns will occur in order to bring about equality."

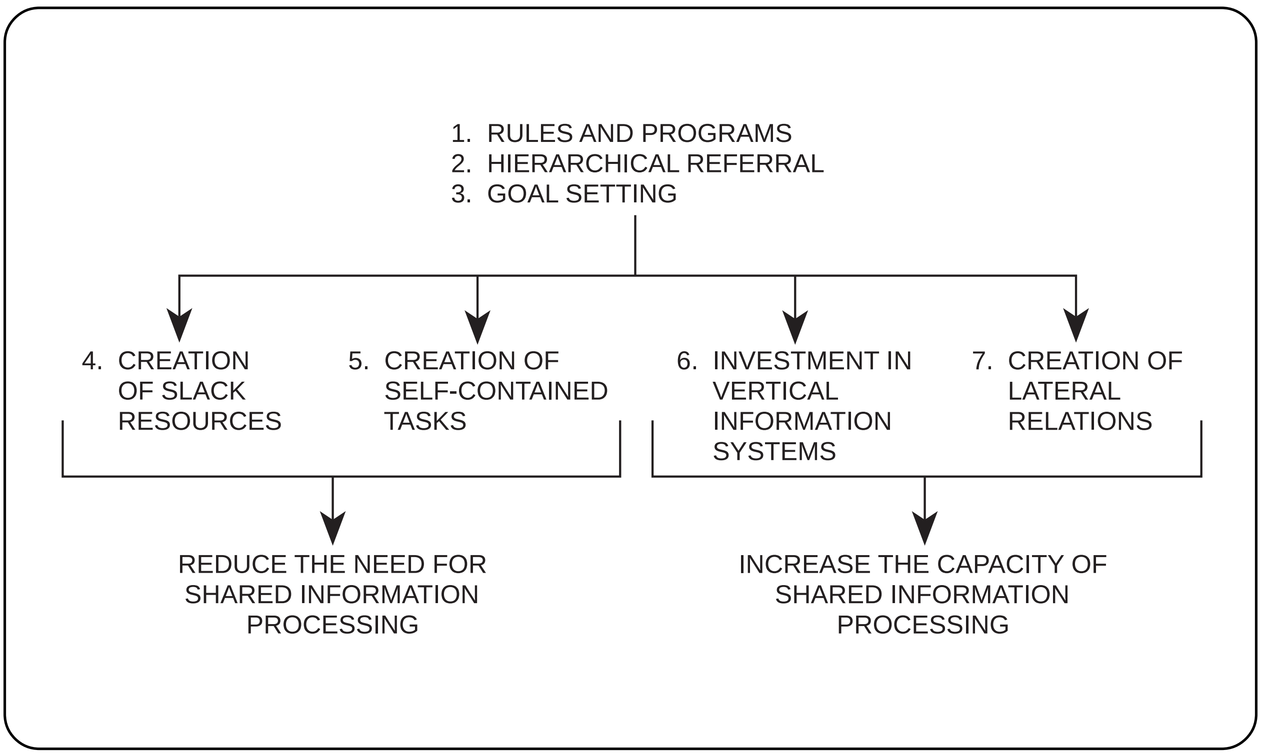

Figure 1.6.2.1.4. *Organization design strategies offer alternatives for managing shared information processing. (adapted from Galbraith, 1973)*

1.6.2.1.5. Corporate Database Example

Many people working out of a corporate database exemplifies the difficulty in sharing.

Corporate databases allow us to share data. Sharing data was never easy without the computer; with the computer the problem becomes messier. The popularity of the personal computer makes the problem of shared data an individual as well as an organizational problem (Frank, 1984).

Defining Corporate Database

A corporate database is a collection of all data within an organization, driven to third normal form and available through controlled measures to anyone within the domain of that organizational structure. This definition presupposes the following conditions:

1. Data are integrated from a number of previously discrete files, databases, or other access and retrieval systems.

2. Data can be shared among multiple users according to certain rules and procedures, without compromising data integrity.

3. The corporate database is a single repository for the totality of data for that domain of responsibility. (For example, in a noncomputer-based system, the corporate database could comprise all of the filing cabinets and their contents in a given organization.)

Certain features distinguish a *corporate* database from any other kind of database. To define a corporate database, one first must determine the organization level (domain of responsibility) the corporate database will comprise. If a company is the corporate database, then a department of the company can be nothing more than a custodian of one partition or portion of that database, at most. In short, a corporate database is mutually exclusive of other databases that might exist within an organization.

Our definition of a corporate database includes the necessity of controlling or minimizing redundancy. The aim is to reduce inconsistency in both data entry and data updating. The goal is the ability to share data that are accurate and consistent. Therefore, the system must include a means of intelligently sharing data and information. As C. J. Date (1981) defines it: "By shared, we mean that individual pieces of data in the database may be shared by several different users, in the sense that each of those users may have access to the same piece of data (and may use it for different purposes). Such sharing is really a consequence of the fact that the database is integrated."

Integration of databases implies the database is, according to Date's definition, "...a unification of several otherwise distinct data files, with any redundancy among those files partially or wholly eliminated." In practice, this would mean that any piece of data exists in one place and one place only (assuming a corporate database structure), and if anyone accesses data from the corporate database, it must be returned to the corporate database. This way, it is impossible for two versions of the same piece of data to co-exist in either the same or in different databases. This also implies the database is normalized.

Sharing of the Corporate Database

As indicated in our definition, the corporate database includes procedures and rules by which individuals can share the data contained in it. However, within some environments, one must deal with the aspect of classified data, which seems to be directly at odds with the notion of shared data. Classifying data restricts sharing; thus, the problem is developing tools that permit us to relate these data to those who need it, without compromising classification, data integrity, and sharing of non-classified data. The needed corporate database should be able to intelligently share information, including classified data. This would entail developing levels of control for sharing. In theory, if you have a document that contains a classified figure, that number would never appear in that document until you accessed the document from the corporate database. The document would then have to access the classified data from the database to include the figure. This accommodates the requisite level of sharing and prevents the classified figure from having to appear in several locations or files simultaneously.

Within a decentralized organization structure, the temptation exists to create auxiliary repositories of data and information. This owes to considerations involving both corporate culture and human nature: it's often easier to work out of a "localized" file than to have to access a centralized repository which we've defined as a corporate database. Replication of data in locations other than the corporate database works at cross purposes with the rationale for having a corporate database in the first place. In general, nowhere but in the corporate database should there exist aggregations of data from or of data *derived* from the corporate database. This is achievement of the third normal form. Those needing to share that data have one, true, primary source for it: the corporate database. The farther one moves data away from its primary repository, the greater the chances that data integrity will be compromised.

Distributed database literature cites methods for managing the technical aspects of sharing data. Rothnie et al. (1980) and Kohler (1981) agree the two-phase locking (2PL) method of concurrency control is the best way to serialize data requests and updates. Though the technical problems (software, hardware, and networking) are well-defined and solutions exist, the broader, more-general problem of sharing needs to be addressed (Kohler, personal communication).

In many organizations, data are not stored centrally, nor are they stored in one medium. For example, a database might be every file cabinet, telephone directory, mainframe computer terminal, personal-computer floppy disk, and notebook. But this isn't a *corporate* database. A corporate database wouldn't permit duplication (redundancy) among the various storage and retrieval media such as the file cabinet and the floppy disk, both of which might contain different versions of the same piece of data. If, for example, data taken from a mainframe computer file and copied onto a PC floppy disk are altered on the floppy and not on the host file, then a sharing problem results. Investigation is required to control this intelligently to make sure there is no duplication of data within a particular domain of responsibility. This would require development of instruments to identify all of the data, where they are located, what data are dependent upon other data, and how to guarantee that when someone borrows a piece of data they don't compromise its integrity or that of that of the corporate database.

Special Concerns in Establishing Corporate Databases

Hierarchy of decision mechanisms is an important consideration (Galbraith, 1973). If qualitative data are put into the system, one wants decision mechanisms close to the data, because qualitative data (unlike quantitative data) can lose integrity as they move away from the source.

In terms of lateral communication (horizontal): Different personalities place emphasis on maintenance of different kinds of data. Changeovers common in some organizations can affect how data are maintained and handled. New people might stress different levels of concern, interest, and importance, depending upon who's managing. What results is a corporate database problem in terms of keeping the corporate database clean. For instance, if one manager wants data files A, B, C, D, E thoroughly maintained and updated, another may come on board and insist that D, F, H, I, and J are the most important. Then, the data in A, B, C, and E may fall into disrepair, and if we assume a computer-based system, it might not always be possible to determine when data have become outdated. (In a filing cabinet system, physical appearance of the paper may give a clue.) Thus, the corporate database is growing as new and changing demands are put upon it, but only the most recent data files are being maintained. One needs to be able to clean up the data in those files, or risk a problem with data integrity down the line.

The reverse problem can also occur as different personalities in management dictate shifting values of data in a corporate database. A new manager may place a high value on data files that had been maintained by a person long since departed. If these data haven't been kept current, problems can arise.

If we gather and maintain data about data, then we also need to determine which data, what are their value, location, etc. This sort of activity requires a data administrator. The function of this person would be to determine data about data. With accurate data about data, the organization can then manage and maintain the corporate database, reduce or eliminate redundancy, and know who's been using which pieces of data.

In effect, we need more *data about data*:

1. When it was put in.
2. Who put it in.
3. Why was it entered.
4. When was it updated and how often.
5. Level of confidence in the data.

We need to clearly define the functions of the data administrator, and to identify specific data about data requisite for meeting the terms of the definition of a corporate database. The goal is to move from the real-life situation toward the ideal, where we have a shared corporate database. Doing this requires:

1. Data about data.
2. Defining the function of the data administrator.
3. Moving data toward a single location and with little or no redundancy (third normal form).

Not only do we need to determine data about data, but we need data about databases, and especially those which may be geographically dispersed. Among the considerations here would be:

1. Defining partitions.
2. What records are kept in which partitions.
3. What kinds of records are kept where.
4. How old.
5. Who updates the records.

1.6.2.1.6. Hierarchical Planning Example

When different levels in an organization develop plans, they must share data and information or work at odds with each other during the planning process and afterwards when they implement their plans.

One way we can share information among a number of people at several levels of an organization's hierarchy is through hierarchical planning. Keeping plans at organizations lower in a hierarchy consistent with top management organizational goals doesn't happen automatically. This consistency requires a set of reporting procedures designed to motivate plans whose bottom-up formulation aligns with the top-down directives. Hierarchical planning helps in this process. I'll discuss hierarchical planning for its value in sharing information.

Hierarchical planning is an instrument to measure and evaluate the usefulness and effectiveness of plans. Under such a standardized system, all plans might consist of (1) an executive summary, (2) a series of chapters, and (3) appendices. The objectives would be to gain credibility, increase consistency, reduce workload, and have a plan that can be used.

Defining Hierarchical Planning

Hierarchical planning is top-down directed and bottom-up formulated. Each organization lower in a hierarchy produces its own plan in accordance with directives issued by top management. The plan of the organizations lower in the hierarchy includes an executive summary written to meet top management format and guidelines and includes summary-level data in appendices formatted to suit top management. At the middle level in the hierarchy, the executive summaries are skimmed off the top of each plan of the organizations lower in the hierarchy and built as chapters into the plan for the middle level in the hierarchy. Also the summary-level data, appropriate for use of the organizations in the middle of the hierarchy, become the detail data for the plan of the organization in the middle of the hierarchy.

The contribution to the plan of the organization in the middle of the hierarchy is then the preparation of their executive summary to meet top management format and guidelines and to represent all the chapters of their plan and the summarization of the detail data to meet top management's format. The information in the executive summary of the organization lower in the hierarchy is shared between that executive summary and the chapters of the organization in the middle of the hierarchy. The same is true with the shared data of the appendices.

At the regional, lead, or divisional level (other mid-level organizations in the hierarchy), the process is repeated. The executive summaries of the organizations in the middle of the hierarchy become chapters, data are summarized for appendices, and the higher-level organization writes an executive summary representing their chapters. In the same fashion this process is continued at all levels of the hierarchy including the top level. The result is that information is shared at all the levels, they all are consistent, and productivity is increased.

Aspects of shared information affect the success of hierarchical planning. For good effective hierarchical planning, top management must clearly communicate to all other levels in the hierarchy the goals and objectives to be accomplished by the plans. In turn, these mid-level organizations must properly interpret these goals and objectives and integrate them into their plans. Their executive summaries should represent the plans' contents if the summary documents represent plans of all the lower levels in the hierarchy.

Sharing in Hierarchical Planning

Promoting consistency at and through the hierarchical levels can also help prevent hoarding. There's less demand for additional information from the top down when the upper level gets the information it wants and needs. Information may be power, but data aren't. Data should be open, and this is a necessity if we're to develop information from those data (and the personal biases involved). Data-hoarding impinges on human considerations that view data-hoarding as a means of cutting off the flow of information.

Chakraborty and David (1981) cite lack of discipline and motivation for effective planning. The continuous review and accountability brought on by the plan invoke fear and resentment within those preparing the plans. Plans threaten the independence of the manager by exposing forecasting errors to others within the organization. Qualitative data won't usually make it up the chain of command intact; formatted qualitative data have a better chance; quantitative data is closer to a sure thing (Galbraith, 1973).

All definitions of management include planning, but we must distinguish between the introspective, coordinative process of planning and the resulting product. We want to produce useful products, or tools, to be used as guides for when we perform the control function of management. However, these formulation tools usually sit on the shelf and gather dust. The problem is that the process and products don't fit the manager and what he or she manages.

How Are Government Organizations Affected?

A tremendous number of plans are generated within government organizations: contractors have plans, the field offices have plans, the area offices have plans, various units at headquarters have plans. In some cases where the activities of multiple government agencies overlap, each of the agencies may have its own set of plans, and, in fact, government subgroups may have their individual, independent, inconsistent plans. The problem is those plans aren't very well coordinated, and in some instances, may actually embrace conflicting goals and objectives. In these situations sharing is needed, and parochialism must be held to a minimum. Here, the tools managers should be using don't work together to serve the business of planning and execution.

There can also be difficulties at the top administrative levels within a government organization in terms of understanding plans formulated by entities across the organization's broad areas of responsibility. In part, these difficulties can stem from some rather basic and often simple differences in physical and editorial formats, bases of assumption, constraints, and goals and objectives. This makes planning and coordination more difficult.

The industrial engineer's approach to management says to plan from the top-down and to implement from the bottom up. But this cannot always be the case in an organization. A perfect example is a waste clean-up organization, where planning occurs from the bottom-up, because the real "forcing function" in dealing with waste products (which result from production activities) is in the field, not at the headquarters level.

In planning top-down, however, there is a headquarters Master Plan, and the lower echelons can then fit their goals and objectives into those of the Master Plan, and in theory, at least, if all of the individual goals and objectives at the lower levels are met, then the goals and objectives of the Master Plan will be met. But in some government organizations this scenario is muddied by the fact that there is wide-scale decentralization, numerous self-contained tasks, geographical dispersal, large number of hierarchical levels, and many different kinds of plans (program, strategic, etc.).

Special Concerns in Establishing Hierarchical Planning

We need to test strategic plans, program plans, and other plans in the same manner that emergency plans are tested. Emergency plans are tested to see how well a group of related plans work together to achieve a common objective, and where differing jurisdictions are involved. This tests the quality of sharing and leads to development of common plan attributes: format, assumptions, and goals and objectives. In short, the goal is tools consistent with all stakeholder's plans, incorporating data integrity and lending themselves to sharing.

1.6.2.1.7. A Simple Sharing Data Situation without Computers

Even in traditional office settings without computers we've never learned to share data, information, decision mechanisms, and information processors.

In his landmark book discussing the Theory X and Theory Y of management, Douglas McGregor implies that we need to share in our high-technology society. McGregor says, "No individual in society is completely independent. Interdependence is a central characteristic of the modern, complex society. In every aspect of life we depend upon each other in achieving our goals. We don't grow our own food, make our own clothes, provide our own transportation or shelter, educate ourselves. We've learned that as a society we can have more of everything we want by specializing individually. However, the price of specialization is dependence on others." (Douglas McGregor, *The Human Side of Enterprise*, McGraw-Hill 1985.)

Webster defines sharing as "to have or use in common with others." Sociologists who study sharing are interested in the common aspect of what we share. With the coming of the information age, problems in effectively sharing data, information, decision mechanisms, and information processors have become more difficult. The key to more effectively sharing is to understand sharing and understand how we share manually without computers or automation. Just as we learn to dance by first learning the steps and then applying the music with ever-increasing tempo, I'll examine manual methods of sharing to derive the basic steps and then develop the considerations for sharing more effectively when using computers. Automation merely increases the speed, volume, and audience of the sharing environment. In short, for sharing we must understand how we walk before we can run.

We've always shared corporate data. We simply haven't thought of it as such. Consider the company file cabinets, a database of corporate data. All of us need to access these files at some time—either to put things in, take things out, or just look around (read, write, review, and update). I'll illustrate the concept by describing an example of writing a report (creating information) that requires some data contained in the filing cabinets. I retrieve the necessary data from the files and decide not to make copies of the data or indicate that I've taken the data. I use the data retrieved as the foundation for my report by cutting and pasting the data for my report. After completing the report, I replace the old report in the file with my new one, thus returning some of the uncut data to the files, losing the rest, and including some of the information generated in writing my report. Sound familiar?

Now, let's look at what I did to write that report. First, I borrowed data from the corporate files without indicating I did so. Another person needing something from the filing cabinets while I have the data will either recognize that those data are missing, or won't know. In the former case, the missing material must be identified, located, and retrieved. In the latter, new information may come from incomplete data.

Second, I've taken corporate data, edited some, lost some, and exchanged some. Another person using these data to make information to support decision-making won't know the data are tainted. There's no indication of my assumptions in the bias, if my changes have precedence over the original, or when, or what was done to the data. The person doesn't even know if the data he or she first retrieved are the original data. For that matter, I don't know if the data I used are the original data either.

Third, I've not considered the value of the data in terms of risks and consequences—both good and bad. I haven't considered who should be allowed to access the data. (The illustration in Figure 1.6.2.1.7. shows an example of computer crime—a form of sharing we don't want.) When I returned the new report to the file, I may have updated the data making them appear up-to-date. Have I really improved the data? Are the data more accurate? Are the data more current? Could my changes result in a decision with potentially severe consequences?

I'll bet my example of borrowing from the file cabinet is familiar to you, but I'll continue to thicken the sharing plot. Let's look at sharing the information I just created in my report. I've finished my draft of the report, my information document, but I want several people to review what I've written. I make several copies of my report and distribute the copies. I've just shared information.

Consider several factors in the sharing of this information. For example, the time frame (shelf life) of the data help determine the applicability of the data. I need to know the location of all copies of my report if I want them returned. The value of the reviewer's comments, the nature of his or her data source, and his or her own hidden agenda are all critical in my understanding of what I'm expecting from the reviewer. The priority and sequence of dissemination and collection, and the level of each review (i.e., check for typos, substance, philosophy) help determine the bias of the reviews (sharing) as the information sharing progresses. Many questions must be answered and understood prior to making decisions about the effectiveness of the review (sharing) process.

In my story, I've discussed sharing data and gleaning information. Now I'll continue the story to include sharing decision mechanisms. Each recipient returns his or her marked-up copy of the report to the secretary for the final draft. After sharing information, changes are received from several sources. How do I incorporate each of these changes into a single document. Whose changes take precedence? Who decides? What are the effects of first-made versus last-made changes, uninformed changes due to different understandings, and inaccurate changes? What is the time frame during which the information is valid? Have all the reviewed copies been turned in, and if not, where are they? Which of the reviewer's inputs is most valuable? Should any of the reviewers see each other's comments during the review process? The secretary is besieged by reviewers, each of whom knows best. He or she must produce consensus on the new report.

What process does the secretary use to resolve differences in reviews? How does he or she use the process? What constitutes the final draft? All these questions relate to sharing the decision mechanism. As the secretary and the reviewers interact, they're acting as the decision mechanism for the final decisions.

There's one more thing to share in my story. Remember the report I drafted several paragraphs ago? I used the secretary's word processor to produce the report. Consider the word processor, as a simple data processor. The owner of that word processor had it configured with certain margins, leading, etc. I used the word processor for my report and altered the configuration to my liking.

Again, we can ask the same questions. Whose alterations are acceptable? Is the word processor still in use, or am I finished? Will the word processor be in use again shortly? Who's the user? Of what value is the use? How much time was spent in determining what was reconfigured, resetting the configuration, and then complaining about it?

Something seemingly as simple to share as a word processor can alter the data produced. Altering data may change the information generated. Changing information may alter the decision. Changing the decision may change the action taken on what is managed. A different action may alter the measured data. And the cycle through the Management System Model begins again. With each iteration through the cycle, I've altered the balance among the what is managed, who manages, and what is used to manage components of the Management System Model.

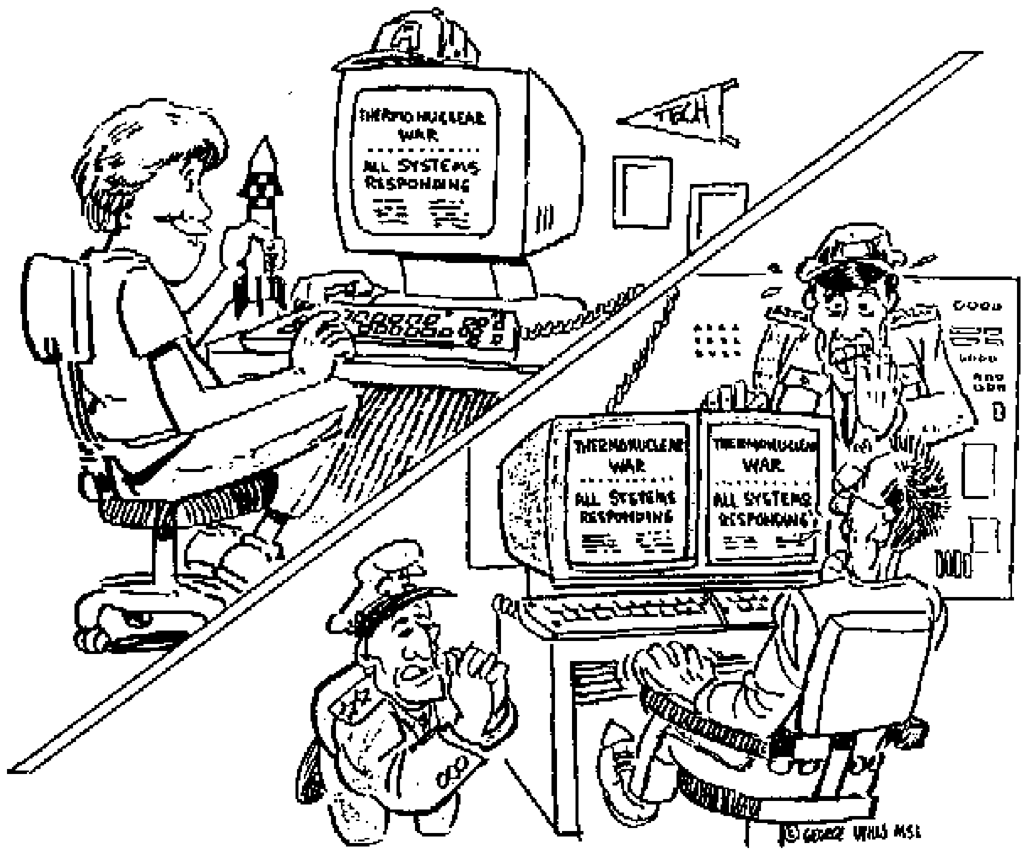

Figure 1.6.2.1.7. *"I think I'll share some of this government official's corporate data."*

1.6.2.1.8. Questions about Sharing Apply to Shared Information Processing

We've never produced a successful corporate database and information sharing network because we've never answered fundamental questions about the experience of sharing.

Can you show me a successful corporate data base and information sharing network? I've heard a lot of people talk about how good it's going to be when she or he has corporate data. But, I've never seen a real operating shared information processing experience that the sharers felt good about.

We've come a long way with information systems and personal computers. But now, in addition to working independently, we want for many of us to work with the same information and data. We want to share. We don't know how to share. We can't share computer-based data and information for the same reasons we can't share data and information in file cabinets, rolodexes, notebooks, and other mechanisms serving the same functions as computers. We don't understand what it means to share or what a sharing experience involves.

Technology is forcing managers to share information more than ever before. Competition is forcing a manager to encourage innovation, delegate authority, and change his or her standard operating procedure. The key to providing managers with the best information is to understand how managers share data, information, decision mechanisms, and information processors. I call this collection of activities shared information processing.

You need to use your management tools better by participating in more shared information processing. To use your management tools well, you must first learn how to share. Even before recent changes in technology, such as networks, copy machines, and large databases, you knew you weren't sharing. Technology has made the problem worse, because now you believe technology helps you share. You believe new technology is improving your performance and productivity. Unfortunately, technology isn't helping you share better, but instead is helping you fail faster and on a more global scale.

My position is quite simple. Until we understand how we share cookies, library books, office files, data, and information, we won't be able to improve our use of management tools. Our attempts at sharing are hurting, not helping, our productivity.

Shared information processing is a difficult concept to understand and use. I suggest we separate the concept into 1) information processing and 2) sharing.

The Management System Model (MSM) highlights the concept of information processing by modelling the conversion of data to information through management tools and the conversion of information to action through decision making. The MSM brings us an understanding of the domain of responsibility of the decision maker. The MSM also brings us the human characteristics of the decision maker within the domain of responsibility.

I'll now use the MSM to highlight the concept of sharing. I'll link the information processing model and the sharing model when we consider what we're sharing. That is, when what we're sharing is data, information, decision mechanisms, or information processors, then we've linked the general sharing model with the information processing model.

We never learned how to share data and information in file cabinets. We never realized the dilemma of sharing versus hoarding, or protecting, information. We never figured out the issues of priorities and ownership of information.

Until we understand the dynamics of sharing, we aren't going to realize any additional benefit from our sophisticated information systems. What we need is a focusing mechanism: a model of shared information processing, simple and general enough to apply easily and broadly to sharing, yet detailed and specific enough to help identify key shared information processing variables and their relationships. Such a model will allow us to study shared information processing.

The first step to understanding sharing is to know what questions to ask. The second step is to answer them. My model begins to answer the questions. The answers and the model are in Module 1.6.4.8. Here are the questions.

First, what constitutes a sharing experience? How do we delimit the experience? How do we get a sharing experience? How do we know we got the experience? This view is a macro-view or static view of sharing.

Second, what is the result of sharing? Are there different kinds of results? Are there different kinds of sharing? These questions relate to what I call the product of sharing.

Third, what elements make up a sharing experience? Which are necessary, sufficient, or nice? The elements are the things I look for from a microscopic view to identify or build a sharing experience.

Fourth, what tools or techniques help sharing? How do we apply the tools to the elements? Once we have the elements for sharing, we use tools to operate on those elements to generate sharing.

Fifth, what's the process or procedure to relate the elements and tools so we consistently get the desired product? What are the steps or phases in the process? What is the sequence and timing of those steps? The process tells us how to use the tools on or for the elements to get the sharing experience we want.

If you like analogies, compare my five sets of questions to the idea of baking a cake. Baking the cake is the experience. The kind, size, and so on of the cake is the product. The ingredients are the elements. The cooking utensils and equipment are the tools. And the recipe is the process. If you don't know these things, you'll bake the cake randomly, won't have any idea what cake will result, are apt to hurt yourself or destroy the cake, and can't develop skill or improve your cake baking.

1.6.2.1.9. A Model for Sharing

We can understand sharing better by relating the products, elements, tools, and process of the sharing experience.

To diagnose, design, or conduct a sharing experience, we have to *define the product*, *know the elements*, *be able to use the right tool at the right time*, and *have developed a process*. So we must characterize the experience generally, and specifically in terms of product, elements, tools, and process. This means we have to understand, operationalize, measure, and relate variables of the sharing experience and its product, elements, tools, and process. My model will describe and begin to define these things.

What Are the Products of Sharing?
The result of sharing is a transfer or exchange of something or change in something you already have. We can determine the result as an output or outcome of the experience. The result can be good, bad, or neutral. The product of sharing will be affected by what is shared, how it's shared, who shares and why they share, and when and where the sharing takes place.

What Are the Elements of Sharing?
The elements of sharing will tell us the what, how, who, why, when, and where of the sharing experience. In Figure 1.6.2.1.9.1., I present the elements of the sharing experience. By design, Figure 1.6.2.1.9.1. is a simple view of the sharing experience. The sharing experience is quite complicated, and a comprehensive figure would be too complicated to draw.

The stakeholders in Figure 1.6.2.1.9.1. are *who* shares. There must be at least two stakeholders for sharing to occur. Usually, more than two stakeholders participate in a sharing experience; but as the number of stakeholders increases, the number of possible relationships between stakeholders increases as a function of two to the power of the number of stakeholders.

Every stakeholder has a need to share. This need is a combination of the value, motivation, and intent influencing *why* stakeholders share. I assume the major reason stakeholders share is to maximize their overall gain/loss ratio.

The sharing experience is initiated and perpetuated by motivators. Motivators may be either internal or external to the boundaries of the sharing experience. Motivators serve as forcing functions and/or boundary conditions. Motivators affect the motivation of stakeholders and influence the boundaries of the sharing experience. A motivator could be a simple sharing opportunity for two or more stakeholders. However, motivators could also be mandated by someone outside the sharing environment.

An example of an external motivator is the Freedom of Information Act, which could lead two stakeholders to share information. (For interesting discussions of how external mandates affect sharing, see R.N. Clark, "Collusion and the Incentives for Information Sharing," *The Bell Journal of Economics*, V14, 1983, pp. 383-394 or Ester Gal-Or, "Information Sharing in Oligopoly," *Econometrics*, V53, N2, 1985.) Motivators for sharing could come from within the sharing environment. Gatewood describes information sharing among Southeast Alaskan salmon seiners as "a wise strategic maneuver" (J.R. Gatewood, "Cooperation, Competition, and Synergy: Information-Sharing Groups among Southeast Alaskan Salmon Seiners," *American Ethnolo-*

gist, V11, N2, 1984: p. 362). Economic prosperity and increasing prestige motivate their sharing.

Linkage mechanisms connect stakeholders. The linkage mechanism represents the sharing process and shows how things are shared. Linkage mechanisms bring together tools we use to help us share. Examples of tools for shared information processing include notebooks, file cabinets, computers, phones, and many more. An entity is *what* is shared. For example, in shared information processing, stakeholders can share decision mechanisms, information, data, or computers used to process data into information. These entities of sharing correlate to the activities of shared information processing: data, information, decision mechanisms, and information processors. Of course, stakeholders can share other things indirectly related to shared information processing, like office space, a secretary, or a budget.

The environment represents *where* and *when* the sharing experience takes place. The environment delimits the sharing experience.

What Are the Tools of Sharing?
The tools of sharing are used to help stakeholders share. Sharing tools include meetings, mail, telephone, telefax, copy machine, computer terminal, and many more. In sharing, stakeholders transfer or exchange ownership or change something they already own, all affecting the stakeholders of the sharing experience. The transfer or exchange can be 1) one-to-one, 2) one-to-many, 3) many-to-one, or 4) many-to-many. Sharing tools help accomplish one or more of these types of transfer or exchange. As intervenors, we can contribute to sharing by developing good tools and knowing which sharing experiences a given tool will work in. The tools help bring the elements of sharing together. They help with such things as when (schedule), who (personality type), where (facilities), and so on.

The Process of Sharing Links Stakeholders.
A stakeholder is more than just a human being; a stakeholder represents a domain of responsibility. A domain of responsibility contains, in addition to the human manager, the physical things the manager is responsible for and the tools used to manage.

I'll look at the simplest combination of stakeholders in a sharing environment. In Figure 1.6.2.1.9.2., I look at the sharing experience occurring between two stakeholders. So Figure 1.6.2.1.9.2. is a close look at a portion of Figure 1.6.4.8.1. and highlights the linkage mechanism, or sharing process.

The *need* in Figure 1.6.2.1.9.2. includes the reasons for or the purpose behind a sharing experience. The need of a stakeholder includes the value to the stakeholder, the intent of the stakeholder, and the motivation of the stakeholder. Examples of value, intent, and motivation are gain/loss, parallel versus serial, and altruistic versus selfish, respectively.

The *entities* in Figure 1.6.2.1.9.2. are what the stakeholders share from within their own domains of responsibility. The entities influence the motivations of either stakeholder to share, because shared entities are used to assess the gain/loss ratio.

For the salmon seining example, skippers of salmon seine fishing vessels made various calculations before they decided to share information. The entities being shared aided in these calculations. The skippers had to make decisions about where to fish. This decision affected what information was shared. Gatewood suggests skippers decided to share information so they could "make wise decisions as to where to fish while reducing travel time and related costs" (p. 357). The decision about where to fish was common to all skippers. But, those skippers who shared information did so based on the calculation of how they could increase their catch by sharing information versus the losses they would experience if they didn't share information. The skippers actually shared many other things: common fishing grounds, the possibility or increasing or decreasing their prestige as skippers, and their ability or inability to attract the more skilled crew members.

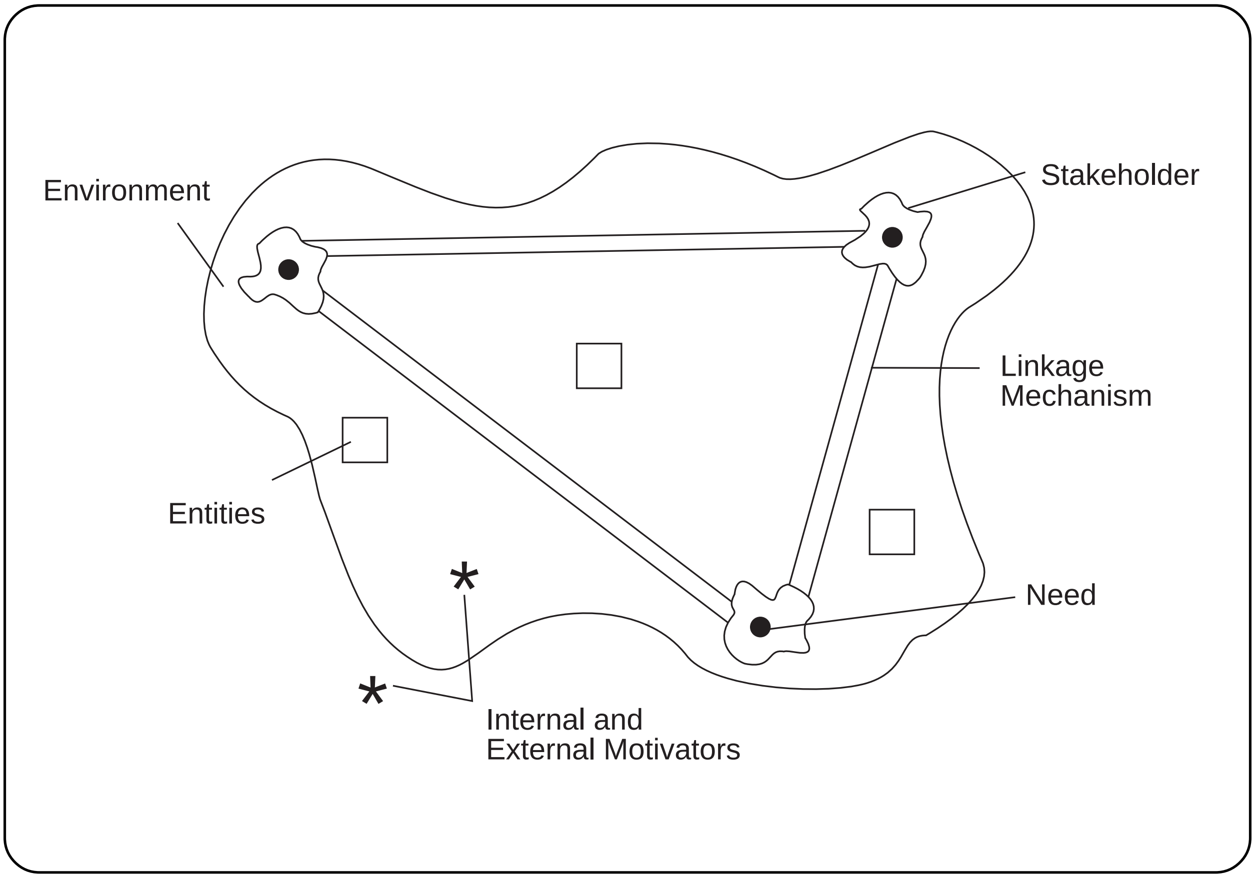

Figure 1.6.2.1.9.1. *The elements of the sharing experience show how sharing works.*

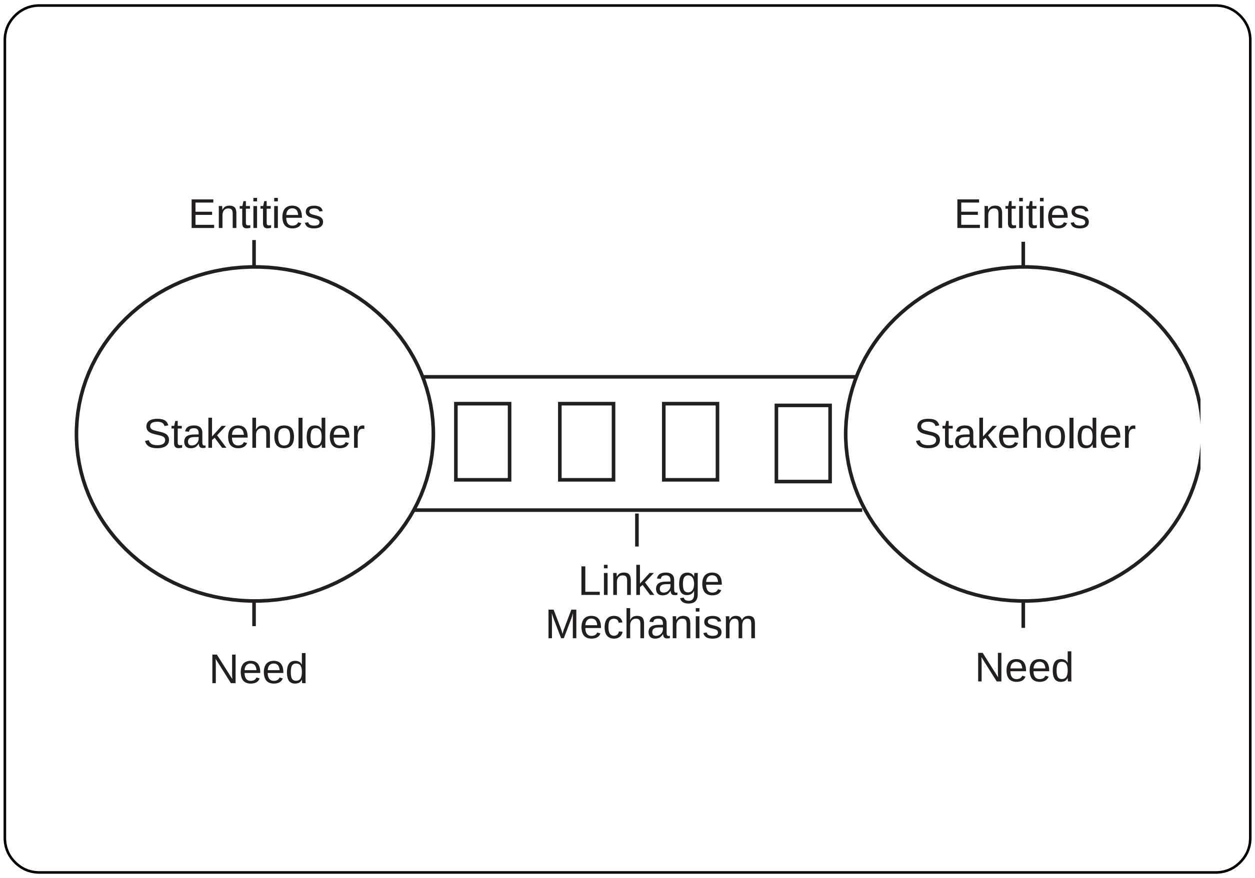

Figure 1.6.2.1.9.2. *The sharing process, including the linkage mechanism highlights the process element of the sharing experience.*

1.6.2.1.10. The Phases of the Sharing Process.

The sharing process involves a cycle of four phases: recognition, formulation, execution, and evaluation.

The sharing process is the map for putting the elements and tools together to achieve the desired results in a sharing experience. The sharing process, like any process, should be considered in terms of activities, time, resources, and performance. I believe sharing occurs in four phases, represented by the linkage mechanism in Figure 1.6.4.8.2. Figure 1.6.4.8.2. shows the sharing process as a linkage mechanism between stakeholders. The sharing process is like any process in management. The process is cyclic in that we learn by the sharing experience, and learning affects that experience or other experiences in the future. The phases of the sharing process include recognition, formulation, execution, and evaluation.

Stakeholders must *first recognize* the opportunity to share. Part of the recognition occurs when the stakeholder examines the gain/loss ratio. Will I benefit or lose if I share? The recognition phase shouldn't be considered one-sided, since there will be recognition by both stakeholders. In the seine fishing example described by Gatewood (See Module 1.6.4.8.), both skippers had to recognize the opportunity for sharing and the attendant benefits to each for sharing to occur.

Once the opportunities associated with sharing have been recognized, the stakeholders will enter the *second* phase and will *formulate* a plan. Using the seine fishing example, the plan involved where to fish based on the information shared between the two skippers.

Third, the stakeholders will *execute* their respective plans. I believe this phase is the most mechanistic because it's most heavily influenced by the tools stakeholders use to share.

Fourth, the stakeholders will *evaluate* the sharing experience based on its result. The stakeholders will evaluate the outcome of the sharing process for continuing and updating the process to meet their needs. The evaluation phase will result in a recognition of future sharing opportunities; and the cycle starts again.

Consider the similarity between the steps in the Plan-Do-Study-Act Cycle and the phases of the sharing process. Plan relates to formulate. Do relates to execute. Study relates to evaluate. And act relates to recognize. Since Plan-Do-Study-Act comes from the scientific method, I'd expect correlation to sharing.

A sharing experience is an activity and can be managed like an activity. That is, project management concepts are transferable to the sharing experience and applicable to the recognition, formulation, execution, and evaluation phases of the sharing process. We use the sharing tools during the sub-activities of sharing experience.

What Can We Do to Improve Sharing Performance?

I believe our ability to share information is similar to our capacity to process information. The way shared information processing affects our organization's performance and productivity is influenced by our ability to share. Obviously, having the best information (through appropriate sharing) affects our organization's product or service and affects our productivity in producing our product or service from our resources.

But let's focus on how well we share. How do we figure out what is the right thing to share and figure out how to share that thing right? What can we do to improve our ability to share; that is, improve our sharing performance? Galbraith (Jay Galbraith, *Designing Complex Organizations*, Reading, Massachusetts, Addison Wesley, 1973) gives us strategies for processing information.

I believe we can adapt and transfer his strategies for sharing data, information, decision mechanisms, and information processing. Transferring Galbraith's ideas, I believe we can 1) reduce the need for sharing or 2) increase the capacity for sharing. We can reduce the need for sharing by 1) creating slack resources or 2) creating self-contained tasks.

If we over-commit resources to a mutual problem, we don't need to share as much information or to share it so well. If we separate information and decisions using that information, we don't need to share between the stakeholders who are making the decisions in their self-contained units.

We can increase the capacity for sharing by 1) improving information systems, especially vertical information systems, or 2) creating lateral relations. As we develop future information systems, we must consider building more integrated data and information stores. Informal non-threatening data and information exchanges enhance our capacity for sharing. We need to establish these relations by developing mechanisms to help the relations work better.

Finally we have to consider the opposite of sharing: hoarding. Protecting data and information can often be a good form of hoarding. We have to distinguish between when to share and when to protect or we'll hurt our organization's performance.

Most managers don't know how to share. Most managers expect new technology and sophisticated information systems to help them share information better. Until we understand the dynamics of sharing and the importance of the elements of sharing, we won't share well—which may be worse than not sharing at all. I believe my model of sharing helps us understand what sharing is and how we can integrate the concept of sharing with that of information processing. We have a handle on describing sharing. Now we can observe sharing and, by trial and error, find tools and techniques to help or hinder sharing in a given sharing experience. Ultimately, I want to find out why tools and techniques work so we can characterize a sharing experience and prescribe what tools will work in that experience and predict the results.

1.6.2.1.11. Interaction Among People—Edouard Manet

1.6. Group Decision Making

1.6.2. Group Decisions (More than Two)

1.6.2.1. Information Sharing

1.6.2.1.12. Nominal Group Technique

1.6.2.1.12.1. The Value of the Nominal Group Technique

NGT is wonderful for idea generation and efficient meetings, but not quite so good for effective meetings and consensus.

Nominal Group Technique (NGT) is a common, valuable, often misused tool for group decision making. You misuse the NGT when you expect NGT to bring a group to consensus. Consensus requires identifying, acknowledging, scoping, confronting, and resolving conflict; and NGT alone will accomplish none of these activities. However, NGT is wonderful for free and abundant idea generation and for efficiently (not effectively) bringing a group to a relatively-well-documented decision. An efficient meeting runs smoothly and generates results. An effective meeting is on the right topic, involves the right people, occurs at the right time, and generates the *right* results.

In a world of wasted or even counterproductive group interaction in meetings, any semblance of process, progress, or result can help people feel productive, which is good. However, in this environment being lulled into a temporary feeling of agreement and commitment followed by no follow through on decisions made will make people even more frustrated than before, which is bad. Therefore, if you use NGT for what it is best suited for and are careful that people have realistic expectations, NGT can be wonderful. Furthermore, the individual steps of NGT are wonderful examples of steps you can custom tailor into a group decision making process to achieve specific results you want.

The steps of NGT sometimes are most useful when you use only one or two of the steps in a facilitation process to move a stagnated group forward. I add a few steps to the standard five-step NGT process so I can help some of NGT's weaknesses. For NGT, helping weaknesses doesn't resolve weaknesses. Your best bet is to recognize the strengths and weaknesses of NGT and use NGT in whole or in part to take advantage of the strengths.

Where does NGT fit into facilitation? In the 7-P model for meetings in Module 1.6.2.2.13.1., the sixth P is for process. NGT is a set of steps that suggests a process for facilitation. NGT is a process tool for facilitation. You can use one or more of the NGT steps as you identify the process you want to use for facilitating the group. Also, the 7-P model requires before you begin the process (such as NGT) that you have clearly defined the issue to be worked on (the third P is for problem) and the people who will participate (the second P is for people). Example issues might be 1) What are the action items we need to accomplish to increase our sales by 20% this year?, 2) What skills do management systems engineers need to be successful?, and 3) How can we find better programmers in a highly competitive market for good talent? (Consider the 7-P model. The fifth P is for participation. When using the NGT, participation is free and open information sharing and controlled, facilitated participative decision making.)

Each participant needs to know his or her role in the meeting and what contribution is expected of him or her. When a willing and able participant doesn't have a role, he or she will contribute something, and that something is usually disruptive. You also need to make sure all the perspectives of the issue under consideration are fairly represented among the participants. Unrepresented stakeholders and other critics will discredit the results of decisions made by a group, thus discrediting the composition of the group. When assembling the group, consider all stakeholders. Any stakeholders not represented are not going to be committed to the result. The NGT is designed to get relatively equal and unbiased ideas from each participant in the group and to rank order the ideas.

The words nominal group mean a group in name only. To make an effective intervention in the workings of an organization supported by the group, you need to convert the nominal group into a real group. A real group is a group of people who share common interests and are able to communicate well so they can develop consensus around neeeded results that they are committed to following through with.

The potential problem with a real group is group think. Group think is when a group is so close and collaborative that a bad idea in the group isn't challenged enough and the group risks going to Abilene (Jerry Harvey, "The Abilene Paradox: The Management of Agreement," *Organizational Dynamics*, Summer 1988, pp. 17-34. [Kurstedt, Module 1.6.2.2.11.]) and other dysfunctional behavior.

I find that 16 participants is the best number of people to be facilitated in group decision making. My nuclear engineering background suggests a magic number related to 16. (Four squared is 16, and two squared is four.) My facilitation experience suggests that more than 16 is difficult and less than 16 isn't good representation—unless, of course, the number of participants less than 16 is everyone with a stake in the result. I have facilitated groups with as many as 40 people and as few as three. The problems with large groups are not moving the process at a fast enough rate to keep everyone's interest and having trouble making sure everyone has ample opportunity to express their views. The problems with small groups are inadequate representation, and lack of mutual stimulation of creative idea generation.

Successful NGT (or any participative decision making tool) requires a convener (usually a manager) who believes in participation and the value of group action. If potential group members believe any participative activity is an empty activity, he or she will find a way out of the meeting and send someone in his or her place who may not have the ability, understanding, or authority to represent his or her constituency. Then, you will have an empty activity. A good convenor provides a need, impetus, and resources to bring the group together and supports the group action before, during, and after the meeting.

I've never had a group with a bad result from the interaction of the participants. I've had participants who were outliers, with strange, angry, or misguided ideas. But the will of the group filters the ideas of outliers well. I recommend that the convenor agree to implement to group's ideas at the outset—or at least agree to implement some fraction of the ideas, like 70%, 80%, or 90%. That means that the convenor believes that 7, 8, or 9 of about ten high-priority ideas generated by the group are as good as or better than what the convenor might generate. See Module 1.6.2.1.13. for a good reason to believe that the group's result may be the one to use.

Since a well-constituted group has broader and more specific knowledge than any one person, the odds are in favor of the group's result. Since the group members or the constituencies of the group members will probably be the ones to implement the ideas or will have the ideas implemented on them, the group's result clearly is the one to follow. The convenor may have some inside information affecting an idea or two, but groups will accept that response, even after the fact. That is, if I do my best to generate a result and you tell me the majority of what I did is meaningful and will be implemented but due to inside information you can't share with me, you'll make minor changes, I'll buy in.

If the participants in a group believe most or all of their hard work will be implemented, they'll be motivated and bring an even greater sense of responsibility to their work. I am positive the group will generate an excellent, responsible action plan. I recommend the convenor follow the plan.

Successful NGT requires a facilitator who only works the process and doesn't get involved in the content of the discussion. The objectives of the facilitator are to move the process forward and to ensure that each participant believes he or she has had adequate opportunity to express his or her views. Our studies have shown that people feel more like consensus if they feel they've had adequate opportunity to express their views. No other variable seems to have much effect on their feeling of consensus—at least feeling consensus during the meeting and shortly thereafter.

Based on my experience, the big worry is that a short time after the NGT meeting there is little commitment to the NGT results and the meeting doesn't yield anything tangible but the meeting itself. Especially after a well-facilitated NGT meeting that generates a feeling of accomplishment not usually felt in meetings and a feeling of having had opportunity to express views, a participant can become even more frustrated when the results lead nowhere after the meeting. Some consultants have been quite successful in leading good NGT meetings with a feeling of accomplishment and a feeling of consensus and then escaping before participants attach any responsibility to the consultant for no follow up or follow through.

The key to true consensus is not only acceptance, but agreement and commitment. Agreement and commitment imply that people are willing and ready to follow up and follow through. One consideration as a facilitator is to get the group to define realistic expectations on the group's ability to follow up and follow through. To make something tangible happen, the group and its members need to be ready, willing, and able to carry out the actions implied by the decisions they make.

In my experience, I tell the group up front that NGT is good for idea generation and for efficient meetings and decision making. I also tell the group that idea generation is necessary but not sufficient for good consensus and that they have to work on consensus after the NGT part of the process. The NGT gets them part way there but not all the way to consensus. Groups understand and appreciate the truth and are thankful for any progress made in a meeting, thereby making NGT successful over the long haul. To move beyond the idea generation in NGT, the facilitator needs to be good at dealing with and resolving conflict and then moving on to consensus.

The NGT steps I'll discuss are shown in Figure 1.6.2.1.12.1. The first five are standard NGT steps. Steps six through eight are steps I've added over the years to make NGT more effective.

1. Silent generation of ideas.
2. Round robin offering of ideas.
3. Combination and clarification of ideas.
4. Voting and ranking of ideas.
5. Selection of high-priority ideas.
6. Sanity checks on high-priority ideas.
7. Sanity checks on left-out ideas.
8. Scoping of high-priority ideas.

Figure 1.6.2.1.12.1. *The NGT steps help a group creatively generate ideas and surface a high-priority list of ideas the group can support.*

1.6.2.1.12.2. Idea Generation and the Nominal Group Technique

NGT helps everyone contribute a large number of diverse ideas as a pool for selecting the high-priority ideas.

The first two NGT steps, silent generation of ideas and round robin offering of ideas, will encourage people to look within themselves for good ideas, without being affected by others. And then the participants will be in a situation where the ideas of other people will stimulate even more ideas from them. These two steps ensure that each person participates and that the participation is roughly equal. These steps help you, as facilitator, give all participants ample opportunity to express their views. When you do the round robin offering of ideas efficiently with the help of good people acting as recorders, you'll generate a level of excitement and expectation people aren't used to in meetings.

In silent generation (Step 1), the purpose is to generate as many ideas as possible, without any discussion. You want each participant to think of all possible ideas, from very general ideas to very specific ideas. Since there's no discussion, no person is influenced by any other person at this step. Those people who are more introverted or less apt to speak out can generate as many ideas as anyone else. One advantage of this step is that people aren't influenced by dominating personalities. You can also use machines that collect ideas anonymously in subsequent steps so people aren't fearful when generating more-controversial or possibly less-realistic ideas in this step.

Once people clearly know the issue under consideration, you should give the participants several minutes to write down their ideas. Don't give them too much guidance on what the ideas should look like, either in form or in substance. Any idea is worthy at this point. Different people have different experience, outlook, and personalities. So, you'll get a number of very different ideas. Some ideas will be general, some specific, some seemingly off base. All ideas help at this point to stimulate other ideas; and the group will cull out ideas that don't fit in later steps. Remind the participants that they can add to their list of ideas during the next step (round robin offering of ideas). Therefore, you don't have to wait the next step until everyone has written down everything they know. When you think each participant has several ideas written down, begin the next step.

In your group, you may have a participant who isn't used to being involved and who will sit back and watch. Remind everyone that in the next step you'll call on each person in sequence (perhaps starting at the front left-hand side of the room) to offer up one of his or her ideas. You'll find that the person who sits back will get involved sooner or later during the round robin step.

In round robin offering of ideas (Step 2), the purpose is to lay out all possible ideas for everyone to see and to stimulate new ideas as this step proceeds. The person who has been sitting back gets stimulated too. Unless we use a form of high technology, the way we show ideas is on flip chart paper, or we can use big Post-it notes. The facilitator recognizes each person in the room, one at a time, to offer his or her favorite idea—only one—and records the idea on the flip chart.

The facilitator will go around the room as many times it takes for everyone to offer all their ideas, one at a time. The reasons for offering ideas one at a time are to give everyone a chance and to give people the opportunity to think of new ideas stimulated by someone else's ideas. Remind the participants that if someone else identifies his or her idea, it's okay; the idea is on the flip chart—that's all that matters at this point. Record all ideas. No idea is bad or silly, too general or too specific. If an idea looks like someone else's, ask the two offerers if the ideas are the same. If either participant says no, then record both. Allow no discussion during this step. The spoken words are for offering ideas and clarifying the process only.

As you go around the room, some people will either have offered all their ideas or will have their ideas offered by someone else. At that time, a person can pass; and you go on to the next person in sequence. When going around the room the next time, be sure to recognize each person who passed before. Often they'll come up with additional ideas because of something someone else offered. The purpose is to generate as many ideas as possible. When you have a lot of passes in group, by that time you can recognize people with a glance and they'll respond orally or with a head nod. You can move very fast now. At this point, people recognize the end is in sight and they'll perk up a little. When you get everyone to pass, you can stop this step. I've shown a typical flip chart page in Figure 1.6.2.1.12.2.

As you record ideas on the flip chart, be sure to leave room between ideas. In later steps, you'll want space to write some numbers. Five or six ideas on a flip chart page is enough. When you get to 50 to 70 ideas, you'll have ten to twelve flip chart pages taped up (or tacked up) around the room. Being surrounded by charts lends a strong sense of accomplishment. Remember, you'll always need individual idea numbers. Often, it's handy to record the name of the person offering the idea (especially in large groups). You'll need to identify the offerer later when combining and clarifying ideas in Step 3.

For tracking purposes, you should sequentially number the ideas offered. Depending on the concern for attaching a person's name to each idea, the facilitator can record the person's name with his or her idea. Actually, one way to help NGT be successful is to have one or two (preferably two) recorders to put the ideas on the flip charts. Good recorders are crucial. A good recorder hears well (doesn't have to hear an idea over and over again) and writes legibly very fast. The facilitator wants to move quickly around the room to keep everyone's interest. Participants are attentive to the offering of the idea but lose interest and will disrupt by starting side conversations if writing the idea takes time. The facilitator should feel almost like an auctioneer, encouraging bidding of ideas and giving everyone a chance and keeping up a pace and cadence that keeps people interested and involved. The facilitator has no interest in the ideas themselves, only in the involvement in and movement of the process.

Often, people will seek a facilitator who has content knowledge. I don't see great value in having content knowledge except for not misinterpreting jargon when you repeat the ideas for the benefit of your recorders. The facilitator is clearly in charge of the recorders and relays ideas quickly from the participants to the recorders. One recorder writes ideas 1, 3, 5, 7, etc. and the other writes ideas 2, 4, 6, etc. In Figure 1.6.2.1.12.2., I've shown the chart for the first recorder. The facilitator directs ideas by alternating this way to keep things moving faster.

If done well, this step is fun and enlightening for the participants. It's interesting to see new ideas flash up quickly and see the diversity of thinking in any group. You should expect from 40 to 80 ideas. At about five ideas per flip chart page, you'll get eight to 16 pages to hang around the room. Not only is seeing the ideas fun, but seeing all the productivity implied in that many sheets of paper hanging in every direction around the room is fun too. This is the first of two high points in the process. As facilitator, you want to make the most of the good feelings at this step.

ACTION ITEMS FOR INCREASING SALES.

Mary	1.	Advertise more.
Ted	3.	Find better products.
Sue	5.	Change the word benefit to feature in the sign.
Sam	7.	Hire more sales people.
Joe	9.	Hire better sales people.
Phil	11.	Reduce the number of sales people.

Figure 1.6.2.1.12.2. *The typical flip chart page shows ideas generated by sequence number and the name of the offerer.*

1.6.2.1.12.3. The Get-It-Off-Your-Chest Step

Usually, people come to meetings with an issue on their mind. If a participant doesn't get his or her issue off his or her chest, that issue will distract them from the business of the meeting until he or she uses his or her issue to disrupt the meeting.

My experience is that, especially if a participant is a stakeholder in the objective of a meeting, any person coming to a meeting will bring baggage. That baggage can be bad history with someone or something related to the meeting's objective, a concern for the outcome of the objective, or a concern related to but somewhat distant from the meeting's objective. The participant will have his or her issue on his or her mind until you get the issue off. The participant can't get into the flow of the meeting and into the objective of the meeting as long as he or she is dealing with the issue. The participant wants to voice his or her concern. However, you really don't want to start off by getting all the dirty linen and conflict out on the table. The NGT can help you get through his problem.

According to the 7-P Model in Module 1.6.2.2.13.1., you'll have defined the meeting's objective (problem) and process before the meeting. You want to advertise both the objective and the process before the meeting and at the beginning of the meeting. By making the objective and process clear, you'll scope the meeting but you won't solve the problem of participants bringing their issues to the meeting. I suggest the following additional steps in the NGT (steps I've already discussed, but used for a different purpose) to clear the air and focus all the participants on the objective you want.

To clear the air, I tell people in meetings that we start by getting relevant information in front of the group—information that doesn't directly address the objective, but that is relevant. Recall the example issues for an NGT listed in Module 1.6.2.1.12.1. The first issue was, "What are the action items we need to accomplish to increase our sales by 20% this year?" A question that raises relevant information is, "What are the barriers to increasing our sales?" That one is bound to help people get issues of their chests. Another relevant question is, "Why do we need to increase our sales this year?" Questions like these aren't as specific and don't get to a solution like the statement of the issue. However, the generality of the question helps people feel whatever issues they may have on their chest will fit and promotes the participants getting the issues off their chests and onto the flip chart for everyone to see.

The second issue was, "What skills do management systems engineers need to be successful?" A question that raises relevant information is, "What courses should management systems engineers take in school?" When people address their skills and knowledge, they tend to think of the issues related to where and how they got the skills and knowledge they have. The relevant question opens the way for participants to get their issues off their chests.

The third issue was, "How can we find better programmers in a highly competitive market for good talent?" A question that raises relevant information is, "Where are there people who have programming skills?" Another relevant question is, "Why do we need better programmers?"

When you identify the relevant question, you should carry the group through the first two steps of the NGT. You'll not only get the issues off the chests of the participants, but you warm the participants up to the process you're using. Also, if some of the participants have never done NGT, you'll be training them a little bit.

When you finish the first two NGT steps for the relevant question, you'll have five to ten flip charts around the room. As shown in Figure 1.6.2.1.12.3., the participants will feel like they've started in doing something in the meeting process. And, in fact, the relevant information will be relevant and can serve as additional stimulation of ideas as the group moves into the next steps of the meeting process.

Figure 1.6.2.1.12.3. *When we are surrounded by tangible evidence of results from our work, we feel successful.*

1.6.2.1.12.4. Sorting Ideas by Priority

The group will bring the high-priority ideas to the top for scoping, refinement, and action.

The second two steps, combination and clarification of ideas and voting and ranking of ideas, will encourage people to clarify and separate ideas so you can work on a tractable number of ideas. When you do the voting and ranking of ideas carefully and get to the point of tallying and recording scores to show participants where they fit into the group, you generate a level of excitement and expectation people are used to at sporting events.

In combination and clarification (Step 3), your objective is to gather ideas that are really similar and be sure not to lose or submerge anyone's offering. People don't like their stuff discarded. You must gather together ideas that are essentially the same. Also, you must not give anyone the thought his or her idea is gone. The way you accomplish this seemingly mutually exclusive pair of tasks is to ask the group to find similarities. In this step, the only discussion is to clarify an idea that someone doesn't clearly understand. You need to clarify now to be able to discern similarities. Don't allow anyone to make a pitch for his or her idea by saying something like, "We're only doing clarification here; you can show your enthusiasm for your idea in the next step." Do make sure people understand what the words of the idea mean enough to be able to contrast the idea in their own minds with other ideas.

If, for example, ideas #6, #21, and #47 are suggested by a participant to be similar, ask which seems to be the parent for the other two. Assume the participant suggests #21 as the parent idea. Then ask the offerers of the three ideas if they agree with the suggestion. If any of the three disagrees, leave his or her idea alone. If any of the three agrees, fold the other ideas under the parent by first putting a line through the number of the idea to be folded and listing that number next to the number of the parent. Put the number or numbers in the space you left between ideas on the flip chart. If the person offering #6 or #21 disagrees that idea #6 should be folded in, then leave #6 alone. If the people offering #21 and #47 agree #47 should be folded in, then show #47 under #21. The offerers may prefer #21 be folded in under #47. That's okay, of course.

Be sure to tell the participants that when they get the typed version of the proceedings, they'll see the parent listed with the other ideas listed in their entirety (the idea number and all the words) indented underneath. Tell the participants also that, when selecting ideas, they'll select the group of ideas as a package. In my example, #21 and #47 are considered a package. I like to use the term "folded in" for the ideas placed under a parent idea. The important issue is that no idea at this point is more or less important than any other. "Folded in" sounds to me more like a mutual occurrence among the ideas.

Some participants will get carried away by this step and, if you let them, will find similarities everywhere and tend to reduce the entire list down to a handful of superordinate ideas. Superordinate ideas are difficult to implement due to lack of specificity. The facilitator needs to guide the participants to just combine very similar ideas. The group will move logically through this step. That is, the group will do the combination job well for a while and then as time goes on will overdo the job. So, you should call time when the combination step gets essentially finished.

Make sure the group knows that someone will type out the list as combined and clarified as the raw data base of ideas from the meeting. Often in doing NGT, you can have someone bring a laptop computer, type as the process progresses, and provide a printout at any time during the process. If you don't have on-site typing and reproduction of proceedings, make sure each participant gets the results of this step and all the following steps soon after the meeting is finished. Make sure that each person who participates by offering ideas or later voting and ranking can see his or her contribution clearly and exactly. Rapid feedback of group results gives the participants a clear sense of progress and accomplishment.

In preparation for Step 4, voting and ranking, you can add a new step into the process. I don't include this step in my list of NGT steps in Figure 1.6.2.1.12.1. because it's not part of classical NGT and I almost never use the step. I don't use the step mostly because I'm almost never given enough time to do the process the way I'd like; and this is a step I choose to leave out. However, for completeness, I mention the step here. The purpose of the step is to get the participants to review all the ideas and to wrestle with what makes an idea high priority.

In this new step, you can ask questions about relevancy, usability, urgency, importance, resources required, political impact, etc. You can give the participants an exercise in placing the number for each of the ideas in a grid showing one of these measures against another; e.g., a relevance versus resources required grid. You don't need to worry too much about what's on the grid. You want the participants to review the ideas and to consider each idea against each other idea according to some measure. Then the participants are more ready to begin the voting and ranking step. The participants will do the exercise where they sit; and you don't need to gather or record any data on flip charts.

In voting and ranking (Step 4), your objective is to raise to the surface a group of high-priority ideas. Be very careful you don't think or the participants don't think that in doing this step you have a true ranked list of ideas. You'll use one of several methods to get people to vote on the combined and clarified ideas. Through their voting, you'll get numbers that yield data but not decisions. This step is an opportunity to make or break the process. If people think that the data from the vote is consensus, you're in trouble. Voting doesn't yield consensus; voting yields data.

Remember that strength of consensus can vary. Strong consensus implies higher-confidence results. Strong consensus implies acceptance, agreement, and commitment. Americans are pretty good at acceptance of the results of voting. But, do you necessarily agree with someone if you have voted for him or her? And even more importantly, are you necessarily committed to him or her just because of your vote? And if you voted against him or her, what's your level of agreement and commitment?

I've facilitated groups where one of the ground rules was that nothing came out of the group that wasn't unanimous. One group included 15 lobbyists who represented opposing constituencies. Believe it or not, the results were good. It took time because the group had to refine all their thinking to the point of separating out what they could and couldn't agree on. Most people will agree most of the time. However, most people like to focus on their disagreement. By focusing on their agreement and agreeing to separate out and hold respectfully their disagreement, the group accomplished a lot. This was a hard job; and NGT wasn't nearly enough, but I often used individual steps of the NGT.

A technique I often use to deal with disagreement, important but tangential ideas, or other related but distracting issues is to list the disagreement, tangential idea, or distracting issue on a separate flip chart. Sometimes I call that flip chart "the parking lot" to give participants the notion of setting an idea aside for a while and not putting the idea away or discarding the idea. Using this technique, you can deal with participants' actions that can be disruptive, distracting, or delaying.

In the voting and ranking step, pass out five to nine 3 x 5 cards, depending on how many ideas the participants have to choose from. Each card should have a line for the idea number in the upper left-hand corner, lines for the words of the idea in the middle of the card, and a line for the ranking of the idea in the lower right-hand corner. Use five cards for 30 to 50 ideas resulting from Step 3 (combination and clarification of ideas), seven cards for 50 to 70 ideas, and nine cards for 70 or more ideas. I've shown a typical 3 x 5 card layout in Figure 1.6.2.1.12.4.

Each participant should take his or her cards (assume for this example, seven cards) and write one idea on each card. The participant should write one number (the parent number for combined ideas) and a few words of the idea (for verification, if necessary) on each card and end up with seven cards with a total of seven ideas. The participants shouldn't write anything on the ranking line in the lower right-hand corner of the card yet.

After each participant has completed his or her seven cards, he or she should rank his or her seven ideas in sequential order, with a seven ranking for his or her favorite idea. Don't define favorite as most important, most urgent, or other characteristic. Let each participant interpret favorite for himself or herself. There are a number of ways to rank the cards. Supposedly, the scientific way to do this part of the step is to identify the most favorite idea and assign a rank of seven in the lower right-hand corner of the card. Then identify the least favorite idea and assign a rank of one on the card. Then, for the remaining five cards, identify the most favorite of that group and assign a rank of six and identify the least favorite with a rank of two, and so on. I do the job differently. I lay my seven cards out in front of me in any order and then by pairwise comparison keep moving cards until I see them all together in the sequence I like. Then I rank them in sequence from a high of seven to a low of one.

During this step of the process, everyone will mill around to read the flip charts more clearly, to stretch, to think better, or whatever. When they finish writing the seven ideas on their cards and rank the cards, they should give their packages of cards to you for you to collect and tally the data. Since everyone moves at a different pace and everyone is milling around, you should announce before starting everyone on the step that when a person has finished the step and given his or her cards to you, they should take a break. But, be sure to tell the participants that as you get the cards you'll be tallying the results and have the results of their voting and ranking posted on the flip chart pages when they return from their break. Knowing they'll soon see results, participants will keep their breaks short to get back to see the results unfolding.

This step is the second of two high points in the NGT process. The participants will be glad to be able to move around some. Most of all, people love to see the results unfold on a scoreboard. It's the American way. Everyone loves to see one idea ahead for a while only to be overtaken by another and to see how well the ideas they voted for fare. While you want to make the most of the fun in this step, you have to keep reminding yourself and the participants that the idea that has the highest score isn't necessarily the highest-priority idea. However, you will find that ten or so ideas will clearly form a top group—a group of higher scores. The voting and ranking usually generates a top group, a large middle group, and a bottom group. Usually the ideas in the bottom group get no votes or maybe one vote.

When you tally the results, you want to track and record both the number of votes and the total score for each idea. Use the space you left between ideas on the flip chart to record the results. You must show both the number of votes and the total score. You may want to include the list of individual votes. For example, assume idea #21 (with #47 folded in) gets votes of 7, 7, 5, 3, 3, 2, 1, 1, 1. You track and record 30/9. This score isn't an average of 3.33. This score is a total of nine people voting a combined score of 30. Write the score 30/9 under the idea #2 in a different color from the idea list. Write the scores under each idea number. You'll likely find some interesting results. The participants will be fascinated with what they've done.

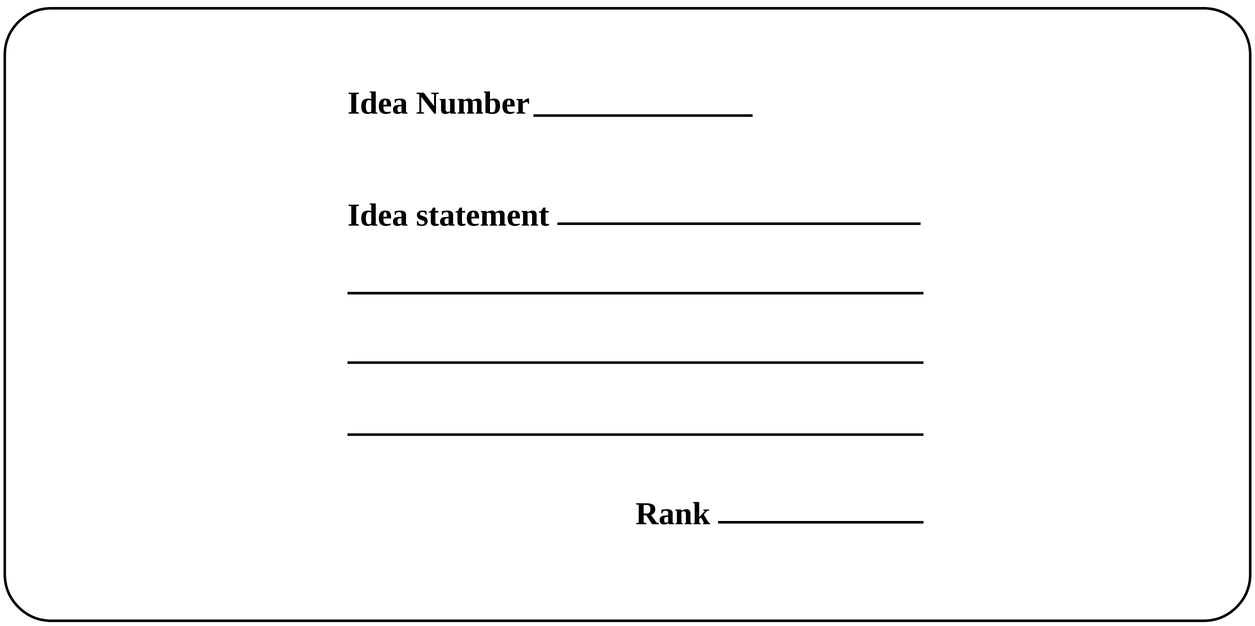

Figure 1.6.2.1.12.4. *The typical 3 x 5 card includes space for the idea number, a few words from the idea statement for verification, and for the ranking of the idea.*

1.6.2.1.12.5. Getting the Ideas to Work on First

The objective of the process should be to get the group to accept and possibly to agree on a list of a doable number of ideas from their long list to work on first because those ideas are of higher priority to the group of participants.

The fifth step of the standard NGT plus the first two of my added steps are needed to separate out from all the ideas generated those ideas that are doable, are of higher priority than the others for the group of participants, are somewhat challenged. You want the group to challenge ideas (especially the higher-priority ideas) to ensure the group feels good about their set of higher-priority ideas, the ideas are at least acceptable to everyone, and, hopefully, everyone agrees these are the ideas to work on before tackling the others. The important situation now is that participants will have (or will soon get) a ranked list of the large number of ideas they've generated. However, some of the ideas are out of bounds, are infeasible, or are low priority. If the group believes time and resources will be spent on some of the ideas, they'll be concerned that the right ideas get time and resources first. As facilitator, your job is to surface those ideas that should be considered higher priority by the entire group and that the entire group will support after the meeting and during the weeks or months when implementing the ideas confronts the many distractions of the typical workplace.

The fifth step of the standard NGT, selection of high-priority ideas, produces a draft list of higher-priority ideas. The first two of my added steps, sanity checks on high-priority ideas and sanity checks on left-out ideas, help generate a more-finished list of high-priority ideas that you'll have a bit stronger consensus on. Be careful. Even though the consensus is a bit stronger, it's still not real strong. Why? Because you won't raise and resolve conflict.

Raising and resolving conflict takes much more time and much more facilitator skill than does the NGT. (The key step in contentious meetings where confrontation, emotions, and conflict are expected is to first participatively generate a list of ground rules for proper behavior, facilitator authority, and moving the process forward.) Whether you expect a meeting to be contentious or not, if you want consensus, you'll have to deal with confrontation and conflict.

In selection of high-priority ideas (Step 5), you'll engage the group in surfacing a reasonable number of ideas the group wants to work on first. As you look at the scores written under each idea, don't look for sequence. Look for groupings. For example, idea #21 may get a score of 30/9 and idea #3 a score of 28/10. Which is higher priority—the one with higher total score or the one more people voted for? Now you're beginning to see why you can't say one idea is higher priority than an idea with a similar vote. You can however, say that an idea with 30/9 is higher priority than an idea with 2/1. So, if you look at the list you can isolate what looks like the top group of higher-priority ideas. I suggest that you write the letter A next to ideas with relatively large numbers in the numerator or denominator of the scores. Write the letter C next to ideas with low numbers in the scores, and write the letter B next to the middle group of ideas. Be careful not to think or to let the group think that these letters clearly demark ideas of greater or lesser worth. You'll get about ten A ideas, ten C ideas, and the rest B ideas.

You still can't be sure that one of the ideas in the A list wasn't an unintentional or intentional block vote by a clique in your group or that one of the ideas in the B or C lists really belongs in the A list. You do have a good feeling that the majority of the ideas in the A list belong there and the majority of the ideas in the B and C lists belong there. The next steps will help you deal with these issues. Without the next steps, you run the risk of someone recognizing the issues I've just raised or other issues that will render your result meaningless and unsupported by the group over the long haul.

At this point, you want to start saying, "Is this set of ideas (the A list) the ideas you want to work on first?" or "Is this list of ideas what you together believe are higher-priority for now?" Ultimately, you want to look each participant directly in the eye (no kidding) and have him or her clearly signify, "Yes." But you may not want to force the issue before you consider the next two steps. (For contentious meetings, the technique of looking each person in the eye for concurrence is a facilitator role to be clearly defined in the ground rules.)

These five steps (silent generation, round robin, combination and clarification, voting and ranking, and selection of high-priority ideas) completes the steps in the standard NGT, at least in terms of how I've done them and the experiences I've had. At this point you have a ranked list of ideas. Some facilitators will numerically number the ideas according to the scores and the vast majority of groups will let you get away with this practice—at least during the meeting. After the meeting, if any of the participants feel uneasy in their gut, they won't actively support the result.

The next steps will get people to feel better about the result and will yield something that smells more like consensus. But, without raising, dealing with, and resolving conflict, you aren't at consensus yet. You might want to call the result weak consensus; but, I strongly suggest you discuss this issue with the group to make sure everyone has realistic expectations.

In sanity checks on high-priority ideas (Step 6), you want to get the group to wrestle with the A list of ideas as a package and first determine if any of the ideas doesn't belong. In my experience, you often find one idea the group agrees to drop from the A list. Sometimes you'll find two ideas. This experience reinforces my notion that the voting and ranking step doesn't generate consensus.

I'm a bit uncomfortable with the term "sanity check," but I use the term anyway. You should tell the group that voting and ranking gave the group data to generate the draft A list of ideas. Now you want the group to generate more data to challenge the A list. Remind the group that the A list is now their focus. The A list is of reasonable size and you'll note is of reasonable substance. That is, the will of the group has filtered the ideas to eliminate unworkable, facetious, mischievous, or unreasonable ideas. The A list is a wonderful start. I've never been disappointed in the workings of the group. You may have some strange people or strange ideas in the meeting. However, the group takes care of itself and the group result is good. The convener of the group (usually a supervisor) might think he or she has a better set of ideas for the issue. (I'll bet the overlap between the convener's list and the group's list is great.) However, if the group or the constituencies represented by group members are to be part of the implementation of the ideas or will have the implementation done to them, you'll get better results if you choose the group's list over the convener's list. See Module 1.6.2.1.13. on calculating whether your solution is better than the group's.

Tell the group that in the sanity checks you're adding data to the voting and ranking results for the participants to challenge their A list. My favorite sanity check is to highlight each idea in the A list, one idea at a time. Ask a show of hands (or other voting method) of those who believe this idea really belongs in the A list. Record the number of votes divided by the number of participants next to each of the A list ideas. You're checking plurality. If fewer than half the people in the room believe the idea belongs, its place in the group is challenged. Now comes the consensus piece. I go around the room one at a time and look each person in the eye and ask, "Do you think this idea should be dropped from the A list?" If any one person says, "No.", I leave the idea in the list. I personally believe that messing with the A list requires unanimity. I, of course, suggest the rule of unanimity to the group and discuss the issue of consensus before I do the look-in-the-eye thing. You need to get the group to realize that it's the A list you're focusing on and that no idea in the list is more important than another at this stage. This focus changes the participants' outlooks and they don't feel an idea in the A list is threatened. I've never had a group with a problem in the unanimity rule for sanity checking.

You may think of other ways to ensure that the group doesn't keep an idea in the A list that shouldn't be there. You don't want the group to get in an "Abilene" condition started by the voting and ranking step. See Module 1.6.2.1.11. for what I mean by Abilene.

In sanity checks on left-out ideas (Step 7), I'm interested in the reverse situation. We checked for what's in the A list that should really be out. Now we check for what's out that should really be in. Again, you want to suggest the unanimity rule.

Ask the group if anyone sees an idea that somehow didn't get many votes but really belongs in the A group. You run a risk here of someone with a pet idea pushing for his or her idea to be included. However, the group is pretty well conditioned at this point to the notion that only talk for clarification is needed; and I haven't experienced many passioned monologues for an idea. I have experienced a real sanity check in this step. I've seen ideas resurfaced that somehow the group knows belongs in the group but didn't vote that way. I've even had ideas from the C list move into the A list. The unanimity rule takes care of pet ideas that don't belong. And retrieving an idea for the A list gives participants a feeling of security for all ideas not on the A list.

Now, you have a better draft of the A list and a little bit stronger consensus. I show an A list in Figure 1.6.2.1.12.5. The unanimity rule seems to bring more agreement to the list. The next step, and usually my last step, brings more sanity and another level of understanding and consensus to the list.

ACTION ITEMS FOR INCREASING SALES.

Sally 21.		Change sales manager.	
	Ted 47.	Hire better sales manager.	
	A	7,7,5,3,3,2,1,1,1	30/9
Mary 1.		Advertise more	
	B	5,3,2,2	12/4
Sue 5.		Change the word benefit to feature in the sign.	
	C	1	1/1

Figure 1.6.2.1.12.5.1. *After voting and ranking, the flip chart page includes the ideas folded in other parent ideas, the votes, the tallies, and the list designation (e.g., A list).*

A LIST.

21. Change sales manager.

    plurality: 5/16

18. Get a new advertising agency.

    plurality: 15/16

1. Advertise more

    moved from B list.

Figure 1.6.2.1.12.5.2. *The flip chart showing the A list allows for additions and deletions resulting from sanity checks.*

1.6.2.1.12.6. Finding Out What It Takes to Implement the Ideas

When the group reviews the scope of each of the higher-priority ideas, the participants cement their agreement and begin on commitment through accountability.

After you have an A list, you need to consider next steps. The first next step is to scope each higher-priority idea on the A list to determine feasibility, to assign responsibility and due dates, and to give the responsible person a head start in scoping the task related to the idea based on the understanding of what the idea means the group attained during the meeting. In fact, this step can be yet another sanity check. That is, if scoping the task shows the implementation of the idea to be infeasible given the situation or resources available or that implementing one or two ideas means no time or resources for the many other ideas, the group can decide to hold the idea aside to accomplish the many other ideas.

Often, the facilitator can help the group come to closure. Especially a nominal group has trouble coming to closure. For example, you can identify and suggest action on action items that come up during the meeting. The key to action on action items is determining the responsible person and due date. You can identify and verify decisions made that extend beyond the process of the meeting. I see these interventions as process interventions and, therefore, within the purview of the facilitator. As you make these kind of interventions, the group will get into the swing of it, and, before long, the participants will identify action items and decisions made.

To do the scoping step, have the participants group themselves into small teams. Each team will take one idea and scope the idea in terms of objective, impact, time, and resources. Have the teams go to breakout spaces and brainstorm and document the scope of the task. Have the teams select a spokesperson to report back to the larger group. Have the spokesperson make his or her report to the group. Have the team record feedback from the larger group. Figure 1.6.2.1.12.6. is a form I use to help the scoping team cover needed issues around implementing an idea. Collect the forms with feedback and have them typed. Pass this information on to the person responsible for implementation.

Now, you must help the group follow through. Have the group decide if they intend to meet again and what the objective of their next meeting is to be. An example objective could be to hear from the implementation teams implementing the ideas so the group can have some input. Another objective is to reconvene at some regular time (e.g., quarterly or annually) to generate a new A list. Since the world is continually changing, the A list may need to reflect the changes. Also, as ideas on the A list get implemented, the participants may want to elevate ideas from the B list to be implemented.

Scoping Form for Action Items

ACTION ITEM NAME____DATE_________

Scoping Team Leader:

Scoping Team Members:

1. Define and Describe. Write down a concise, comprehensive statement of your action item.

2. Define objectives/desired outcomes.

3. Define the expected benefits. To whom?

4. What has to be done? Try to lay out general steps.

5. By when should it be done, and why is the date important? When should it start to make the deadline? What are major milestones?

6. Who should be involved for contribution and/or implementation?

7. Are there people/groups to coordinate or cooperate with? If so, when?

8. What will the action item cost in funding and materials?

9. What are the potential risks from considering and/or implementing the action item?

10. Establish measures of performance: How will we know we have succeeded? How will others know/be persuaded?

11. Actions: What follows form this scoping?

Figure 1.6.2.1.12.6. *The scoping sheet gives the breakout groups direction on what to consider to ensure the total group knows what the idea will require for implementation.*

1.6. Group Decision Making

1.6.2. Group Decisions (More than Two)

1.6.2.1. Information Sharing

1.6.2.1.12. Nominal Group Technique

1.6.2.1.12.7. Experience With the Nominal Group Technique

1.6.2.1.12.7.1. Description of the Experience for Determining Needed MSE Skills

Include general information on the vision of the department and other information that will give good background.

ISE Vision

The vision for the ISE Department is influenced by the environment in which it must function. This environment currently presents extraordinary challenges due to diminished public and government support, increased accountability, and public expectations concerning improved productivity and lower tuition increases. The ISE Department welcomes these challenges and is committed to utilizing innovative and creative systems, technology, and processes to:

- Improve the quality of instruction and advising that are integral to comprehensive curriculum reform now underway.
- Enhance (funded and unfunded) research activities and their dissemination to address the needs of society.
- Improve degree productivity, student support base, and enhance students' likelihood of degree completion.
- Update the educational experience to encompass a global outlook.
- Address the needs of the nontraditional student.
- Maintain a continuous improvement program for faculty, staff, curriculum and facilities.
- Maintain high academic standards commensurate with the long-standing high reputation of Virginia Tech.

Mission Statement

Department of Industrial and Systems Engineering

The faculty of the department is committed to advance the state of the art of the discipline and to communicate existing and new subject matter to students, both undergraduate and graduate. The faculty is also responsible for both the broader education and intellectual growth of students.

Objectives:
The field of industrial engineering embraces a broad spectrum of technical activities including the classical techniques of work methods, production and facilities planning, quality control, and safety. It also embraces the fields of human factors, operations research, manufacturing systems, and organization and management systems, with the latter four fields well defined at the graduate level. Within this framework, the major objectives of our educational programs are as follows:

1. To provide a quality education that will prepare our undergraduate and graduate students for a life-long learning experience in this rapidly changing field and to prepare these students to be future leaders in the industrial engineering profession, in business, and in industry.

2. To conduct basic and applied research to advance the frontiers of engineering and to support the industrial and economic growth of our state and nation.

3. To provide service to the profession, industry, and society to contribute to the advancement of civilization and the betterment of all.

Principles
- Faculty will be committed to the teaching of students.

- Monitoring and improving the quality of instruction and verifying the relevance of our curricula, at both the undergraduate and graduate level, will be an ongoing responsibility. Our students are entitled to no less.

- The total education of the student, as he or she prepares to enter the profession and society, is also an obligation.

- Faculty will be committed to research both for their own professional development and to advance our understanding of the discipline of industrial engineering.

- Research funding and the return of overhead funds accruing from research contracts are important to the well being of the department.

- Faculty will share their research results and facilitate instruction across the discipline through presentations at national and international conferences, and publications in scholarly journals, wider read professional magazines, and textbooks.

- Public service is another obligation and a specific component of the land grant mission of the institution.

- An intelligent, competent, and articulate faculty will be a continuing priority. Toward that aim, the recruitment, development, and retention of faculty colleagues will be a shared responsibility.

- The attraction of undergraduate and graduate students of high academic potential is important to the well being of the department and the discipline.

- Modernization and well-equipped laboratories are important to our success in instruction and research.

- Funds from the private sector are necessary to supplement state appropriations.

- To be a part of a learned profession is a high calling and includes, in addition to high principles and a commitment to seek out truth, a shared respect for colleagues and a diversity of points of view, along with a genuine interest in and support for the students entrusted to our care and education.

The following formal definition of industrial engineering has been adopted by the Institute of Industrial Engineers:

> Industrial Engineering is concerned with the design, improvement, and installation of integrated systems of people, materials, information, equipment, and energy. It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems.

Program Objectives

The ISE Department has as its general objective to provide a superior educational opportunity for qualified students coupled with strong research and extension programs to serve the needs of the Commonwealth of Virginia, the nation and the world. To accomplish this objective the department combines a "hands-on" educational philosophy in conjunction with a systems approach in addressing instruction, scholarship, research and extension in a manner consistent with the stated mission of the College of Engineering. The College of Engineer's position on these areas is stated as:

> "Instruction: to provide, in an environment conducive to learning, the instruction, guidance, and encouragement necessary to insure that each graduate will possess a foundation of knowledge, skills, and ethics essential to his or her progressive and continued development throughout a career in the engineering profession.
>
> Scholarship: to provide the resources and the environment in which faculty and students can achieve academic excellence.

Research: to provide the facilities, faculty, and staff necessary to attract sufficient research funding so that we can continue to perform as a major research institution known for quality research which has significant impact on the practice of engineering.

Extension: to provide the widest possible dissemination of the engineering knowledge gained through study and research and to assist wherever possible in the practice of engineering."

The manner in which the objectives are addressed in the undergraduate curriculum include:

1. Concentrate On The Functional Areas Of Industrial Engineering As Historically Defined: Examples of these well-known functional areas are cost effectiveness (engineering economy and cost analysis), facilities planning and material handling, manufacturing, work measurement and methods engineering, production planning and control (include forecasting, scheduling, and inventory control), human factors, and principles of organization and management. However, the methodology used for analysis in these subject areas includes operations research models and the exercise of systems philosophy, as well as the "traditional" tools (note Section XI.E.).

Although a substantial majority of the undergraduates continue to be employed by industrial and business firms, an increasing number of graduates are hired by a variety of service organizations such as banks, hospitals, major accounting firms, consulting firms, and research groups. Additionally, governmental, military, and educational organizations offer employment opportunities for the industrial engineering graduate. Thus, a primary emphasis on functional areas provides a more flexible educational base than a curriculum structured with purely "applications" courses.

2. Provide A Balanced, Or General, Curriculum: In consonance with the first objective, the functional areas identified above are defined as traditional industrial engineering. By integrating additional, required basic courses in statistics and probability theory, deterministic and probabilistic operations research methodology, and simulation, a balanced curriculum is thus defined. This balanced undergraduate industrial engineering curriculum also retains a fundamental physical and engineering science base (note Section XII.E.).

3. Provide Curriculum Flexibility: Since the practicing industrial engineer is a disciple of change, a minority portion of the undergraduate curriculum should be sensitive to new horizons or contemporary approaches to traditional problems. The recent national emphases on energy conservation and automated manufacturing are cases in point. The ISE Department believes this objective is accomplished by incorporating 12 credit hours of departmental and non-departmental technical, senior approved, and free electives, taken during the senior year, into the required credit-hour curriculum. These electives, plus a judicious choice of required humanities electives, provide an opportunity for (1) undergraduate specialization or (2) more specific preparation for entrance into graduate degree programs. However, the department's philosophy is to control the number and scope of electives (note Section XII.E.).

4. Emphasize Communication Skills, Both Verbal And Written: The successful, practicing industrial engineer must have the ability to communicate effectively at different organizational levels, a fact documented by history and current feedback from the market-place. Individual (or

group) projects and in-class presentations, a standard practice in the ISE curriculum, serve to develop this ability. Further, students are required to take Technical Writing, ENGL 3764 and may elect, and are encouraged to elect, formal communication skills courses as approved electives (note Section XII.K.).

5. Emphasize The Use Of The Digital Computer In The Industrial Engineering Functional Areas: Section XII.L. describes the ISE students' usage of the digital computer.

6. Encourage Professionalism: Attempts to accomplish this objective are made through departmental and individual faculty support of IIE, SME, Human Factors Society, SOLE, ORSA and Alpha Pi Mu student organizations. Further, both academic and non-academic guest lecturers are invited to speak to undergraduate classes. The ISE Department has found that an Advisory Board, with both academic and industrial members, has been very helpful in promoting an environment of professionalism within the department. Further, a policy of encouraging students to serve as regular members of certain departmental committees allows a continuing faculty-student interchange of ideas and results in joint work on departmental projects. Such cooperative effort on behalf of faculty and students has stimulated mutual respect, unanimity of purpose and, in general, fostered a professional atmosphere within the ISE Department (note Sections XIV.A., XIV.B., and XIV.G.).

Action to Correct Previous Weaknesses

There were two specific areas addressed in the last accreditation visit with required action by the department, within its capacity to respond. These will be addressed separately in the following paragraphs, the first being addition of space for the program including the manner in which the added space has been integrated with the department, and second changes in staff.

Space remains a concern and a priority item within the department, however, progress has been made and immediate future developments appear promising. Improvements have resulted from an increase in the space available to the department and in renovation of existing space that has resulted in a better use of space (note Sections XIII.A. and XIII.D.). The most significant addition of new space is the 17,200 net square feet of new space in the recently completed fifth floor of Whittemore Hall. The departmental space in Whittemore Hall is approximately one half of the first, second and third floors and all of the fifth floor. The Manufacturing laboratories and faculty offices occupy the first floor, the records office and faculty offices are located on the second floor, the human factors laboratories and offices occupy the fifth floor and the department office and remaining faculty offices and facilities are located on the third floor.

The expansion of Whittemore Hall has added substantially to the human factors laboratories and also has added 4,100 square feet to the manufacturing instructional laboratories, almost doubling their size. In addition, the manufacturing laboratory space was entirely renovated at a cost of over $100,000 to assure the additional space would be both appropriate and effectively utilized. New undergraduate instructional laboratories were developed in the areas of programmable controllers, automation, advanced automation, and robotics.

1.6.2.1.12.7.2. Silent Generation of Important Courses

Please identify and list below the courses, by title (and number if known) you believe are the most essential to the ISE curriculum. The courses you select don't have to be in the ISE department.

1.6.2.1.12.7.3. Round Robin Offering of Ideas for Important Courses

We'll now go around the room soliciting your ideas one-at-a-time and will write them on the flip charts for everyone to see. We'll continue until all your ideas are on the charts.

1.6.2.1.12.7.4. Combination and Clarification of Ideas for Important Courses

Look at the list of ideas generated in the round robin step. Do you understand what each one means? Do some ideas express the same idea and can therefore be grouped together?

1.6.2.1.12.7.5. Silent Generation of Needed Skills

Please identify and list below the concepts and skills you believe important for industrial engineering students.

1.6.2.1.12.7.6. Round Robin Offering of Ideas for Needed Skills

We'll now go around the room soliciting your ideas one-at-a-time. We'll continue until all your ideas are on the charts.

1.6.2.1.12.7.7. Combination and Clarification of Ideas for Needed Skills

Look at the list of concepts and skills generated in the round robin step. Do you understand what each one means? Are there some ideas that express the same idea and can be grouped together?

1.6.2.1.12.7.8. A Relevance/Resources Required Grid for Ideas for Needed Skills

Relate the relevance of the presented concepts and skills and the resources required to implement them. As you consider the list of all the concepts and skills generated by the group, a relevance/ resources-required grid helps you silently rank the items. The grid is on the next page. Everyone will not only view the list differently, but will also have different measures of the relevance of the concept or skill to industrial engineering students and the requirements for resources (e.g., faculty, laboratories, etc.) in implementing them as part of the ISE curriculum. The grid is personal, for you to place the numbers of the items from the charts produced in the round robin step. You'll have a representation of how you feel about the relevance of and resources required to implement the concept or skill.

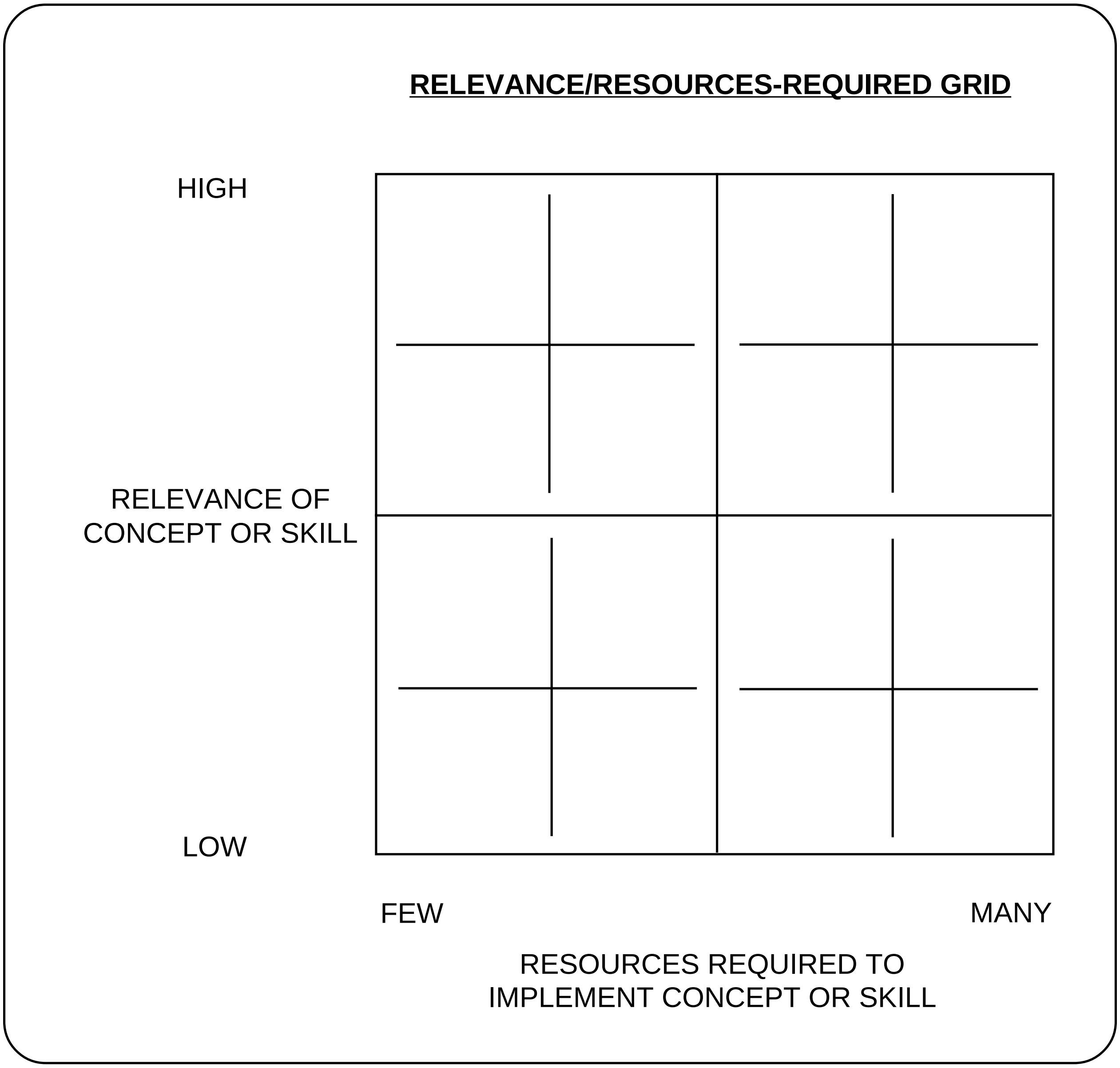

Figure 1.6.2.1.12.7.8. *Relevance/Resources-Required Grid.*

1.6.2.1.12.7.9. Voting and Ranking of Ideas for Needed Skills

There are several ways you can vote on and rank the ideas presented in the round robin step and then combined and clarified. How you do this is subject to your preference. The initial steps are common to all methods. Pick your top seven ideas from the lists on the charts. Write the idea number in the upper left corner of the 3x5 card and a short statement of what the idea is on the cards. Once you've identified the ideas for all seven cards, lay out your cards so you can see all of them. Here are ways to rank your seven cards.

1. Developers of the NGT suggest that you pick the most important of the seven ideas. Give this idea a vote of 7 and put it aside. Then pick the least important of the remaining six. Give that one a vote of 1. Keep alternating from most important to least important until all cards have a vote.

2. Lay out all your cards in front of you. Arrange in order of most important to least important using whatever means you wish. Give the most important item a vote of 7, next important a vote of 6, and so on to the least important with a vote of 1.

1.6.2.1.12.7.10. Selection of High-Priority Ideas for Needed Skills

The facilitator will summarize the NGT results and point out the high-ranking items.

1.6.2.1.12.7.11. Sanity Checks for Ideas for Needed Skills

We'll do a couple of sanity checks against our A list. First, we'll check each idea on the A list by asking our group to signify whether he or she thinks that idea belongs on the higher-priority list. We'll tally the total number of people who think so. Second, we'll ask the group if any idea not on the A list should be put on the A list. If we get unanimity, we'll add the idea.

1.6.2.1.12.7.12. Scoping Documents for High-Priority Ideas for Needed Skills

We could divide our larger group into teams and fill in the form from Module 1.6.2.1.12.6. In doing this step, we'd see the difficulty in converting the idea into action for implementation

1.6.2.1.13. Exercise on Participative Decision Making

The probability of making a decision that results in a lasting effective action increases when we make a collaborative decision among those affected by the decision.

Explanation

We learn from the Management System Model (MSM) that to be of value, a decision must have an action that affects the work process. In the traditional organization, the person making the decision does not carry out the action to implement the decision. In fact, seldom does the decision maker check up to make sure his or her decision is carried out. That is, there's no follow through and follow up on decision making. However, if decisions are made collaboratively, the follow through is automatic and the follow up unnecessary.

The idea of this exercise is for you to convince yourself that whether you're an expert or generally lucky or you can find a consultant who is an expert or generally lucky, you don't want to make decisions based on expertise or luck alone. I want you to answer the question: Why implement the group's idea when you know (suspect) your idea is better? In short: Which is better, decision quality or consensus?

Situation Description

Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They brought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. You've been hired as a management consultant to advise them.

Exercise

Pretend that you're Bob. You've dreamed up the idea of carrying a new line of shoes. You call them designer athletic shoes. You've been thinking about the idea for weeks and have considered all the possible alternatives. You're excited about the idea and your strategy for pulling the idea off. You think you know which vendor, which shoes, a neat ad campaign, etc. You have the whole package laid out—who to get, what to say, what to do.

You've just introduced the idea to Sally and John. They like the idea, but Sally says she has a better vendor. John says he has a nifty idea for an ad campaign and which customers would be interested. But, your whole package (system) is being pulled apart at the seams by the people who are where the action is.

You have more experience in the business than they do. You have a complete package set forth in your proposal. They know the vendors and the customers best. After several days of discussion, you don't come around to their way of thinking and they don't come around to yours. Which way do you go and why?

Fill in the following table. When considering the probabilities the table calls for, include your confidence in what the probability addresses. For example, the probability of a high quality decision should include how confident you are that you as an expert or a lucky person and the group acting as a team will make the highest possible quality decision. Estimate first the probability of a high quality decision for an expert, a lucky person, and the team of you, Sally, and John. Then, estimate the probability of the person who must carry out the decision accepting the decision reached as the right decision. For example, if Sally must deal with the vendors, what's the probability she'll accept as the right decision the decision made by the expert, the lucky person, or by the team, which includes her. Then, estimate the probability of the person who must carry out the decision actually going out and enthusiastically and competently doing what must be done to make the decision a reality. When you have the probabilities for the decision quality, acceptance of the decision, and commitment to carry out the decision, multiply the probabilities together and determine the probability of action that affects the work place due to the decision that's been made.

If action is what's important, who should make the decision? Why? What's the most important thing you've learned from this exercise?

WHO SHOULD MAKE THE DECISION?

Decision Maker	Probability of a High Quality Decision	Probability of Doer Accepting Decision	Probability of Doer Committing to Decision	Probability of Action
Expert				
Lucky Person				
Team Decision				

Quality of decision versus action: Decision isn't important; action is.

Figure 1.6.2.1.13. *Which process for decision making leads to the highest probability of action? (A decision without a corresponding action is of no value.)*

1. Background

1.6. Group Decision Making

1.6.2. Group Decisions (More than Two)

1.6.2.2. Consensus

1.6.2.2.1. Exposure—Various Artists

1.6.2.2.2. Defining Consensus

We sometimes expect and work toward consensus when making group decisions. Decision quality and consensus are different concepts.

Parts of this module were adapted from Kurstedt, H. A., Jr., R. M. Jones, J. A. Walker, and L. I. Middleman, "Achieving Consensus in Environmental Programs," Proceedings of the Waste Management '89 Symposium, February 1989, pp. 113-117, *Best Paper in Symposium Award.*

Introduction

The key defining feature of many government organizations, especially those responsible for uncertain activities like environmental management isn't autonomy but "polyonomy," a term we've invented to signify the diffusion of responsibility and power among many agencies and sub-agencies. The U.S. Department of Energy (DOE) is what we call a "Government Oversight Agency" (GOA); GOA's at all levels of government (federal, state, and local) must implement laws made by the Congress and by state legislatures—must coordinate their overlapping roles and responsibilities. Further, they must learn to cooperate in an arena that rewards adversariality, and they must learn to *maintain* this cooperation over long periods, to adapt to inevitable change.

Research Context

The popularity of books and articles on the "new" management and manager, emphasizing consensus rather than edict, is in part the result of a drastic increase in the number of organizations whose authority isn't complete and autonomous but partial and *polyonomous—literally*, "many-portioned" or "many-ruled." Even the few autonomous organizations left today are undergoing changes to be or remain competitive. Although many people are "only vaguely aware" of it, "modern society is a complex of interdependent groups or teams" (Dyer, William G. *Team Building: Issues and Alternatives*, 2nd edition. Reading, Massachusetts: Addison-Wesley Publishing Company, 1987.). Autocratic management may work in small, centralized, independent, isolated organizations where one person's word is law and where formal and informal public scrutiny is low. Nothing could be further from describing the characteristics of GOA's: large, decentralized, regulated, dependent, and in a veritable fishbowl of public scrutiny. Getting things done within and among GOA's means implementing national policy derived from Congressional legislation. A GOA manager's first step toward such implementation normally meets with resistance from outside agencies and from various levels of parallel sub-organizations within the manager's own organization. That's no accident. Indeed, in principle it's a fine setup: a multitude of mandated checks and balances on everything actually or potentially affecting the public good.

Consensus within such a polyonomous system requires "acceptance-level decisions" (Vroom, Victor H. and Phillip W. Yetton. *Leadership and Decision-Making*. University of Pittsburgh Press, 1973.) in addition to and as distinguished from "technical-level decisions." The latter refer to decisions about what will or won't "work"—for example, what kind of treatment will or won't reduce PCB contamination at a certain waste disposal site to an acceptable amount. The point is, whether there be only one or a number of equally effective and efficient *technical* solutions to such a problem, *none will be implemented unless all affected parties agree (or are compelled).*

The consensus necessary to achieve acceptance-level decisions within, between, and among organizations is often the result of what are called "informal" and "lateral" processes, as contrasted with those of the formal hierarchy. Galbraith (Galbraith, Jay. *Designing Complex Organizations*. Reading, Massachusetts: Addison-Wesley Publishing Company, 1973.) stresses the importance of not leaving informal structures to chance. "These informal processes," Galbraith writes, "are thought to arise spontaneously and are the processes through which most organizations accomplish their work despite the formally designed structure. A typical point of view is, 'If we had to go through channels, we would never get anything done.' The point of view being taken here is that these informal processes are necessary as well as inevitable, but *their use can be substantially improved by designing them into the formal organization....* [A] more important reason for formalization is that these processes do not always arise spontaneously from the task requirements, especially in highly differentiated organizations. *When the relevant participants have different and sometimes antagonistic attitudes...and are separated geographically, the effective use of joint decision making requires formally designed processes*" (italics added).

Defining Consensus

Consensus denotes "collective opinion or concord; general agreement or accord" (William Morris, ed. *The American Heritage Dictionary of the English Language*. Boston: Houghton Mifflin Company, 1976.). Further elucidation comes through the word's origin in the Indo-European root *sent*, meaning "to head for, go" following the prefix *con-* meaning "along with" or "together." This etymology suggests why consensus is necessary to the effective and efficient work of a system (or organization) with many parts. A *system* is a collection of entities, related by structure or communication, such that a perceptible or measurable change in one part causes a perceptible or measurable change in all the other parts. And *work* is the application of a force through a distance. For efficient work, the sum of the movement of the system's interdependent parts must point toward the objective and exert maximum energy in that direction. Organizations need consensus about these two things: the objective and the movement—the ends and the means. If you have the objective but not the ability to move as a unit, you won't get there (zero or low efficiency). If you have the ability to move but don't know where to go, your energy is pointless and will be wasted (zero or low effectiveness).

Defined in this way, consensus is pragmatically and morally neutral. Consensus on means and ends is a necessary condition of progress toward an objective, but it isn't sufficient. For, as a "collective opinion," consensus by itself implies neither accuracy nor morality nor even feasibility. Opinion is, in Plato's words, "something between ignorance and knowledge." The better opinions are those closer to knowledge, and the way you show this closeness is through adequate supporting information. An opinion, though collective among a certain group, can still be bad (evil); wrong (incorrect); and difficult, perhaps even impossible to implement if it has to fight against a strong or stronger opposition. Consider the ancient consensus achieved by Pontious Pilate and his lieutenants, the ongoing consensus among the membership of the Flat Earth Society, and the 1982 Congressional consensus that high-level radioactive waste be permanently disposed of in a deep geologic repository.

Consensus as a State Variable

Consensus, then, is a *parameter,* a variable that must always be taken into account in describing the state of a system. Understanding consensus focuses on interactions within and among systems of people—and between these systems and the population they serve; we're using the term as a gross or macro-level "state variable" characterizing the degree to which a group of people behaves as one person. It's the measure of a group's tendency, as it moves through time, to behave as a unit—irrespective of the force behind this tendency (reward/punishment), the source of the movement (internal/external), or the level of the source (horizontal/vertical/mixed).

We want no mere and stagnant consensus but a living, maintained consensus on good means to good ends, realizing that these goods will grow, develop, and change over time. We need to understand the necessity and the power of flexible consensus maintenance. To approach understanding, don't judge whether a particular proposal for consensus is good or bad. First, understand the factors making up each kind of consensus and take the necessary steps to achieve the kind of consensus desired.

1.6.2.2.3. Other Concepts Like Consensus

Because we don't always want or can't always get consensus, we must consider other concepts that have meanings similar to consensus.

Parts of this module were adapted from Kurstedt, H. A., Jr., R. M. Jones, J. A. Walker, and L. I. Middleman, "Achieving Consensus in Environmental Programs," Proceedings of the Waste Management '89 Symposium, February 1989, pp. 113-117, *Best Paper in Symposium Award*.

Consensus Distinguished from Its Synonyms
When consensus results from participative decision making or from a directive that fits what the group would have chosen had it been asked, based on preliminary research we distinguished degrees of consensus (how collective the opinion?) by placing it between two other levels or values of the state variable:

Acceptance: One or more members find the behavior (idea, plan, decision) undesirable but will go along with it. Acceptance will yield the same behavior as consensus as long as the member or members acknowledge there's no better way to proceed.

Consensus: The behavior (idea, plan, decision) may not be in the form any one member proposed, but it's roughly satisfactory to all and is adopted and implemented.

Agreement: The behavior (idea, plan, decision) has the enthusiastic support of the entire group, all of whom sing off the same sheet of music. Once there's physical evidence of implementation, probably each will attempt to take credit for it.

Consensus, Unanimity, and Compromise
Another word for "agreement" is "unanimity" (literally, "one soul"). Agreement or unanimity is rare. Gordon L. Lippitt (in Bradford, ed., 1978), distinguishes among consensus, unanimity, and compromise: "...there is a difference between unanimous decision-making and a 'consensus' decision. In a consensus type of decision, the members of the group agree on the *next steps*, but those who are not in agreement with the decision reserve the right to have the tentative decision tested and evaluated for later assessment. In other words, certain members of the group will agree that on a 'provisional try' or a 'first-time' basis we could try out a particular alternative; *but* they want to put in a certain evaluative means for testing whether or not the feelings of the majority are the most appropriate for group action. In a very real sense, this is different from compromise. In a compromise situation, the decision is taken from two opposing points of view and becomes something quite different from either of them. In the consensus type of decision, individuals in the group might be saying that they are 'not sure' of the best decision, but realizing the need for action, they will build in some commitment to an action step that will be assessed later."

McGregor (1960), a pioneer management scholar, characterizes an "effective work team" as one in which "Most decisions are reached by a kind of consensus in which it is clear that everybody is in general agreement and willing to go along." "Sometime," McGregor observes, "there are basic disagreements which cannot be resolved. The group finds it possible to live with them, accepting them but not permitting them to block its efforts. Under some conditions, action will be deferred to permit further study of an issue between the members. On other occasions, where the disagreement cannot be resolved and action is necessary, it will be taken but with open caution and recognition that the action may be subject to later reconsideration."

Galbraith (1973) defines consensus in the following context: "The problem solving approach [to group decision making] is intended to achieve a consensus which obviates the need for a powerful leader. Consensus is not unanimity but a state of affairs in which the individual who disagrees with the preferred solution feels as follows: 'I understand what most of you would like to do. I personally would not do that, but I feel that you understand what my alternative would be. I have had sufficient opportunity to sway you to my point of view but clearly have not been able to do so. Therefore, I will go along with what most of you wish to do."

Consensus Distinguished from and Favored over Compulsion

When consensus results from a directive that doesn't fit what the group would have come up with had it been asked, we call it compulsion, meaning that the environment (i.e., one or more people coupled with one or more conditions) forces the group to behave in a certain way and prevents the group from behaving in any other way.

No group is ever completely free of compulsion. The environment always more or less constrains this freedom, making certain behaviors undesirable or impossible and requiring certain behaviors nobody likes. Galbraith (Galbraith, Jay. *Designing Complex Organizations*. Reading, Massachusetts: Addison-Wesley Publishing Company, 1973.) calls compulsion "forcing," which he defines as "power or position or knowledge being used to force a preferred alternative on the rest of the group." He goes on to posit the general ineffectiveness of strictly hierarchical decision processes within a polyonomous context as follows: "Although forcing is not generally recommended, it can result in effective decision making. This will be true if the forced alternative is consistent with organizational goals and the act of forcing does not limit future confrontation and information sharing."

"Forcing," says Galbraith, "will lead to ineffective decisions if it is the dominant mode. If one function or dominant department always forces, then there is no need for a group effort, since information from other departments is ignored. *Suboptimal decisions and poor implementation result when a forced solution is based on local information in the presence of interdependence. The preferred approach to conflict resolution therefore is to use confrontation and problem solving backed up by occasional forcing when lack of agreement stymies the group"* (italics added).

1.6.2.2.4. Actual versus Perceived Consensus

W sometimes think we have consensus when we don't.

Parts of this module were adapted from Kurstedt, H. A., Jr., R. M. Jones, J. A. Walker, and L. I. Middleman, "Achieving Consensus in Environmental Programs," Proceedings of the Waste Management '89 Symposium, February 1989, pp. 113-117, *Best Paper in Symposium Award*.

When we look at consensus as common or unified behavior, we see consensus if the behavior shows it. The observable behavior, however, may or may not be congruent with group members' unobservable internal states. We can define the degree of actual as opposed to perceived consensus as the difference, if any, between the assumptions an external observer or a group member would make about a group's attitudes based on the group's objective (visible) behavior, and the group's subjective (invisible) thoughts and feelings about this behavior. Consensus can be more perceived than actual, or vice versa, both from the perspective of a group member (including the leader or the person who called the group together) and from the perspective of someone outside. The importance of the distinction between actual and perceived consensus may be seen in the following two examples of incongruence, one principally affective and the other principally cognitive.

Avoiding the Trip to Abilene

Unhealthy agreement—the false pretense of consensus born of fear of self-disclosure—can move a group to unwanted behavior as much as, perhaps even more than, an excess of explicit conflict can stymie them. The "Abilene Paradox" (Harvey, J. "Managing Agreement in Organizations: The Abilene Paradox." *Organizational Dynamics*, Summer 1974, pp. 63-80.) is the cautionary tale of a Texas family that reaches a false but powerful consensus and ends up doing something none of them actually wants to do. They somehow find themselves driving a dusty 106 miles in an un-air-conditioned car on a 104-degree summer afternoon from Coleman to Abilene to eat unpalatable food in a fourth-rate cafeteria, instead of doing what they all really want—to stay out on the electric-fan-equipped screened-in porch, play dominos, listen to the radio, drink lemonade, and chat. Having returned from Abilene thoroughly disgruntled, they reveal their true thoughts and feelings—and their bewilderment at how they ever decided on that stupid trip.

Consensus like that which motivated this family is false to the group members' thoughts and desires. In its effects, however, their consensus is actual, and therein lies the danger. We humans are skilled at hiding thoughts and feelings from others, but we forget others are just as good at hiding theirs from us. To avoid and prevent trips to Abilene, group members (meaning, one time or another, everyone) must learn the skills of self-disclosure and learn to overcome the fear of risking this disclosure.

They'll find this learning easiest (though it's never easy) in a work environment where management rewards openness because it sees hierarchy as secondary to merit—where what matters is not the source but the quality of an idea—and where, consequently, all participants feel free, indeed required, to unveil their thoughts. (Many ideas, though suboptimal, may lead to better ideas; and ideas on the fringe may be the most creative and stimulating.) As Dyer (1987) says, "Since the reactions of authority figures set the parameters of other responses in any type of confrontation meeting, it is helpful if the head of the organization [or whoever in an inter-organizational group will be seen as the chief authority figure] can begin the process and can own up to personal concerns about any trips to Abilene that he or she has observed, participated in, led, or may foresee leading."

Avoiding Fragile Consensus

The consensus engendered by Abilene-ism is dangerous because, though false, it's powerful: nobody's intentions somehow get translated into everybody's behavior. But their's another way for a consensus process to go awry. Instead of resulting in *unwanted* behavior, *nothing* (except frustration and anger) results because the decision process that seemed to be going so well suddenly breaks down, taking with it all that the group thought it had settled. What seemed strong is suddenly shown to have been fragile. Fragile consensus demonstrates its fragility when group members take what has been said and make inferences, extrapolations, qualifications, or embellishments based on idiosyncratic or in any case unshared understandings of key word or phrases. "No," say others, "that is not what we meant at all—or is it?"

Brehmer (1976) has shown that such confusion, related to cognitive factors alone, is often sufficient to account for interpersonal policy conflicts, irrespective of emotional considerations or conflicts of interest. Further, Brehmer highlights "inconsistency," not intransigence, in an individual's policy as the factor most likely to produce unresolvable conflicts. Conflicts persist not because people refuse to give up some of their ideas but, paradoxically, because they give them up—or give up parts of them—"too fast." Unless the idea is already part of the receiver's cognitive structure—his or her "theory of the world in the head" (Smith, 1982)—it will jostle some of the things already there. The effect of the receiving mind's partial resistance is confusion—a state of relatively high entropy and hence of relatively low consensus. For a group to achieve consensus, the participants' expressed terms and ideas must be embedded in a context sufficiently rich and integrated to minimize confusion with other terms and ideas.

To mitigate inconsistency-based conflict, Brehmer says, requires more knowledge of "how the persons perceive the policies of their opponents, as well as how the persons perceive the reasons and motives of their opponents in these situations. In general, people do not seem to explain the behavior of other people in terms of cognitive limitations shared by all persons." The most fruitful research path toward an antidote to fragile consensus appears, then, to be a deliberate and painstaking attention to understanding and overcoming impediments to clear communication—communication so designed and practiced that all group members understand written and oral messages 1) as the sender intended and 2) within the context from which the sender sent.

Thus, one focus of our proposed research will be to analyze the human cognitive factors involved in interpersonal communication with the aim of learning how to maximize the signal-to-noise ratio in interpersonal oral, written, visual, and multi-media communication. Another focus is understanding the role of the process in consensus—how a structured process surfaces ideas through open self-disclosure, shares the ideas, sorts them, and develops healthy communications about them.

1.6.2.2.5. How much Consensus is Enough?

Make sure you know how much consensus you need.

Parts of this module were adapted from Kurstedt, H. A., Jr., R. M. Jones, J. A. Walker, and L. I. Middleman, "Achieving Consensus in Environmental Programs," Proceedings of the Waste Management '89 Symposium, February 1989, pp. 113-117, *Best Paper in Symposium Award*.

A behavior-based definition of consensus provides an answer to "How much consensus is enough?". A group member's behavior, either toward or away from the group's ostensible objective (what an observer would predict to be the effect of the group's decision) is analogous to a vector. If the vector sum of all members' behavior is toward the ostensible objective, then there's enough consensus. And "enough" isn't strictly a matter of numbers, of how many participants' vectors point the same way, but of their relative magnitudes, and moreover, the changing magnitude of their vector sum over time. Over time, the objective will be reached if and only if the sum of all consensus vectors is greater than the sum of all antagonistic compulsion vectors.

There's no necessary one-to-one correlation between a group's achievement of consensus on an objective and the reaching of that objective. Consensus by itself, though necessary to reaching the objective, isn't sufficient. The consensus reached in a football huddle may be total, yet the play may fail because, literally and figuratively, it bumps into another and stronger consensus. In terms of the effects of group decision-making, we must measure consensus by discovering how to measure the extent to which the actions and conditions (including costs and schedules) that should follow from the group decision actually do follow, and by how long they remain in effect in comparison to how long the decision-makers expected them to remain in effect.

Why Consensus is Necessary for Government Oversight Agencies (GOA's)

Nowhere is interdependency more apparent than in and among GOA's and in interdependent programs like the Department of Energy's environmental remediation programs. These organizations differ from product and service organizations in the private sector and from other government field offices and public works units. Whereas the latter are close to the provision of services to the public, GOA's are close to the legislative bodies from which they take their mandates. As such they are the interface points between public policy-making and implementation and must participatively interact with legislatures, other GOA's, and other elements within their own organizations. However, when called upon to solve problems GOA's don't have tools, methods, or processes uniquely tailored to fit their participative environment. Rather they have tools, methods, and processes designed for hierarchically structured environments.

Given so much to do with such a (relative) paucity of resources, those people responsible for managing and implementing uncertain activities, like environmental management, must invite consensus on task and funding *prioritization*. Numerous organizations at all levels of government, as well as private interest groups and individual citizens, are bound to be dissatisfied no matter how the funds are spent, *unless there's consensus on the priorities.* But what—this is the key question—*nationally* constitutes the greatest overall benefit to be realized from the available dollars? It's one thing to prioritize activities vertically at each government agency field site (and that's no small matter in itself, for the potential hazards of many waste sites may take years to estimate accurately). It's quite another to prioritize activities horizontally across all field sites. There are simply too many squeaky wheels and too little grease. The first formal activity of the Waste Management Review Group, discussed in Module 1.6.2.2.7., is to review a prioritization model, the Program Optimization System (POS), and recommend ways to assess the degree of consensus likely to result among stakeholders nationally.

If short-term consensus about priorities is hard to achieve at all, it's surely harder to maintain in the moderate run, and it's exponentially more difficult in the long run. This is partly because, like any organization, the Department of Energy's environmental management program will see changes in leadership and personnel (nobody working in any organization will be working there sixty years from now). It's also because GOA managers are, as Kotter (Kotter, John P. *Organizational Dynamics: Diagnosis and Intervention*. Reading, Massachusetts: Addison-Wesley Publishing Company, 1978.) says, "rewarded almost entirely for short-run performance." Though environmental programs are all long-term efforts, funding comes just once a year, and it's impossible with any confidence to allocate dollars you don't yet have. As a result of this short-run focus, "they spend far too much... of their discretionary resources trying to keep current processes effective and efficient, far too little of their time and other resources trying to create or maintain a coalignment, and far too little effort trying to create adaptive element states."

1.6.2.2.6. Examining the Nominal Group Technique (NGT).

The Nominal Group Technique helps us share information in group decision making; but does the technique help gain consensus?

Parts of this module were adapted from Kurstedt, H. A., Jr., R. M. Jones, J. A. Walker, and L. I. Middleman, "Achieving Consensus in Environmental Programs," Proceedings of the Waste Management '89 Symposium, February 1989, pp. 113-117, *Best Paper in Symposium Award*.

We want to find out what works and why it works. We assume no one method works all the time. What works will depend on the group's characteristics and the problem to be solved or the decision to be made. When we find something that works, what we've found is something that works in a particular, constrained situation. If we understand the constraints, we ought to be able to make it work in a similarly constrained situation. And if we get things to work enough times in enough differently constrained situations, we can begin to generalize about why things work.

The Nominal Group Technique (NGT) was first developed by Van de Ven and Delbecq (Van de Ven, Andrew H. and Andre Delbecq. "The Effectiveness of Nominal, Delphi, and Interacting Group Decision Making Processes." *Academy of Management Journal*, vol. 17, no. 4, 1977, pp. 605-621.). NGT is a method—a series of tools applied in sequence—to provide free and equal expression and ranking of opinions in groups which otherwise might be dominated by certain individuals or certain paths of thought. Both the tools for idea proposal and the tools for ranking limit the potential for conflict between group members. The four steps of the NGT proposed by Van de Ven and Delbecq are as follows: 1) Individual members first silently and independently generate their ideas on a problem or task in writing; 2) This period of silent writing is followed by a recorded round-robin procedure in which each group member (one at a time, in turn, around the table) presents one of his or her ideas to the group without discussion. The ideas are summarized in a terse phrase and written on a blackboard or sheet of paper on the wall; 3) After all individuals have presented their ideas, there is a discussion of the recorded ideas for the purposes of clarification and evaluation; 4) The meeting concludes with a silent independent voting on priorities by individuals through a rank ordering or rating procedure, depending upon the group's decision vote. Other practitioners expand NGT to six steps (Rohrbaugh, John. "Improving the Quality of Group Judgment: Social Judgment Analysis and the Nominal Group Technique." *Organizational Behavior and Human Performance,* vol. 28, 1981, pp. 272-288.) (Sink, D. Scott. "Using the Nominal Group Technique Effectively." *National Productivity Review*, Spring 1983, pp. 173-184.), affording more interaction among group members: 5) After the voting and ranking, participants consider the aggregated results to measure the extent to which they've supported their true positions or taken a trip to Abilene. At this point they may revise their rank ordering of ideas; 6) Finally they consider the resources available to implement their high-priority action items, choose a set of these items to scope for implementation, and divide into smaller groups to begin the scoping process, which involves measuring the feasible application of available human, funding, and material resources within known or estimated time constraints.

"Nominal" is the key word describing this method; the group that meets for an NGT session isn't (or isn't necessarily) a regular work group within one organization. It's not a *real* group (a group sharing common aims and values and therefore predisposed to cooperate) but a group in name only (a *nominal* group). The question arises whether consensus is possible within a nominal group; if not, then you have to take a nominal group and somehow transform it into a real group. Can NGT help in this transformation? We need to ask such questions because the set of stakeholders would have to be called a nominal group.

At least one NGT study, Mahler's (Mahler, Julianne G. "Structured Decision Making in Public Organizations." *Public Administration Review*, July/August 1987.), suggests group dissatisfaction with the resulting decision is high; however, the results come from 45-minutes applications with student groups working on unsolvable problems in which they had no stake. Studies made on day-long applications outside classroom situations and with real, pressing, solvable problems have found more favorable results. Mahler is correct in linking the use of pure NGT primarily to the generation rather than to the evaluation of ideas. Indeed, in its original formulation, since ranking is numerical and done by straw vote, a "pure" NGT application gives little chance for conflict between members and therefore little opportunity for persuasion, bargaining, compromise, or what can loosely be called the politics of consensus. In the generative and in portions of the evaluative stage of consensus reaching, this is an advantage; later, however, a group would probably wish to tailor the technique to provide for surfacing enough essential conflicts (ad hoc rather than ad hominem) to increase the probability of results participants won't torpedo once they leave the meeting.

NGT is a popular technique. We know what works in one circumstance will fail in another. We've seen an apparent deadlock become a consensus as if by magic, not in the meeting itself but in the hallway out to the parking lot. We've seen an apparent consensus fall to pieces when participants realized some were using a term to mean one thing and others something different. We see NGT as a group of tools and we believe there must be a fit between the users and the problem to be solved. Just as with computers, you don't simply accept NGT because you heard it worked somewhere else.

We can hypothesize an ideal group on which NGT should work Such a group, of about eight to 12 people, would likely share interest in common issues and be all at about the same level in their organizations. They'd probably be more divergent than convergent in their information gathering styles, preferring open-endedness to closure. NGT would both satisfy their need to brainstorm—it's a great idea-generating technique—and constrain their divergence through the requirement to vote and rank.

Okay. Say (no simple matter) we find the tools that work for our ideal nominal group. We're likely to encounter an actual environmental remediation program nominal group that's "all wrong"—convergent if we want divergent; at levels all over the hierarchies of their respective organizations, larger than we think any group should be to function well together but needing to be that size or else we lose legitimate stakeholders who if not included will vitiate the efforts of the rest. Well, we don't have a perfect tool, so we try to combine or modify tools we know to get as close as possible. In our research we must ask: what are the important characteristics of groups and what are the important characteristics of tools? Then we can hope to synthesize an answer to the question of the relationships between these sets of characteristics and why they hold.

We must identify all tools, methods, and techniques that might apply to our real-world nominal groups and keep a running list, a living list. We'll do test runs, we'll discover that a certain tool works nine times out of 10 and use that fact as a reference point. We'll ask, if you change the group in such-and-such a way, what must you do to the NGT to make it work? We'll start to understand what parts of NGT work in different situations and begin to generalize and to understand why. In our attempt to understand why and confirm that understanding, we'll first generalize tool by tool; then group of tools by group of tools. Finally, we'll hope to generalize in terms of all consensus tools. When we can do this, we can predict outcomes and prescribe the sets of tools likeliest to facilitate consensus within various given situations.

1.6.2.2.7. The Waste Management Review Group (WMRG): A Forum for Consensus.

A specific example of group decision making for reviewing environmental issues illustrates the consensus concepts.

Parts of this module were adapted from Kurstedt, H. A., Jr., R. M. Jones, J. A. Walker, and L. I. Middleman, "Achieving Consensus in Environmental Programs," Proceedings of the Waste Management '89 Symposium, February 1989, pp. 113-117, *Best Paper in Symposium Award*.

Whereas with NGT we start with a tool or a group of tools (a method) and try to figure out how that method yields or doesn't yield consensus, with WMRG we start with a group, a group specifically selected for the necessity of its members' knowledge and experience to the furthering of environmental cleanup and remediation. The idea for such a group came from the realization that another group, the Technical Review Group (TRG) convened by Martin Marietta Energy Systems, Inc. was increasingly spending its time on policy issues rather than on purely technical issues. Since both kinds of issues are vital to environmental cleanup and remediation, it was decided to form a second group devoted entirely to policy. The WMRG's chartered scope is to provide l) objective reviews, evaluations, and assessments of current plans, projects, and activities related to DOE's environmental management policies and actions mandated by Congress, the Executive Branch, and the DOE; and 2) research, analysis, and communication necessary to substantiate the reviews, evaluations, and assessments and provide useful information, conclusions, and recommendations to a new organization, the Waste Policy Institute (WPI).

The WMRG was chartered and convened under the auspices of WPI, a not-for-profit university-related corporation at Virginia Tech. The principles for assembling the WMRG were instinctive, intuitive. It had to be done that way because we don't know enough about GOA team building processes to have put it together scientifically. What we tried to do was exhaust the categories representing those constituencies in the general population which must form part of the consensus necessary to ensure success. The five categories from which we chose members are universities, industry, States and Indian tribes, the Federal government, and public interest groups and professional societies.

Though not all members know each other, the WMRG starts out probably closer to a real group than a nominal group. But though for this reason it should find it easier to achieve consensus on prioritization in its review of the Program Optimization System (POS), what DOE needs is far beyond the consensus of that group. What DOE needs us to do in our research is figure out how to configure WMRG so it's a faithful microcosm of the population it needs to represent. To put it another way, our job wasn't to set up the group. Setting up the group was a necessary precondition, like setting up experimental apparatus. Our research mission is to discover the extent to which our partitioning of DOE's environmental remediation program world has yielded the right constituencies—all the right ones—so this wider world will look at the WMRG's conclusions and adopt them because the WMRG's consensus is representative; because the WMRG sample represents the relevant population.

The convener of the TRG attends but is not a member of the WMRG. The convener of the Ad Hoc Waste Contractors Group attends but is not a member of the WMRG. And I, the convener of the WMRG attend but am not a member of the TRG and the Ad Hoc Waste Contractors Group. We call it "interdigitation."

We watch the extent to which consensus on technical issues and consensus on policy issues combines to yield a larger, synergistic consensus. The WMRG and related activities thus provide an ideal real-world laboratory for our research, a perfect opportunity to study intra-group consensus, inter-group consensus, and extra-group consensus.

1.6.2.2.8. Types of Consensus

Does our group get consensus or represent consensus?

Parts of this module were adapted from MSL's progress report in 1991 on its research grant to study consensus in DOE's environmental management program.

We defined three different types of consensus: intra-group, inter-group, and extra-group. You might ask, "Why separate consensus into different types?" From our preliminary literature search, we've found consensus is thought of as a state among individuals. Consequently, measurement techniques have been derived to measure consensus among individuals (intra-group consensus). We believe, however, there are consensus situations where these methods are applicable but not feasible due to their complexity. In some environments, especially DOE, consensus is necessary among groups of individuals, or agencies (inter-group consensus). When trying to measure consensus between groups of individuals, the methods commonly used are too complex. Consensus is also necessary between DOE and its external environment, the public (extra-group consensus). We recognized there are different types of consensus which arise from different situations and must be measured in different ways.

We defined intra-group consensus as a state achieved between three or more people after sufficient discussion has occurred for every individual to voice their opinion. Each individual then accepts the outcome which isn't the same as the one any individual wanted going in. Consider Galbraith's explanation: "The problem solving approach [to group decision making] is intended to achieve a consensus which obviates the need for a powerful leader. Consensus is not unanimity but a state of affairs in which the individual who disagrees with the preferred solution feels as follows: 'I understand what most of you would like to do. I personally would not do that, but I feel that you understand what my alternative would be. I have had sufficient opportunity to sway you to my point of view but clearly have not been able to do so. Therefore, I will go along with what most of you wish to do.'"

This type of consensus deals with human interaction on the micro level. It deals with small group interaction and decision making.

If we try to measure intra-group consensus as a state variable describing the degree to which a decision is carried out, we risk measuring the wrong indicator of consensus. In the intra-group situation, a decision is made irrespective of the ability of the group to carry it out. Therefore, measuring the extent to which a decision is carried out may only be indicative of the power the group wields within the organization, not the actual consensus achieved in the intra-group situation. To measure intra-group consensus, you must deal with the human aspects of decision making and interaction.

We believe to achieve consensus, a group must transform from a nominal group (a group in name only) to a real group. This transformation requires the raising and resolution of underlying conflict among group members. That is why we believe the Nominal Group Technique, for example, is better for information sharing than it is for deriving consensus.

We defined inter-group consensus as the degree to which two or more groups (who have achieved intra-group consensus) within a larger group or organization, agree on actions to take place or issues of importance to the organization. This type of consensus, unlike intra-group consensus, deals with human interaction on a macro level between two or more independent groups or societies. This is the type of consensus the different government oversight agencies need to coordinate their actions.

We believe inter-group consensus can be measured by the actions taken as a result of the consensus achieved between groups. When dealing with groups, we can model each group's preferences, values, and opinions as a single point and then proceed with the same methods used for intra-group consensus. This would not be very accurate however. When two or more *groups* of individuals are asked to come to consensus, we assume their consensus is to relate to some course of action. This allows us to measure the strength of inter-group consensus by measuring the degree to which consensus decisions are carried out (regardless of quality).

An important point must be made regarding the measurement of consensus. The choice of using either *interaction methods* such as those proposed for intra-group consensus or *activity methods* such as those proposed for inter-group consensus really depends on the power of the group to carry out any decisions made. If a group has the power to implement their consensus decision, intra-group consensus can be measured with the methods proposed for inter-group. Likewise, if the groups coming to inter-group consensus don't have any power but are acting in an advisory role, then inter-group consensus must be measured with the methods proposed for intra-group consensus.

It's not clear conflict resolution is needed to get inter-group consensus when the groups are advisory and power isn't a question. We have set up a consensus group called the Environmental Management Review Group. This group plays a consultative role and as such can't have its consensus measured by the actions carried out as a result of their recommendations. To do so might measure the power of the group members or the quality of their recommendations, but it definitely would not measure the degree of consensus achieved by the group members. DOE is made up of many groups which must act in concert with each other. Therefore, they need inter-group consensus on the actions taken within DOE. Inter-group consensus, in this case, is best measured by the extent to which these actions are carried out.

Extra-group consensus is a state achieved between one or more groups in an organization and one or more groups in the external environment outside the organization. The difference between extra-group and inter-group consensus is that for extra-group consensus the group in the external environment doesn't have the power to directly affect the actions of the domain or organization being analyzed. The organization, however, needs acceptance of the external group to be most effective in carrying out their actions. For example, if we look at EM, inter-group consensus is achieved between the oversight agencies and extra-group consensus is achieved between GOA's and DOE. If, however, we look at DOE, the consensus achieved between GOA's and DOE is a higher level of inter-group consensus than the consensus achieved between the GOA's. Extra-group consensus in this case is the consensus achieved between the GOA's or DOE's office for Environmental Management (EM) or DOE and the various groups making up the public of the United States.

DOE has often acted without considering the wants of the public or states affected by their decisions. They have tended to bring in the affected outside parties after the fact — after decisions are made — to get their reactions, not to involve them in the decision making process from the beginning.

In the case of the Environmental Management Review Group (EMRG), by the definition we just proposed, the unit of analysis must be DOE. EMRG was set up to represent a range of stakeholders—together representing the public. Therefore, the outside group is the public and the organizational unit of analysis must be DOE. We're looking at extra-group consensus between EM (a group within DOE) and the public of the United States. Consensus between EM and DOE on any actions taken as a result of EMRG recommendations will be inter-group consensus. In actuality, EMRG will come to intra-group consensus among themselves, but EM is using them to model inter-group consensus among public interest groups. If EMRG's intra-group consensus doesn't accurately model inter-group consensus among public groups, the extra-group consensus between EM and the public will be weak or non-existent. By setting up EMRG, DOE is attempting to get information on how to involve the public earlier in the decision making process. This attempt moves DOE further toward the goal of including stakeholders at the beginning of the decision process. It isn't enough, however.

This type of measurement can't be measured by any of the methods discussed so far. Since an external group has no direct say in any actions taken within the domain being considered, extra-group consensus can't be measured by any actions taken within that domain. This doesn't mean an external group can't influence the actions taken within an organization. They can influence actions through pressure, lawsuits, lobbying, etc. They don't, however, have the ability to directly tell the organization what they should do. We think, to measure this type of consensus, you need to measure external groups' reactions to the actions taken as a result of inter- and intra-group consensus. In the case of DOE, extra-group consensus with the public might be measured indirectly by the response of congress to their actions since Congress is supposed to represent the public. It might also be measured by reactions printed in newspapers or demonstrations by public groups.

1.6.2.2.9. Consensus as a Continuum

The strength of the consensus we get depends on where we are in the continuum of consensus.

Parts of this module were adapted from MSL's progress report in 1991 on its research grant to study consensus in DOE's environmental management program.

Consensus isn't a discrete variable. It's a continuum encompassing different levels of interaction. If we just consider measuring consensus by the actions taken as a result of the consensus to say "yes, we have consensus," or "no, we don't have consensus," we're looking at consensus too narrowly. If we want to look at consensus as a group acting as one, we must differentiate different consensus levels. It's too simple to consider a situation where people are coerced into certain actions on the same level as people who freely agree to act in a certain way. We can say consensus is achieved in each of these situations, but we must go further and define the level of, or strength of, the consensus.

The difference between types and levels is this: a level is a measure of the cognitive aspect of consensus and a type is a classification of the consensus situation. A level is a point on a continuous scale, a type is a discrete situation. Each type of consensus can have any level of consensus.

We define these terms in the following way:

coercion - one person defines the behavior (idea, plan, decision) and has power to, and uses power to force other group members to accept the behavior.

compulsion - one or more people (the total being a minority in the group) are the main drivers of the behavior (idea, plan, decision) while the others "go along".

acceptance - one or more members find the behavior (idea, plan, decision) undesirable but will go along with it.

agreement - the behavior (idea, plan, decision) has support of the entire group although it isn't the ideal behavior for some or most of the members.

unanimity - all members unanimously and enthusiastically agree on and support the behavior (idea, plan, decision).

We must realize that, in each of the levels defined above, actions are taken that lead us to conclude consensus was achieved. The strength of the consensus, however, is vastly different in each of these situations.

Strength of consensus is some combination of the attitudinal and the behavioral sides of consensus. A group can leave a discussion thinking they have achieved unanimity (regardless of whether the decision is of good or poor quality); but, if nothing is done to implement the actions decided upon, the consensus was very strong attitudinally but very weak behaviorally. If we combine these two parts of consensus multiplicatively, the consensus achieved is very weak. Likewise, if a group leaves a discussion and the members are angry and very factioned but they carry out the behaviors agreed to, the consensus is weak from an attitudinal standpoint but strong from a behavioral standpoint. The overall consensus achieved is then weak. The only way to assure a strong and lasting consensus is to achieve both a strong attitudinal and behavioral consensus.

One area where consensus is important in an organization is to agree on the information requirements that the organization needs. The reason you need to agree on the information requirements is: if you have limited resources, you can improve, computerize, or move forward only on some of the information requirements but not on all of them. So what you want to do is agree on the relative importance of the various information requirements. There are several ways to do this. The typical way is to bring in the information specialist unit in your organization. Have them conduct interviews, which is one way of trying to derive consensus, talk to all the stakeholders, meld everything together into an approach, and then return to the stakeholders for their concurrence on something like an information requirements document. The problem is, it takes a very long time to gather the information, produce the document, and get concurrence. In the meantime, everything has changed. Information requirements themselves h ave changed. So it's very difficult to keep up. Also, developing information requirements is considered a support activity and not a line activity, so it's hard to get people's attention. Therefore you don't get people's full attention on the information requirements document.

Another approach to getting consensus on information requirements is to bring stakeholders together in a workshop setting. The stakeholders include people with information requirements and the information specialists. In a workshop setting, the stakeholders can 1) concentrate on this support activity, 2) interact, and 3) move forward quickly. You would use consensus techniques or tools in the workshop to try to come to consensus. You'd also use information systems techniques in the workshop. The workshop then includes a structured approach to getting consensus and a structured approach to identifying information.

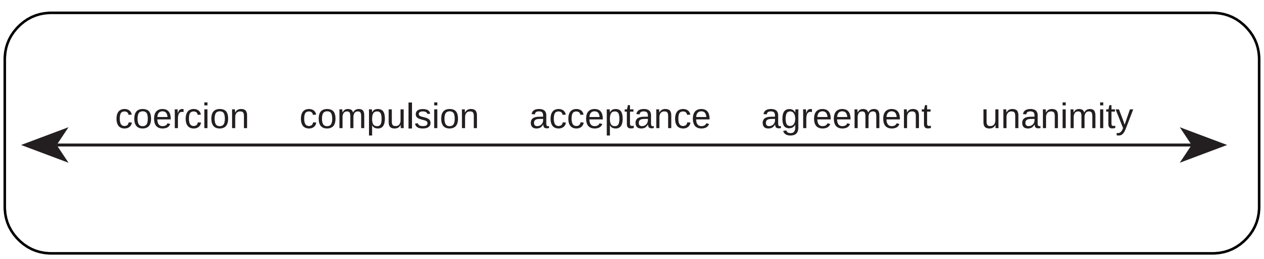

Figure 1.6.2.2.9. *The strength of consensus is a combination of cognitive and behavioral factors. To quantify the cognitive factor, consider five levels of consensus along a continuum.*

1.6.2.2.10. Techniques Related to Consensus

As we work toward consensus, we can choose from a number of techniques one that will best fit our situation.

Parts of this module were adapted from MSL's progress report in 1991 on its research grant to study consensus in DOE's environmental management program.

Consensus is an ideal group decision state, often strived for, but rarely achieved. Ideally, consensus assures complete understanding of the issues and options, total agreement on the best solution, and complete commitment and support for that solution (Gentry, 1982). Research concerning whether individuals or groups make better decisions isn't conclusive, but does suggest groups make better decisions under certain conditions . Achieving consensus depends on a number of variables. We're building a paradigm of consensus which relates variables and is the framework for our research. We've identified and are studying a number of these variables. Several of these variables are the role of facilitators, experts, conflict, and information availability as they relate to consensus.

Measuring consensus is difficult. The best way to characterize consensus is as a "hypothetical construct." We often presume consensus exists at some point when everyone's ideas have been combined into one complex whole. We may not be able to measure consensus directly. We may need to infer it. Some ways consensus has been measured are by degree of agreement, individual feelings about the probability of an event occurring, interaction patterns within a group, and individual preferences. [One way to deal with conflict is avoidance, (Thomas and Kilman). In that this method is included, NGT involves consensus because it makes "full use of available resources and [resolves] conflict creatively."]

Adding to this confusion is the fact that consensus refers to both 1) an ideal situation in groups (product) and 2) the ideal means to achieve group goals (process). Consensus in a small group setting can apply to a decision making process or the product of the process. Jay Hall, defines consensus as "a decision process for making full use of available resources and for resolving conflicts creatively." If we look at consensus as the ideal goal in groups instead of a process, we are still faced with different meanings. Definitions used in the literature for consensus range from the degree to which the most influential people in a group agree to perfect unanimity among *all* group members. Some people refer to consensus as a state of mind, a "we" feeling among the participants in a group, Irving Janis emphasizes the negative aspects of this in his book *Groupthink*. He defines groupthink as "....the desperate drive for consensus at any cost that suppresses dissent...."

Examples of decisions environmental management groups made that can benefit from consensus include prioritization, resource allocation, selection, and compliance. I'll describe a number of techniques that help deal with consensus for these decisions.

While it's important to find ways to measure consensus so we know whether or not we've achieved it, our foremost task is to find how to achieve it in the first place. We've focused heavily on techniques for achieving agreement. We've studied a number of group techniques for idea generation: brainstorming, brainwriting, idea writing, and forced relationship techniques.

Brainstorming is one of the most widely used group techniques for creating ideas. The theory is that verbally inputted ideas from group members will spark other ideas from other participants. These new ideas may in turn spark other ideas from other group members, and so on. Alex Osborn, the originator of brainstorming, calls this "organized ideation." The process should result in a large pool of ideas.

Brainwriting differs from brainstorming because participants generate and submit ideas on 3x5 index cards instead of verbally inputting ideas. An advantage of this process over brainstorming is group members are more likely to submit any idea simply because the source of the idea is unknown to the group.

Idea Writing is a more structured version of brainstorming and works best with groups of four or five. Each participant writes three ideas separately on three index cards and passes the cards to the left. The next participant sorts the cards in any manner he or she wisher (e.g., importance, usefulness, simplicity) to help structure his or her thoughts on the problem. The participants add three more ideas to the cards they have and then pass them to the left. This process continues until each participant has written twelve ideas and sorted the last stack received.

Forced Relationship Techniques are structured techniques to aid in stimulating new ideas. Two or more ideas, objects, or methods are forced together to produce something new. Because of the structure of these techniques, they generally result in a more-focused list compared to unstructured techniques like brainstorming or brainwriting. Forced relationship techniques include transformation and attribute changing. Transformation is used to change an object or a process to make it more useful. Attribute changing breaks an object or process down into its characteristics and generates a list of possible ways to change the attribute.
We've also studied group techniques for problem cause identification: pareto analysis and cause and effect analysis. Various techniques are employed to examine the cause of a problem.

Pareto Analysis delineates the causes of a problem and helps the group focus on the most important causes. It does this by using a *pareto diagram*. The pareto diagram consists of a combination bar graph and line graph. The X axis of the pareto graph is typically the individual causes of the problem. The Y axis is typically a measure of the problem (e.g., cost to the company). By viewing separate causes of the problem together, measured on a common scale, it's easy to see what causes are the greatest contributors to the problem.

Cause and Effect Analysis also incorporates a graphical method, *cause and effect diagram*, to show relationships between causes and the effect of those causes for a given process or problem. The effect of a problem is listed at the end of a long arrow. Then all causes of the effect are grouped by category and linked along the arrow. This produces a "fishbone-like" diagram. This diagram can be used to understand the relationship between causes of a problem and aid the users in identifying "attack areas" for problem resolution.

Our research effort has mainly focused on group techniques for idea generation and decision formulation. We've studied and tested a number of techniques for group decision making: Nominal Group Technique, Improved Nominal Group Technique, Delphi Technique, and "Generic" Interactive Group Decision Process.

Nominal Group Technique (NGT) is a structured group decision technique consisting of four steps: 1) individual silent generation (i.e., group members write their own ideas about the problem), 2) round-robin recording of ideas (i.e., each group member, one at a time, presents one of his or her ideas to the group without discussion, 3) group discussion for the purposes of clarification and evaluation, and 4) individual voting on priorities through rank-order or rating procedure. "The group decision is the 'pooled' outcome of individual votes" (Van De Ven & Delbecq, 1974).

Improved Nominal Group Technique (INGT) adds several steps to NGT. First it uses Delphi's (see below for description of Delphi technique) method of inputting and review of ideas (through the mail) *before* the meeting takes place. Next, instead of inputting ideas for clarification and evaluation verbally (as in NGT), INGT has group members submit ideas on 3x5 cards (maintaining group anonymity). Inputting ideas on 3x5 cards also allows more than one input at a time (reducing bottlenecks). Last, INGT provides for post voting, ranking discussion, and a second round of voting and ranking if the group so desires.

Delphi Technique is a group decision process that provides for the systematic solicitation and collation of judgments on a particular topic through a set of carefully designed sequential questionnaires interspersed with summarized information and feedback of opinions derived from earlier responses (Van De Ven & Delbecq, 1974). Two iterations of questionnaires and summary reports are used. The first questionnaire is designed to obtain information on the topic or problem. It is distributed anonymously to participants through the mail. (Note: This is the "diverging" questionnaire). The participants generate their responses to the questionnaire and mail these back to the administrator of the process. The responses are summarized into a feedback report. This report, along with a second questionnaire designed to probe more deeply into the ideas developed in the first questionnaire, is sent back to the participants. (Note: This is the "converging" questionnaire). Participants independently (and anonymously) evaluate the feedback and respond to the second set of questions. Typically, participants will be asked to vote independently on priority ideas. Participants return their second responses to the administrator by mail. Generally, a final summary and feedback report is sent to all participants.

"Generic" Interactive Group Decision Process is an interactive group decision process with a typical format that starts with a problem statement by the facilitator to the group. A group discussion for generating information and pooling judgments follows. The meeting concludes with a majority voting procedure on priorities, or a consensus decision.

We've researched group techniques for decision formulation, decision analysis, and judgment evaluation. These techniques go beyond formulation of decision and analysis of result. These techniques are Consensus Mapping and Social Judgment Analysis.

Consensus Mapping group decision process assumes a task group has already (a) generated a list of ideas about a particular issue or problem under consideration, (b) clarified the meaning of those ideas, and (c) conducted a preliminary evaluation (i.e., ratings or prioritization) (Hart, et.al, 1985). Therefore, consensus mapping would start where a process like NGT would finish. Consensus mapping uses two to four task groups (usually five to nine members each).

Social Judgment Analysis (SJA) is based on Tolman and Brunswik's approach to cognition (Tolman, 1932; Brunswik, 1943; Tolman and Brunswik, 1935) and includes: (a) placing a weight (i.e., a particular degree of importance) on a piece of information, (b) developing a "functional form", or a functional relation between each piece of information and the final judgment, and (c) using a particular method for integrating all dimensions of the problem (this is called "organization principle").

SJA uses "cognitive feedback" to help reduce disagreement and improve the quality of judgment. It allows participants to deal openly with conflict and/or disagreements in underlying judgment policies. They can see the exact locations of agreement and disagreement. Participants examine the weights and functional forms of other participants. Therefore, they can understand why another participant makes a particular judgment by looking at the importance the other participant places on each piece of information and the functional relation between each piece of information and the other participant's final judgment. These functional relationships are represented by individual "cognitive maps."

We examined a few group techniques incorporating conflict. These techniques for arriving at a decision include conflict as part of the process. They are: Dialectical Inquiry and Devil's Advocacy.

Dialectical Inquiry uses conflict among two teams to arrive at a quality decision. It develops two different recommendations, based on contrary assumptions, from the same data. The group divides into two teams, each team taking a side. The teams debate each recommendation to spell out the implications of each decision, revealing its underlying assumptions, and challenging (defending) those assumptions as effectively as possible. The assumptions that survive the scrutiny of the debate (along with new assumptions formed during the debate) are grouped and recommendations are formed by the group members. These final recommendations are the group's solution.

Devil's Advocacy also uses conflict to arrive at a quality decision, but it does it differently than dialectical inquiry. In this approach, a solid argument is developed for a reasonable recommendation. This recommendation is then subjected to a formal critique that attempts to show why the recommendation should not be adopted. Through repeated criticism and revision, a mutually acceptable recommendation is formed.

So the difference between dialectical inquiry and devil's advocacy is that dialectical inquiry starts with two recommendations and employs a debate to arrive at a mutually exclusive decision, while devil's advocacy uses one recommendation and employs criticism and modification to arrive at a mutually exclusive decision.

We've studied the few documented group techniques for gaining consensus: Hall's Consensus Guidelines and Social Judgment Analysis.

Hall's Consensus Guidelines provides rules to follow for gaining consensus. Hall (1971) noticed through experimentation that groups with formal training perform consistently better than groups without. He summarized the behaviors of the most effective groups and translated them into a list of guidelines for consensus gaining. The guidelines are:

1. Avoid arguing for your own rankings. Present your position as lucidly and logically as possible, but listen to the other members' reactions and consider them carefully before you press your point.

2. Do not assume that someone must lose when the discussion reaches a stalemate. Instead, look for the next-most-acceptable alternative for all parties.

3. Do not change your mind simply to avoid conflict and to reach agreement and harmony. When agreement seems to come

too quickly and easily, be suspicious. Explore the reasons and be sure everyone accepts the solution for basically similar or complementary reasons. Yield only to positions that have objective and logically sound foundations.

4. Avoid conflict-reducing techniques such as majority vote, averages, coin flips, and bargaining. When a dissenting member finally agrees, don't feel that he or she must be rewarded by having his or her own way on some later point.

5. Differences of opinion are natural and expected. Seek them out and try to involve everyone in the decision process. Disagreements can help the group's decision because, with a wide range of information and opinions, there is a greater chance that the group will hit upon more adequate solutions.

Social Judgment Analysis, which we've already described, can also be included as a consensus gaining technique.

The above discussion illustrates some of the state-of-the-art techniques available for decision making in general and the consensus process in particular. But a "tool kit" of available techniques doesn't provide us a sufficient understanding of consensus. Nor does the tool kit enable us to validly measure consensus, or know when we've achieved it.

1.6.2.2.11. ABILENE

Read Jerry Harvey, "The Abilene Paradox: The Management of Agreement," *Organizational Dynamics*, Summer 1988, pp. 17-34.

1. Background

1.6. Group Decision Making

1.6.2. Group Decisions (More than Two)

1.6.2.2. Consensus

1.6.2.2.12. Conflict

1.6.2.2.12.1. A Model for Conflict

If you understand positives and negatives of conflict, you can use conflict to your advantage.

This module is based on the presentation by Grunau, M. H., and H. A. Kurstedt, "The Effects of Conflict and Its Resolution on Decision Quality and the Strength of Consensus in Consensus Groups," TIMS/ORSA Joint National Meeting, May 1991.

I describe a model relating intragroup conflict and its resolution attempts to group consensus and decision quality. Consensus groups are groups trying to produce high-quality decisions with strong agreement and support for these decisions. I differentiate task conflict from social conflict and competitive conflict resolution from collaborative conflict resolution. After analyzing the consequences of these types of conflict and their resolution strategies, I urge managers not to be afraid of task conflict. Task conflict is a functional element of a decision making process, whereas social conflict can be dysfunctional. I propose the use of collaborative conflict resolution in consensus groups. I propose steps for managers to follow when trying to achieve collaboration in a meeting.

Groups trying to achieve consensus are usually made up of people with a variety of different opinions, goals, roles, personalities, and backgrounds. These differences will naturally cause interpersonal conflict. Conflict and its resolution during the meeting can be the key to a successful meeting; for example, enabling a consensus group to come up with a decision of high quality and strong acceptance among the group members. However, if conflict isn't managed properly, conflict will be detrimental to the group and the meeting products. The goals of consensus groups are 1) to create satisfaction and commitment to the group decision and process and 2) In conflict, provide an environment that stimulates creative thinking and allows group members to express their views without being punished. Conveners, facilitators, managers, and group members need to understand and learn the possible consequences of intrapersonal conflict so they can intervene in the group process before damage occurs.

A Model Relating Conflict and Conflict Resolution to Consensus and Decision Quality

As illustrated in Figure 1.6.2.2.12.1., I believe a group meeting can be divided into two components: l) the group process including the physical gathering of the group members and their interaction and 2) the products of the group process. For the sake of analyzing conflict in decision making groups, I divide the group process component into two blocks: the conflict and the attempt to resolve the conflict. Although there are many different types of conflicts and conflict resolution strategies, here I'm primarily interested in task conflict versus social conflict and collaborative versus competitive conflict resolution strategies.

I believe it's difficult to separate conflict from the attempts to resolve conflict. In fact, the literature makes little distinction between them. Frequently the attempt to resolve one conflict causes a new conflict. This is my justification for the feedback loop in Figure 1.6.2.2.12.1. The loop shows the reciprocating actions of conflict on conflict resolution and vice versa.

The products box in Figure 1.6.2.2.12.1. contains dimensions affected by the different types of conflict resolution strategies. At the same time these dimensions are mediating variables affecting decision quality and strength of consensus. For clarification, I believe decision quality relates to the goodness or correctness of a decision, whereas consensus strength relates to the degree to which group members agree and support the group's final decision.

Managers Need to Understand Conflict to Resolve it Effectively.

Two fundamental beliefs exist about the phenomena of conflict. Hegel (Hegel, G.W.F., *The Essential Writings,* Harper & Row, 1974.) said conflict is the precedent and consequence of any change. Tjosvold (Tjosvold, D., Cooperation Theory and Organizations, *Human Relations,* 1984.) has shown conflict occurs naturally in any kind of meeting. Often, managers in groups ignore these findings because they're afraid of conflict's potential harmful outcomes. So, managers passively ignore or actively suppress conflict. If conflict is the input and output to change, or if change is the input and output of conflict, then conflict must be a controlling variable of change. Conflict becomes a powerful tool to proactively manipulate change. Conflict occurs naturally because of people's diverse experiences, personalities, interests, and beliefs. We must reduce our fear of conflict to learn how to effectively use conflict.

The consequences of mismanaged conflict have been described in the literature. Mismanaged conflict can lead to intolerance among group members (Simmel, G., *Conflict and the Web of Group-Affiliation,* New York: Free Press, 1955.), lead to low commitment or support of the group and the final decision (Pfeffer, J., *Power in Organizations.* Boston: Pittman, 1981.), reduce the trust among group members (Deutsch, M., *The resolution of conflict*, New Haven: Yale University Press, 1973.), reduce the amount of information shared between the group members (Rabbie, J.M. & Wilkens, G., Intergroup Competition and its Effects on Intra- and Intergroup Relations. *European Journal of Social Psychology,* Vol. l, 1971.), and therefore, reduce the quality of the group decision (Wall, V.D., Galanes, G.J., & Love, S.B., Conflict, Conflict Management, Satisfaction and Decision Quality in Small, Task Oriented Groups, *Speech Monographs,* 41,1974.).

The potential positive outcomes from well-managed conflict are an increase in information sharing and a greater number of creative alternatives generated within the group, an increase in the satisfaction with group process and the resulting decision (Wall, V.D. & Nolan, L.L., Perceptions of Inequity, Satisfaction, and Conflict in Task-oriented Groups, *Human Relation*, 1986.), an increase in interpersonal attraction or a better decision.

When I speak of well-managed or poorly-managed conflict, I speak about attempts to resolve conflict. Therefore, I must find conflict resolution techniques later on which match the consequences of well-managed conflict.

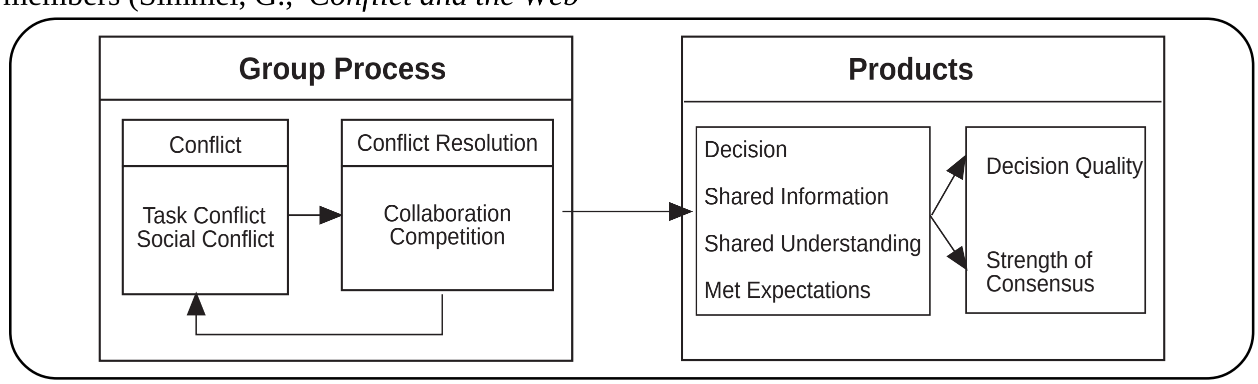

Figure 1.6.2.2.12.1. *A model relating conflict and conflict resolution to decision quality and consensus.*

1.6.2.2.12.2. Functional and Dysfunctnal Conflict

When dealing with group decision making, consider task conflict as useful and social conflict as dysfunctional.

This module is based on the presentation by Grunau, M. H., and H. A. Kurstedt, "The Effects of Conflict and Its Resolution on Decision Quality and the Strength of Consensus in Consensus Groups," TIMS/ORSA Joint National Meeting, May 1991.

I Classify Conflict According to Who the Conflict Involves and What the Conflict Pertains to.

Conflict can be either interactive or non-interactive. The difference lies in who the conflict involves (Figure 1.6.2.2.12.2.). Interactive conflict requires the involvement of two or more parties and is expressed in the form of *communicated disagreement.*

An example of interactive conflict in a dialogue is the statement of one person that when shopping he prefers the use of plastic bags while another person states that he would rather use paper bags. Both statements are in disagreement with one another and have been communicated between two parties. A non-interactive conflict occurs within a person; and, therefore, affects one group member only. Non-interactive conflict is not openly visible and can be experienced in the form of guilt, cognitive dissonance, frustration, and uncommunicated disagreement. An example of non-interactive conflict may be not meeting an individual's expectations. I believe non-interactive conflict often leads to interactive conflict.

I list social conflict and task conflict for what the conflict pertains to, although they're not always easy to distinguish. Social conflict is a contradiction of emotions about other members and their behaviors. An example might be a disagreement merely based on the fact that one individual is male and the other one female, or that two people have had a joint negative past experience. The nature of social conflict is mostly irrational and emotional. Task conflict on the other hand is disagreement on the problem to be solved during the meeting. Task conflict for example may be a disagreement on one of the alternatives generated to solve a particular problem. Task conflict is rational, logical, and factual. The difference in the characteristics between task and social conflicts has implications on their respective usefulness in decision making groups.

In Consensus Groups, Social Conflict Can Be Dysfunctional while Task Conflict Is Functional.

Since social conflict is aimed at individuals, not at the task to be solved, it diverts the group's attention from the purpose of the meeting, which is to make a decision. Individuals exposed to social conflict may feel a need for saving face or for retaliation. These activities are based on an individuals' sense of equity and are aimed at the person they believe is responsible for the existence of social conflict. That is, people want to feel they were treated justly or they were able to get even. During a meeting, these activities take up additional time, prolonging the group process. The dysfunctionality of social conflict is also evident when we view how it can be resolved. The successful resolution of social conflict requires more resources, such as skilled mediators or facilitators.

Conflict occurs naturally in groups primarily because people are different. These differences in personalities and backgrounds for example will cause each group member to view the problem to be solved from a different angle than other group members. Therefore, we shouldn't be afraid to permit or even raise task conflict, because it occurs naturally and focuses the group on the goal of the meeting: to make a decision. Task conflict sets the stage for sharing information and generating creative alternatives, since individuals sense the group is scrutinizing the task, not the individuals. This reduces group members' fear of other group members' judgments and they'll feel less inhibited to speak out. As I mentioned before, task conflict is based on logic, rationale, and facts. These elements make the conflict resolution process less time consuming and less sensitive, since it is easier and more convincing to reason with facts than with ambiguous emotions. Group members will be more committed to the final group decision knowing they've scrutinized the problem from as many angles as possible. If they perceive all relevant information was shared and the group was able to generate creative alternatives, group members will be more convinced they have come up with a good decision.

From this analysis I conclude social conflict should be avoided and task conflict should be permitted and even raised. Having looked at conflict, let's look at conflict resolution.

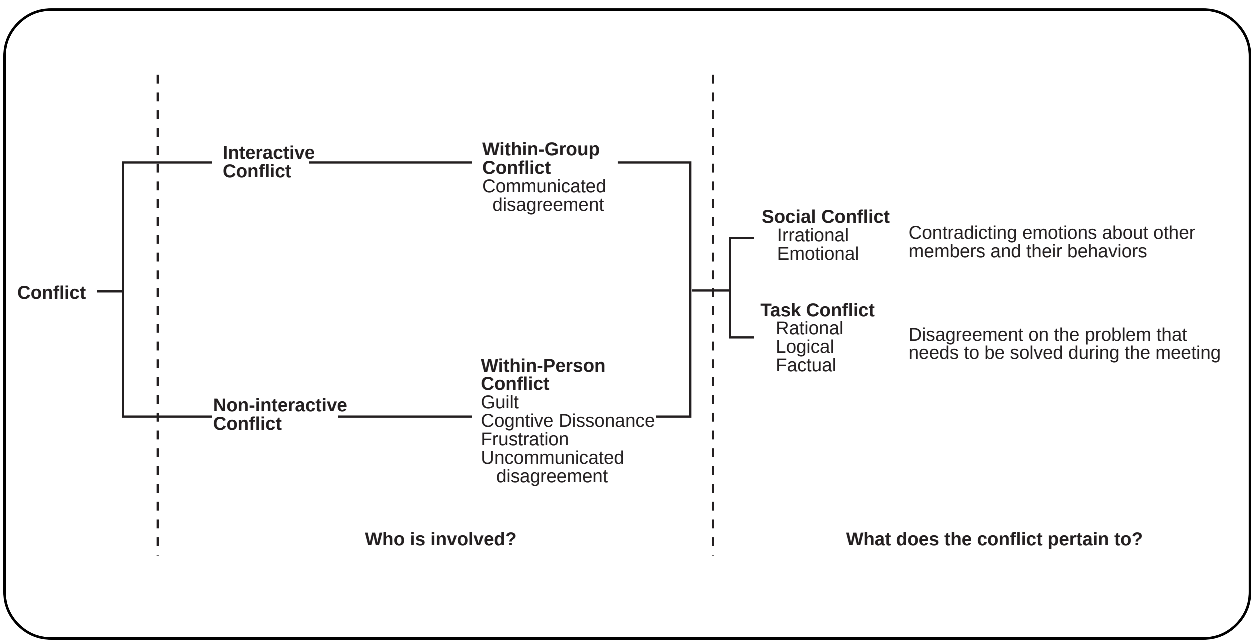

Figure 1.6.2.2.12.2. *Conflict can beclassified into who it involves and what the conflict pertains to.*

1.6.2.2.12.3. Conflict Resolution

You need to learn different conflict resolution styles to be able to handle conflict when it arises.

This module is based on the presentation by Grunau, M. H., and H. A. Kurstedt, "The Effects of Conflict and Its Resolution on Decision Quality and the Strength of Consensus in Consensus Groups," TIMS/ORSA Joint National Meeting, May 1991.

There Is No One Best Conflict Resolution Strategy for all Situations.
Too often we get trapped feeling comfortable with one particular conflict resolution style and we begin to apply it to all conflict situations in life. Eventually, we'll fail. Each of the five conflict resolution strategies in Figure 1.6.2.2.12.3. is applicable in certain situations.

Even our English language supports the use of all conflict resolution styles with phrases such as "leave well enough alone" for avoidance, "kill your enemies with kindness" for accommodation, "split the difference" for compromise, "might makes right" for competing, and "two heads are better than one" for collaboration (Thomas, W.K, & Kilmann, R.H., Thomas-Kilmann Conflict Mode Instrument, Tuxedo, New York: XICOM, Inc, 1974.). Each strategy may be expressed in different ways. For example, avoidance can be practiced by defusing the issue, resigning or giving up on the problem, covering-up vital aspects that should be considered, isolating or withdrawing oneself from the group, showing indifference toward the problem, or simply refusing to help find a solution.

However, when the situation is one requiring a small group to come up with a good decision while at the same time having strong consensus on this decision, some conflict resolution styles on this list are less applicable than others. I believe collaboration will be the most effective approach for consensus groups. I'll contrast competitive and collaborative conflict resolution styles. In the everyday use of these terms, collaboration is often used to refer to the absence of conflict, while competition refers to challenge and high aspirations. However, we must break our paradigms on what we believe collaboration and competition are. I'll define what competitive and collaborative conflict resolution are.

Competitive Conflict Resolution Can Be Dysfunctional in Consensus Groups.
A competitive situation is defined to be one in which individuals are assertive yet uncooperative; an individual pursues his own concerns at the expense of another group member. Competitive conflict resolution is a power-oriented mode in which one uses whatever power seems appropriate to win one's position. Competition is caused when group members perceive their goals are negatively linked (Deutsch, M., *The resolution of conflict*, New Haven: Yale University Press, 1973.). This means one group member can achieve his or her goal only when another group member doesn't achieve his or her goal. Negatively linked goals create win/lose situations: one individual wins, another loses. An increase in group hostility is the result of win/lose situations. Intragroup hostility could be an example of the reciprocating actions between conflict and conflict resolution. The hostility is a consequence of the conflict resolution attempt, producing a new conflict requiring additional conflict resolution attempts in the future.

When group members believe they can't achieve their goal because they're competing with someone else, they're also less inclined to share relevant information with the rest of the group, since it might give other group members an advantage. Deutsch found competitive conflict resolution stifled innovation. The reason is based on fear of expressing innovative ideas that would help someone else achieve their goal while reducing the chance to achieve one's own goal. In a competitive conflict resolution phase, individuals expect other group members won't help them achieve their goal. They're suspicious other group members' messages and influence are attempts to mislead them from their goals.

Collaborative Conflict Resolution is Functional

A collaborative conflict resolution is defined as being assertive and cooperative. The difference then between competition and collaboration is their degree of cooperativeness. Collaboration is an attempt to work with the other person finding some solution fully satisfying the concerns of both. It requires exploring the issue to identify the underlying concerns of the individuals and to find an alternative to meet both sets of concerns. Collaboration is caused when group members perceive their goals to be positively linked. This means one group member can achieve his or her goal only when others achieve their goals as well.

Positively linked goals create win/win situations. Both parties perceive they win. When individuals in the group perceive other group members value their presence, threat and hostility appear to a lesser degree or are reduced. This provides a medium for group members to safely express their views and dare to think up innovative or creative alternatives. The increase in group participation caused through collaboration increases the stake of the group members in the group process and the final decision. The result is an increase in group commitment to the group process and the final solution. The reduction of threat and hostility among group members has another consequence. Group morale and satisfaction of individual group members increases. The only drawback to collaboration in consensus groups is that collaboration is very time consuming.

From this analysis, I conclude that collaborative conflict resolution is desirable, whereas competitive conflict resolution is dysfunctional. To make sure, I'll look at the requirements for strong consensus and decision quality. The best match between the decision quality and consensus requirements and conflict resolution strategy consequences should prescribe the type of conflict resolution strategy applicable for consensus groups.

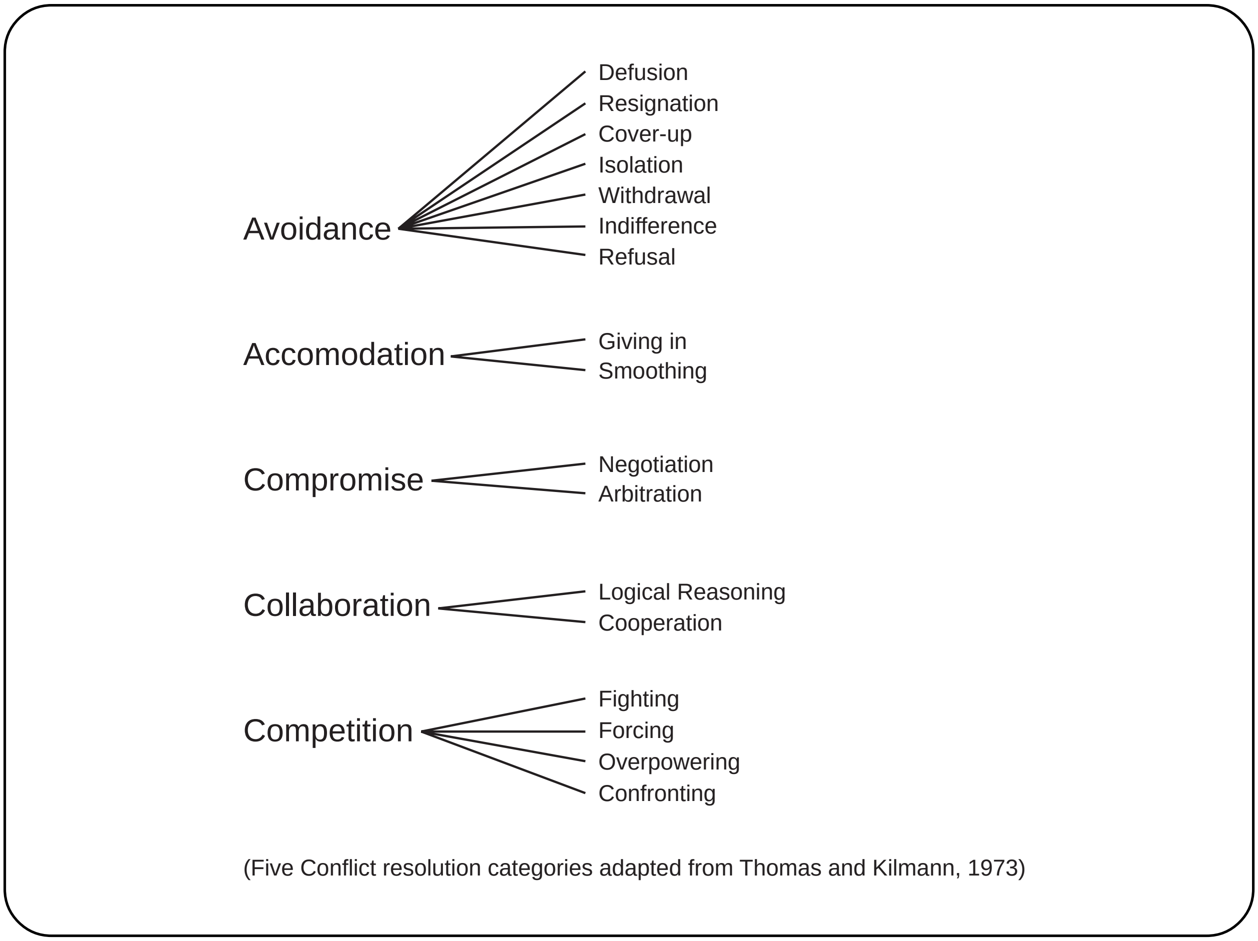

Figure 1.6.2.2.12.3. *Different conflict resolution styles are applicable in different situations.*

1.6.2.2.12.4. Achieving Consensus by Including Collaboration

Group facilitators and managers can induce collaborative conflict resolution in groups.

This module is based on the presentation by Grunau, M. H., and H. A. Kurstedt, “The Effects of Conflict and Its Resolution on Decision Quality and the Strength of Consensus in Consensus Groups,” TIMS/ORSA Joint National Meeting, May 1991.

To Achieve Strong Consensus and High Decision Quality, Certain Requirements Have to Be Met.
The literature lists the following requirements to achieve consensus. All group members must have the opportunity to express their opinions (Hall, J., Decisions, Decisions, Decisions, *Psychology Today*, 1971.). This increases group participation and therefore commitment to the group process and the final decision. Further, the group must share relevant information with one another. A group is less likely to gain consensus if they feel vital information has been withheld from them. If group members are finally satisfied with the group process and their decision made in a joint effort and their own individual expectations or goals are met, the largest and most important obstacles to achieve consensus are overcome.

The requirements for high-quality decisions are similar, in that they require the sharing of relevant information and the pooling of generated creative alternatives (Janis, I., *Victims of Groupthink*, Boston: Houghton-Mifflin, 1972.). Looking at these requirements, collaborative conflict resolution is clearly a better match to achieve strong consensus and high quality decisions than competitive conflict resolution.

Choose a Conflict Resolution Strategy According to the Situation.
Before I conclude with some propositions for inducing collaboration, I would like to list situations in social and task conflict when either collaborative or competitive conflict resolution strategies are applicable (Figure 1.6.2.2.12.4.). Competitive conflict resolution isn’t suitable for social conflict, since it only increases further hostility. However, it’s applicable in some nonconsensus task-conflict situations. For example, emergencies require quick and decisive action in which a bias for action is frequently more important than gaining consensus. Sometimes groups come up with necessary but unpopular actions that need to be implemented. A competitive approach may be the only way to divide up the tasks for implementation.

The last situation in which competitive conflict resolution is justified is a situation where individuals need to protect themselves from otherwise ruthless exploitation of another competitor who would otherwise take advantage of any noncompetitive behavior. In situations demanding strong consensus and good decisions, collaborative conflict resolution is more applicable for both social conflict and task conflict.

Competition should be used when the meeting’s goal is known to be complex to take advantage of the diversity of opinions. Collaboration should be used when managers request critical thinking of group members and their commitment to a decision.

Social conflict should be resolved collaboratively, since rationalizing emotions through constructive verbalizations of emotions begins to break down the irrational nature of social conflict.

I Propose Six Steps to Achieve Strong Consensus and High Decision Quality by Inducing Collaboration.

I conclude by proposing six steps group facilitators and managers should know of when they intend to induce collaborative conflict resolution within groups.

1) Group members should be informed before the meeting that the manager requests group members to collaborate. This will set their expectation and reduce some of the group members' anxiety.

2) Managers should plan informal ice breakers before the consensus meeting starts. Social ice-breakers may make group members feel their goals are more positively linked.

3) The use of structured conflict techniques can prevent additional social conflict since they put group members into artificial roles. Examples of such techniques are devil's advocacy and dialectical inquiry.

4) A key component affecting managers and facilitators is how group members will be rewarded. During the meeting, group members showing efforts to collaborate need to be rewarded to reinforce their behaviors and to serve as models to other group members. When all group members are collaborating according to the manager's expectations, the entire group, not just selected individuals, must be rewarded. The manager's expectations must be realistic, otherwise these expectations become a frustration and a disincentive.

5) Social conflict should be anticipated or quickly resolved so the group has sufficient time to raise, permit, and resolve task conflict.

6) If managers expect groups to reach consensus, they must give the group the necessary resources—primarily time.

	Social Conflict	**Task Conflict**
Competitive Conflict Resolution		• For *emergencies* • When *unpopular actions* need to be implemented • To *protect yourself* from others taking advantage of noncompetitive behavior
Collaborative Conflict Resolution	• To *reduce hostility* between groups • To *refocus* the group on the task again	• When meeting's purpose is *complex* • To gain *commitment* • Increase critical thinking • Increase strength of *consensus* • Increase *decision quality*

Figure 1.6.2.2.12.4. *Which conflict resolution strategy is applicable for what type of situation (conflict)?*

1.6.2.2.12.5. Conflict Management

We can manage conflict and move competitive conflict toward collaborative conflict.

This module was adapted from Grunau, M. H. and H. A. Kurstedt, Jr., "The Effects of Incentives on Conflict Management, Perceived Strength of Consensus, and Decision Quality," *Proceedings of the 27th Annual Meeting*, Southeastern Chapter of the Instute of Management Sciences, October 1991, pp. 68-70.

Introduction

Decision-making groups trying to achieve consensus are usually made up of people with a variety of predispositions. These predispositions cause social pressures which naturally lead to conflict (Thomas, K. (1976). Conflict and Conflict Management. In M. Dunnette (Ed.), *Handbook of Industrial and Organizational Psychology*, 889-935. New York: Rand McNally & Co.). Improperly managed conflict is detrimental to the group and the meeting's products. However, providing a conflict environment that stimulates creative thinking and open information sharing can enable groups to reach consensus and a high quality decision.

A Model of Conflict in Meetings

Figure 1.6.2.2.12.5. shows a conceptual model of conflict in meetings. My concept is that people bring the ingredients for conflict to meetings. The ingredients include group members' different backgrounds, personalities, goals, opinions, and expectations.

This conflict might be based on who the group members are attending the meeting, what the problem is that will be dealt with during the meeting, how the people in the meeting expect to interact with one another, and why the group members come to the meeting.

Conflict may not be perceived by all members of the group. Unless conflict is brought out in the open and managed, it will more than likely go undetected. Using the model to get the best products of a meeting, group members must make the choice to deal with existing conflicts. Then we can identify, surface, and finally manage the conflicts by displaying functional behavior.

The type of behavior displayed by group members in meetings can be influenced through pre-imposed meeting incentive structures. Depending on the type of incentive (group or individual) the type of conflict management strategy used during the meeting can be influenced before or during the group process.

Essentially, there are three ways to manage conflict. Group members can escalate conflict, reduce conflict, or they can do nothing about the conflict. Raising the conflict may mean exploring the underlying reasons in more detail or making sure all possible disagreements are aired and dealt with. A simple way to reduce conflict temporarily could be to intentionally avoid or to smooth over the conflict.

The justification for the feedback loop between the conflict management box and conflict itself lies in their reciprocating actions. Frequently it is the characteristics of a conflict resolution attempt that spurs a new conflict. Therefore, the consequence of managing one conflict can produce a new conflict. All attempts to deal with conflict have some kind of effect on the group process. I call the effects "products," The products box in Figure 1.6.2.2.12.5. contains variables that reflect the state of the group and its intereactions at the end of the meeting. These variables, for example, include the degree to which a group has come to consensus on a decision or how strongly the group believes they have reached a high quality answer.

Distinction between Conflict and Conflict Management

In the literature, conflict has been viewed primarily from two different angles. Some researchers believe conflict is internal such as someone's belief or perception of disagreement (Schmidt, S.M., Kochan, T.A. (1972). Conflict: Towards Conceptual Clarity. *Administrative Science Quarterly*, Vol. 17, 359-370.), while others stress conflict to be external reflected in people's contradictory actions and behavior (Katz, D., Kahn, R.L. (1972). *The Social Psychology of Organizations*. 2ed. John Wiley & Sons, INC, New York.). I support the notion that conflict is internal. I define *conflict* as a state and label it uncommunicated disagreement while I define *conflict management* as the process following the state of conflict. The process is the communication of the disagreement. Therefore, conflict management relates to a behavior aimed at resolving the conflict.

Potential Conflict Consequences

The potential negative consequences of mismanaged conflict have been described in the literature. Mismanaged conflict can reduce tolerance among group members, commitment or support of the group and the final decision (Pettigrew, A. (1973). *The Politics of Organizational Decision Making*. London: Travistock.), trust among group members (Tjosvold, D., Andrews, I.R., Jones, H. (1983). Cooperative and Competitive Relationships between Leaders and Subordinates. *Human Relations*, Vol. 36, 1111-1124.), the amount of information shared among the group members, and the quality of the group decision.

The potential positive outcomes from well-managed conflict are increased information sharing and a greater number of creative alternatives generated within the group (Hoffman, L.R., Harburg, E., & Maier, N.R.F. (1962). Differences and Disagreements as Factors in Creative Group Problem Solving. *Journal of Abnormal and Social Psychology*, Vol. 2, 235-244.), increased satisfaction with group process and the resulting decision, increased interpersonal attraction (Johnson, D.W., Johnson, R.T. (1974). Instruction Goal Structure: Cooperation, Competitive, or Individualistic. *Review of Educational Research*, Vol. 44, 213-240.), and a better decision (Coser, L.A. (1956). *The Functions of Social Conflict*. New York: The Free Press.).

Collaborative and Competitive Conflict Management

There's no one best conflict resolution strategy that group facilitators can use in all conflict situations. Here, I focus on two very different conflict management styles: collaboration and competition. Collaborative efforts are defined as being assertive and cooperative. They're most applicable for decision-making groups, where management has allocated sufficient resources such as time. Collaborative conflict resolution attempts permit the sharing of information in a non-threatening environment, producing a shared understanding of this information and a high degree of group satisfaction. Collaboration results in a win/win situation. One party can win only if the other wins also. Competitve efforts are defined as being assertive yet uncooperative. They're applicable in situations requiring quick and decisive actions, and require fewer resources. However, competitive conflict resolution attempts can create threatening environments reducing the amount of information group members are willing to share and decreasing shared understanding as well as satisfaction with the group decision. Competition results in a win/lose situation. One party can win only if the other loses.

Incentive Structures

Thomas, Deutsch, Coser, list incentive structures as one way to manipulate behavior when managing a conflict. Coser hypothesized incentives geared toward the individual produced social pressures to compete against other indviduals causing interpersonal competition. On the other hand, incentives geared toward groups give groups a common goal. This causes intergroup competition, which in turn causes intragroup collaboration. Sherif (Sherif, M., Harvey, O.J., White, B.J., Hood, W.R., Sherif, C.W. (1961). *Intergroup Conflict and Cooperation: The Robber's Cave Experiment*. Norman, Oklahoma: University of Oklahoma Press.) supported this hypothesis with the "robbers' cave" studies. After strongly competitive behaviors occurred among individuals in groups, superordinate group goals were introduced. These goals gave all individuals a common goal and focused their attention away from the internal conflict. Competitive behaviors within the group shifted towards competitive behaviors between the group and the outside. The introduction of a superordinate goal can be compared to the introduction of a new incentive, producing different social pressures and causing a shift in the conflict management strategy.

Perceived Consensus and Decision Quality

Consensus and decision quality are two variables we can measure to determine the success of group decisions. I define consensus to be a state where a common judgment has been reached by most of those concerned. Consensus exists when a group makes and supports a decision. I believe the following five subcomponents can be used as measures of consensus. The subcomponents are group members' agreement with the decision (Scheff, T.J. (1984). Toward a Sociological Model of Consensus. *American Sociological Review*, 32-46.), acceptance of the decision (Tjosvold, D., Field, R.H.G. (1983). Effects of Social Context on Consensus and Majority Vote Decision Making. *Journal of Social Psychology,* 500-506.), support or commitment to the decision (DeStephen, R.S. (1983). High and Low Consensus Groups: A Content and Relational Interaction Analysis. *Small Group Behavior*, 143-162.), an understanding of the information shared to come up with the decision, and satisfaction with the group process and the decision. Therefore, I can express consensus as a function:

Consensus = f[agreement, understanding, acceptance, satisfaction, commitment]

I view consensus not as a binary variable, but as having different levels of strength.

Often the quality of a particular decision can't be determined right after the decision is made; especially if a problem doesn't have one correct answer. Frequently, the decision needs to be implemented and its quality judged, based on the consequence its implemention had. Therefore, since it is difficult to measure the actual quality of a decision directly, I believe it is more appropriate to consider the process elements required to achieve a particular level of decision quality. Janis believes the primary requirement for high-quality decisions is the sharing of relevant information. Coser argues decision quality is primarily influenced by the generation of a multitude of alternatives from which the group can choose. I believe there is no one variable solely responsible for a group process ensuring high decision quality. Therefore, I measure decision quality through the subject's perception of two components which are believed to be important for high decision quality. I express perceived decision quality as a function of two variables:

Perceived decision quality = f[perceived opportunity to express views, perceived generation of alternatives]

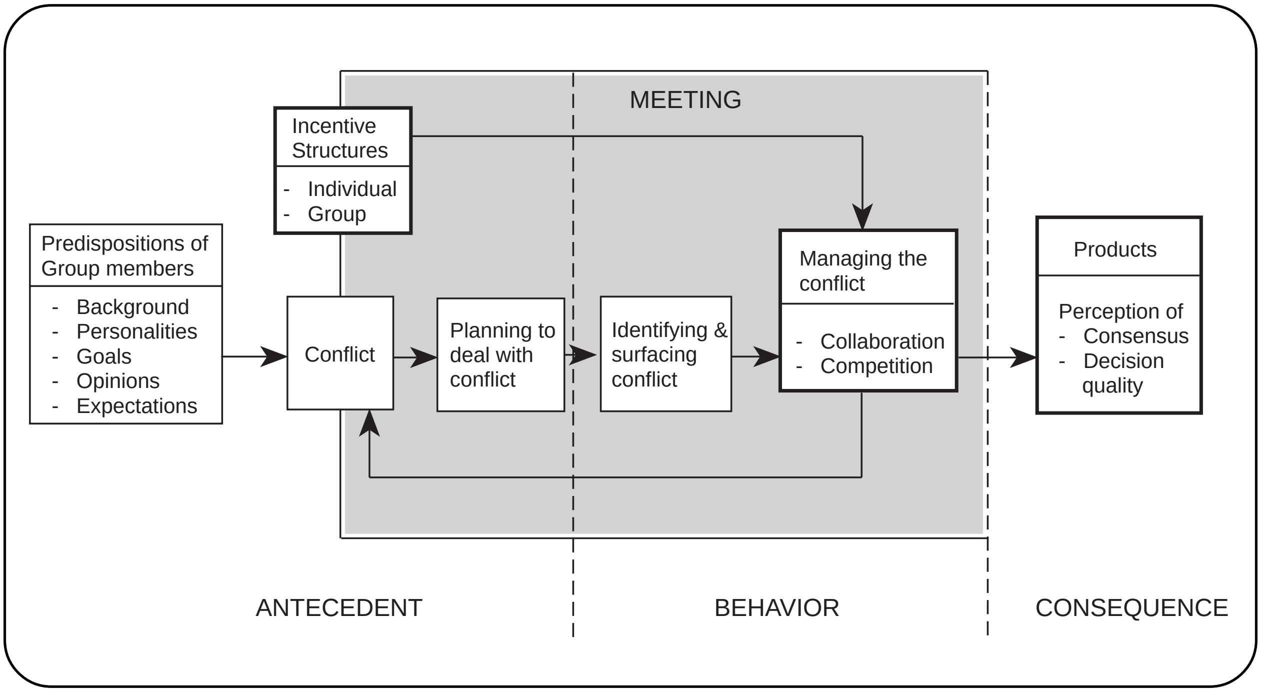

Figure 1.6.2.2.12.5. *Broad Conceptual Model of Conflict in Meetings*

1. Background

1.6. Group Decision Making

1.6.2. Group Decisions (More than Two)

1.6.2.2. Consensus

1.6.2.2.13. Group Dynamics

1.6.2.2.13.1. A Model of Group Decision Making

Managers can better manage groups by understanding the components of group decision making.

Figure 1.6.2.2.13.1. depicts a model I've developed for understanding group decision making. The model portrays the important components of groups. Managers should consider each component when planning, managing, or facilitating groups. The model also shows relationships between group-related variables. The model is useful for all types of decision-making groups including consensus groups. The model portrays a group during a single meeting, but it's also useful for understanding groups over time. To make the model easier to remember, I've named each component with a word beginning with the letter "P."

Precipitator

The **precipitator** is the person, condition, information, or event causing a manager to form a group. Example precipitators include: changes in the group's environment, organizational crises, top management decrees, organizational culture changes, and specific problems in a work area. Usually, the precipitator is a variable that can't be controlled. However, understanding the reasons for bringing a group together helps the manager design and manage the group process. Understanding the precipitator helps group members understand their purpose. Usually, the precipitator determines which of the next four components in Figure 1.6.6.1. the manager should consider next. For example, if a lack of communication between two divisions is the precipitator, the people involved should be members of the two divisions.

Purpose

The **purpose** is what the group expects to accomplish. The purpose answers the question, "What do we want to come out of this meeting?" Example purposes include: to make a decision, to reach a consensus, to develop a list of ideas, and to share information. The purpose usually determines the desired product(s). The purpose tends to be outcome-oriented. Outcomes are the intangible products the group will work toward.

People

The **people** are the individuals associated with the group, both inside and outside the group. The convener, facilitator, group leader, group members, and advisors to the group are all people who may be associated with the group. Participants in decision making should be the stakeholders in the issue being discussed. When looking at the people involved in the group, managers should consider the characteristics of each individual (e.g., expertise, organizational position) and the characteristics of the group (e.g., size, homogeneity). Understanding the characteristics of the people involved will help you design group processes.

Problem

The **problem** is the specific task before the group. The need to improve performance on an assembly line, replace a retired employee, or share information about monthly production are examples of group problems. The problem is the output expectation or the task problem. This is the tangible output the group should produce. The problem often dictates the process the group will use. For example, if the problem is to generate multiple ideas for increasing productivity, the process will likely include some form of brainstorming.

Participation

Participation is the degree to which group members take part in decision making. Participation involves whether the decision will be made by one group member or all group members. In a consensus group, all group members make the decision and all group members can express their views. Possible types of participation include delegation, consultation, information sharing, and conflict resolution.

Process

Once you determine the purpose, people, problem, and participation, you can plan for the group process. The **process** is all aspects of the group interaction. We divide process into two categories: group process issues and group techniques. Group process issues include expectations, conflict, and cohesiveness. Group techniques include idea generation techniques, nominal group technique (NGT), and devil's advocacy. Managers should match the process to the other components in the model. For example, if the group is heterogeneous groups and wants to give all group members a chance to express their views, NGT is appropriate. The "Choosing the Proper Group Technique" module helps managers choose techniques based on the components of the model.

Products

The **products** are results of the group process. Products can be divided into outcomes and outputs. **Outcomes** are intangible results of the meeting such as consensus, cohesion, or commitment. **Outputs** are tangible results of the meeting such as decisions, ranked lists, action items, or plans. For a meeting to be successful, the products should address the purpose. For example, if the purpose is to increase productivity, one product should be a list of specific productivity improvement ideas.

Time Sequence of Components

The components of the model in Figure 1.6.2.2.13.1. have a time sequence associated with them. The precipitator occurs at time zero. The purpose, people, problem, and participation components are all design issues the manager decides before the meeting occurs. The process occurs during the meeting. The products are generated during, at the end of, and after the meeting. The model is a systems view of groups. The precipitator, purpose, people, problem, and participation are inputs to the system. The process is the system itself. The products are the outputs of the system. Because all systems operate in some environment, we also must consider the effects of the environment on groups.

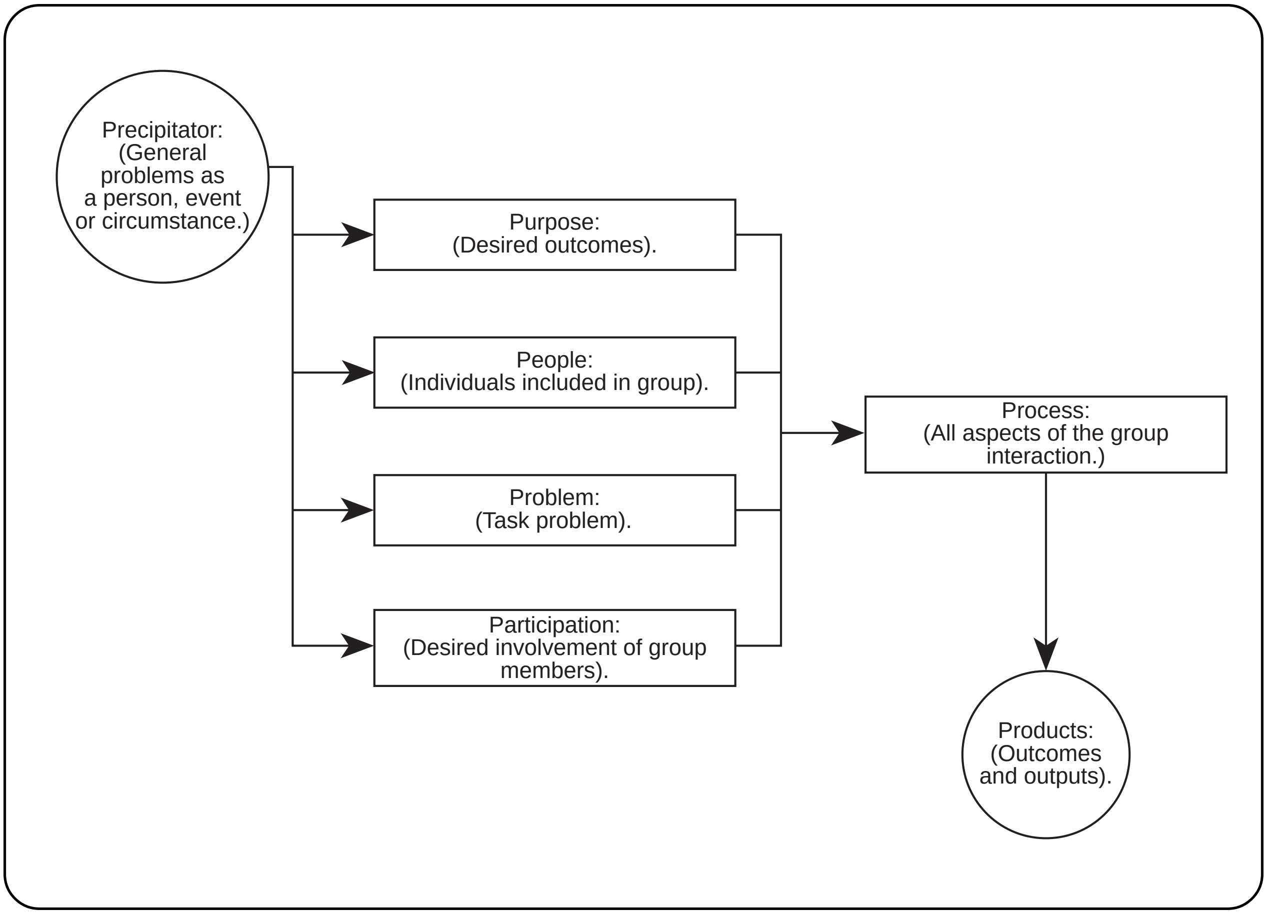

Figure 1.6.2.2.13.1. *The group decision-making model portrays the important components of group decision making.*

1.6.2.2.13.2. Examples of Applying the Model of Group Decision-Making.

We can understand the group decision making model better by applying the model to examples of group interaction.

The consensus conceptual model illustrates categories of constructs involved in consensus and the relationships among the constructs. This model is viewed from the meeting convenor's perspective in solving a general problem. A precipitating event or issue motivates the convenor to plan a participative problem-solving session or observer to observe a population. The convenor calls a meeting or session (or observer observes) for a purpose. For example, the convenor may want a group decision, a written report or sharing of information. At this point, other components of the conceptual model come into play. People are needed to carry out the task or address the problem. The level and type of involvement of group members constitute participation. The process consists of actions that lead to the products. The products include both outputs and outcomes.

Example 1

A fire destroys your house. The **precipitator** is the fire that motivates a group action. To organize group actions, you (the convenor) must plan the **purpose**, **people**, **problem**, and **participation**. (This **precipitator** leads to the problem, which in turn leads to purpose, participation, and people.) The **purpose** or outcome expectation of the group action is to shelter your family for the next 50 years. The **people** needed include: an electrician, a plumber, a builder, etc. The **problem** or output expectation is to build a house. The **participation** or process expectations are the roles the people are expected to play in the group action. The participation might be the plan of action which includes: the builder constructing the house frame, then the electrician and the plumber working simultaneously to complete the house infrastructure, and then the carpenter to do the finish work.

Once group actions are planned, the people must then go through the actual **process** of building your house. All this work eventually leads to your final product. Your **products** will include your house as an output and the satisfaction of sheltering of your family as an outcome.

Example 2

The Department of Energy (DOE) formed the State and Tribal Governments Working Group (STGWG) after DOE received a letter signed by ten governors from states housing DOE facilities. The **precipitator** (the letter) expressed the governor's concern over the waste management and environmental remediation at DOE facilities and suggested new waste management and environmental policies. This precipitator led to the **purpose** of forming STGWG which was to start a dialogue with the affected states and Indian tribes to have a more congenial and productive relationship. (Note that a different precipitator might lead to people, problem, or participation first. This precipitator led to purpose.) The **people** included were: representatives from nine of the states whose governors signed the letter, representatives from two Indian Nations with DOE facilities on their ceded territory, and representatives from the National Governors Association, the Association of Attorneys General, and National Conference of State Legislators. Their roles were to give DOE feedback and carry information to their constituencies. DOE asked STGWG for help with the task or **problem** of developing a Five Year Plan for Environmental Restoration and Waste Management. Consultation and information sharing were the chosen forms of **participation**. As a result of the five previous components (precipitating the need, defining the purpose; choosing the people, problem, and participation), DOE chose a **process** giving the STGWG members great flexibility and time for private executive sessions. DOE made it clear they didn't expect consensus. Finally, the **products** consisted of outputs: the draft of policy recommendations and a Five Year Plan, and outcomes: better working relationships between DOE and the states and Indian tribes.

Example 3

STRATEGY SUMMIT

Initial Assumptions

PRECIPITATOR:	The primary mission at the Hanford site has changed from the production of nuclear materials in support of national defense to becoming national and world leaders in environmental restoration and remediation. To address this mission change, the U.S. Department of Energy (DOE) field office and DOE's contractors joined together in the Hanford Integrated Planning Process, resulting in the Hanford Mission Plan (HMP). To augment the strategic planning process and site management system, a summit that helps direct resources in the most effective and efficient manner is proposed. The leadership represented by the "Corporate Board" must develop a common understanding of the elements required for the successful continuity of programs and funding sources. The focus on achievable, demonstrative, and dramatic results will help convince the customer, Congress, and the various stakeholders that the ongoing investment in Hanford provides clear long-term benefits to the nation and short- and intermediate-term benefits to the region.
PURPOSE:	The purpose of the Strategy Summit is to identify and focus on the major achievements participants should commit to over the next 12-18 months, and to gain commitments from participants on organizational and integrated responsibilities and how they will result in the identified achievements.
PEOPLE:	To fulfill the purpose, participants must come from organizations responsible for carrying out commitments at Hanford.

The following list of participants includes the DOE Hanford field office and key contractor organizations that developed the Hanford Mission Plan.

• DOE Field Office	(5)
• Westinghouse Hanford Company/BCS	(5)
• PNL/Battelle Memorial Institute	(2)
• Kaiser Engineers Hanford Company	(2)
• Hanford Environmental Health Foundation	(1)
	15

The summit will be facilitated by Management Systems Laboratories (MSL), an independent, objective "honest broker." MSL facilitates the State and Tribal Government Working Group (STGWG) to provide independent public state and tribal review and comment on the Department of Energy's (DOE) Five Year Plan (FYP) for Environmental Restoration and Waste Management. MSL also facilitates the Stakeholders' Forum, intended to broaden public input into DOE's FYP and policy decisions. Specifically, Dr. Harold Kurstedt will be the lead facilitator. He will be supported by Dr. Brian Kleiner, Don Mausshardt, and Ralph Erickson.

PROBLEM:

To build on the strategic planning process and document, individual and integrated commitments are needed focusing on achievable, demonstrative, and dramatic results. Achievable results must be defined within budget and time demands. These demands must be balanced with the demonstrative and dramatic results needed for the customers and other stakeholders.

PARTICIPATION:

Summit participants will have an equal voice in generating ideas and comments. Equal opportunity to express views will be achieved by utilizing nominal group technique strategies and tools. Consensus will be pursued regarding integrated plan agreements and concerns. Agreements will be reached regarding responsibilities and commitments. In general, an open discussion format will be used to discuss a strawperson model for a new way of viewing the site and operations. The details follow:

PROCESS:	PRELIMINARY AGENDA	
8:00 - 8:10	1) Welcome/Purpose of Meeting The DOE Manager overviews the purpose of the meeting and proposes the site and organizational benefits of inter-organizational planning and cooperation. He establishes DOE's expectations for the summit.	DOE
8:10 - 8:15	2) Introduction of facilitator The Westinghouse President introduces H. Kurstedt and the MSL team. H. Kurstedt presents expectations and guide-lines for the summit process.	WHC
8:15 - 8:45	3) Hanford Mission Plan Overview Participants will be briefed on the purpose, process, and content of the Hanford Mission Plan.	WHC
8:45 - 11:00	4) Obtain consensus on areas of agreement and concern a) Group silently generates perceived Mission Plan strengths and weaknesses b) Round robin communication of Plan strengths and weaknesses c) Discussion of weaknesses with brainstorming session on solutions to weaknesses	Group
11:00 - 2:00	5) Strawman model of new way of doing business a) Presentation of model by WHC b) Group silently generates perceived difficulties with model and barriers to achieving dramatic results at the site c) Round robin communication of barriers d) Discussion of barriers and brainstorming of ideas for breaking down barriers	WHC
2:00 - 5:00	6) Planning of strategic projects a) Based on Strawman and Mission Plan discussion, group silently generates projects that can demonstrate major accomplishments in the next 12 - 18 months that will	Group

delight DOE and key stakeholders (e.g., Congress, the public)

b) Round robin listing of projects
c) Group discusses merits and potential problems with projects listed
d) Groups votes and ranks projects to set priorities
e) Beginning with first project, identify responsible parties, required schedule, define budget implications, and gain necessary commitments. Iterate through list of projects.

5:00 - 5:30 — 7) Closing remarks — Contractor Principles

a) Each contractor has the opportunity to offer closing remarks, feedback on summit, or challenges for the future.
b) DOE offers closing comments, including expectations for the future.

PLACE: Members should be isolated from day-to-day routine interruptions. This is best achieved at an off-site, comfortable location. DOE desires to have the summit take place in February, 1992.

PRODUCTS: The outcome of the summit will be a commitment from participants as to individual and integrated responsibilities and how they will result in the identified achievements. Ultimately, achievable, demonstrative, and dramatic results will be attained. The summit process should help build relationships that will foster rapid movement toward developing a shared vision.

1.6.2.2.14. THE CONSENSUS GUIDE

Read modules II.A., II.B., II.D., V.B., VIII.B.3., and VIII.B.4., from MSL's "Building Consensus and Improving Quality in Decision Making: A Handbook for Managers."

The module from this document is included on the next 20 pages.

1. Background

1.6. Group Decision Making

1.6.3. The Facilitation Skill

1.6.3.1. Subordinating Your Ego—James A.M. Whistler

1.6.3.2. A FACILITATION GUIDE

Read "Meeting Facilitation: A Practical Guide for Running Effective Meetings."

This document is included on the next 20 pages.

1.6.3.3. OBSERVATIONS FROM FACILITATING STGWG

The thirteen lessons learned from my experience in facilitating the State and Tribal Government Working Group for the U.S. Department of Energy point out the difficulty in two-directional, two-mode empowerment.

This module is taken from Kurstedt, H. A.,Jr., "Lessons Learned from Facilitating the State and Tribal Government Working Group." *Proceedings of the Waste Management 1994 Symposium,* February 1994, Vol. 2, pp. 1151-1154.

INTRODUCTION

Facilitating the State and Tribal Government Working Group for the U.S. Department of Energy (DOE) has revealed and defined lessons learned I believe should become principles for organizing and facilitating public involvement groups. The State and Tribal Government Working Group (STGWG), formed in 1989 as DOE's first national public involvement group, includes gubernatorial representatives from states with DOE facilities, affected Indian Nations, and state government associations. STGWG has met quarterly to provide input to the DOE-EM Five-Year Plan for Environmental Restoration and Waste Management and associated policy issues potentially affecting the health and safety of workers, the public, and the environment.

As a neutral, third-party facilitator of these meetings since 1989, I've identified lessons learned and listed them below as observations followed by discussions explaining each one. STGWG members have reviewed the first ten lessons and their conceptual justifications and have tacitly accepted them. I've developed the last three lessons recently. I've written the lessons to be understandable and applicable to all DOE stakeholder/public involvement activities. These lessons are corroborated by my experience developing or facilitating two other DOE public involvement programs: the Environmental Management Advisory Committee (EMAC) and the annual Stakeholders' Forum.

I believe you can substitute the name for any stakeholder group for STGWG and substitute the name for any convenor, or sponsoring agency, for DOE, and the lessons learned will transfer. Other substitutions also apply, such as substituting a state system for lessons about the federal system. Therefore, this paper isn't about STGWG or DOE. Instead, this paper is about improving stakeholder group activities based on fundamental, generalizable lessons learned from the STGWG experience.

OBSERVATIONS FROM FACILITATING STGWG

1. If DOE brings organizational results rather than organizational processes to STGWG, the best DOE can expect is criticism.

2. If DOE brings the urgent instead of the important to STGWG, the best DOE can expect is frustration.

3. A person outside the federal system sees any insider as speaking for the entire perceived system.

4. The need for stakeholders to feel informed doesn't necessitate discussion of or response to all issues.

5. If STGWG members seek individual aims before system-wide clean-up aims, STGWG fails.

6. The facilitator must focus on the meeting process not the meeting content.

7. Public involvement and consensus require leadership and training from everyone.

8. Without specific action items, participants feel non-productive.

9. Each participant remembers his or her uncompleted perceived action item as a failed promise of the group and/or its convenor (DOE).

10. When stakeholders are involved, their feedback turns constructive.

11. Without constancy and consistency of purpose, STGWG flounders for meaning and existence.

12. STGWG doesn't feel empowered just because DOE says so or even because DOE's intentions are good.

13. If DOE doesn't recognize the inherent variation in stakeholders' descriptions of DOE, they'll feel maligned.

DISCUSSION OF OBSERVATIONS

1. If DOE Brings Organizational Results Rather Than Organizational Processes to STGWG, the Best DOE Can Expect Is Criticism.

Through the famous funnel experiment, W. Edwards Deming (1) shows that if you act on results your efforts will move you farther and farther away from your target. However, if you act on the process and improve the process you can improve your results and get closer to your target. Results are necessary only as a window into the process. Mathematically, there's no way around this issue.

People involved in organizational processes are forward thinking. People involved in organizational results are backward thinking. If the objective is to improve, then the only ways available to STGWG for acting on organizational results most likely will make matters worse; and if the acting on the results is advice, the only possible advice is criticism.

If DOE brings an organizational result to STGWG like a plan (such as the Five-year Plan), method (such as a prioritization system), policy (such as the Indian policy), and so on and asks for input, the input they'll get is what's wrong with the plan, method, or policy, not what's right with it. Bringing a settled-on process isn't much better. For positive input, DOE must bring a process in the formulation stage and supply only the aim of the process and the constraints on the process. The process begets the result; so, if a group works the process cooperatively, the group members own the results together.

To make a contribution, STGWG can make suggestions toward a good or better process and can participate in the process. They will own the results as much as DOE does. Given these results, the only thing left to do is to figure out a way to improve the process to get better results.

2. If DOE Brings the Urgent Instead of the Important to STGWG, the Best DOE Can Expect Is Frustration.

Participative interaction and involvement is heavily front-end loaded, time-wise. In other words, you can't push participative interaction faster than the ability for a large group to give each person a chance to express his or her views and to work on gaps between suggestions.

Typically, DOE comes to STGWG in a perpetual condition of being up to their ears in alligators. Anyone in this situation would want to share any alligator with any sympathetic ear. While these issues are important and STGWG needs to be fully informed, no participative process can act quickly—relative to individual decision making and action taking. Issues with a reasonable lead time can be affected and improved through public involvement. Stephen Covey (2) and Peter Drucker (3) say we must learn to put the important before the urgent.

People who're working together on a process for a long-term solution accept expediencies needed to keep up with day-to-day situations while crafting the solution.

3. A Person Outside the Federal System Sees Any Insider as Speaking for the Entire Perceived System.

Outsiders don't delimit responsibilities of the insider the way insiders do. Generally speaking, STGWG members feel they're outside the federal government system. So, to them, anyone in the federal government represents and is responsible for everything the federal government does.

There are two ways to deal with this untenable situation. In the short term, the federal government representative can make connections between the outsider and the person inside the federal government appropriate to the outsider's concern. In this way, the insider represents the parts of the perceived system for which they aren't responsible as a broker or match-maker. In the long term, when the outsider participates enough in developing and contributing to the processes of the perceived system, they'll be able to divide the larger system into its subsystems until they see the insider as responsible for what the insider feels they're responsible for.

This misunderstanding of extent of responsibility and authority clears up when the stakeholders gain ownership of the processes in the ominous system they feel outsiders of.

4. The Need for Stakeholders to Feel Informed Doesn't Necessitate Discussion of or Response to all Issues.

Informed people are more comfortable with each other and make better decisions both for themselves and for the group. People who feel uninformed or misinformed feel threatened. However, there are more efficient ways than formal STGWG meetings to inform STGWG and DOE of each other's situation and needs. Document distribution, news dissemination (immediate happenings), and workshops in coordination with formal STGWG meetings can help the formal meetings be more productive.

5. If STGWG Members Seek Individual Aims before System-wide Clean-up Aims, STGWG Fails.

Deming says, "If the parts are optimized, the system will not be. If the system is optimized, the parts will not be." (4) STGWG members must be eternally vigilant of issues carrying the potential of distracting them from the national clean-up effort.

If STGWG members focus on the common aim of the group (the common system), they can achieve cooperation. However, if STGWG members begin to focus on the aims of their individual state or tribe (the parts of the system), they get wrapped up in competition—usually for a limited resource, such as funding.

Each STGWG member represents a part (subsystem) of the national clean-up effort (common system). Any issue having the potential to cause STGWG members to refocus from national clean-up to a parochial need represents a threat to STGWG's contribution.

When perceiving multi-million-dollar funding as potentially available to STGWG, members become distracted into a zero-sum game for optimizing the parts (each State's portion of the funding) at the expense of the whole (National clean-up). As STGWG matures, it will increase its potential energy and power. Everyone will be tempted to focus that power on their specific needs. Doing so will hurt STGWG. STGWG must always focus on the national clean-up effort.

6. The Facilitator Must Focus on the Meeting Process not the Meeting Content.

The facilitator must be an honest broker. The facilitator is responsible to balance moving the meeting process forward to the needed conclusion with ensuring each stakeholder gets ample opportunity to express their views. When the quality of a decision can't be tested, group members perceive information sharing, resolution of conflict, and opportunity to express their views as decision quality or consensus. (5)

In any group (and especially a group as large as STGWG), a facilitator's full-time job is scrupulously watching for hesitation in participating by group members, concern that questions aren't addressed or answered, desire that the sequence of generated ideas be followed, all agenda items are fairly addressed, action items are recognized and followed-up, and many more. This full-time job is not concerned with logistics like seating and writing ideas on paper. Instead, the job is to ensure stakeholders get to express their views, are heard or know the reason why not, and that diverse ideas get a fair hearing.

The facilitator must ensure meeting process expectations are set and met. For example, when consensus isn't needed or sought, the worst idea is to expect consensus. The facilitator must make sure the group sets the expectations they need and can produce.

7. Public Involvement and Consensus Require Leadership and Training from Everyone.

Leadership for participative groups can come from the facilitator in terms of the meeting process, from the convenor in terms of needs and constraints, and from the group members in terms of meeting content and products. Max DePree says the art of leadership is "liberating people to do what is required of them in the most effective and humane way possible." (6) In STGWG, DOE, STGWG members, and the facilitator have the opportunity to practice the art of leadership.

To come to worthwhile group results, participants must learn about the system they're addressing, current and long-term issues, and group process implementation.

8. Without Specific Action Items, Participants Feel Non-productive.

People like tangible evidence of accomplishment—especially in time-consuming meetings. Documented decisions made, items for action, and action items addressed provide tangible evidence. When an issue is raised that needs a decision or action, the facilitator or any group member needs to make sure a specific action item is identified and assigned and that a date and method for bringing the resolution to the group is documented for later reference and check off. Without regular and frequent tangible evidence of accomplishment, group members feel they're bringing up old issues ignored in the past so they can be ignored in the future.

9. Each Participant Remembers His or Her Uncompleted Perceived Action Item as a Failed Promise of the Group and/or its Convenor (DOE).

Sooner or later, a person remembers any issue for which they thought an action was to be taken. To him or her, the perceived action item becomes an actual action item that isn't carried out. Then trust is weakened. It's easier in the long run to track all action items and confront forgotten or low-priority action items with the person who cares.

Stakeholder groups and government convenors are responsible for a public trust. Neither the group nor the convenor deserves or achieves the public trust until they can achieve mutual trust within the group and between group members and the convenor. Mutual trust is paramount—the foundation on which everything else is built. As priorities compete for attention during periods of rapid change and the surfacing of important issues, mutual trust must come first.

10. When Stakeholders Are Involved, Their Feedback Turns Constructive.

Stakeholders involved in process issues rather than result issues contribute by improving the process rather than criticizing the results. Faced with process-formation issues, the tendency is to improve the process—resulting in suggestions for what is to come. Faced with results issues, the tendency is to improve the results—resulting in criticism of what is past.

I've adapted an old Chinese proverb to read: Tell 'em and they'll forget; show 'em and they'll remember; involve 'em and they'll understand. I'll restate this idea in stakeholder meeting terms: Give 'em a briefing and they'll forget; take 'em on a tour and they'll remember; listen actively and integrate their ideas (I'll discuss empowerment later.) and they'll understand. When a member of the group understands the purpose, constraints, needs, issues, status, and progress, he or she wants to help. His or her response to any associated occurrence is largely constructive.

Don't get into the stakeholder group business unless you're after understanding. People who understand feel a sense of ownership. Ownership leads to cooperation and wanting to improve rather than to sitting and criticizing.

The convenor needs to recognize what's constructive. When STGWG's agenda includes results and urgent issues—things most conducive to criticism and frustration—constructive involvement can seem critical.

11. Without Constancy and Consistency of Purpose, STGWG Flounders for Meaning and Existence.

STGWG must develop and preferably get ownership through participation in developing STGWG's purpose. The purpose of STGWG is the purpose of the group, not necessarily the purpose of DOE. While STGWG must focus on the national cleanup aim, they must have a purpose for their interaction, or a group aim. The purpose, or aim, of the group can't be limited or capricious, because the purpose won't be maintained long enough for the group to be successful. When the purpose is met or becomes superfluous, a new purpose must be developed immediately for the group to continue.

STGWG was established ostensibly to review the Five-year Plan, but DOE couldn't mesh the review process with the production process with any reasonable lead-time due to gliches in releasing budget numbers and in getting internal approvals on plan content. Although STGWG has commented extensively on the Five-year Plan and has suggested improvements in the process, STGWG has felt frustrated with the stated purpose and hasn't yet found another. The only way to improve this situation is to face up to the empowerment issue in lesson 12.

Bill Scherkenbach says that constancy of purpose is necessary for success. "As Dr. Deming says, 'Do you know that doing your best is not good enough? You have to know what to do. Then do your best.' These are profound words because they summarize the two important messages in [Deming's] first point: that of knowing what to do—establishing the constancy of purpose and then doing your best—maintaining consistency of purpose." (7) STGWG and DOE are both doing their best, but with no constant and consistent purpose for the group, STGWG flounders. Who is responsible for STGWG's purpose?

12. STGWG Doesn't Feel Empowered Just Because DOE Says So or Even Because DOE's Intentions Are Good.

Neither DOE nor STGWG, nor perhaps anybody else, knows exactly what empowerment means or how to do empowerment. In empowerment, we don't know what it takes to get the behavior we consider to be empowered behavior. We think that if we say "You're empowered." the person or people we said it to will behave the way we expect. We believe that if we go beyond words and give the person or people space and resources, they'll act empowered. Can we give them the responsibility and authority? How about accountability? Even if we could give them all that, what about their empowered behavior? We must give them something more fundamental. We must give them an attitude. An attitude is a belief that influences emotions, behavior, and what the members of the group think.

To me, empowerment means more than the idea you have the right to make decisions and take actions. I believe empowerment means you have the 1) self-confidence, 2) optimism, 3) perceived control, 4) purpose, 5) trust, 6) self-esteem, 7) accountability, 8) causality, 9) loyalty, 10) stewardship, and 11) ownership to do what needs to be done. Without these eleven attributes, can you really fulfill your responsibilities for contributing to a group? These eleven attributes mean that, through empowerment, a person feels: 1) "I can do it," from self-confidence; 2) "I expect the best," from optimism; 3) "I can make a difference," from perceived control; 4) "I'm doing something meaningful," from purpose; 5) "I feel safe," from trust; 6) "I believe in myself," from self-esteem; 7) "I care," from accountability; 8) "I have a choice," from causality; 9) "I belong," from loyalty; 10) "I want to serve," from stewardship; and 11) "I get joy from what I do," from ownership.

Part of perceived control are the freedom and resources to make decisions and take actions. Only this freedom and these resources come from an external locus of control. Everything else comes from within the person. If you buy any of my eleven attributes and associated feelings in addition to the issue of freedom and resources, you must then believe a person can't empower another person. A person can only empower himself or herself. Empowerment isn't a state of being—"I am empowered." Empowerment is a state of feeling—"I feel empowered."

You can't empower a group any more than you can empower an individual. DOE can't empower STGWG, no matter what their intent is. DOE can only support the group as the group empowers itself. We're in a new paradigm here. Empowerment isn't for the impatient or the uncaring.

STGWG-type groups need to find empowerment in two directions: from their states, tribes, or associations to act as individuals and from the DOE to act as a group. Empowerment of a group is different from empowerment of an individual. For example, the individuals each may have self-confidence, but the collective group may not. Or, for another example, a person may trust his or her state, but not DOE or the other members of the group. I believe the attributes of an empowered group are the same as those for an empowered person. But, we're looking at collective (additive or multiplicative) variables, not individual ones.

13. If DOE Doesn't Recognize the Inherent Variation in Stakeholders' Descriptions of DOE, They'll Feel Maligned.

The key word here is inherent. All actions carry variation. Any stakeholder group will voice opinions ranging from the negative to the positive, across a fairly wide range. Therefore, there will always be the most negative opinion and the most positive opinion. Variation is part of nature and we have to accept variation. Focusing on only the negative opinion to the point of being closed to hearing an opinion in the middle of the range (let alone the positive opinion) is dangerous. The wildly positive description of DOE is of no more import than the wildly negative description, except both extremes are necessary so we can get a middle. Both the middle of the range and the size of the range are valuable bits of information. You have to be able to set aside your ego to receive both the negative and positive comments equally and in such a way they both point toward the middle.

My experience with facilitating groups related to DOE and in many other circumstances is that when groups work together they end up at the most reasonable position—far from both extremes. If you don't trust the stakeholder group to obtain the best result, your overt or covert reaction to the negative end of the range of opinion will taint the group's work. DOE's culture and history come from an ego-based approach to the world.

Stakeholders' comments don't necessarily reflect attitude or potential behavior but are many different color threads woven into a multi-color fabric of participation in and understanding of the issues. DOE must deal with the fabric, not with individual threads, and especially not with threads of a color they don't like.

CONCLUSIONS

STGWG is one model for stakeholder involvement; and represents an important link in the chain of history for the way civilized people must address multifaceted national or international problems. We must learn all we can from the STGWG experience if we are to move into a government that recognizes its customers and knows how to serve them.

STGWG has made major contributions to the success and understanding of stakeholders groups. They initiated key advances on the part of DOE by stimulating the 30-year target for clean-up and by engendering DOE's recognition of the sovereignty of the Indian Nations. They broke ground in learning lessons about stakeholder groups.

The crux of a successful stakeholder group is resolving the issue of empowerment. For a

STGWG-type stakeholder group, we have four degrees of freedom: a two-directional, two-mode empowerment. One direction is from the state, tribe, or association; the other direction is from DOE. One mode is to feel empowered as a person; the other mode is to feel empowered as a group.

Techniques for empowerment are elusive. However, I believe a classic example technique is active listening. Until STGWG members and DOE become skilled at active listening, they'll practice active talking to nobody's benefit.

The rest of what is needed for a successful stakeholder group is the scope of empowerment. Is STGWG empowered to critique results or influence a process within DOE? What is the purpose of STGWG? How can the facilitator support the group as each member expresses his or her views and as the group generates tangible evidence of accomplishment?

Many of the lessons are intertwined. For example, can you be empowered in a group where there's no constancy and consistency of purpose?

1. Background

1.6. Group Decision Making

1.6.4. Managing Change

1.6.4.1. Anticipating Change

The only constant in life is change.

As an industrial engineer, you'll be faced with managing in a time of frequent and dramatic change. To move with change, you'll need information-based tools. Fortunately, management tools are becoming more sophisticated to help manage the effects of change. For example, the computer is nothing more than a modern device allowing you to distill greater quantities of rapidly changing information. The better information you have, the better decision you can make. For the best decision, you must get the right information to the right people about the right things at the right time. Tools not working toward your needs work against you and are at odds with each other. Selecting the right tool for the right purpose is critical. Someone else's miraculous tool may be disastrous for you.

Anticipating Change

Tools should work together to help anticipate change. Anticipate has two synonyms: 1) to prevent or forestall and 2) to foresee or divine. I use anticipate to include predicting change and doing something about it, making it happen or preventing it from happening, whichever best serves our needs.

You anticipate and recognize change through information. Is this change inevitable? What can I do to work with this change to the organization's best advantage? The manager's experience, judgment, and capability are paramount. All information is biased; however, the bias should be the manager's, especially when dealing with change.

Types of Change

Change occurs either in the environment around the management system or in the management system itself. Environmental changes include government regulations, unexpected interest in your product or service, a new competitive product, or a legal crisis (e.g., the acceleration problem of the Audi 500). Internal changes include corporate takeover, a reorganization, formation of a union, or discovery of a new product concept (e.g., new uses of Arm and Hammer baking soda).

Along the vertical axis of the cube in Figure 1.6.4.1.a., you'll see planned changes. These are changes we plan and cause. At another point on the same axis is unexpected changes. These are changes we plan *for* and respond *to*. Planned changes are easiest to manage, but unexpected changes are not necessarily counter-productive. You can often use unexpected change for benefit.

On the horizontal axis are revolutionary changes. These occur rapidly with great impact. They sometimes propel businesses into mass confusion, causing them to focus on the side effects of the change instead of the change itself.

Further along the horizontal axis, you'll find evolutionary changes. These changes have well-defined stages occurring over sufficient time to allow the organization to adjust to each stage. These changes are heavily managed and allow time to involve specialists (experts) and ensure each functional activity is efficient and effective.

I've illustrated the parameters of change in Figure 1.6.4.1.b. This figure expands on the framework for anticipating change and shows you the various changes possible.

As illustrated in Figure 1.6.4.1.c., there are three dimensions of change: 1) progression, 2) prior knowledge, and 3) consequence. Progression measures if the change is evolutionary or revolutionary. Prior knowledge measures if the change is planned or unexpected. Consequence tells you if the result of change is helpful or harmful.

Changes Affect Components of the Management System Model.

All Management responsibilities can be viewed through the Management System Model (MSM). When the components of the MSM are in balance, the manager will want more from his or her management tools. He or she will cause the management system to change (mature) by seeking more sophisticated tools. The maturity stages of the management system must be accomplished in sequence: 1) visibility, 2) control, and 3) optimization.

Both environmental and internal changes affect your management responsibilities through their impact on the components of the MSM. Use your management tools to respond to change by concentrating on the MSM interfaces. By doing so, you move the domain of responsibility to a new state and stabilize it there. Any type of change affects corporate growth or decline. Through effective management, you can direct any change to work for you.

Tools to Manage Change

A Management Information System (MIS) is one of the tools used to manage; it makes up the data-to-information chain. The MIS links the measurement-to-data interface with the information-portrayal-to-information perception interface. Success with the MIS isn't good. MIS failures (which in my estimates, run at about 70% of the time) include projects which are one or more of the following:

1) not finished on time

2) exceeding reasonable cost before any return

3) lacking follow-through

4) obsolete

5) lacking a proper fit

A Decision Support System (DSS) is more comprehensive than an MIS; it includes all the tools within the what is used to manage component, and it addresses their interrelatedness. Based on my definition of DSS, I doubt there has been a successful one.

An Expert System (ES) is a methods tool. An ES includes the replication of an expert's knowledge of facts and rules for generating new facts or hypotheses from what is known. These facts and rules are applied to a very limited, well-defined domain of responsibility. ES along with quantitative models and heuristics are the best tools to use in managing change.

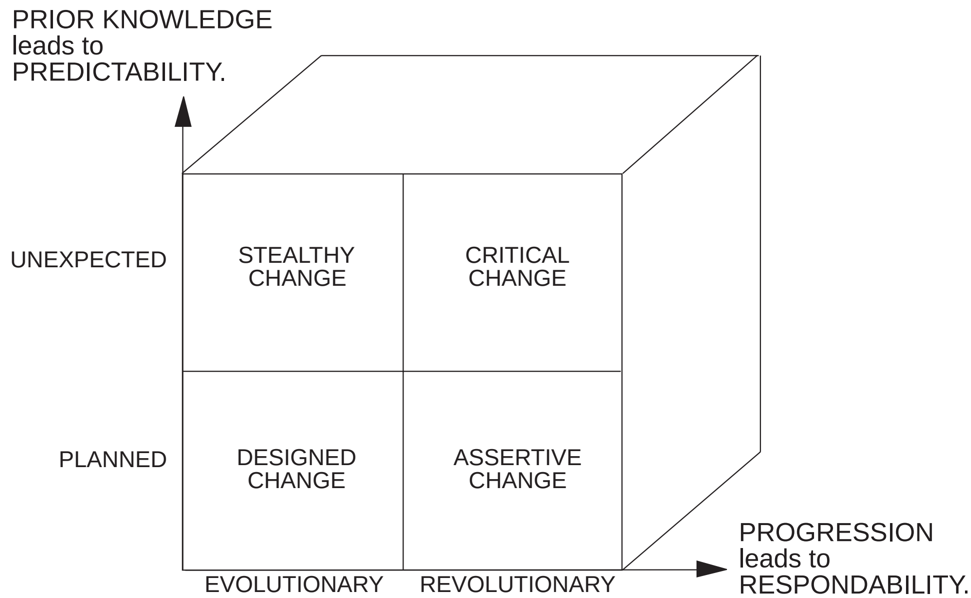

Figure 1.6.4.1.a. *A framework for anticipating change has four categories.*

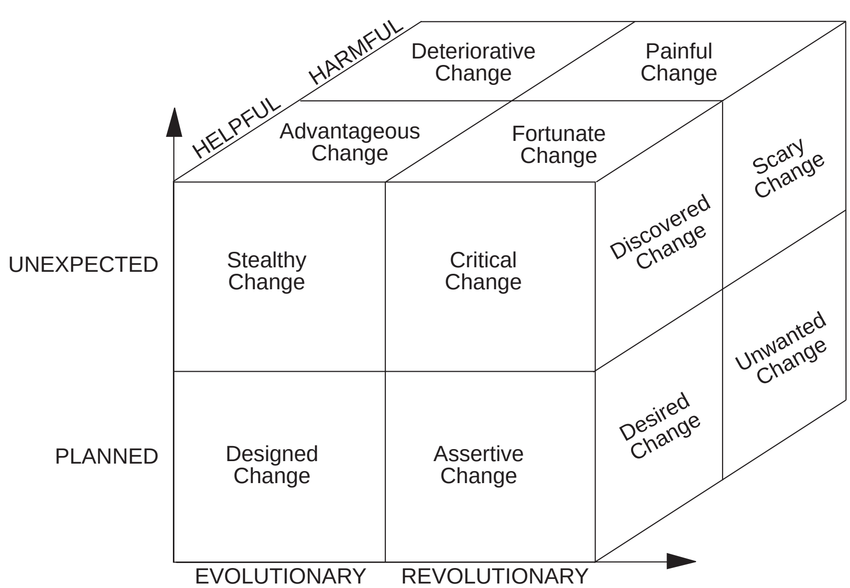

Figure 1.6.4.1.b. *Stacking sub-cubes yields sub-faces as parameters of change.*

DIMENSIONS

Sub-Cube	Progression	Prior Knowledge	Consequence	Type of Change
1.1.1	Evolutionary	Planned	Helpful	Controlled
1.1.2	Evolutionary	Planned	Harmful	Perverse
1.2.1	Evolutionary	Unexpected	Helpful	Serendipitous
1.2.2	Evolutionary	Unexpected	Harmful	Problematic
2.1.1	Revolutionary	Planned	Helpful	Heroic
2.1.2	Revolutionary	Planned	Harmful	Botched
2.2.1	Revolutionary	Unexpected	Helpful	Windfall
2.2.2	Revolutionary	Unexpected	Harmful	Crisis

Figure 1.6.4.1.c. *Dimensions of change determine types of changes.*

1.6.4.2. Being a Change Master

You can be the master of change rather than letting change be the master of you.

The following paragraphs are based on Change Masters by Rosabeth Moss Kanter.

Environment Affects Change.
Rosabeth Moss Kanter defines change as a "disruption of existing activities; a redirection of organizational energies." Change requires new agreements, tools for action—and the right environment.

Managers and employees cling to existing standards in a certain environment—Kanter refers to this change-resisting environment as *segmentalist*. Different departments of a given company are completely separate and compartmentalized. Managers try to downplay problems. If one department has a problem, the manager of that department tries to solve it alone. In a segmentalist company, a problem is divided into subproblems, each assigned to subunits. As a result, each department or subunit has only one goal and one piece of the problem. At this rate, the entire problem may never be solved.

Changes can flourish in a *integrative* environment. Managers and employers on all levels are more likely to work together in such an environment. Integrative conditions encourage fluidity of boundaries, the free flow of ideas, and the empowerment of people to act on new information. Subproblems are aggregated into larger ones to provide more insight. Integrative managers consider the whole before taking action.

Movers and shakers promote change—almost for change's sake. They like loose, rather than fixed, situations. They build off other changes, both negative and positive. So if you want to make a positive change, you can most easily do it when the environment or other parts of the company are changing, either for the better or the worse. The most difficult time to make a difference is when the company is at a status quo.

People Behind Change
People who innovate within an organization are *corporate entrepreneurs*. They test limits and create new possibilities for organizational action by pushing and directing the innovation process. They don't start businesses, but they do improve them. All corporate entrepreneurs have three sets of power skills to help them manage change effectively. The first set of skills is in persuading others to invest information, support, and resources in new initiatives. The second is the ability to manage the problems associated with the greater use of teams and employee participation. And the third is understanding how change is designed and constructed in an organization.

Power is intimately connected with the ability to produce; it is the capacity to mobilize people and resources to get things done. The three basic commodities of organizational power are: information, resources, and data.

Information gathering is the first step to change. The more available the sources, the better. A corporate entrepreneur can learn a lot by actively listening to information circulating the neighborhood. It's also beneficial for the entrepreneur to move outside established categories to get a variety of viewpoints. Multiple perspectives are key. The right information can open the door to resources and support.

When these sources of power are tapped, innovation can begin. A prototypical innovation, led by a corporate entrepreneur, has three identifiable waves of activity:

1) problem definition: acquisition and application of information to shape a feasible, focused project.

2) coalition building: development of a network of backers who agree to provide resources and/or support.

3) mobilization: the investment of the acquired resources, information, and support in the project itself.

Corporate entrepreneurs are visionaries, and their leadership depends on their ability to keep everyone's mind on the shared vision. They aren't dictators or solo artists. As the project progresses, entrepreneurs become more like politicians and public relations agents than technical experts. Their power comes by mobilizing others through one or more of the following methods:

1) persuading more than ordering

2) team building (frequent staff meetings, sharing information, etc.)

3) seeking input from others

4) showing political sensitivity (Know existing stakes in the issue; be considerate of other areas' needs. Their needs could be tied to your project and help sell it.)

5) willingness to share rewards and recognition

Once corporate entrepreneurs have gathered and focused information, they must use their intuition to take imaginative leaps into unknown territory. They must assume what's still uncertain in the minds of others is still possible. They must sell their solution project to the company.

The most salable projects will be:

1) trial-able: can be demonstrated on a pilot basis

2) reversible: allows the organization to go back to preproject status if it doesn't work

3) consistent with sunk costs: builds on prior resource commitments

4) concrete: tangible

5) familiar: consistent with a successful past experience

6) congruent: fits the organization's direction

7) with publicity value: visibility potential if it works

If these features aren't present, projects can still move ahead if they're either marginal (appear off-to the-sidelines so they can slip in) or idiosyncratic (can be accepted by a few people with power without requiring much additional support).

The Building Blocks of Change

Most companies handling change effectively go through a series of steps to reach their goals. Their change isn't global, but partial. They experiment, they research, and they move cautiously. Good managers know this and use it to their advantage. They have more time to gather information and build a successful strategy. A company's capacity to meet new challenges is increased when its managers follow the five major building blocks to productive corporate changes.

1) Departures from tradition. This may be purely accidental, or it may be driven by an

entrepreneur. Sometimes unusual or deviant events bring about "solutions looking for problems." Maybe there is no plan so the company innovates by default. In innovative, integrative companies, it's more likely the entrepreneurs will move beyond the job-as-given.

2) Crisis or galvanizing event. These may come from outside the organization—e.g., a lawsuit, a competitive new product introduction. But the events may be within an organization's borders—e.g., a new demand from a higher-level official, a change of technology. The event or crisis is demanding and requires a response.

3) Strategic decisions. This is the point where leaders enter, and strategies are developed to build new methods, products, and structures into official plans.

4) Individual "Prime Movers." No matter how brilliant a new strategy is, it has little chance of being carried out unless there's someone with power pushing it.

5) Action vehicles. The last critical force is making sure there are mechanisms to carry out the plan or strategy. Changes in training and communication are important. People need to learn how to use the new structure, method, or opportunity. Rewards must change to support new practices.

2.0. Building Management Tools

2.1. Approaches for Building Tools

2.1.1. MODELING—PIETER BRUEGEL.

2.1.2. The Data-To-Information Chain.

Since all management tools convert data to information, you follow much the same procedure and use similar tools, guides, and skills in building the tools .

As an industrial engineer, you'll likely be asked to produce a management tool, whether it be an organization structure or a management information system. To do so, you'll need three things: 1) existing tools and guides, 2) a procedure to tie tools and guides together and to build such a tool, and 3) the systems analysis skills to use the tools as methods and carry out the procedure. You'll either have the resources and the authority to build the tool within your domain or you'll have to contract out to have someone else build the tool for you. In either case, you'll want to be familiar with the needed procedure and skills.

We've seen the Management System Model (MSM). It shows us what our management system looks like and how it works. Once we've delimited a domain of responsibility, we can use the MSM to more clearly probe into what makes up that domain.

Any domain has management tools, although they may not be very sophisticated or structured. They may only be in the heads of a few people in the organization and not consistently or widely used. For example, the real organization structure (one of the management tools) may not be written down but instead in someone's head. The marketing plan may be in someone else's head. The plan really exists, but you have to ask the person who knows to find out what the marketing plan really is. Best of all, if you ask the right person, you'll get the most up-to-date version of it. However, it's hard to get everyone to sing off the same sheet of music if we have no sheets of music to sing off of. So, we opt to write down some version of the plan and let everyone read the same, albeit usually out of date, information.

The same thing is true with the data-to-information chain, or MIS (Management Information System). It may be in someone's head. The marketing *plan* is usually best found in one person's head, but the latest marketing *data* are in a whole bunch of people's heads, which is even more reason to write the data down. Where do we write them? On paper, the back of an envelope, in a notebook, on cards, in a computer, or wherever. You'll find some pretty primitive MIS out there.

Let's take a moment to recall what the MIS is. It's the data-to-information chain that routinely converts data to information. The data-to-information chain is special, and different from other management tools, because it most frequently and regularly acquires, stores, retrieves, and manipulates data to compare to reference points (biases) to make and display information.

Figure 2.1.2. shows the data-to-information chain and emphasizes the links we use to get data and step them through a routine process to provide information for decision making. Notice the parallel between this figure and the MSM. The operation is *what is managed*. I'll use those terms interchangeably. Management intelligence represents the *who manages*. The point of the figure is to show the details of one of the management tools in *what is used to manage*.

All the tools convert data into information. The one in Figure 2.1.2., the MIS, converts data frequently and routinely. Because of the amount of data, the frequency and speed we need to convert them, and the varying rates at which different data become out of date, we'll focus (l) on the steps (links of the chain) and substeps of the conversion process and (2) on the steps we use to figure out what tool to build and to design, build, implement, evaluate, and modify that tool.

Each link in the chain represents a type of technical expertise we need in building and operating an MIS. The links you see full-on represent things we have to build (emphasizing nouns) and the links you see on-side represent what we have to do with data or information (emphasizing verbs) to get to the storage or the programs, etc. As an industrial engineer, these links should intrigue you. You're trained to solve general problems like these. Shouldn't inventory analysis apply to data storage? We have fast and slow movers in data. Data also have shelf lives. Should materials management apply to acquiring and retrieving data? How about human factors and information portrayal?

For links of the data-to-information chain, I use terminology typical of MIS and especially computer-based MIS. I believe we could generalize these links and apply them, or groups of links or sublinks, to any type of management tool that converts data to information.

Whether in a primitive form, like someone's head, a clipboard, or a card file, or in a sophisticated form, like computerized data bases, we're sorely tempted to think most about how good a new MIS could be. We should really first think about how good the existing MIS is.

Put this firmly in your mind. When you look at a management tool, start by considering what's right with the existing tool, not what's wrong with it. Remember the manager, or user, has a management system. They may not be able to tell you about components and interfaces, but components and interfaces are there. And the management tools are there and they work (for better or worse) in relation to *who manages* and to *what is managed*. The tools are what they are for a reason and they match the interfaces about as well as can be done without anyone realizing the interfaces are there to be matched. So there's really more right with the tools in regard to the MSM than there is wrong. If you don't figure out what's right, you'll probably build a tool that fixes a lot of what was wrong with the old tool but does little of what was right with the old tool (neglecting dumb luck, of course). We call what you've built a failure.

So, we can figure out what we have in the domain of responsibility by using what we know about the MSM and the various ways we can characterize the management system (like the pursuits, endeavors, and so on). We also know we start by looking for what's right with the existing tools. But where are we to be when we build a new tool and how do we get there from here? (By the way, I've just stated the engineering method in its simplest form: know where you are, know where you want to be, and figure out how to get from here to there.) We can solve any problem by doing those three things. However we don't have to do the first two in that order. Also, it's hard to do the third without doing the first two. How many people try to do the third step too soon?

We can figure out where we want to be in designing management tools by using management system analysis (MSA) to logically figure out what data the management tools should be accessing based on what information those tools should be portraying to support decision-making. We can also use something called the automation objectives model I'll describe later.

What I'm going to do now is concentrate on a procedure to use for getting from here to there in management tool building. I'll talk about this procedure now for two reasons. First, books on MIS focus on such a procedure. Second, implementing the procedure requires a set of skills all industrial engineers should have. I want to focus much of this book on those skills. [By the way, industrial engineers should have these skills for building any kind of management tool. Remember plans, quantitative models, and the like convert data to information too. They're just not as repetitive, frequent, and routine as the MIS. For that matter, industrial engineers should have these skills for solving any problem—or better yet, for figuring out what problem they have to solve and then solving it.

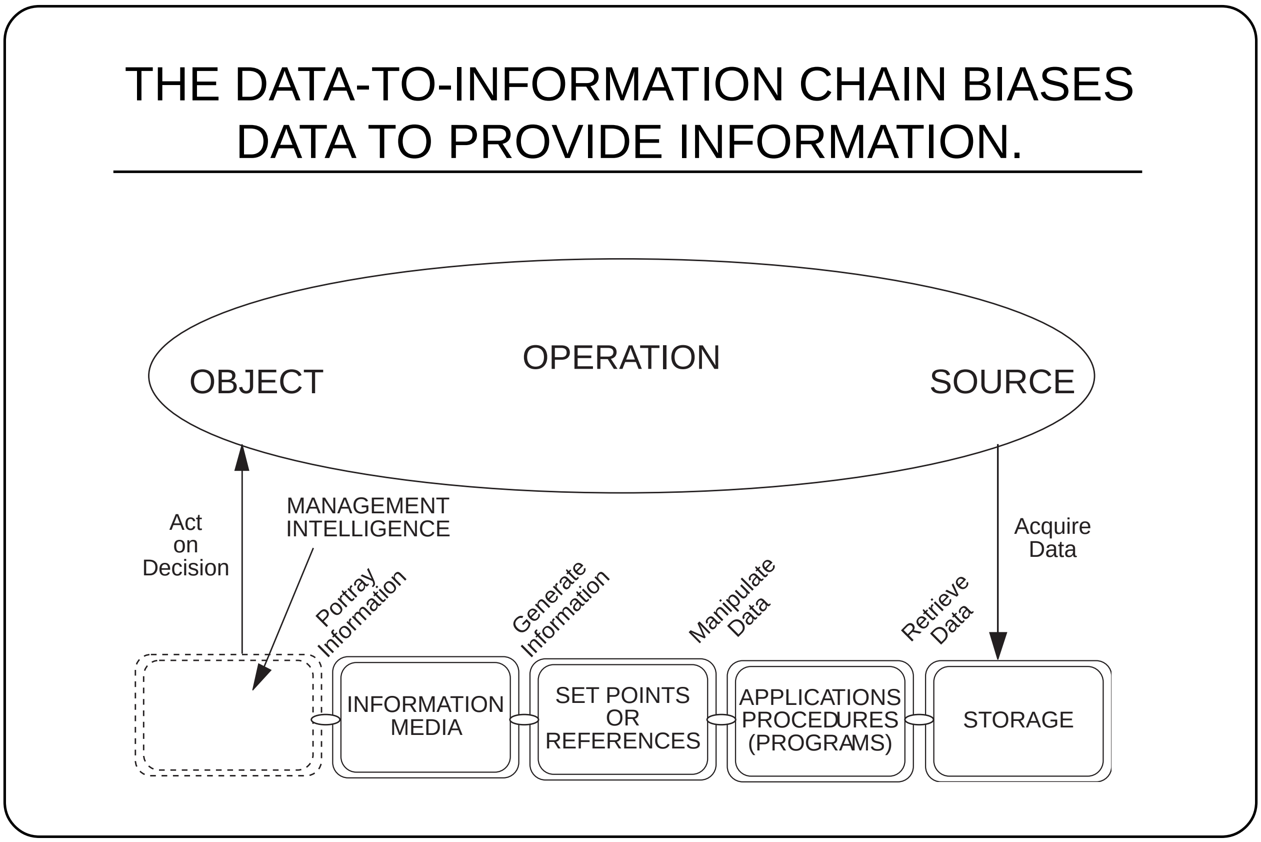

Figure 2.1.2. *The data-to-information chain biases data to provide information.*

2.0. BUILDING MANAGEMENT TOOLS

2.1. APPROACHES FOR BUILDING TOOLS

2.1.3. THE SYSTEM LIFE CYCLE

2.1.3.1. THE SYSTEM LIFE CYCLE

The steps and stages for developing any management tool flow logically.

The management tool building procedure is easier to outline and describe in terms of the MIS. So I'll focus on the MIS in this discussion. We can look at this procedure from many perspectives. Each perspective shows us something different. Figure 1.1.20.1.3. is a control-oriented view highlighting activities and decisions. Building an MIS is like building anything else—it's a project. Project management skills are needed—but more of that later. A control-oriented diagram is logical—call it a logic diagram**.** It shows decision points and branching. (Figure 1.1.20.1.3. is so general you don't see much branching; but, of course, each decision in the figure has more than one possible outcome.)

Figure 2.1.3.1. highlights the work flow in building an MIS. The process flow diagram in Figure 2.1.3.1. is similar to the logic diagram for the system life cycle in Figure 1.1.20.1.3. The process flow diagram neglects the decisions between the activities. Figure 1.1.20.1.3. emphasizes the logic in building a management tool and the frequent management input and decision needed in building the tool. Figure 2.1.3.1. emphasizes the value of prototypes the difference between the working MIS and the goal, and the universality of evaluation and documentation.

Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. focus on the process of building an MIS. They focus on the information and the information-conversion processes (for example, in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. the structured analysis process converts the feasibility document into structured specifications.) Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. emphasize information conversion processes in the rounded rectangles and information flows on the arrows. The processes in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. are the activities in Figure 1.1.20.1.3. We've talked about the different systems analysis tools of logic diagrams and information flow diagrams. Information flow charting, like what we see in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b., is especially suited for viewing what we want to do when we build a management tool or especially an MIS. You'll see a lot more about information flow charting in this course. That's another systems analysis skill.

Figures 1.1.20.1.3., 2.1.3., and 1.1.20.1.1.a. and 1.1.20.1.1.b. represent three ways of making pictorial representations of what we need to do to build a management tool. The logic diagram in Figure 1.1.20.1.3. looks at decision points, branching from decisions, and the actions getting us from one decision to the next. The work flow diagram in Figures 2.1.3.1. shows us the steps we take in an effort, the sequence of those steps, and the outcomes from the steps. The information flow diagram in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b. highlights the information flows and information conversion processes.

Engineers like pictorial representations because engineers think logically and in sequential steps and they're used to dealing with more tangible or quantitative presentations of their ideas and their results. You can use these three different pictorial representations for almost anything. In Figures 1.1.20.1.3., 2.1.3.1., and 1.1.20.1.1.a. and 1.1.20.1.1.b., we're looking at building the MIS. Later we'll use these three representations to look at the domain of responsibility of the user—a domain we're building the MIS to serve. As a matter of fact, that's exactly what we'll do in one of the early steps in the procedure for building the MIS. We'll do at least information flow diagrams for the domain we're building the MIS for.

Let's now look more closely at the steps of the procedure in Figure 2.1.3.1. we commonly use to build an MIS. The analysis steps and implementation steps are the responsibility of the manager using the resulting management tool. Also, they're historically the weakest steps, and probably the steps most responsible for the 70% failure rate in management information systems. Note that the manager plays a crucial role in building the management tool.

Two circumstances which lead to the high failure rate are (l) an inaccurate analysis of the management situation, usually from a failure to *follow-through* causes an inappropriate MIS design, and (2) an appropriate MIS is not *followed up*—monitored, maintained and enhanced to ensure an ongoing fit to the information requirements of management.

The first pitfall is avoided by careful attention to the analysis steps in the process flow diagram. Out of these steps will come a clear picture of management's information needs. Once these needs are accepted and documented, the situation should not be fought. In the military, we learn "don't fight the situation." Once you understand the situation for what it is, work with it—don't wish it away or assume the situation is something it isn't. This adage applies to management tool building—the MIS must be designed *to complement the situation.*

The second pitfall is avoided by insisting on a system *follow-up*. This is achieved by following up the implementation steps of the process flow diagram as shown in Figure 1.1.20.1.1.b.

The design steps are for the tool builder. The tool builder must be good at getting information from the user out of the analysis steps, putting that information into practice in the design steps, and then handing off the results to the user so the user can be successful in the implementation steps.

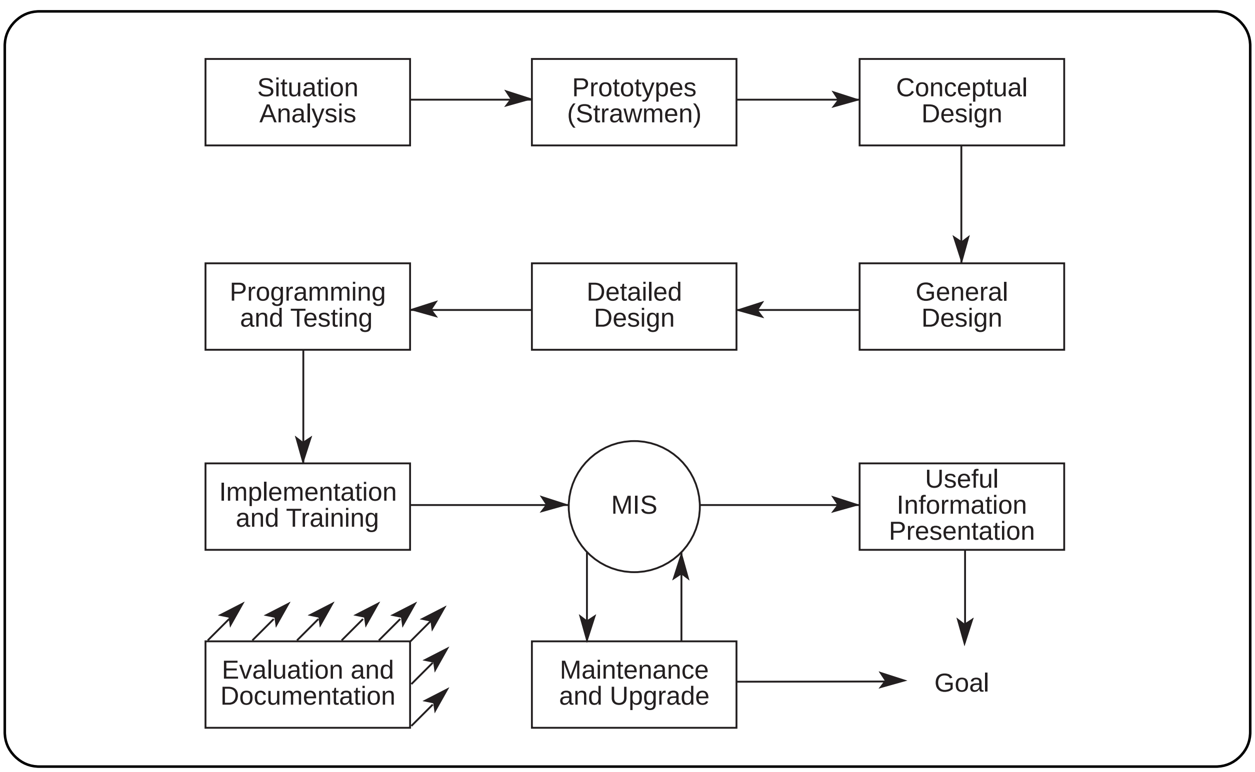

Figure 2.1.3.1. *The process flow diagram includes the user.*

2.1.3.2. An Overview of the Nine Steps

The nine steps in the system development life cycle highlight where you'll use your system analysis system.

Note the graphic portrayal of the Implementation Procedure Diagram in Figure 2.1.3.1. The first three steps, combining to form the Analysis Stage, yield a conceptual design which defines the objective(s), and serves as a monitor on system design. The Design Stage, which follows, requires special training and experience—it almost always includes the assistance of automation specialists.

The MIS is actually a complete system following the seventh step: Implementation and Training. The goal, however, hasn't been reached. The goal is to have an ongoing flow of appropriate action based on appropriate information. In terms of the Implementation Procedure Diagram, the goal is reached only after the system has been in place, been maintained and upgraded, and used to present useful information.

Two more steps, the eighth and ninth—Maintenance and Upgrade; and Useful Information Presentation—are probably the most overlooked. They are absolutely essential, however, to the success of the system.

The most difficult and the most important steps don't belong to one stage and don't follow one or several of the nine steps. These important steps are documentation and evaluation. We all have experience with computer systems, plans, time management techniques, and other tools we can't use very well because the documentation is poor. In these cases, we're concerned with user documentation. In truth, poor user documentation, operational problems in the system, and improper fit can usually be traced to poor documentation during one of the steps in the Implementation Procedure Diagram. A correct, clear, concise, comprehensive information requirements document resulting from the situation analysis step helps us ensure a good fit. Design documents at the several design steps help initiate operational problems. In short, we need documentation at each and every step in the Implementation Procedure Diagram. These documents are crucial for communication—communication between users and analysts and between analysts and tool builders.

Evaluation is probably the most neglected step of all. Many people don't like conducting evaluations because they don't like being evaluated themselves. Evaluation must start during the first step and continue throughout all the steps of the Implementation Procedure Diagram.

System development seldom proceeds in a purely sequential fashion. Once there is agreement on an integrated design of the overall system (following the Conceptual Design Step), the remaining steps are often applied incrementally to subsystems of that overall design.

With these considerations in mind, we can now turn to the nine steps of development in the Implementation Procedure Diagram.

2.1.3.3. The Analysis Stage

The analysis stage is most important because it's the foundation for the following stages.

Although the Implementation Procedure Diagram has the built-in dual-path feature, it is best understood by way of a close look at its individual steps, and the role those steps play in the three stages of systems development.

The first three steps of the Implementation Procedure Diagram comprise the Analysis Stage (Figure 2.1.3.1.). These steps are 1) Situation Analysis, 2) Prototype Development, and 3) Conceptual Design.

Situation Analysis is the most important step because it ensures the right approach to the right problem. Remember: once the situation is understood and management's needs are defined, the system must be built to cater to that situation. In other words, change the system before you change the situation. This step *belongs to the manager*—it is where the goals, strategies, and priorities of the system are defined.

This step is critical, so I'll divide it into seven substeps. These substeps are a) define the domain of responsibility; b) develop management issues, and define the *Critical Success Factors*; c) understand the existing system; d) determine information needs; e) uncover gaps and overlaps; f) prioritize needs in terms of consequence and immediacy; and g) identify the potential for creating prototypes.

The second substep defined above, the development of management issues, is much studied and reported; many methods are used for determining information needs.

Critical Success Factors (CSF)
These are factors which management deems necessary to the success of their organization. The most common CSF's would include cost structure, product quality and innovation, customer satisfaction, management development, and any change in corporate culture and attitudes. Note that four of these common CSF's are soft data—they are intangible entities which cannot be quantified.

In the third substep of Situation Analysis, you should evaluate existing management information capabilities. Many of these capabilities will find their way into the implemented design—in a much more integrated manner.

The second step in the Analysis Stage is Prototype Development. Prototypes (also referred to in Figure 2.1.3.1. as "strawmen") are small preliminary subsystems developed to meet immediate needs and allow critical feedback. Prototypes pay for themselves through immediate application; they pay again because they help clarify the architecture of the final system. Often a manager needs something concrete to look at; this step provides just that. This step is borrowed from the bottom-up approach to systems development; the other two analysis steps are taken from the top-down.

The third and final step in the Analysis Stage is the Conceptual Design. This step ensures that overall system requirements are considered before specific, narrow capabilities are developed. The necessities of the system are defined here: 1) the system goals; 2) the functions that must be performed to meet those goals; and 3) the information required to carry out those functions.

Following the completion of the Conceptual Design step, a document should be presented to management for approval and establishment of development priorities. This document might be called the Systems Concept Document. It should contain as much detail as possible—the tighter the specifications, the smaller the likelihood that the designed system will stray from them.

2.1.3.4. THE DESIGN STAGE

In the design stage you determine how you're going to meet the situation to satisfy the information requirements of the decision maker.

Steps four through six of the Implementation Procedure Diagram comprise the Design Stage. These steps are: 4) General Design, 5) Detailed Design, and 6) Programming and Testing. Generally, this stage is of least importance to the manager, since much of its execution will be carried out by automation specialists. As we emphasized before, tighter specifications in the Analysis Stage will make a big difference here. Still, a manager must understand the components of this stage, since its output will have a huge bearing on the final system.

The General Design step initiates the System Design Stage. With the system concept defined (and documented), General Design again focuses on user needs. Flow charts are developed to illustrate system processes (not computer processes, but the flow of activity—people's procedures and interfaces). I've defined user issues in a manner similar to that used for resolving management issues in the Situation Analysis step.

Later in the General Design step, important relationships between the subsystems must be determined. This holds true for both manual systems and automated systems. Inputs, outputs, and all files necessary to the system are identified here. System output formats are very important and historically have been neglected.

Following this, gross estimates of the size of the system have to be made. As a result of these estimates, and other management considerations, computer hardware and software needs are defined; most importantly, development priorities are established.

This design procedure focuses on information flows in and out of a mode. The General Design step results in a General System Specification (which, needless to say, ought to be a formal system document) which serves as the functional baseline against which system capabilities can be judged.

With the user requirements well established, the Detailed Design step focuses on the technical development of a system to meet those requirements. User-related processes are translated into specific programs with detailed performance and test specifications. Data bases are designed here and input and output formats are completed.

All technical issues must be identified and resolved in this step. Following this, computer hardware and software requirements are specific. The Detailed Design step results in the development of the Detailed System Specification, which will serve as the technical baseline for all ensuing development and implementation.

In the Programming and Testing step, computer resources are acquired, computer programs are written from the detailed design, and documented used procedures are developed and tested. Programs are prepared in accordance with approved standards and conventions. Unit tests must be performed here, and the operational data bases are loaded. Test plans and acceptance specifications are established in this step.

After establishing acceptance criteria, we conduct system and subsystem testing of both computer hardware and software. Successful execution of the Progamming and Testing step results in documented computer programs, programmers' guides, input screens, output formats, and documented test procedures and criteria.

In discussing the degin steps, I talked about data bases, input screens, hardware, and software. If the MIS is not computer-based, I'd talk about file cabinets, data gathering forms, rolodexes, and procedures for gathering, storing, and updating the data kept in the manual system.

2.1.3.5. The Implementation Stage

In the implementation stage you find out how well you meet the information requirements.

The final three steps (seven through nine) of the Implementation Procedure Diagram comprise the Implementation Stage. These steps are: 7) Implementation and Training; 8) Useful Information Presentation; and 9) Maintenance and Upgrade.

The Implementation and Training step is a transition to the new system. Users must be trained here, and the old equipment and procedures are replaced with the new. This step is accomplished through the integration of tested systems procedures and programs, documented human procedures, and trained people, into a cohesive people machine system.

User manuals and training sessions are designed in this step. Procedures are established to back up system use and protect the user against loss. Often, implementation is applied incrementally, to ensure proper integration before the entire system is activated.

The result of this step is an installed management information system, but the work is far from done—the following two steps are critical to the success of the system; historically they have been the most overlooked.

The Useful Information Presentation step takes into account a number of important considerations about the nature of information. Information is *biased data*; as such, it should be biased to meet the needs of the system user (in this case, the manager(s) who retested the system).

To satisfy the cognitive style of the user, the presentation of information must match information *portrayal* (whether it be graphic, table, checklist, or text) and *perception* (the value the user places on the data and information). The interface between information portrayal and perception is a critical point of resolution—the result should be that the manager is sufficiently comfortable and confident in the system to guarantee the system's integration into the decision-making process. As a tool builder, you should try to secure some sort of formal declaration of this confidence.

Although the system is now up, running, and used, the possible pitfalls are many. This is where the Maintenance and upgrade step comes in. To be useful for any length of time, the system must be continually upgraded to include any needed improvements as the user matures in using the system the manager's operation changes and evolves. Additionally, the system must be maintained to correct for bugs that surface through continued use.

Periodically, the system should be evaluated. This is usually a difficult process; nobody likes to be evaluated nor to have his or her system brought under scrutiny. Nonetheless, evaluations will ensure the system fits the changing needs of management, personnel, and any auxiliary organizations involved with the system. Additionally, a system operator should be designated, and the procedures for operation should be defined and documented.

The result of this final step, which actually continues through the life of the system (Figure 2.1.3.1.), is a system which works to meet its goal.

2.1.3.6. The Follow-Up Stage

A procedure is necessary but not sufficient.

The follow-up, emphasized so heavily through the steps in the Implementation Stage, is of paramount importance. Many systems fail because managers believe the work is over when the MIS is up and running—nothing could be further from the truth. The MIS, it must be remembered, is not equivalent to the goal.

By careful attention to the steps in the Implementation Procedure Diagram, you can make your MIS fall into the 30% success group. But management must be committed to its presentation and use. During the conceptualization activities, a manager should consider the desirable extend and sophistication of the system. This will ensure resources and commitment are sufficient to complete all the steps in the Implementation Procedure Diagram. And, of course, flexibility is also a key—a good smaller system is a better result than a sophisticated system failure.

The nine steps in the Implementation Procedure Diagram are needed for successful MIS development, but their completion does not guarantee a desired result. Since a manager must depend on MIS to give personal and crucial service, a comparable measure of energies must be given to the development and implementation of the system.

2.1.4. Classical Approaches and Their Hybrid Descent.

Use a dual path approach to implement the system development life cycle so you can make the most out of the advantages of both classical approaches.

Figures 1.1.20.1.3., 2.1.3., and 1.1.20.1.1.a. and 1.1.20.1.1.b. represent a hybrid of the two classical approaches to system development. Because of Figure 2.1.3.'s attention to conceptualization, emphasis on prototype development, and detailed implementation stage, it offers a hybrid approach to ensure the MIS meets the manager's information needs.

There are two classical approaches to system development. These are the evolutionary (or bottom-up) approach and the systems (or top-down) approach. The bottom-up approach came first and was primarily responsible for operational automation. The top-down approach came into the MIS world when computers began to be of use to higher levels of management.

The bottom-up approach states that the way to develop an overall system is to start with lower-level functions (such as file updating and transaction processing), and progress to more conceptual considerations (such as control and decision modules).

The advantages of the bottom-up approach are (l) it proceeds step-by-step, in accordance with demand; (2) it allows for early gratification with a preliminary product at little cost; (3) it builds on transaction processing; (4) it minimizes the risk of building a large-scale system which doesn't operate properly; (5) the overall probability of failure is reduced, because smaller, simpler systems are being worked with; and (6) there is less likelihood of developing an overly sophisticated system.

However, the bottom-up approach has as many disadvantages as it does advantages. The main disadvantages are (l) as management's needs change, system redesigns are frequent; (2) if one section of management decides not to be integrated into the system, the evolutionary process is halted; (3) data inconsistencies are more probable, once the system becomes more comprehensive; (4) priorities are not easy to define; (5) the suborganization needs of the final system will be loosely integrated; and (6) the hardware supporting the various functions may not integrate easily.

The top-down approach states that the way to develop an overall system is to start with the organizational goals and objectives (such as improve personnel assignment and increase sales by 20%) and progress to more practical considerations (such as payroll and sales projections). The top-down approach assumes the systems needed to provide information can be developed once the information needs of management are determined. The approach seeks to develop a model of information flow in the organization and to design the information system to suit this information flow.

The advantages of the top-down approach are (l) there is allowance for greater development flexibility; (2) higher management is quickly committed and involved; (3) the total organization is included in the design; (4) planning is done strategically, rather than on a strictly operational basis; (5) new data are easily integrated into the system, again because of the flexibility of the design; and (6) all the elements of the management system are considered.

There are a number of disadvantages to developing a management information system in this way; notably, (l) it’s difficult to derive the system plans from the objectives and activities of the organization; (2) it’s difficult to assign cost and value to the modules; (3) the order of module development isn’t necessarily related to organizational support or most potential use; (4) management loses faith when they don't see early results; and (5) there’s a terrifying risk of building an enormous system which doesn't work properly.

When evaluating the pros and cons of the two classical approaches, the tool builder and user must consider several considerations. You must balance risk and results. Will the results be small, periodic, and early? How clearly and correctly do you understand what the final system should do or will intermediate products provide helpful feedback? How tangible are the results, whether early or large, infrequent, and late? What's the risk of improper fit in terms of size, sophistication, and applicability of the system? What's the advocacy for the system? High-level? Fickle or solid? What are the needs for system integrity and integration? Is the first focus one of functional tasks or one of organizational objectives? How will the system evolve?

From the classical approaches, we’ve been and will continue to develop hybrids. The idea, of course, is to employ the best contributions from the two classical approaches. At Management Systems Laboratories, we call the hybrid approach a dual-path approach, to indicate that both bottom-up and top-down principles and activities are used to enhance the advantages, and neutralize the disadvantages, of each.

Figure 2.1.3. emphasizes the strict development of organization-wide system specifications through Situation Analysis, thus ensuring that a designed system will meet the needs and desires of all levels of management, from operational to strategic. At the same time, Figure 2.1.3. provides for early system prototypes, thus allowing the immediate gratification provided by the bottom-up approach.

Basically, the steps of Figure 2.1.3. allow the manager to plan from the top-down, and design from the bottom-up. Several smaller functions can be designed while the complete system is being planned.

We haven’t been able to use a dual-path approach for too many years. Ten years ago, the cost of programming and databases would have made it prohibitive. The modern relational database structures and other technical developments have relieved the constraints that kept the dual-path approach from being cost-effective.

2.0. Building Management Tools

2.1. Approaches for Building Tools

2.1.5. Analyzing Information Flow

2.1.5.1. DIAGRAMMING INFORMATION FLOW.

By diagramming the flow of information between conversion processes, we can get to the data elements we need about our work process.

Charting

Charting is a tool we use to help gather information, make sure it's complete, verify its accuracy, and communicate the ideas we've charted. We're familiar with many types of pictorial representations. As engineers, we draw parts we want machined. As managers, we chart our organization to see who reports to whom. Remember the pictorial representation, or chart, is only as good as the data it's based on. The chart can quickly get out of date, and the chart can be drawn from bad information (or data) in the first place.

Flow Diagramming

When we chart, or diagram, the flow of something, we're interested in identifying the steps in, or the flow of, a process and in showing precedence. We want to know what comes before (predecessor) and what comes after (successor). Since charts are two dimensional (or, at best, three dimensional), it's hard to completely capture a multidimensional situation like management. We pick what we want to show and develop a convention for how we chart things, so we can show what we want to show consistently. As long as we're consistent, any convention will do. By convention, I mean what symbols we use, how we number or name things, how various charts link together, and so on. How consistent we have to be depends on what we're going to do with the chart. Must the entire organization use the same convention in everyone's charting? How about everyone in the discipline (e.g., industrial engineering)?

In flow diagramming, we show something flowing into or out of a process. We can worry first about what flows (in our case, information) and later about what the flow goes into and out of or what happens to the flow inside the thing (in our case, information conversion processes) it goes into. Or we can worry first about the things that transform the flows (what they are and what they do) and later about what the flows are that are affected by the transformations. Whether we start with the flows or the transformations is a matter of preference; and, in some organizations, may be a convention. In information flow diagramming, some books discuss only one preference and the other books discuss only the other preference.

Flow diagrams also show sources (where flow comes into the picture from) and sinks (where the flow goes out of the picture to). (Remember, the terms sources and sinks come from heat transfer. Sources are where heat comes from. Sinks are where heat goes.) In addition, flow diagrams show accumulations (merging) of the flows and distributions (extracting) of the flows. Flow diagrams aren't logic diagrams. They aren't supposed to show branching, or choice. A flow diagram may show several pieces of information or multiple copies of the information coming into or out of a conversion process. The flow diagram won't show a decision determining what information is sent and won't convey the idea of following one path over the other based on the decision.

How to Use Flow Diagrams

Flow diagrams will help you improve your gathering information about the organization (or whatever) you're studying. You'll gather all kinds of bits and pieces of information. True understanding of what you're studying depends on your ability to put the bits and pieces together, and to do so correctly and completely.

A flow diagram helps you sort out the bits and pieces and to try to relate them to each other in different ways. You should find out what the flows or conversion processes are from the people who do the flows and processes and know them best. Then link them together by showing flows as arrows and conversion processes as circles or ovals. Now you have an integrated picture. Check to see if the person Fred said got a piece of information from him in turn said they got that information from Fred. Can you see what's going on? If not, you're probably missing something—or it's wrong. Is the information flow easy to understand? Does a portion of the flow not make sense to you? Now look at what you think is going on and see if you have any questions; then go ask more about what you're not sure of.

When you verify if you captured the ideas correctly or ask for more information, use the flow diagram. Show the diagram to the people you gathered the information from and see it makes sense to them. You may have problems with confusion between information about what the flows are or about what the people you're getting the information from would like the flows to be. You also may have a hard time getting several people to agree on any one version you show them. You'll have to decide when you know what's going on "well enough," and, at the right time, abandon your iterations in improving the flow diagram. Knowing when to abandon your iterations comes from experience.

Information Flow

Consider a domain of responsibility. Delimit that domain. Now draw an oval representing the boundary of the domain. Show information flows into and out of the domain by drawing arrows across the boundary. All information flows are shown as arrows. The arrows are like pipelines, and the information can flow back and forth. Many information flows are not one-directional. That is, in the transfer of the information, there is give-and-take between the sender and receiver. Usually, however, the flow is predominantly in one direction. You can show the dominant direction with an arrow head.

Let's focus on information-flow-type diagrams and develop some convention. Many books like to use the term data flow diagrams (DFD). I prefer information flow diagrams because information is what's transferred. Information, however, is made from data. The information portrayal format (the thing that moves, or flows) contains selected data elements.

Figure 2.1.5.1.a. shows the symbols we'll adopt as convention. The arrows are the information flows and the circles, or bubbles, are the information conversion processes, or the processing functions. These diagrams are sometimes called bubble diagrams. Sometimes a flow diagram can get quite large or have a lot of flows. To keep from getting too much on a page or from having a lot of crossed lines, we'll use small circles as transfer indicators. If an arrow goes to a small circle with a four in it, look for another small circle with a four in it and an arrow going away from the circle. These circles pictorially link the same information flow.

We show an organization *outside* our domain of responsibility that sends information to or receives information from our domain as a square. We often store information (and data). A three sided rectangle represents a file, or data store. Finally, we use the triangle to show merging and extracting information flows.

The Context Diagram

In Figure 2.1.5.1.b., I've shown the domain of responsibility for a human resource management department in the engineering division of a company. I've shown the domain as an oval and included only a few simple examples of the context of this domain. That is, I've shown just a few of the information flows into and out of the department and the external entities related to those flows.

The diagram in Figure 2.1.5.1.b. is called a context diagram because it places the domain in context with its environment. Notice that the diagram doesn't include arrows between any two of the external entities—because we're not concerned with information passed between them. These information flows aren't in our domain of responsibility. Sometimes, we don't show what the information flows are in a context diagram. (We don't label the arrows.) Then, we're usually trying to delimit our domain. Sometimes we do label the arrows. Then, we're using the context diagram as a first step in information flow diagramming.

Also take note that all arrows either *come from* an external entity or *go to* one; there are no arrows going away from the system into thin air or coming from thin air. This representation is accurate because, in real life, all information sent out of a system has to go somewhere—it doesn't vanish. And conversely, information coming into the system has to come from somewhere—it doesn't just appear on your doorstep. Some authors don't include boxes for some external entities because they feel some entities are so well known, they're obvious. For clarity, I prefer to include all external entities you can think of.

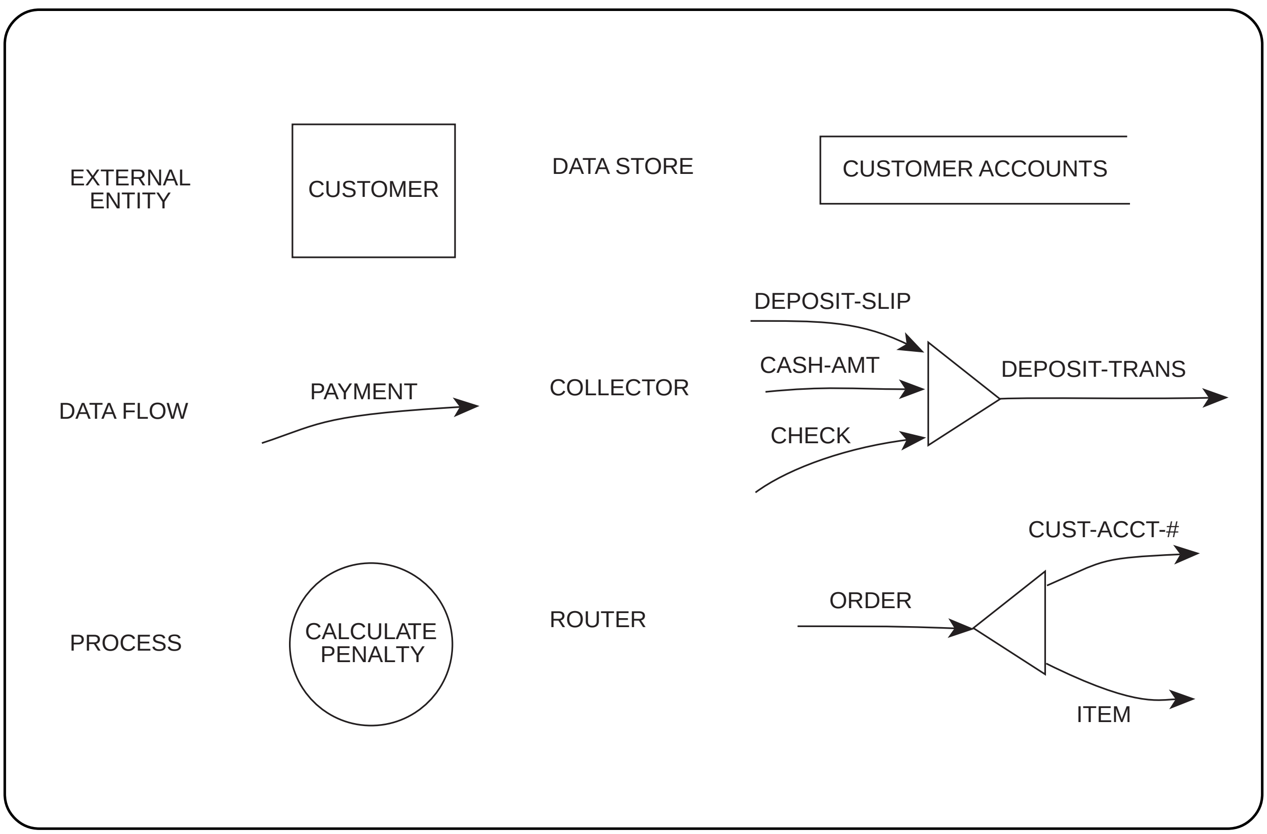

Figure 2.1.5.1.a. *Data flow diagram symbols and meanings. (adapted from Powers, Adams, & Mills, p. 258)*

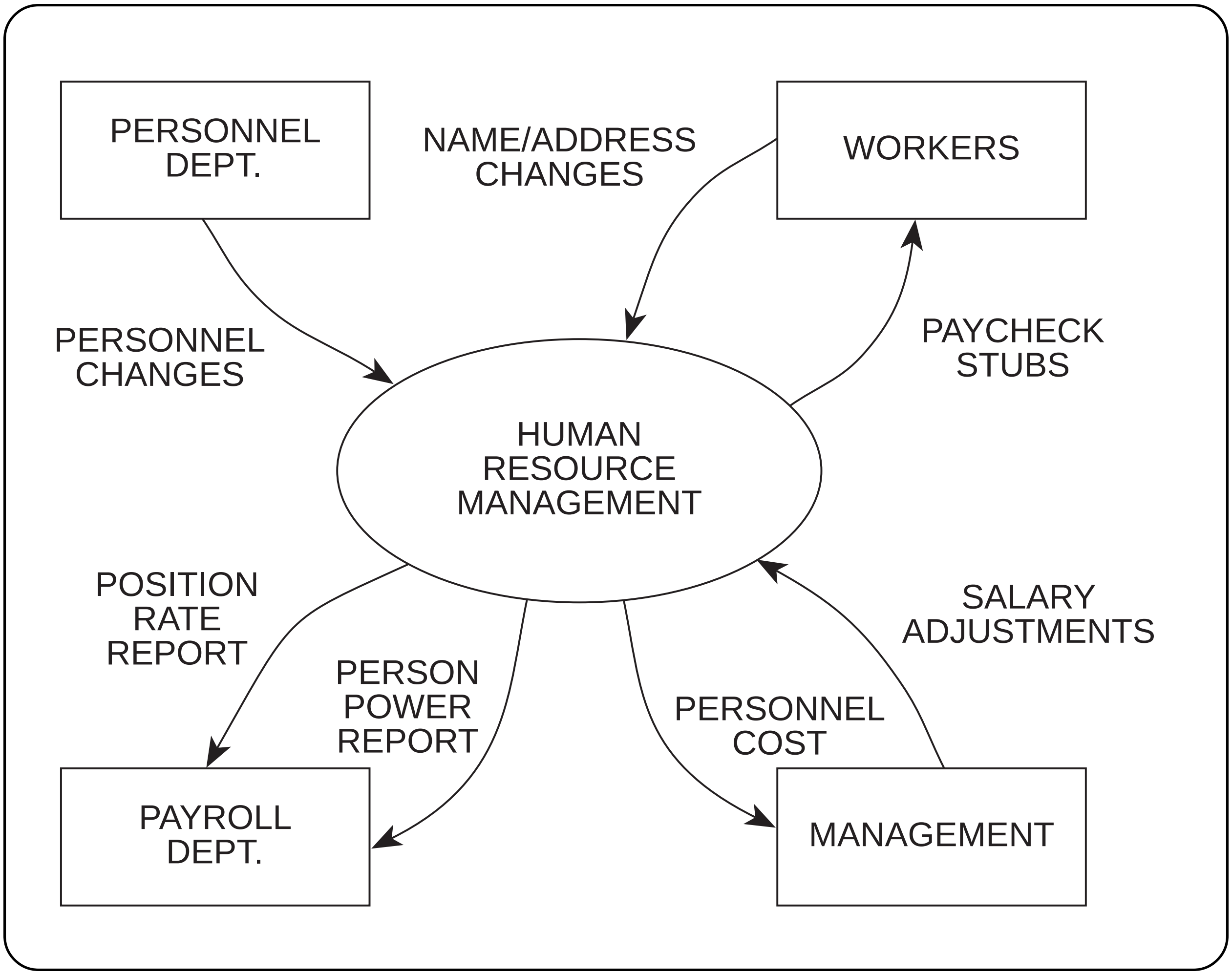

Figure 2.1.5.1.b. *An example context diagram shows the domain in relation to its environment.*

2.1.5.2. Different Levels of Data Flow Diagrams.

By continually partitioning a conversion process, you can develop information flows to the detail you need to identify all data elements.

Partitioning

After you've created a context diagram for the system, your next step is to think about the information flows *within* the system. But since there are so many flows inside the domain, you must break down, or *partition*, the domain into subdomains so you can track the information flow in greater detail. This partitioning involves creating an information flow diagram for each of the subdomains. I'll call these level-1 diagrams. You'll continue partitioning each process, and thereby create new sublevels, until you have a suitable representation of all the information flows. Each of the subdomains will bear the number of the higher level from which it came plus an additional digit for the current level. (See Figure 2.1.5.2.a.) Just remember: processes have 1 digit at level-1, 2 at level-2, and so on.

To sum up the system levels, understand that there is only one context diagram, one level-1 diagram (processes numbered like 1, 2...), several level-2 diagrams (1.1, 1.2...), and many more level-3 diagrams (1.1.1, 1.1.2...), for however many levels you need to capture all information flows. See Figures 2.1.5.1.b., 2.1.5.2.b., and 2.1.5.2.c. to help you visualize the levels of diagrams .

Figures 2.1.5.1.b., 2.1.5.2.b., and 2.1.5.2.c. all refer to the same domain. Figure 2.1.5.1.b. is the context diagram. Figure 2.1.5.2.b. is the level-1 diagram showing the human resource management department partitioned into four major parts. This division was made by function. We can divide, or partition, the domain many different ways. The important thing here is all the subdomains must total the entire domain.

One common way to partition is by functions. Other ways include partitioning by process steps, by customer types, by vendors, by product, and by geography.

Figure 2.1.5.2.c. is the level-2 diagram (two digits identify the sub-subdomains). Figure 2.1.5.2.c. is the domain of the person responsible for computing pay. The number 2 and 4 domains are outside the domain of computing pay but part of the human resource management domain. In Figure 2.1.5.2.c., these domains are shown as external entities and identified by the numbers of the conversion processes in Figure 2.1.5.2.b.

We can adopt the convention that entities external to the subdomain but internal to the domain are identified by their number. If one of the information flows from outside the larger domain had flowed into the computer pay process (Notice from Figure 2.1.5.2.b., none do.), we would show that in Figure 2.1.5.2.c. as a square with the name of the external entity written in it.

I'll recap our partitioning discussion. We begin with our entire domain of responsibility as a context diagram. Remember that since the domain is a management *system*, it's already part of a larger system. We divide, or partition, the domain into subdomains. We can partition any number of ways. We choose the way that helps us the most. I chose the way the book I took the figure from did it. We partition the domain into subdomains. If our original domain is large enough and we partition the domain like the organization chart is structured, each subdomain is someone's domain of responsibility.

We can further partition each subdomain into logical parts—all adding up to the whole. And we can partition any or all of those parts, or subdomains, into their parts, or sub-subdomains. We continue doing this until we've identified every information flow and information conversion process in the original domain. We'll end up with many information flows. And each information flow has many data elements in it. *It's the data elements that the MIS developer wants to identify so he or she can figure out ways to acquire, store, retrieve, and manipulate those data.*

When you try to do a data flow diagram (DFD) or information flow diagram and start with a blank sheet of paper, what do you do? One book (Yourdon) says you should draw in the information flows and then look at the flows going into or out of a process to figure out what the process is and to name it. For example, in Figure 2.1.5.2.b., if a valid transaction flows in and a sorted transaction flows out, the conversion process is the "sort transaction" process. Another book (Powers, Adams, and Mills) suggests starting with the process bubbles and then figure out what the flows are. I've tried both and usually end up doing it the Powers, Adams, and Mills way. Maybe what a person chooses to do depends on personality type.

To give you another look at partitioned DFDs, review Figures 2.1.5.2.d., 2.1.5.2.e., 2.1.5.2.f., and 2.1.5.2.g.. Figure 2.1.5.2.d. is the context diagram for the domain of responsibility called APT (Astro-Pony Toutshops) which is, from what I can tell, a bookie. Figure 2.1.5.2.e. is the level-1 diagram for APT. APT also has been partitioned by function. You'll notice this looks more like the second level of APT's organization chart. Look at the external entities on the level-2 diagrams. Use the external entities to find inconsistencies and, therefore, potential problems.

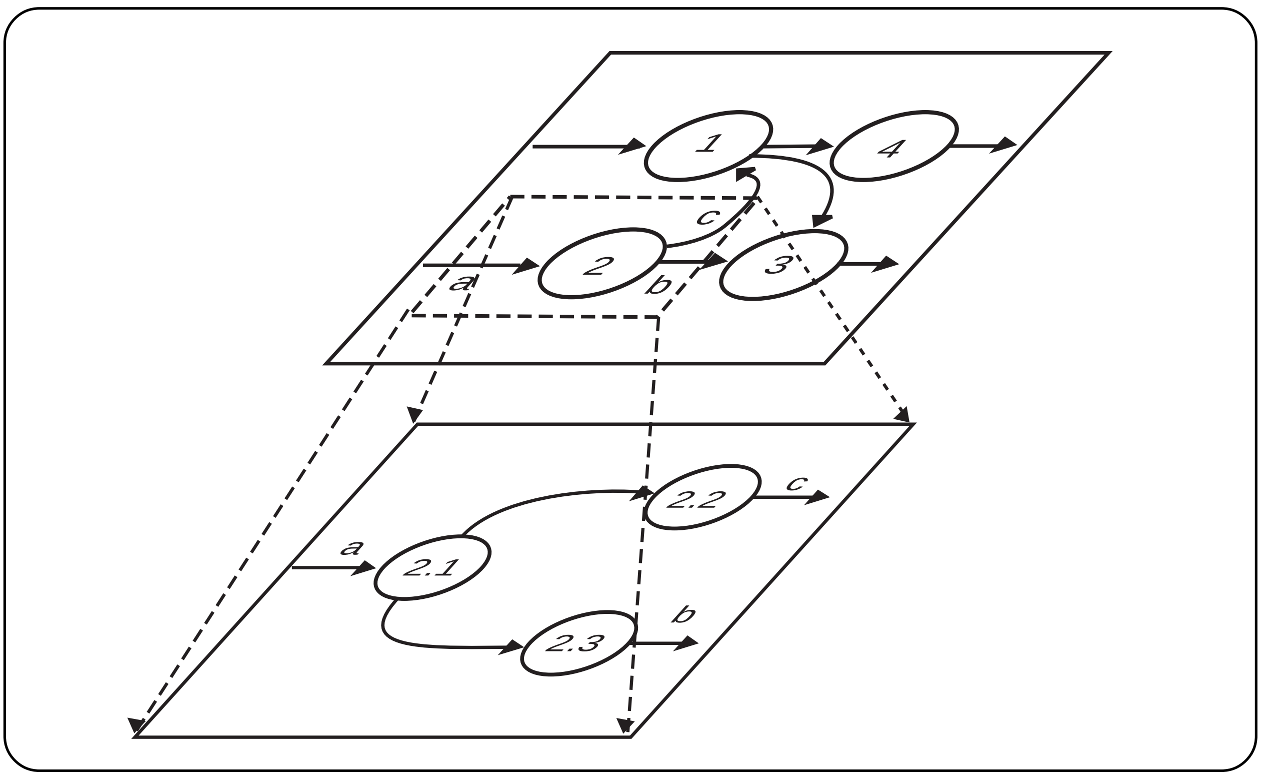

Figure 2.1.5.2.a. *We can partition domains into subdomains, subdomains into sub-subdomains, etc. (adapted from deMarco, p.72)*

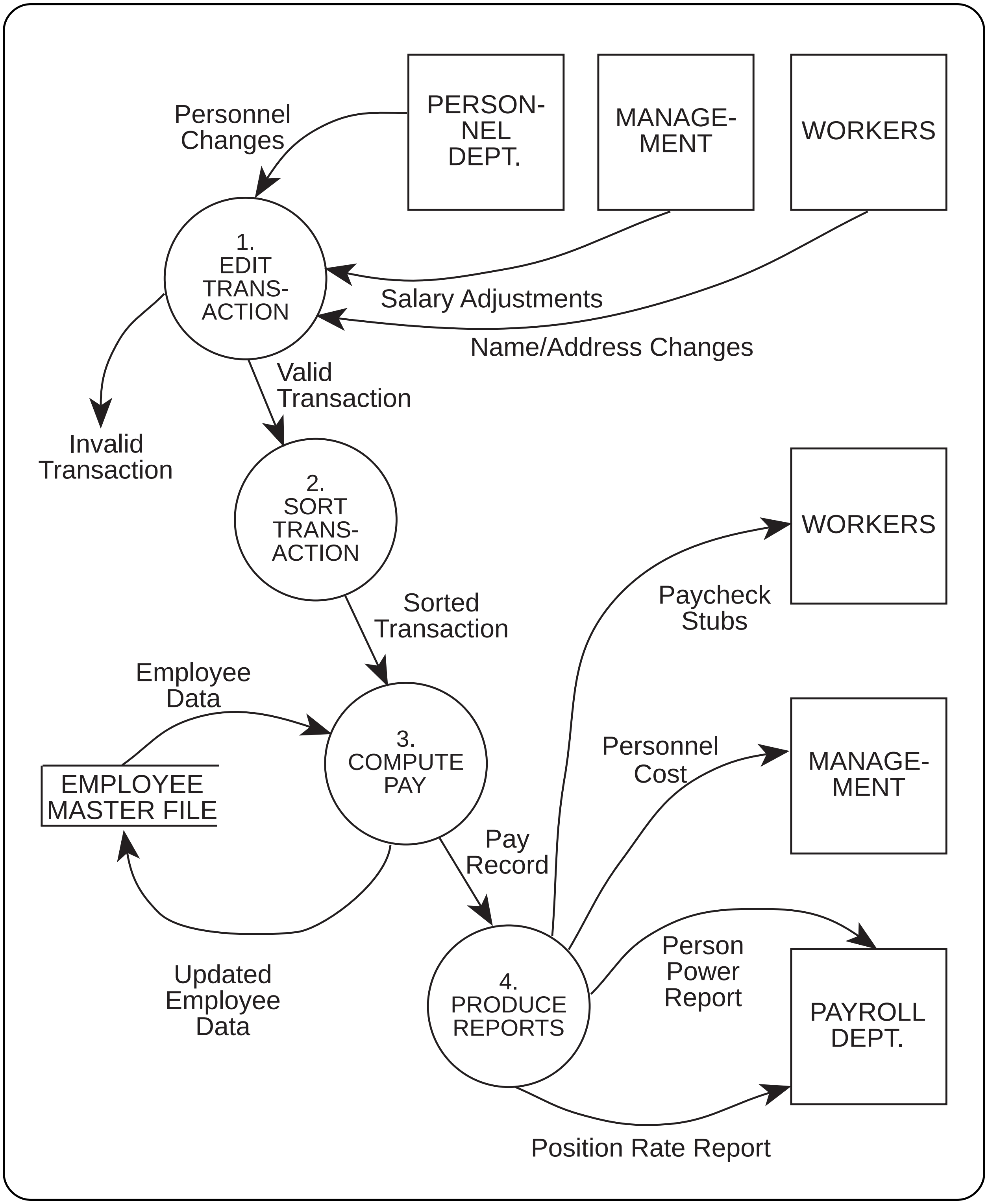

Figure 2.1.5.2.b. *An overview data flow diagram. (adapted from Yourdon, p.13)*

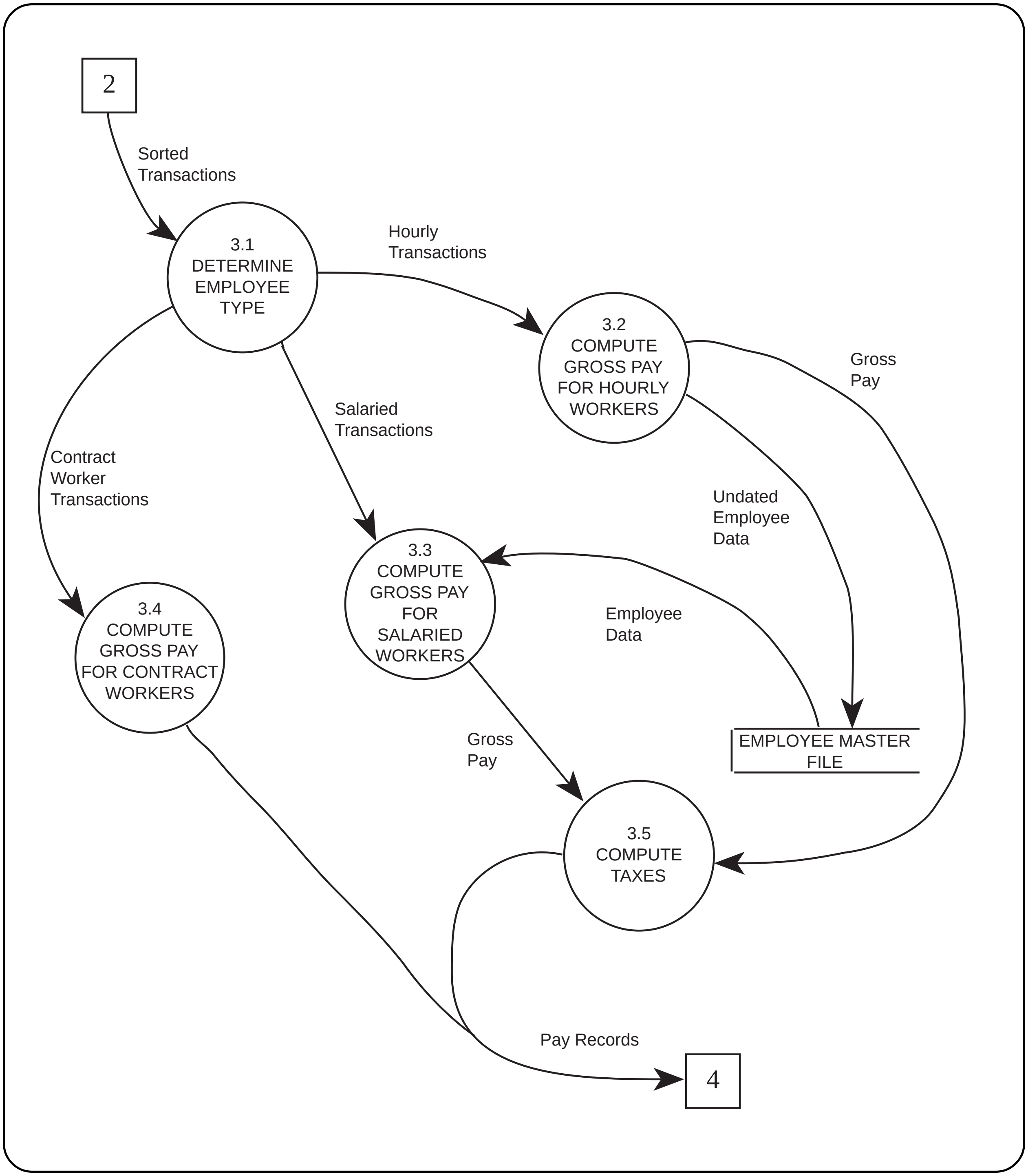

Figure 2.1.5.2.c. *A detailed data flow diagram. (adapted from Yourdon, p.14)*

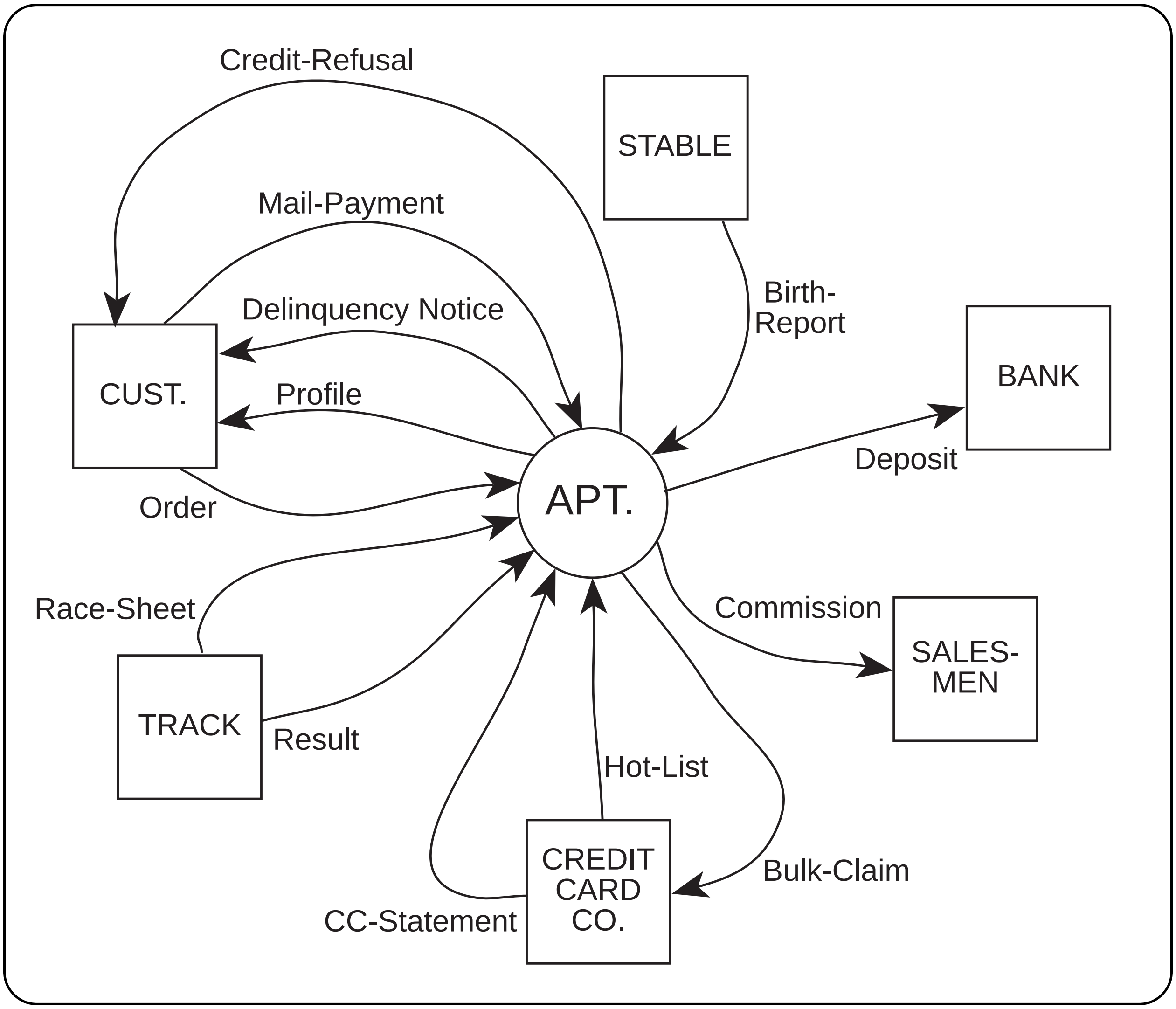

Figure 2.1.5.2.d. *Example context diagram. (adapted from deMarco. p.90)*

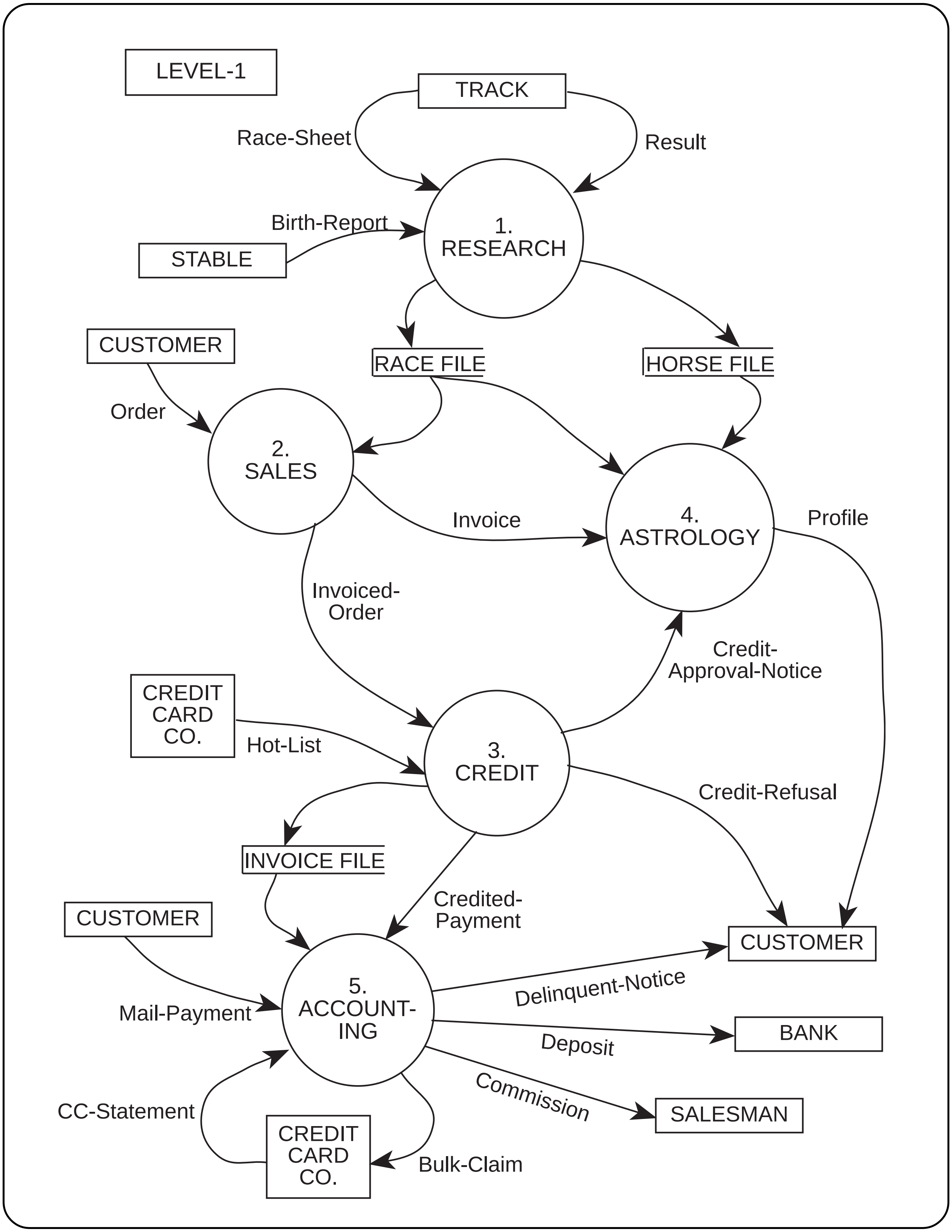

Figure 2.1.5.2.e. *Level-1 Data Flow Diagram. (adapted from deMarco, p. 92)*

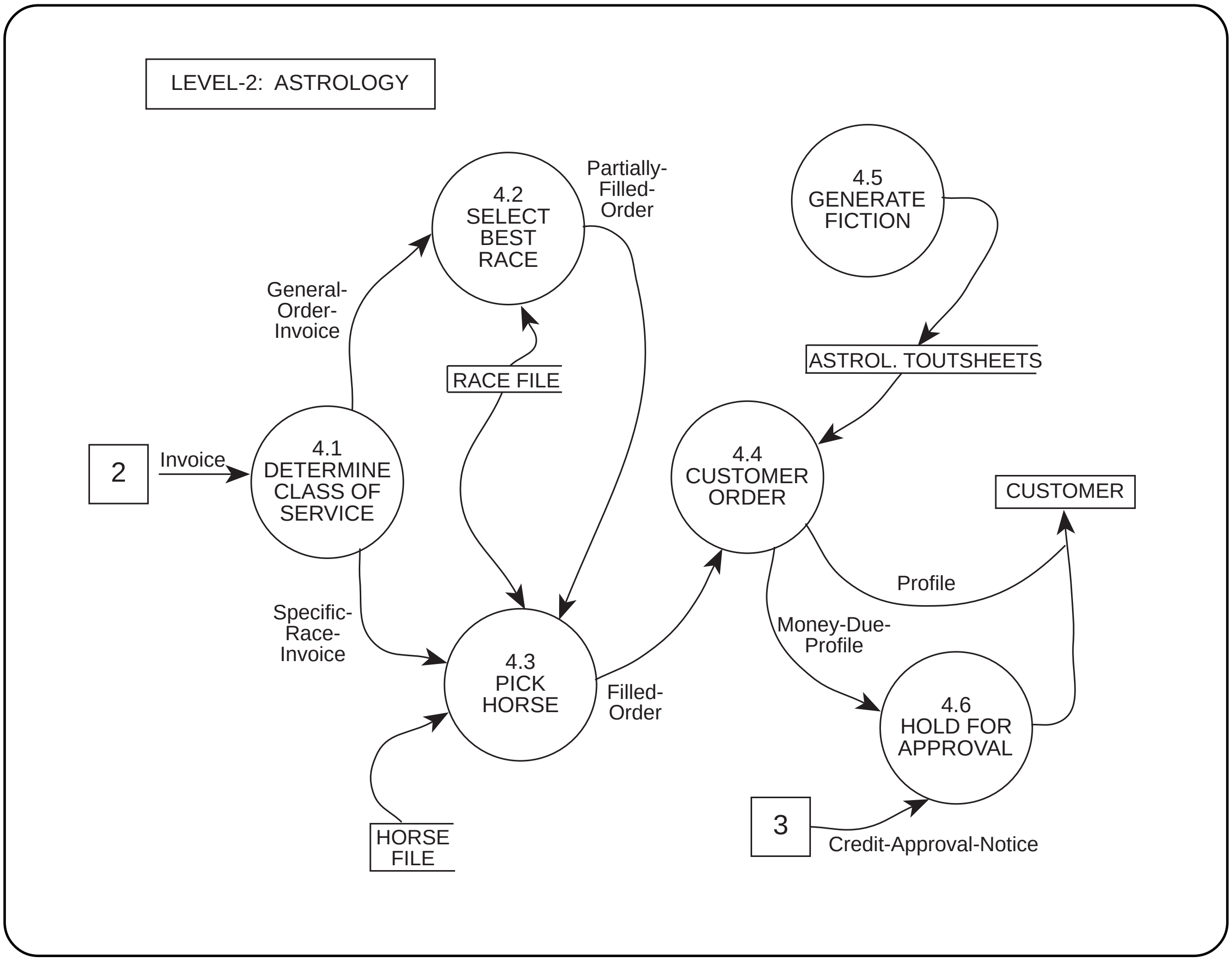

Figure 2.1.5.2.f. *Level-2 Data Flow Diagram. (adapted from deMarco, p.97)*

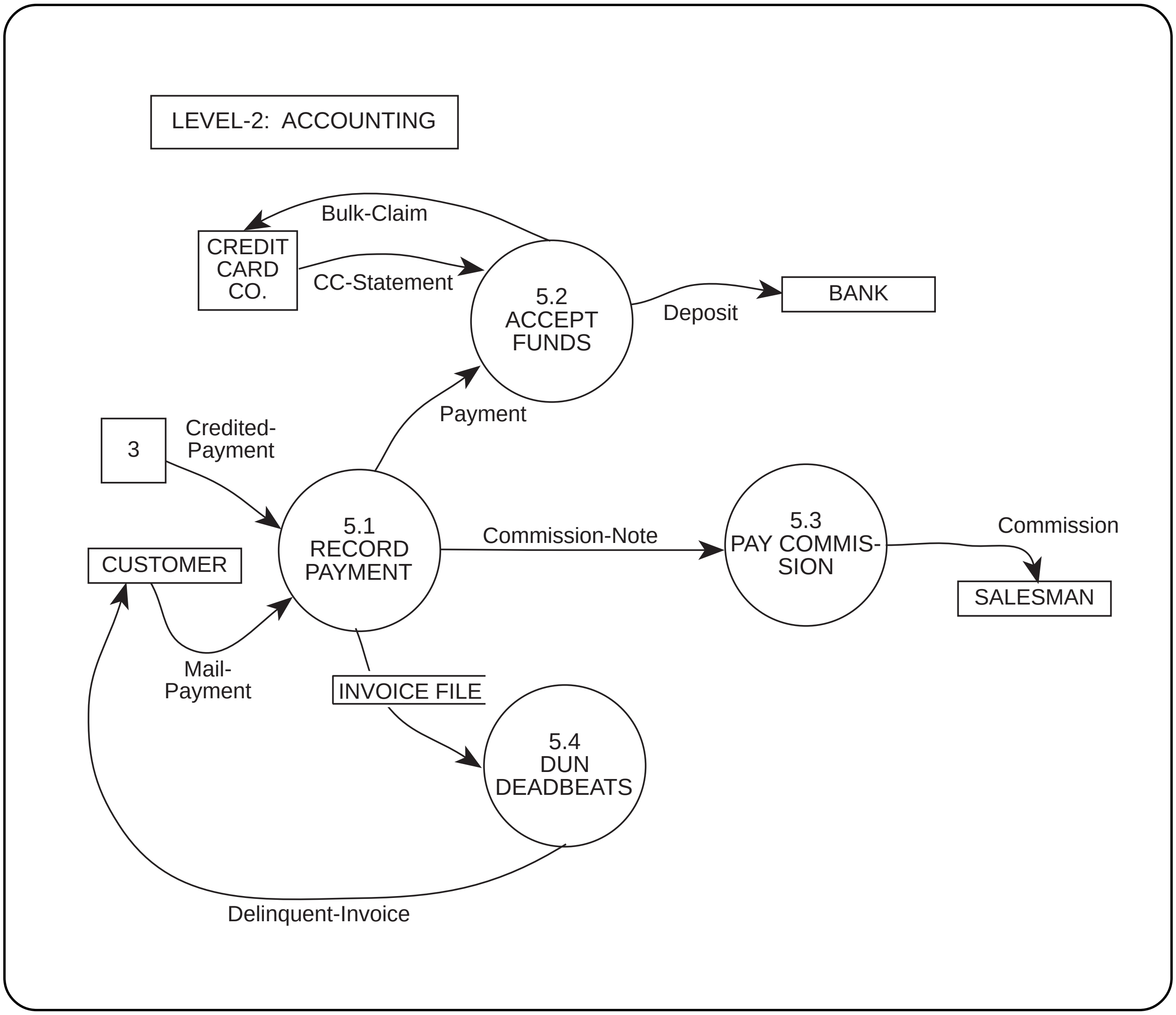

Figure 2.1.5.2.g. *Level-2 Data Flow Diagram. (adapted from deMarco, p.101)*

2.1.5.3. Physical Versus Logical Diagrams

Physical information flow diagrams are best for gathering and verifying information; and logical information flow diagrams are best for communicating with automation specialists.

The next major consideration in information flow diagramming is that there are two ways to chart information flow on an information flow diagram. These ways are physical and logical. Physical models focus on how a job gets done: the physical means such as documents, people and forms. Logical models represent what the system does and concentrate on the data and the underlying process used to manipulate the data. Look at Figures 2.1.5.3.a. and 2.1.5.3.b. Figure 2.1.5.3.a. shows a report flowing in a physical model. Figure 2.1.5.3.b. shows what happens to the same report in a logical model. Figure 2.1.5.3.c. summarizes the key differences between physical and logical models.

The physical model shows how the information progresses sequentially through a system. (See Figure 2.1.5.3.a.) Logical models, however, show that a piece of information can be acted on by more than one process at any one time—in a parallel fashion. (Refer to Figure 2.1.5.3.b.)

Physical models are good for making sure you've captured the information flows and the communication into, out of, and within a system. They're also easier to understand by a relative novice. He or she can look at the physical model and see department names or people and grasp what's going on in the domain of the diagram. However, sometimes on physical models, items that flow into or out of a process may not be logical—they actually occur, of course, but it's not always clear why. Logical models are better because they make clear the reasons why something flows in or out; they're good for automation and mechanization of a process.

The logical model's drawback is that it is not readily understood by the average person. The symbols may be too complex.

Use the characteristics in Figure 2.1.5.3.c. to compare Figures 2.1.5.3.d. and 2.1.5.3.e. You can see an additional convention in Figure 2.1.5.3.e. The book from which I got the figure uses a single slash in the lower left-hand corner of an external entity to show that entity is repeated on the diagram. They repeat the student external entity because they don't want to draw such a long arrow from the external entity to wherever it's going. It's a matter of making the diagram look pretty.

Much of information flow diagramming is convention; that is, the symbols and other techniques vary from author to author. Each has his or her own preferences. I'm not saying here you should adopt my conventions; I just want you to be able to look at anyone's information flow diagram and understand it. Remember that a convention must be used *consistently* within a work to maintain clarity.

You can look at yet another example of physical and logical information flow diagrams. In Figure 2.1.5.3.f., you see a fairly cluttered physical DFD. This one is more typical. Notice how well you could use this diagram with the people you're gathering information from to see if you've captured what's going on. The symbols are simple. I advise drawing the external entities on the diagram, so you can verify them too.

In this case, you can see an intermediate step to converting physical DFD's to logical ones. Figure 2.1.5.3.g. is that intermediate step. The names have been dropped and the processes are more information conversion. Notice on Figure 2.1.5.3.f. that Jerry must have several duties and different kinds of documents come across his desk. Offices are like that. Often there's no rhyme or reason for the combination of things a person has to deal with. Figure 2.1.5.3.g. is still physical but a whole lot more logical.

Figure 2.1.5.3.h. is the logicalized DFD. Now we're ready to talk to the computer programmers. We've analyzed the situation and put what we've learned into terms an automation specialist can work with.

It takes some getting used to be able to capture the data, make physical DFD's, find errors and inconsistencies, review the information with the managers in the domain, convert to logical DFD's, and communicate with the automation specialists. For this book, I don't expect you to be able to do all this, but I do want you to be familiar with the concepts, the differences in convention, the differences between physical and logical diagrams, and the usefulness of the DFD's. I'll talk more about DFD's when we study system modeling. DFD's aren't the only tool we have to capture information about how an organization uses its information.

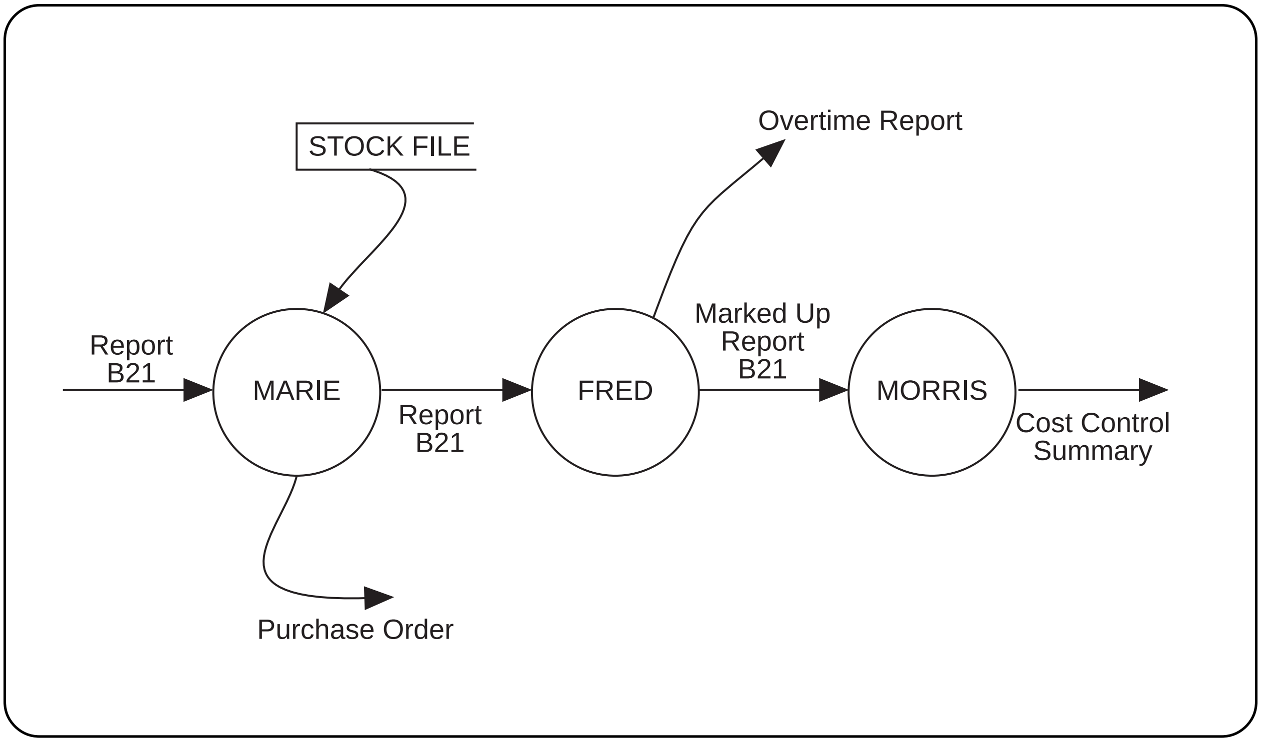

Figure 2.1.5.3.a. *Example physical model. (adapted from deMarco, p.29)*

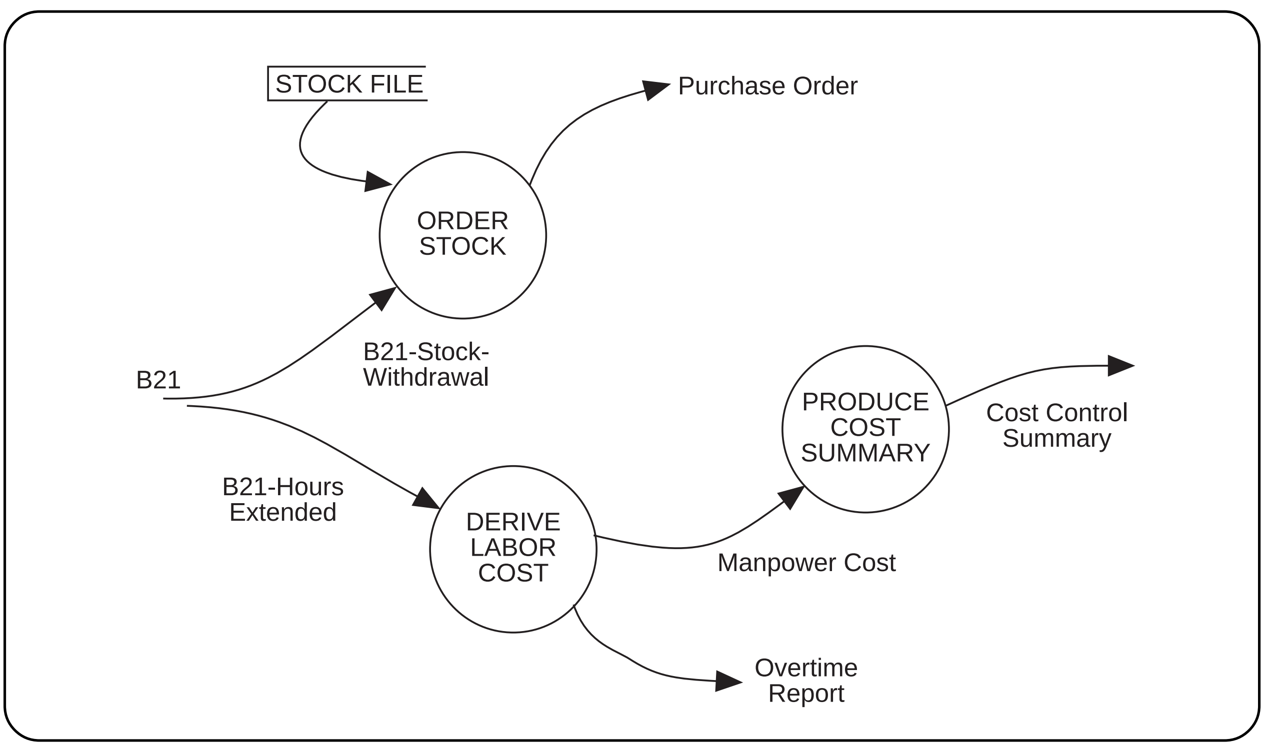

Figure 2.1.5.3.b. *Example logical model. (adapted from deMarco, p.29)*

MAJOR CHARACTERISTICS OF MODELS

	Physical	**Logical**
Viewpoint	How procesing is done	What the system does
Processes	Sequential	Often parallel
Names	Documents, people, forms	Underlying data and processes
Data Flows	Excess (tramp) data	Only data used or produced by the process
Controls	Includes controls for crossing man-machine boundaries	Limited to essential business controls

Figure 2.1.5.3.c. *Summary of key differences between physical and logical models. (adapted from Powers, Adams, & Mills, p.161)*

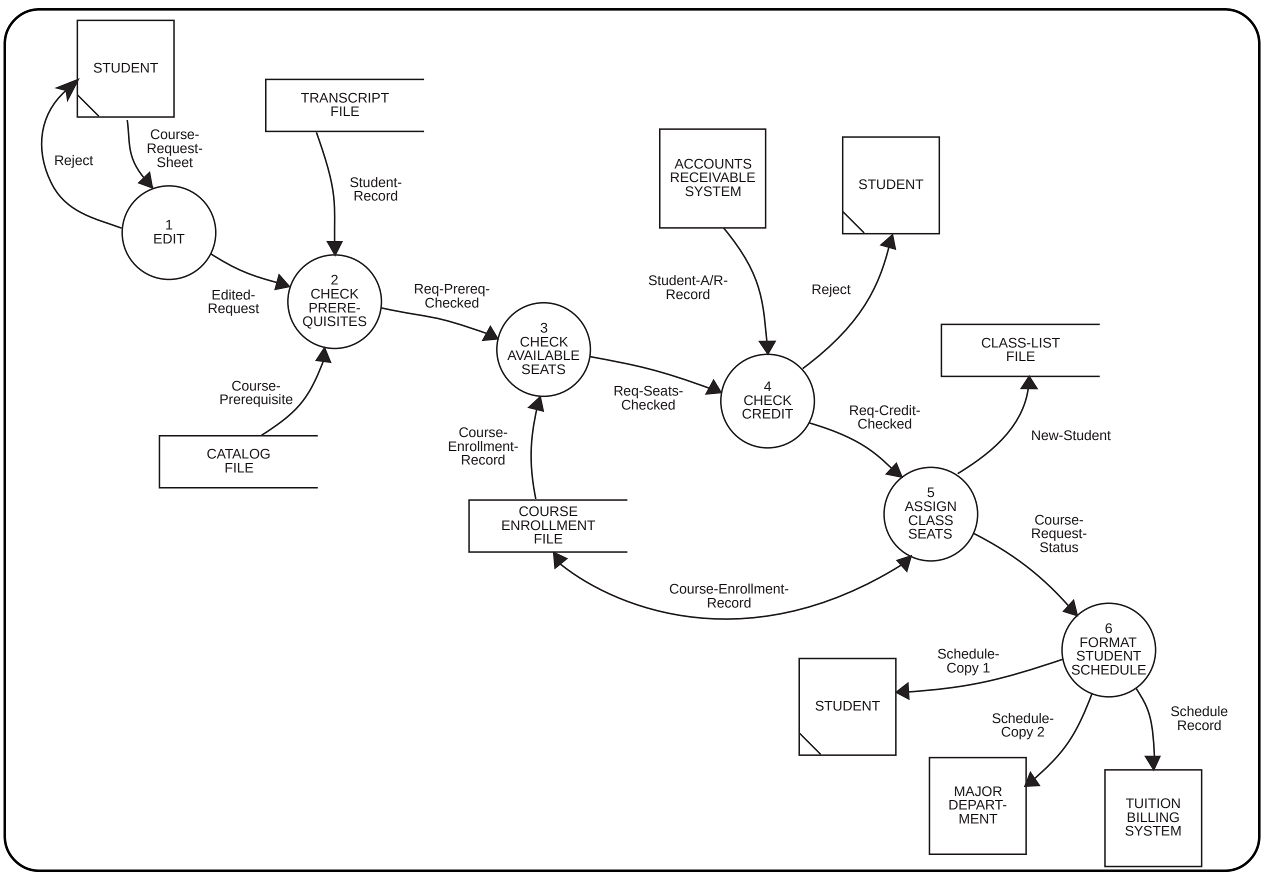

Figure 2.1.5.3.d. *Data flow diagram that emphasizes physical characteristics of a student registration system. (adpated from Powers, Adams, & Mills, p.162)*

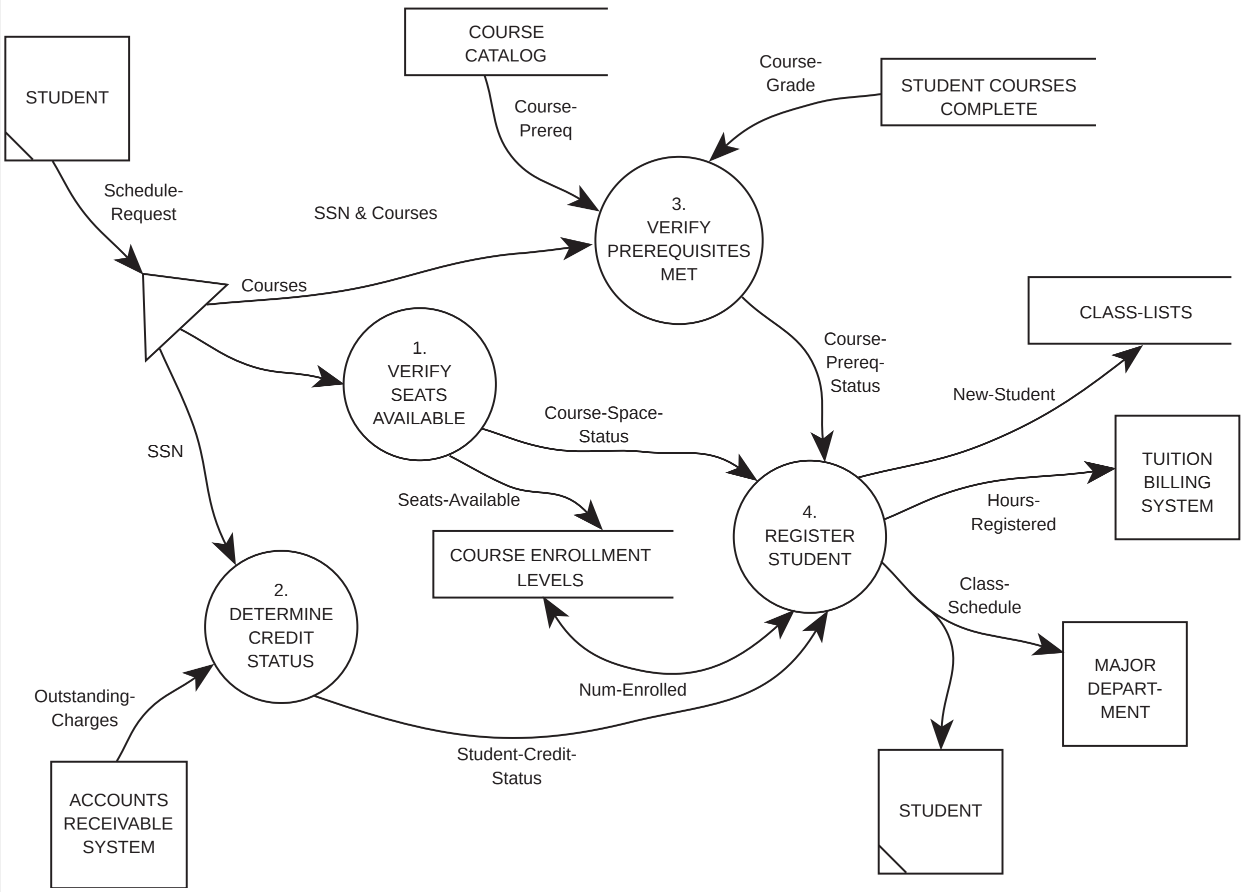

Figure 2.1.5.3.e. *Data flow diagram that emphasizes logical characteristics of a student registration system. (adapted from Powers, Adams, & Mills, p. 163)*

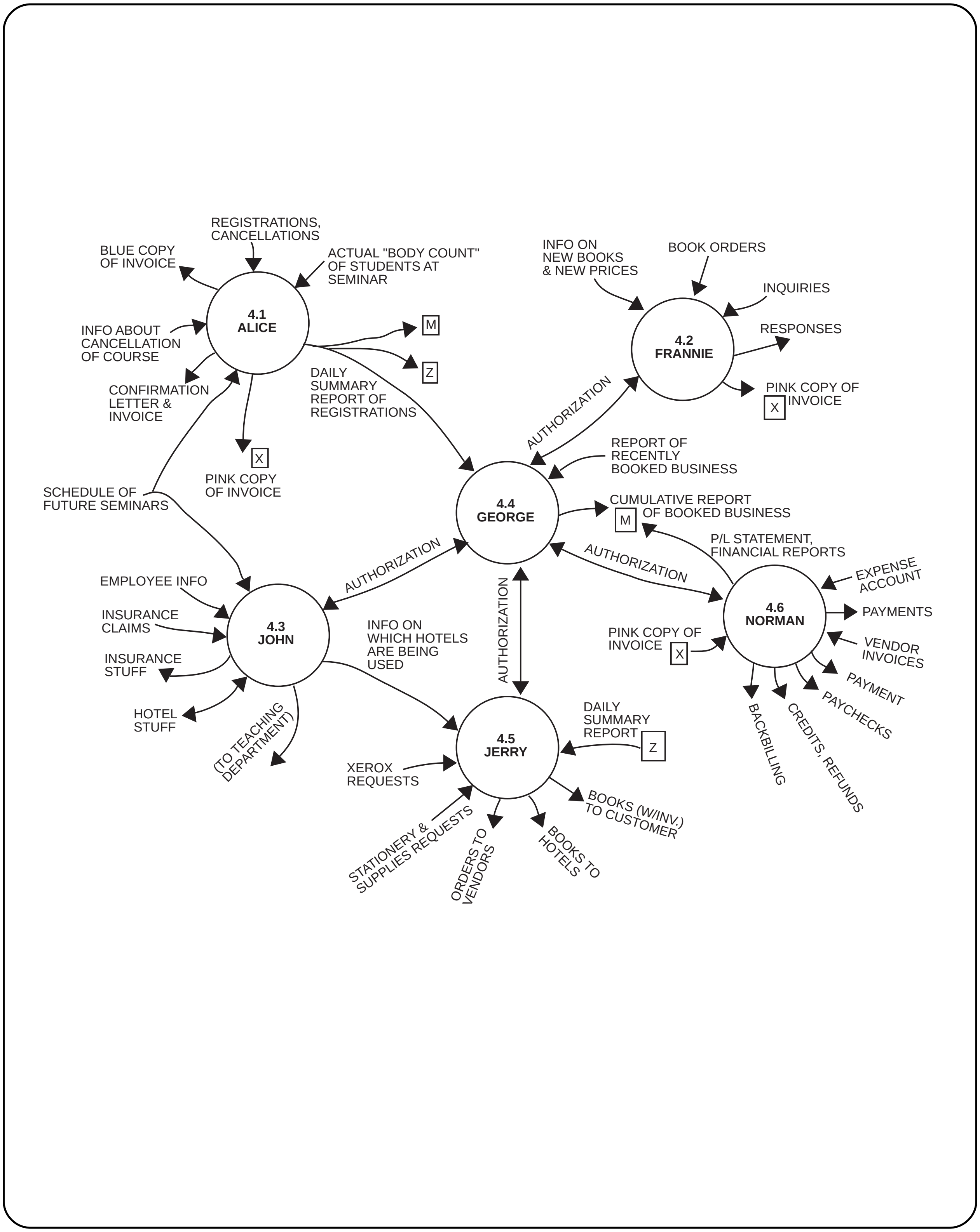

Figure 2.1.5.3.f. *Current physical DFD. (adapted from Yourdon, p. 67)*

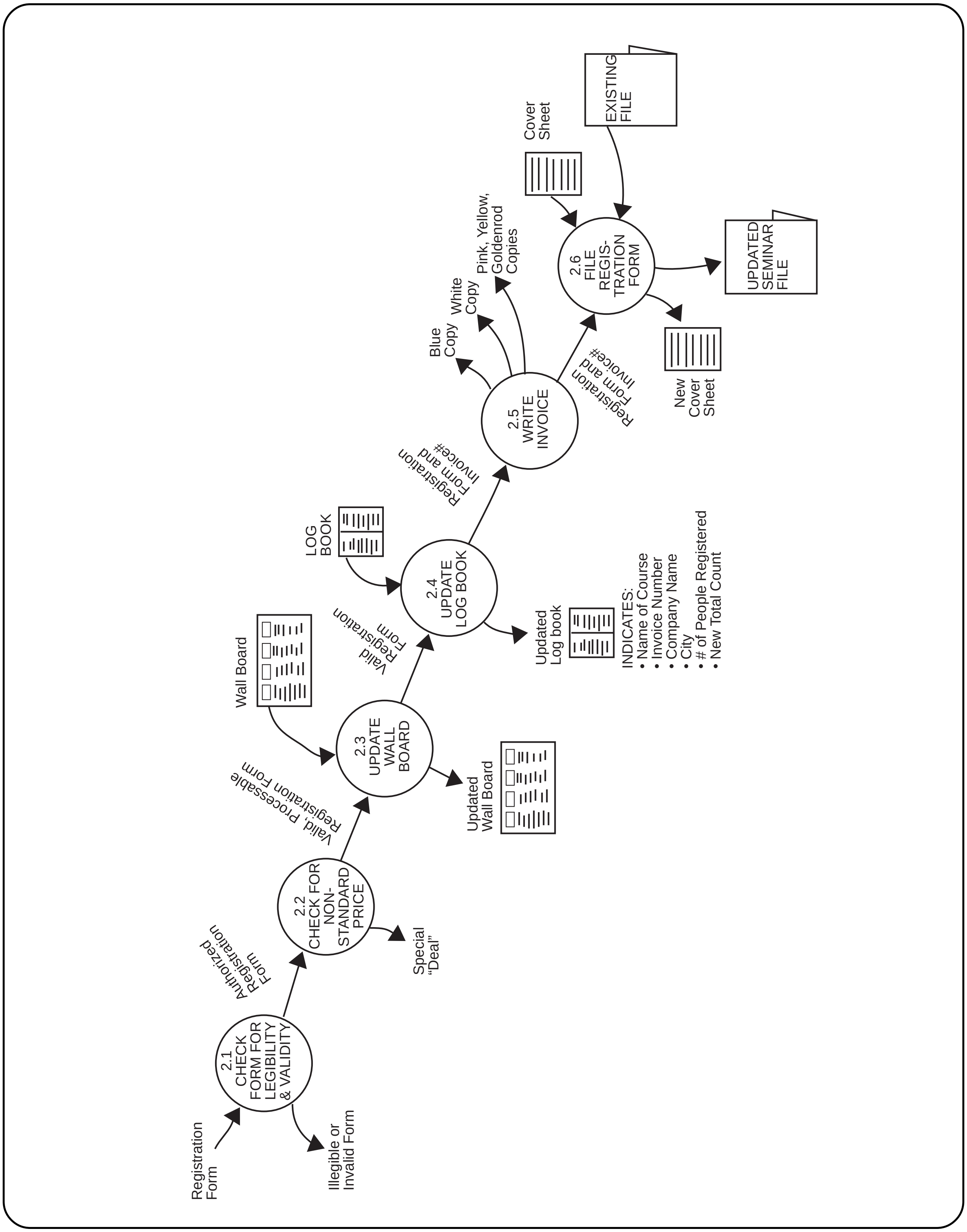

Figure 2.1.5.3.g. *A semi-logical data flow diagram. (adapted from Yourdon, p. 76)*

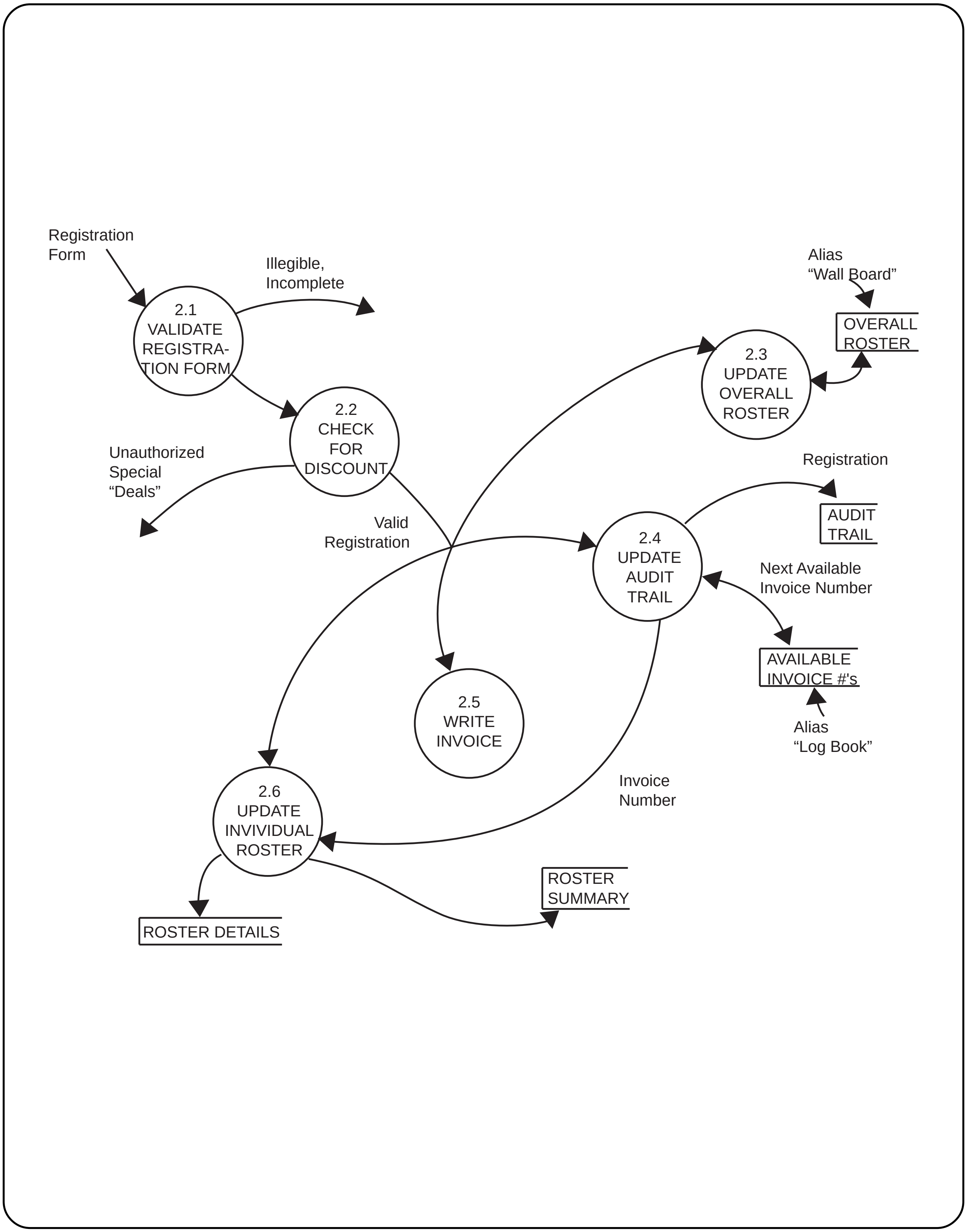

Figure 2.1.5.3.h. *A logical data flow diagram. (adapted from Yourdon, p. 77)*

2.1.5.4. Exercise on Analyzing Information Flows.

Explanation

In Module 1.1.18.10., you did a context diagram for a domain of responsibility. The context diagram is a zeroth-level DFD. You can partition the domain of responsibility to produce more detailed DFD's. Your objective is to continue to partition domains and subdomains until you find every information flow in the organization. When you know each information flow, you can figure out the data carried along with each piece of information. The name of the game is to find the data requirements so you can find out how to acquire, store, retrieve, and manipulate only the needed data to later make information through comparing indicator data to reference data.

You want to use management system analysis. Start by surveying the work and knowing and delimiting the domain of responsibility. Then you can find the decisions made to manage the work flow. With the information flows, you can get to the data you need so you can figure out what measurements to make of the work flow to ultimately run through management tools to support decision making.

Situation Description

Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They bought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. You've been hired as a management consultant to advise them.

Exercise

Partition the domain of responsibility of the shoe store. Start with the context diagram from Module 1.1.18.10. Retain all external agencies as you move to higher-level, more-detailed data flow diagrams. Draw a level-1 DFD for the shoe store. Then draw a level-2 DFD for any one of the conversion processes in the level-1 DFD. Have you yet reached the level of detail you need for that conversion process so you could get your hands on the data involved?

2.0. BUILDING MANAGEMENT TOOLS

2.1. APPROACHES FOR BUILDING TOOLS

2.1.6. SYSTEM MODELING TOOLS

2.1.6.1. Top-Down, Bottom-Up, Dual-Path—Jean-Francois Millet

2.1.6.2. DATA FLOW DIAGRAMS.

Data stores and external agencies play key roles in supporting information flows and conversion processes in information flow diagrams.

In analyzing a domain of responsibilities, one of the things we want to do is communicate what we've discovered. If you build a model of the domain, you'll have an effective method of communication. Since one of the key elements in analyzing a domain is to trace the flow of information, you'll find information flow diagrams to be one of the most beneficial models you can build.

Use Information Flow Diagrams to Model the Domain.

You saw the symbols used in information flow diagramming when you read the module on analyzing information flow. In this module we'll apply the symbols in greater detail.

Let's begin by looking at how names (or descriptions) are assigned to the information flow diagram symbols. Consider these three guidelines:

1. All names should be meaningful descriptors.

2. Names for data flows (arrows) and data stores (open rectangles) should reflect the composition of the data.

3. Process bubbles (circles or ovals) should be named with *strong verbs* and accurately reflect the process taking place, or the transformation of data.

Here's a strong warning: difficulty in assigning names can indicate a lack of understanding of the domain and its information flows. If this happens, you'll want to gather more information about the domain.

When You Construct an Information Flow Diagram Remember These Construction Hints.

As you put together information flow diagrams, I'll give you two rules to keep in mind.

1. Use bubbles only to show processing or transformation of data. You shouldn't have data flowing in and out of a bubble without the data having been processed in some way.

2. All data flows must either *begin or end* at a process or both. This means there must be a process associated with each flow. Flows may not begin and end at a data store or an external entity. For a correct example, see Figure 2.1.6.2.b. Figure 2.1.6.2.a. is wrong because the data flows both begin and end at data stores or an external entity—there's no processing taking place.

An information flow diagram can be checked quickly by scanning it for obvious construction errors. For example, see Figure 2.1.6.2.c. For starters, the oval for conversion process 1 receives three inputs but doesn't put out any data. What good is a process if it doesn't output any information? The oval for conversion process 2 produces two information flows but doesn't receive any. Where does its information come from? All processes must have both inputs and outputs. A third easily identifiable problem is the data flow starting at data store 1 and ending at data store 2. There's no process involved. The same problem occurs with the flow from external agency 1 to data store 1. All information flows begin or end with a process. A fifth problem occurs when there's no access to data store 2. Data store 2 receives data, but nothing is ever used from it. The sixth problem is that external agency 1 feeds data store 1. In this domain we don't care about an external agency that doesn't relate to a process in the domain.

One purpose of information flow diagramming is to communicate what you've found out about the domain. Good communication is clear and simple. Information flow diagrams are simple because they involve a few simple symbols. But when we put hundreds of these symbols together, we can get a huge chart that's hard to use.

A mechanism used to keep information flow diagrams simple is hierarchical or top-down partitioning. You were introduced to partitioning in the analyzing information flows module. Remember, partitioning involves breaking out details associated with individual processes. Partitioning creates new diagrams to show information flows in greater detail.

Since even the most basic of systems might contain 200 process ovals and too many overlapping flows, we choose to use multiple levels of relatively simple information flow diagrams.

Individual information flow diagrams can be kept relatively simple because, at any point, a single process oval can easily be partitioned into separate, lower-level information flow diagrams. A product of the partitioning process is often called a child of the original process, call the parent.

Remember that the flows in and out of a child diagram or out from any conversion process oval (in to any oval from outside the diagram or out of any oval to outside the diagram) must be the same as the flows in and out of the parent oval in the higher-level diagram. See Figures 2.1.6.2.d. and 2.1.6.2.e. and try to match the net flows in 2.1.6.2.e. to the flows in 2.1.6.2.d. You can find all the flows into and out of the parent oval for conversion process 4 in Figure 2.1.6.2.d. going into or out of the child ovals for conversion processes 4.1 through 4.4 in Figure 2.1.6.2.e. For example, information flow j in Figure 2.1.6.2.d. flows into conversion process 5. You can show conversion process 5 as a square in Figure 2.1.6.2.e. since it's external to the domain of conversion process 4 in Figure 2.1.6.2.d. It's all a matter of convention. You may notice in Figure 2.1.6.2.e. that two input flows come into the system from entities in the mother diagram and two output flows go to entities in the mother diagram.

An Example

Consider the data flow diagram shown in Figure 2.1.6.2.f. This is a level-1 diagram for a simplified course registration system for college students.

The external agencies in the diagrammed system are a student (STUDENT), faculty (FACULTY), and the university's accounts receivable systems (A/R SYSTEM).

The data flow diagram shows that the student submits a registration request (REG-REQ) to the system. As part of the processing, the registration systems accesses the balance due for the student (STUDENT-BAL-DUE) from the accounts receivable system. If the student still owes money to the university, the system prepares and delivers to the student a statement for this balance due (STMT). If there is no balance due, the transaction is considered to be a "clean registration," and conversion process 1 sends each individual class request (CLASS-REQ) on to the next conversion process.

For each class request, a test of available space is made. If the class assignment is received, the student social security number (SSN) is added to the data store 2 for that class (CLASS-

LISTS). At the same time, an entry (CLASS-RECD) is made to indicate a completed class registration in the record for this student within the student master (STUDENT-MASTER) data store 1.

Next, the classes received (CLASS-RECD) and classes denied (CLASS-CLOSED) are compiled on a schedule of classes (SCHEDULE) sent to the student.

The data store 1 of student master information is used to issue a tuition bill (TUITION-BILL) that is sent to the student and also to update the accounts receivable system (NEW-BAL-DUE).

Finally, the STUDENT-MASTER data store 1 is used, together with the CLASS-LISTS data store 2, to prepare lists of students registered in the various classes (COURSE-ENROLLMENT) for delivery to the faculty.

Note that both the external entity STUDENT and the data store STUDENT-MASTER appear twice in this diagram. The reason for this repetition is to avoid crossing data flow lines. A special convention has been established for handling this type of situation. If an external entity must be repeated, each occurrence is marked with a single slash in the lower right-hand corner. If a second entity is repeated, a double slash is used for each occurrence of that entity, and so on. A similar convention is used when data stores are repeated, with the slashes appearing in the lower left-hand corner. (This example is taken from Powers, Adams, and Mills, pp. 259-261)

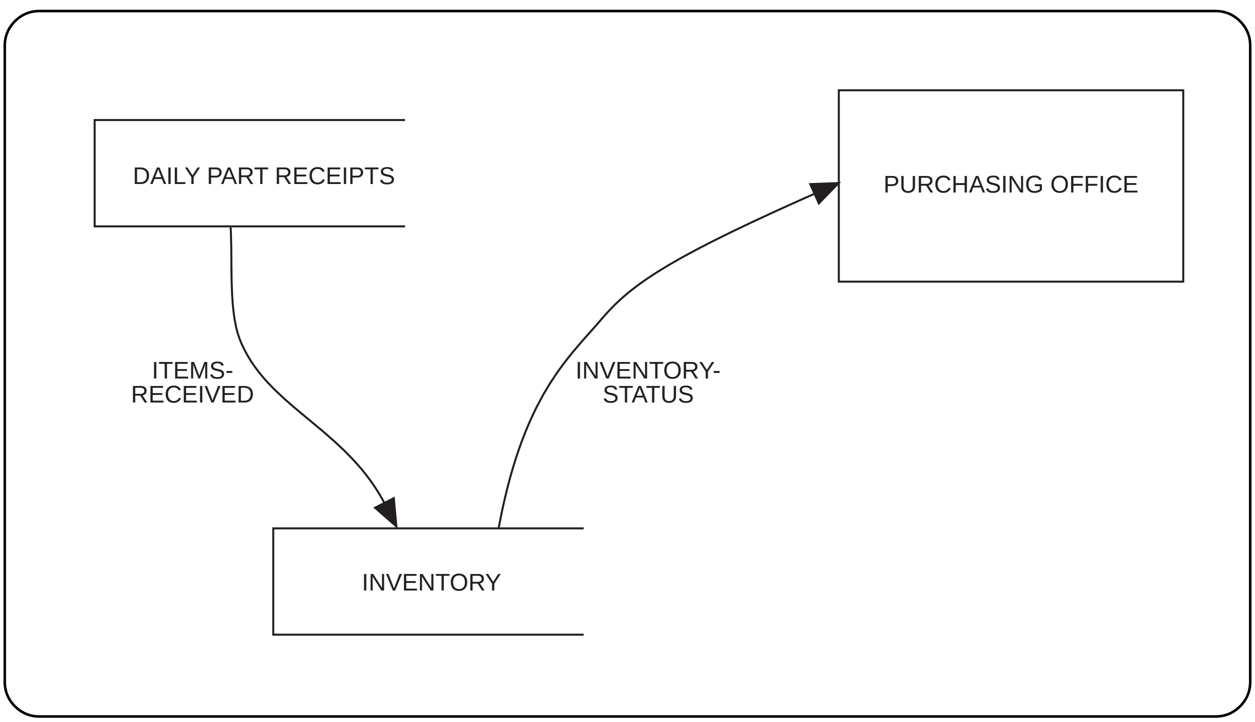

Figure 2.1.6.2.a. *This information flow diagram is incorrect because there are no processing ovals. (adapted from Powers, Adams, and Mills, p. 264)*

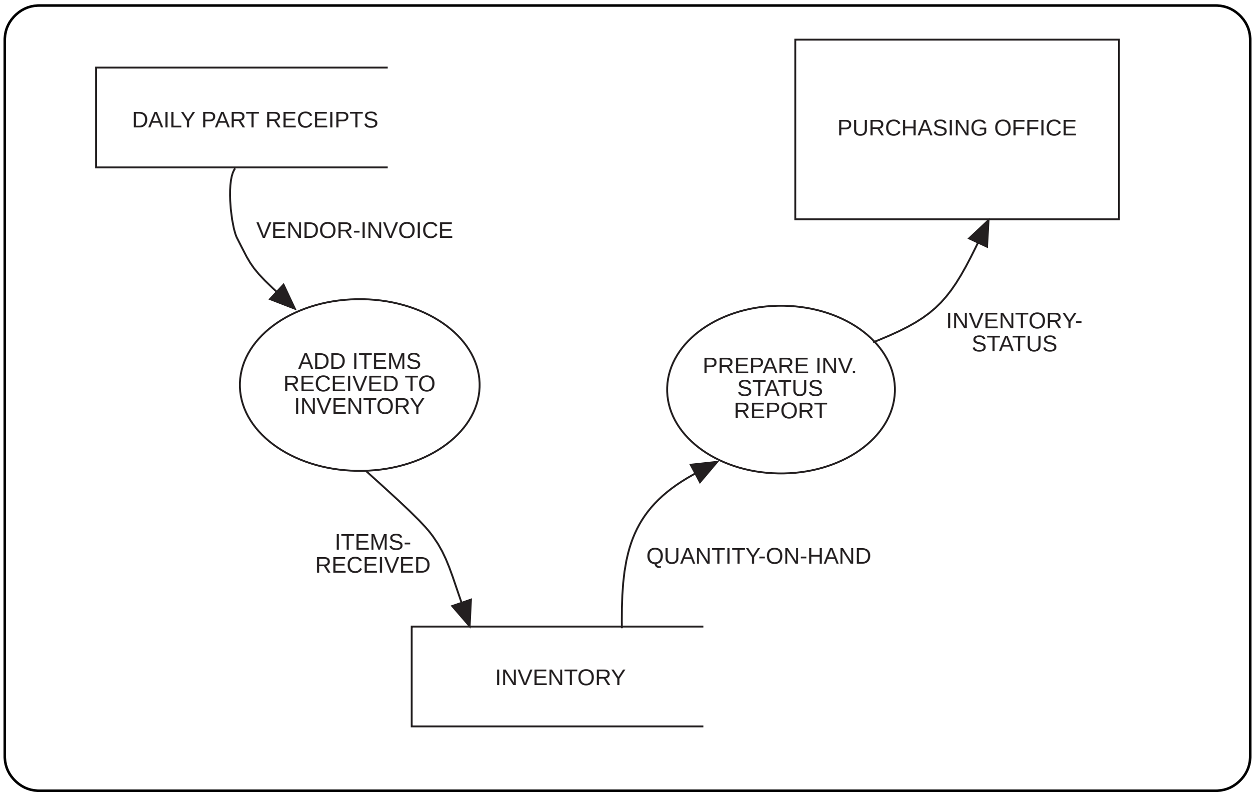

Figure 2.1.6.2.b. *This diagram shows a correct approach for the information flows in Figure 2.1.6.2.a. (adapted from Powers, Adams, and Mills, p. 265)*

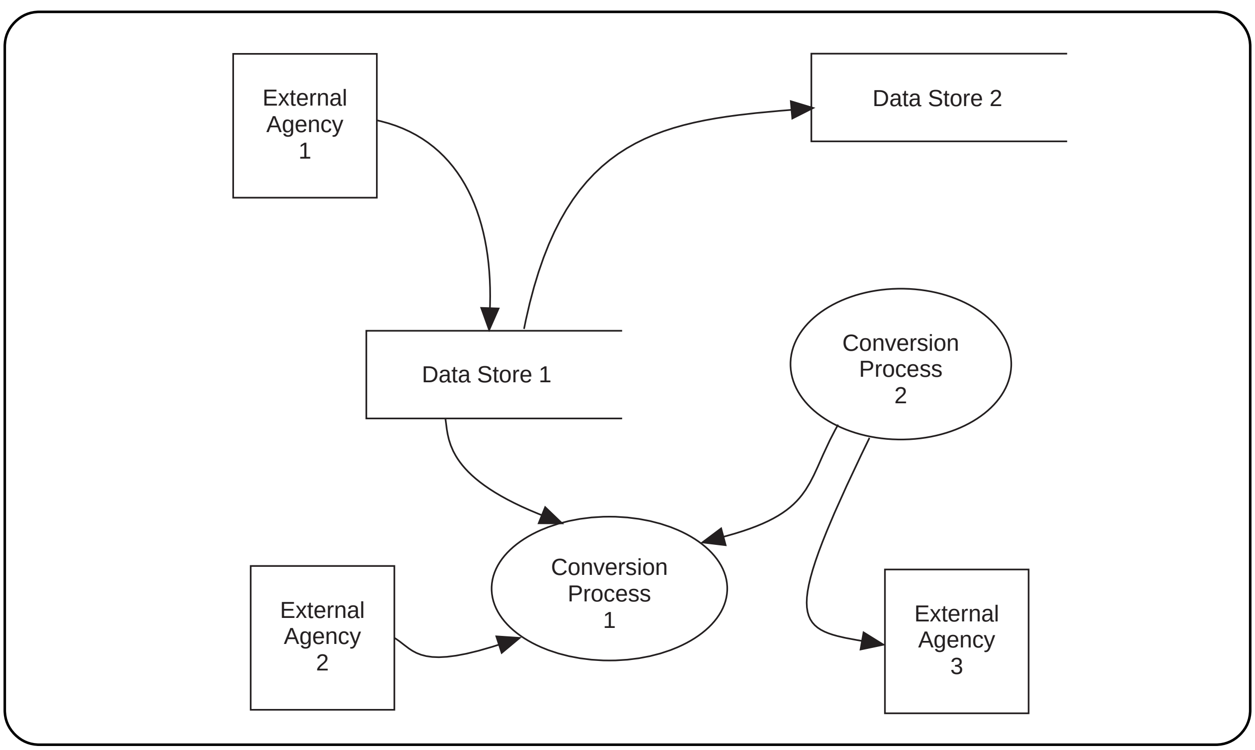

Figure 2.1.6.2.c. *Can you find six errors in this information flow diagram? (adapted from Powers, Adams, & Mills, p. 268)*

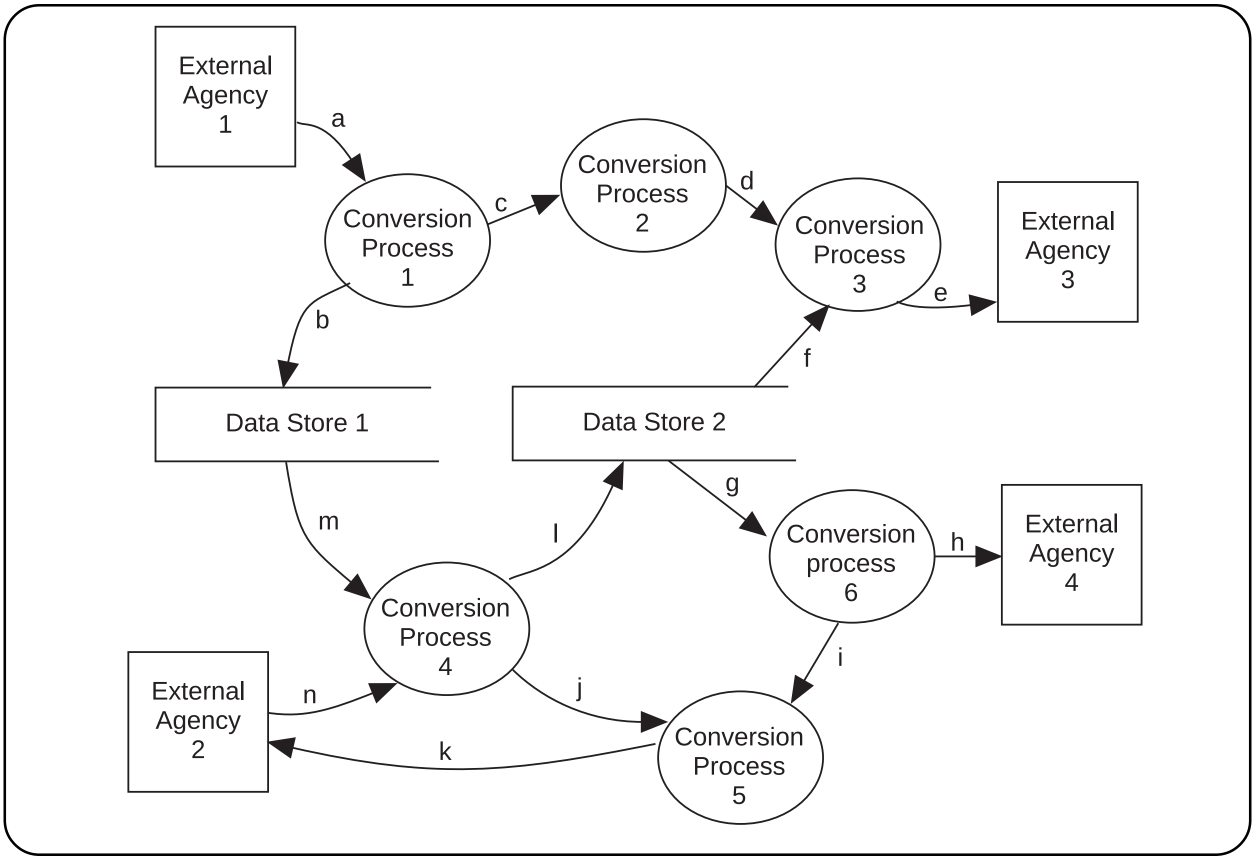

Figure 2.1.6.2.d. *This level-1 information flow diagram represents a partitioned context diagram.*

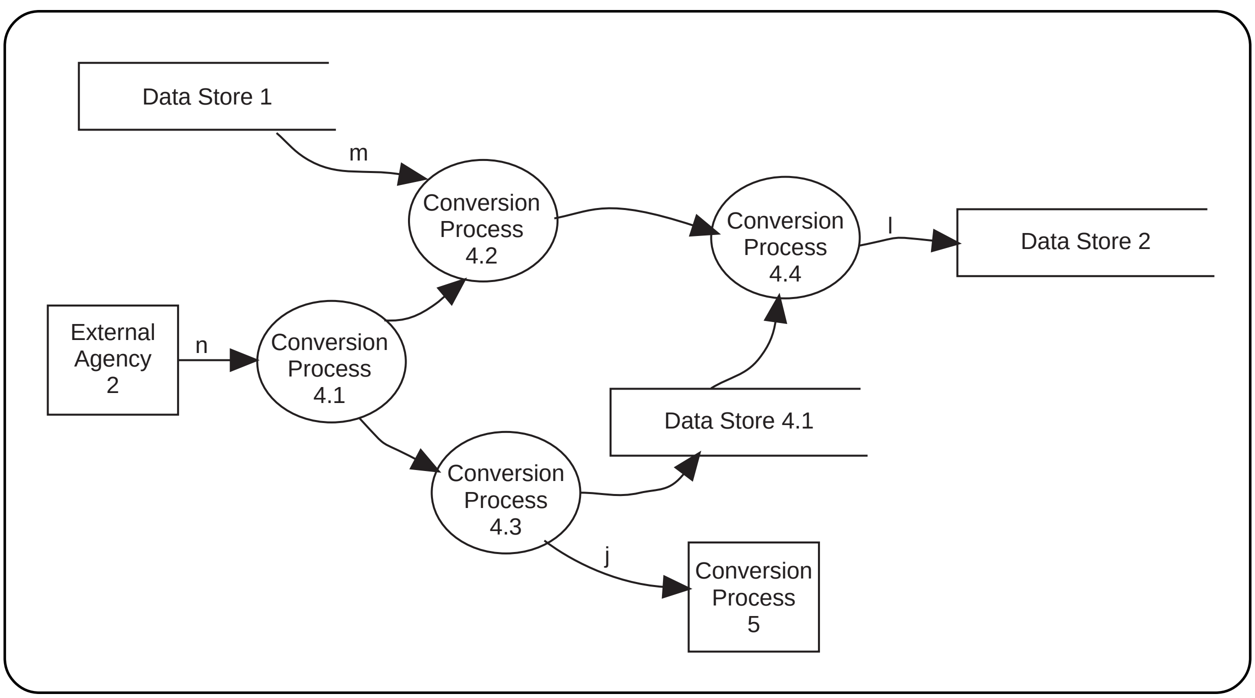

Figure 2.1.6.2.e. *This level-2 information flow diagram shows the partitions for conversion process 4 shown in Figure 2.1.6.2.d.*

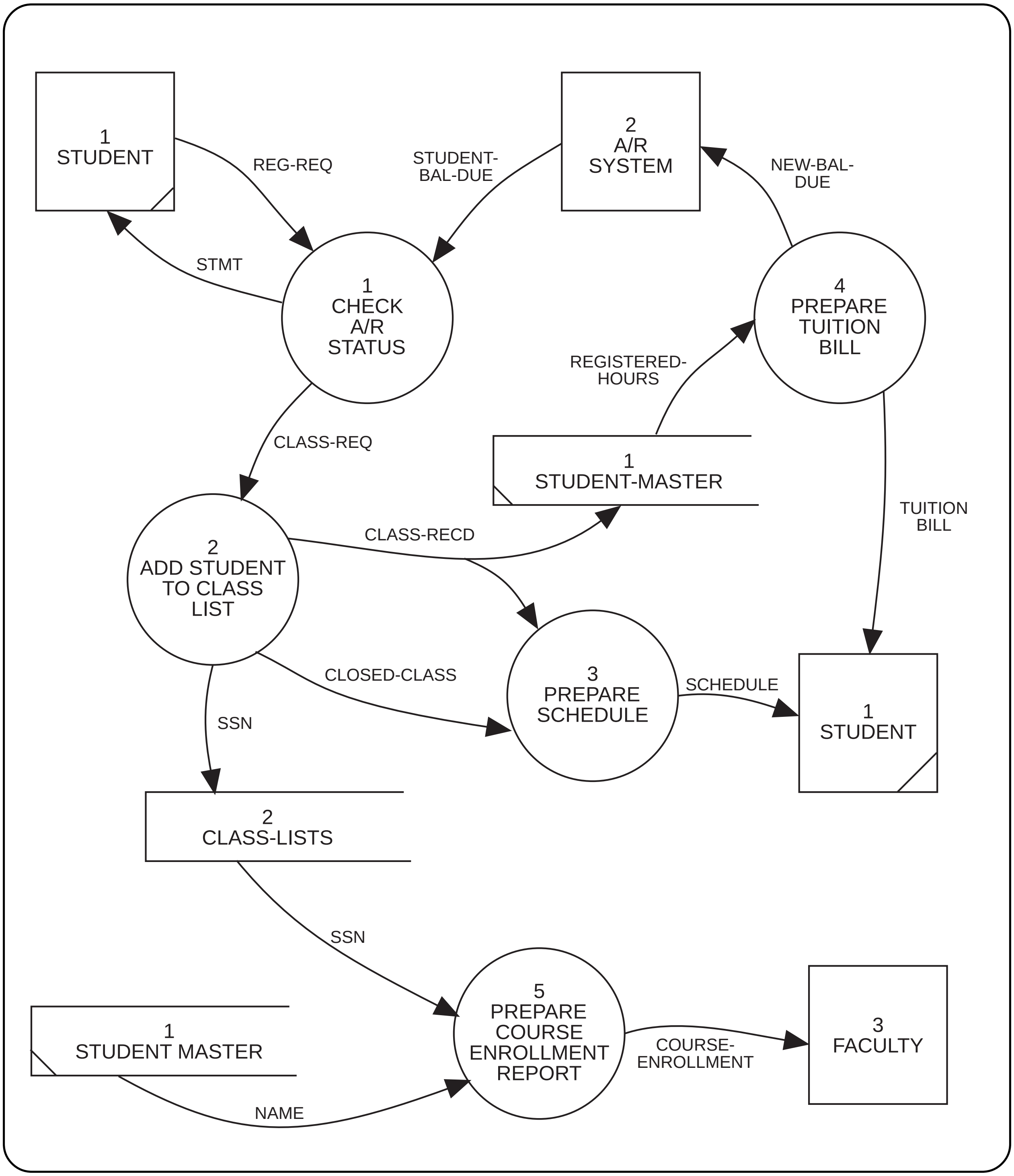

Figure 2.1.6.2.f. *Data flow diagram for simplified course registration system. (adapted from Powers, Adams, & Mills, p. 260)*

2.1.6.3. DATA DICTIONARY.

Once we have the information flow diagrams, we can pull the data elements out of each information flow to form a data dictionary.

Use the Data Dictionary to Define Data
(The discussion of the data dictionary is adapted from Powers, Adams, and Mills, pp. 286-290.)

In developing information flow diagrams we must name the components. We must name information flows and data stores. The names we assign must be used consistently throughout system documentation and in the programs developed to implement the system. Therefore, we must establish a common vocabulary, or *data dictionary*. The data dictionary contains the names assigned to all information flows and data stores, with exact and complete definitions for each term or data element in them.

I've said information flows are pipelines carrying information formats or packets of data. Each packet may contain several elements of data. In building a data dictionary, both individual elements and packets of data need special identities and definitions of their own.

We call a basic unit, or piece, of data not broken down into more detailed units a *data element*. Examples of data elements include customer account number, student social security number, balance due, and billing amount.

We can picture a data packet as a *data structure*. A data structure consists of two or more logically related data elements. Data structures can be made up of other data structures, as well as of individual data elements. To illustrate, in the student registration system shown in Figure 2.1.6.2.f., the data structure for a registration request includes the student's social security number plus an iteration of course requests. This data structure consists of one data element and a series of other data structures. The social security number, which can't be broken down meaningfully, is a data element. Each course request, however, consists of several data elements, including department number, course number, section number, and credit hours to be awarded. Thus, each course request is a data structure composed of four data elements.

We have powerful techniques for describing data structures. These techniques are similar to those of everyday English syntax and grammar. For example, rules of normal English grammar require that a sentence contain two basic parts: a subject and a predicate. These basic sentence parts are, in turn, broken down into parts that can include nouns, verbs, adjectives, adverbs, articles, etc.

In the same sense, we can identify data structures in terms of three basic structures, or rules of grammar. These rules establish structures using *sequence*, *selection*, and *iteration*. For example, consider a file made up of a sequence of three items: a header record, the body of the file, and the trailer record. The header record may contain information on how to process the body of the file. The trailer record may contain control information such as instructions for cross-checking calculations. In other words, the file, as a whole, is described simply as a sequence of three items—header, body, and trailer.

Next look at the body of the file. The body can be considered a file in its own right, because it is made up of an iteration of a variable number of records. In an iterated file, each record may be of the same type and follow the same format. But the file may have records of several different types, such as a personnel record, a skill-experience record, a salary-history record, and so on. A file of this type constitutes a use of the selection rule. That is, each record is of one type or another, depending on a selection indicator contained in the record. Moving to a more detailed level, a personnel record might be considered a sequence of things like name, address, phone number, marital status, and so on, together with a sequence of subrecords. One of those subrecords might be a list of children—an iteration of zero or more names.

We use specific notations to implement syntax rules. These notations are illustrated in Figure 2.1.6.3.a. We'll first look at *sequence*. Within data structures, a sequence simply means linking together data elements or data structures. Components in a sequence are grouped into a single data structure by means of plus signs (+), which assume the meaning of "and."

Iteration, or repetition, of data elements or structures within larger data structures is indicated in Figure 2.1.6.3.a. by braces ({...}). Thus, for example, within a student record, the iterated completed courses would be enclosed in braces. Optional data elements can also be considered as iterations because an optional item may be used either zero times or once. Thus, optional data items may be enclosed in braces or may be indicated by parentheses.

The third operation for building data structures is selection. Selection refers to choosing one and only one item from a group of data elements or structures. This is indicated by bracketing. The example in Figure 2.1.6.3.a. illustrates the data structure for a course request—you can choose to either drop or add a course, with no other alternatives.

Figure 2.1.6.3.b. illustrates the data dictionary syntax applied to the example of an EMPLOYEE-FILE, taken from Powers, Adams, and Mills. Note how the increasing levels of detail in the figure reflect the hierarchical partitioning of information flow diagrams. As a general rule, the data structures that define the data flows of higher-level data flow diagrams will tend to be higher-level data structures. As the information flow diagrams are partitioned into child diagrams, the corresponding data structures tend to be decomposed on the same basis.

DATA STRUCTURE NOTATION CONVENTIONS

SEQUENCE

EX:

COURSE = DEPT-NUM
+ COURSE-NUM
+ COURSE-TITLE
+ CREDIT-HOUR-RANGE
+ TERMS-OFFERED
+ DESCRIPTION

REPETITION

EXACTLY N ITERATIONS	${}_{N}\{...\}$
ONE TO N ITERATIONS	${}^{N}\{...\}$ OR $\{...\}_{\text{CONDITION}}$
UNLIMITED ITERATIONS	$\{...\}$
OPTIONAL	${}^{1}\{...\}$ OR (...)

EX:

STUDENT RECORD=
SOC-SEC-NUM

$$+\left\{\begin{array}{l}\text{DEPT-NUM}\\ \text{+COURSE-NUM}\\ \text{+YEAR-TERM}\\ \text{+CREDIT-HOURS}\\ \text{+GRADE}\end{array}\right\}_{\substack{\text{ALL COMPLETED}\\ \text{COURSES}}}$$

REGISTRATION-REQUEST=
SOC-SEC-NUM

$$+\,{}^{10}_{1}\left\{\begin{array}{l}\text{DEPT-NUM}\\ \text{+COURSE-NUM}\\ \text{+SEC-NUM}\\ \text{+CREDIT-HOURS}\end{array}\right\}$$

SELECTION—EXACTLY ONE OF SEVERAL OPTIONS

EX:

$$\text{COURSE-CHANGE-REQUEST} = \left\{\begin{array}{c}\text{ADD-COURSE}\\ \text{DROP-COURSE}\end{array}\right\}$$

Figure 2.1.6.3.a. *These examples of data structure notation conventions illustrate sequence, repetition, and selection.. (taken from Powers, Adams, & Mills, p. 29)*

EMPLOYEE-FILE = HEADER-RECORD
+BODY
+TRAILER-RECORD

BODY = (BODY-RECORD)

$$\text{BODY-RECORD} = \left\{ \begin{array}{l} \text{PERSONNEL-RECORD} \\ \text{SKILL-EXPERIENCE-RECORD} \\ \text{SALARY-HISTORY-RECORD} \end{array} \right\}$$

PERSONNEL-RECORD = NAME
+EMPLOYEE-NUMBER
+BIRTH-DATE
+HOME-ADDRESS
+PHONE
+(SPOUSE-NAME)
+^{10}{PREVIOUS-EMPLOYER + DATES}
+^{15}{CHILD-NAME}

Figure 2.1.6.3.b. *These notations show different, increasing levels of detail for data dictionary syntax.*

2.1.6.4. Structured English

We can use formal English statements to set out processing rules for converting information flows.

(The discussion on Structured English is quoted from Powers, Adams, and Mills, pp. 305-308.)

“Not all processes involve the consideration of multiple conditions and resulting outcomes like those considered above. Many processes lend themselves, instead, to a more straightforward sequence of steps or the iteration of smaller processes. In such instances, a series of formal English statements, using a small, strong, selected vocabulary, can be used to communicate processing rules. This tool is known as structured English.

“One of the values of structured English is that verbal statements are a natural medium of communication between users and programmers. Users are generally comfortable with English statements. At the same time, the format of structured English is sufficiently precise so that it will not be misinterpreted by designers or programmers. To maintain the communication link with the user, however, care must be take to avoid having structured English statements look like pseudocode.

“Structured English uses three types of constructs:

- Sequence
- Selection
- Iteration

SEQUENCE:
Set penalty of 10% of 90 day-arrears.
Set net-bill to sum of curr-charge plus previous-balance plus penalty.

SELECTION (IF-THEN):
    If 90 day arrears is over $50
Then
    Set penalty to 15% of 90 day-arrears.
Otherwise
    Set penalty to 10% of 90 day-arrears.
Set net-bill to sum of curr-charge plus previous-balance plus penalty.

SELECTION (CASE CONSTRUCT):
Select the appropriate case.
    Case 1 (Customer-type is residential).
        .
        .
        .
    Case 2 (Customer-type is commercial).
        .
        .
        .
    Case 3 (Customer-type is industrial).
        .
        .
        .
    Case 4 (Customer-type is institutional).

ITERATION:
For each account record in the customer-master-file:
    Set consumption to the difference of
        Current-read less previous-read.

    If consumption is positive,
        Then
            Select the appropriate case.
    Case 1 (Customer-type is residential):
        .
        .
        .

        Case 2 (Customer-type is commercial).
            .
            .

.
.
.

Otherwise
Write the account-number and ser vice-address to the accts-not-billed report.

(pseudocode from Powers, Adams, and Mills, pp. 306-307)

"Examples of structured English statements for these three constructs are shown above. Note the major techniques of structured English used in these examples:

- Strong verbs are used to begin statements that describe initiation of an act or implementation of a decision.

- Statements are formatted with multiple levels of indentation. These indentations correspond with processing blocks.

"As is the case with decision trees and decision tables, use of structured English statements is at the discretion of the analyst. These three tools can be used singly or in combination, depending upon the process being described."

2.1.6.5. An Integrated Example.

Through an integrated example, we can see how the data flow diagram, the data dictionary, and structured English work together.

I've quoted a section of Tom deMarco's book *Structured Analysis and System Specification* to illustrate a combination of system modeling tools applied to a special example. Notice some difference in convention from my preceding discussion. You shouldn't have any problem with the difference. For example deMarco uses the term data flow diagram instead of information flow diagram.

"The purpose of this chapter is to give you a look at each one of the tools of Structured Analysis at work. Once you have a good idea of what they are and how they fit together, we can go back and discuss the details.

3.1 A Sample Situation

"The first example I have chosen is a real one, involving the workings of our own company, Yourdon Inc. To enhance your understanding of what follows, you ought to be aware of these facts:

1. Yourdon is a medium-sized computer consulting and training company that teaches public and in-house sessions in major cities in North America and occasionally elsewhere.

2. People register for seminars by mail and by phone. Each registration results in a confirmation letter and invoice being sent back to the registrant.

3. Payments come in by mail. Each payment has to be matched up to its associated invoice to credit accounts receivable.

4. There is a mechanism for people to cancel their registrations if they should have to.

5. Once you have taken one of the company's courses, or even expressed interest in one, your name is added to a data base of people to be pursued relentlessly forever after. This data base contains entries for tens of thousands of people in nearly as many organizations.

6. In addition to the normal sales prompting usage of the data base, it has to support inquiries such as

- When is the next Structured Design Programming Workshop in the state of California?

- Who else from my organization has attended the Structured Analysis seminar? How did they rate it?

- Which instructor is giving the Houston Structured Design and Programming Workshop next month?

"In early 1976, Yourdon began a project to install a set of automated management and operational aids on a PDP-11/45, running under the UNIX operating system. Development of the system—which is now operational—first called for a study of sales and accounting functions. The study made use of tools and techniques of Structured Analysis. The following subsections present some partial and interim products of our analysis.

3.2 A Data Flow Diagram Example

"An early model of the operations of the company is presented in [Figure 2.1.6.5.a.] It is in the form of a Logical Data Flow Diagram. Refer to that figure now, and we'll walk through one of its paths. The rest should be clear by inference.

“Input to the portrayed area comes in the form of Transactions (“Trans” in the figure). These are of five types: Cancellations, Enrollments, Payments, Inquiries, plus those that do not qualify as any of these, and are thus considered Rejects. Although there are no people or locations or departments shown in this figure (it is logical, not physical), I will fill some of these in for you, just as I would for a user to help him relate back to the physical situation that he knows. The receptionist (a physical consideration) handles all incoming transactions, whether they come by phone or by mail. He performs the initial edit, shown as Process 1 in the figure. People who want to take a course in Unmitigated Freelance Speleology, for example, are told to look elsewhere. Incomplete or improperly specified enrollment request and inquiries, etc., are sent back to the originator with a note. Only clean transactions that fall into the four acceptable categories are passed on.

“Enrollments go next to the registrar. His function (Process 2) is to use the information on the enrollment form to update three files: the People File, the Seminar File, and the Payments File. He then fills out an enrollment chit and passes it on to the accounting department. In our figure, the enrollment chit is called “E-Data,” and the accounting process that receives it is Process 6.

“ Information on the chit is now transformed into an invoice. This process is partially automated, by the way—a ledger machine is used—but that information is not shown on a logical Data Flow Diagram.

“The invoice passes on to the confirmation process (which happens to be done by the receptionist in this case). This task (Process 7) involves combining the invoice with a customized form letter, to be sent out together as a confirmation. The confirmation goes back to the customer.

3.2.1. Some Data Flow Diagram Conventions

“If you have followed the narrative so far, you have already picked up the major Data Flow Diagram conventions:

- *The Data Flow Diagram shows flow of data, not of control.* This is the difference between Data Flow Diagrams and flowcharts. The Data Flow Diagram portrays a situation from the point of view of the data, while a flowchart portrays it from the point of view of those who act upon the data. For this reason, you almost never see a loop in a Data Flow Diagram. A loop is something that the data are unaware of; each datum typically goes through it once, and so from its point of view it is not a loop at all. Loops and decisions are control considerations and do not appear in Data Flow Diagrams.

- *Four notations symbols are used.* These are:

    - The name vector (called a data flow), which portrays a data path.

    - The bubble (called a process), which portrays transformation of data.

    - The three-sided rectangle, which portrays a file or data base.

    - The box (called a source or sink), which portrays a net originator or receiver of data—typically a person or an organization outside the domain of our study.

“Since no control is shown, you can’t tell from looking at a Data Flow Diagram which path will be followed. The Data Flow Diagram shows only the set of possible paths. Similarly, you can’t tell what initiates a given process. You cannot assume, for instance, that

Process 6 is started by the arrival of an E-Data—in fact, that's not how it works at all. E-Data's accumulate until a certain day of the week arrives, and then invoices all go out in a group. So the data flow E-Data indicates that data path, but not the prompt. The prompting information does not appear on a Data Flow Diagram.

3.2.2. An Important Advantage of the Data Flow Diagram

"Suppose you were walking through [Figure 2.1.6.5.a.] with your user and he made the comment: 'That's all very fine, but in addition to seminars, this company also sells books. I don't see the books operation anywhere.'

"'Don't worry, Mr. User, ' you reply, 'the book operation is fully covered here,' (now you are thinking furiously where to stick it) 'here in Process...um...Process Number 3. Yes, definitely 3. It's part of recording payments, only you have to look into the details to see that.'

"Analysts are always good at thinking on their feet, but in this case, the effort is futile. The book operation has quite simply been *left out* in [Figure 2.1.6.5.a.]—it's wrong. No amount of thinking on your feet can cover up this failing. No books flow in or out, no inventory information is available, no reorder data flows are shown. Process 3 simply doesn't have access to the information it needs to carry out books functions. Neither do any of the others.

"Your only option at this point is to admit the figure is wrong and fix it. While this might be galling when it happens, in the long run you are way ahead—making a similar change later on to the hard code would cost you considerably more grief

"I have seen this happen so many times: an analyst caught flat-footed with an incorrect Data Flow Diagram, trying to weasel his way out, but eventually being forced to admit that it is wrong and having to fix it. I conclude that it is a natural characteristic of the tool:

"When a Data Flow Diagram is wrong, it is glaringly, demonstrably, indefensibly wrong.

"This seems to me to be an enormous advantage of using Data Flow Diagrams.

3.2.3 What Have We Accomplished With a Data Flow Diagram?

"The Data Flow Diagram is documentation of a situation from the point of view of the data. This turns out to be a more useful viewpoint than that of any of the people or systems that process the data, because the data itself sees the big picture. So the first thing we have accomplished with the Data Flow Diagram is to come up with a meaningful portrayal of a system or part of a system.

"The Data Flow Diagram can also be used as a model of a real situation. You can try things out on it conveniently and get a good idea of how the real system will react when it is finally built.

"Both the conceptual documentation and the modeling are valuable results of our Data Flow Diagramming effort. But something else, perhaps more important, has come about as a virtually free by-product of the effort: The Data Flow Diagram gives us a highly useful *partitioning* of a system. [Figure 2.1.6.5.a.] shows an unhandily large operation conveniently broken down into eight pieces. (If any interface is left out, the diagram is simply wrong and has to be fixed.)

"Notice that the use of a Data Flow Diagram causes us to go about our partitioning in a rather oblique way. If what we wanted to do was break things down, why didn't we just do that? Why didn't we concentrate on functions and subfunctions and just accomplish a brute-force partitioning? The reason for this is that a brute-force partitioning is too difficult. It is too difficult to say with any assurance that some task or group of tasks constitutes a "function." In fact, I'll bet you can't even define the work function except in a purely mathematical sense. Your dictionary won't do much better—it will give a long-winded definition that boils down to saying a function is a bunch of stuff to be done. The concept of function is just too imprecise for our purposes.

"The oblique approach of partitioning by Data Flow Diagram gives us a "functional" partitioning, where this very special-purpose definition of the word functional applies:

"A partitioning may be considered *functional* when the interfaces among the pieces are minimized.

"This kind of partitioning is ideal for our purposes.

3.3. A Data Dictionary Example

"Refer back to [Figure 2.1.6.5.a.] for a moment. What is the interface between Process 3 and Process 7? As long as all that specifies the interface is the weak name "Payment-Data," we don't have a specification at all. "Payment-Data" could mean anything. We must state precisely what we mean by the data flow bearing that name in order for our Structured Specification to be anything more than a hazy sketch of the system. It is in the Data Dictionary that we state precisely what each of our data flows is made up of.

"An entry from the sample project Data Dictionary might look like this:

Payment-Data = Customer-Name +
Customer-Address +
Invoice-Number +
Amount-of Payment

"In other words, the data flow called "Payment-Data" consists precisely of the items Customer-Name, Customer-Address, Invoice-Number, and Amount-of-Payment, concatenated together. They must appear in that order, and they must be all present. No other kind of data flow could qualify as a Payment-Data, even though the name might be applicable.

"You may have to make several queries to the Data Dictionary in order to understand a term completely enough for your needs. (This also happens with conventional dictionaries—you might look up the term perspicacious, and find that it means sagacious; then you have to look up sagacious.) In the case of the example above, you may have to look further in the Data Dictionary to see exactly what an Invoice-Number is:

Invoice-Number = State-Code +
Custom-Account-Number +
Salesman-ID +
Sequential-Invoice-Count

"Just as the Data Flow Diagram effects a partitioning of the area of our study, the Data Dictionary effects a partitioning of the area of our study, the Data Dictionary effects a top-down partitioning of our data. At the highest levels, data flows are defined as being made up of subordinate elements. Then the subordinate elements (also data flows) are themselves defined in terms of still more detailed subordinates.

"Before our Structured Specification is complete, there will have to be a Data Dictionary entry for every single data flow on our Data Flow Diagram, and for all the subordinates used to define them. In the same fashion, we can use Data Dictionary entries to define our files.

3.4 A Structured English example

"Partitioning is a great aid to specification, but you can't specify by partitioning alone. At some point you have to stop breaking things down into finer and finer pieces, and actually document the makeup of the pieces. In the terms of our Structured Specification, we have to state what it takes to do each of the data transformations indicated by a bubble on our Data Flow Diagram.

"There are many ways we could go about this. Narrative texts is certainly the most familiar of these. To the extent that we have partitioned sufficiently before beginning to specify, we may be spared the major difficulties of narrative description. However, we can do even better.

"A tool that is becoming more and more common for process description is Structured English. Presented in [Figure 2.1.6.5.b.] is a Structured English example of a user's invoice handling policy from the sample analysis. It appears without clarification; if clarification is needed, it has failed in its intended purpose." (quoted from deMarco, pp. 37-43)

Conclusion

As we've looked at system modeling tools, I hope you've noticed we don't need to include a computer in our thinking. Consider the data stores in the information flow diagrams. They can be metal card files or Rolodex files, etc. Of course; the information flows can be hand-written pieces of paper, carried from desk to desk by hand. We can also write a data dictionary for that hand-written piece of paper—and we can describe what the piece of paper does in Structured English.

POLICY FOR INVOICE PROCESSING

```
If the amount of the invoice exceeds $500
        If the account has any invoice more than 60 days overdue
                hold the confirmation pending resolution of the debt.
        Else (account is in good standing),
                issue confirmation and invoice.
Else (invoice $500 or less),
        If the account has any invoice more than 60 days overdue,
                issue confirmation, invoice and write message on the
                credit action report.
        Else (account is in good standing),
                issue confirmation and invoice.
```

Figure 2.1.6.5.b. *Structured English example of a user's invoice handlling policy. (taken from deMarco, p. 43)*

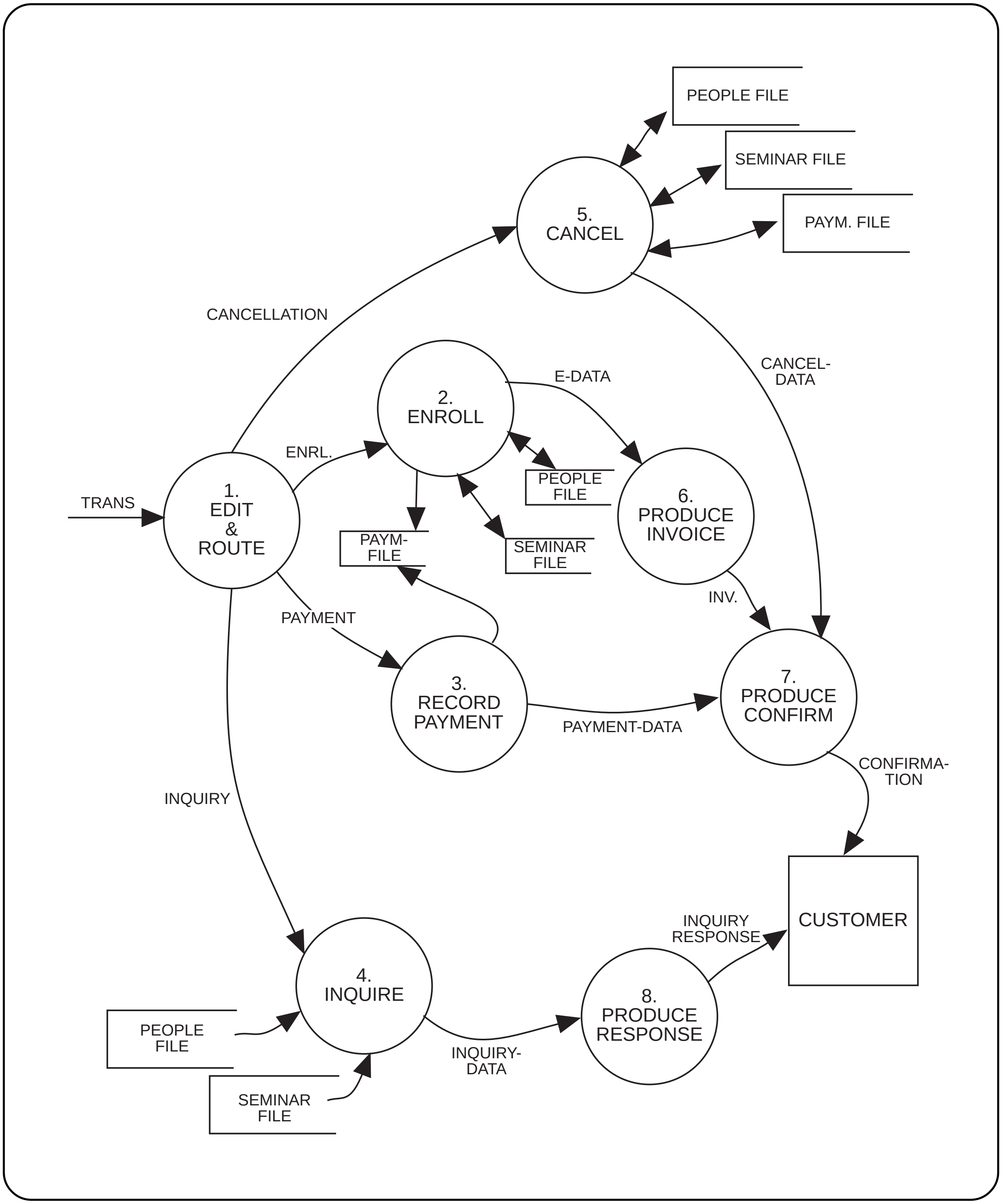

Figure 2.1.6.5.a. *Model of the operations of the company. (adapted from deMarco, p. 39)*

2.1.6.6. Diagramming MSL's Personnel Accounting.

By diagramming MSL's personnel accounting system, you can review the partitioning of the domain and more-detailed data flow diagrams.

I'll use Management Systems Laboratories' personnel accounting system as our domain of responsibility in an example of information flow diagramming. Figure 2.1.6.6.a. is a context diagram for the personnel accounting system, showing its relationships with the external environment. We'd like to track the flow of information in two ways—physically and logically. Let's begin with a physical model, since it will be easier to follow. We'll record how information, whether in the form of hardcopy reports or electronic versions of these in computers, are passed from person to person and what actions he or she takes on this information.

MSL employees keep track of what they work on each hour of the day, and a code is assigned to all the different projects a person works on. Employees are paid from many different accounts according to their time spent on each project. For example, if Mr. Green works three hours on an emergency management plan for Westinghouse, the amount ($) that equals his wage rate times three hours comes out of the Westinghouse project account and that amount of money goes toward paying his salary. So you can see why it's important for the employees to log their time because each account has a budgeted amount of money that can be spent on employees' labor. See Figure 2.1.6.6.b. for a sample timesheet that is compiled by an employee and submitted to his or her supervisor at the end of each pay period.

To track the timesheets and other pieces of information through the system, I've constructed a physical information flow diagram (Figure 2.1.6.6.c.). As you can see in the figure, the supervisor signs the timesheet and then forwards it to Wanda, who enters the hours charged to each project code on the accounting system on the computer. Wanda then compiles the total personnel cost figures and sends them to Diane. Although not shown in this process bubble, Diane combines the personnel cost information with materials costs, travel expense costs, and other costs that are charged to the individual project codes. Diane uses all of this cost information to produce a preliminary project cost sheet to tell project managers how much was spent from each project account, and how it was divided between employees' labor, materials bought for the project, etc.

Let's now look at the bubble labelled "Elizabeth." She's the personnel director and she coordinates the personnel information flow in MSL. Note how she receives job and salary information from Tech's personnel department and uses that information to give Wanda the hourly and fringe benefit rates, who uses these data to produce the total personnel cost reports. Wanda, in turn, sends a report to Elizabeth to give her the percentage of employees' time spent per project so Elizabeth can create an LDR (labor distribution report). This information gets passed to Sharon who drafts the actual reports, circulates them for approval and signatures, and then sends them back to Elizabeth. She now sends the LDR to an external entity—Tech's Sponsored Programs Office. This office has direct contact with MSL's sponsors, who give MSL money to do research projects for them. Sponsored Programs needs the LDR's to show the sponsors we're keeping within budget guidelines.

Elizabeth and Sharon share another flow of information. Elizabeth passes salary and personnel data to Sharon so she can produce P3-A forms that go to Tech payroll, who draft the employees' paychecks. I don't show an information flow arrow for carrying payroll checks back to the employees because this flow would connect two external entities. If you recall your diagramming rules, we don't concern ourselves with flows outside our domain of responsibility.

We can use Figure 2.1.6.6.c., the physical information flow diagram, to understand what's going on in MSL. We also use the physical diagram to make sure MSL people agree with our understanding. MSL people will think in terms of who does what to whom; and that's what we show in Figure 2.1.6.6.c.

Now let's prepare the information for possible automation. We have to think about the information flows logically. What's done to convert one information flow into another? Figure 2.1.6.6.d. shows the way we want to partition the domain from Figure 2.1.6.6.a. Using the partitioning in Figure 2.1.6.6.d., we can draw Figure 2.1.6.6.e.—a level-1 logical information flow diagram. The next steps (not shown here) are to partition each of the four bubbles (conversion processes) and to draw four level-2 logical information flow diagrams. The information for drawing the level-2 diagrams comes from Figure 2.1.6.6.c.

Think about how you would use Figure 2.1.6.6.c. to discuss the operation of MSL's personnel accounting system with someone who knows nothing about information systems. Think also about how you would produce the level-2 diagrams using Figures 2.1.6.6.c. and 2.1.6.6.e. Finally, think about the difference between physical and logical information flow diagrams from the table in the section called Analyzing Information Flow.

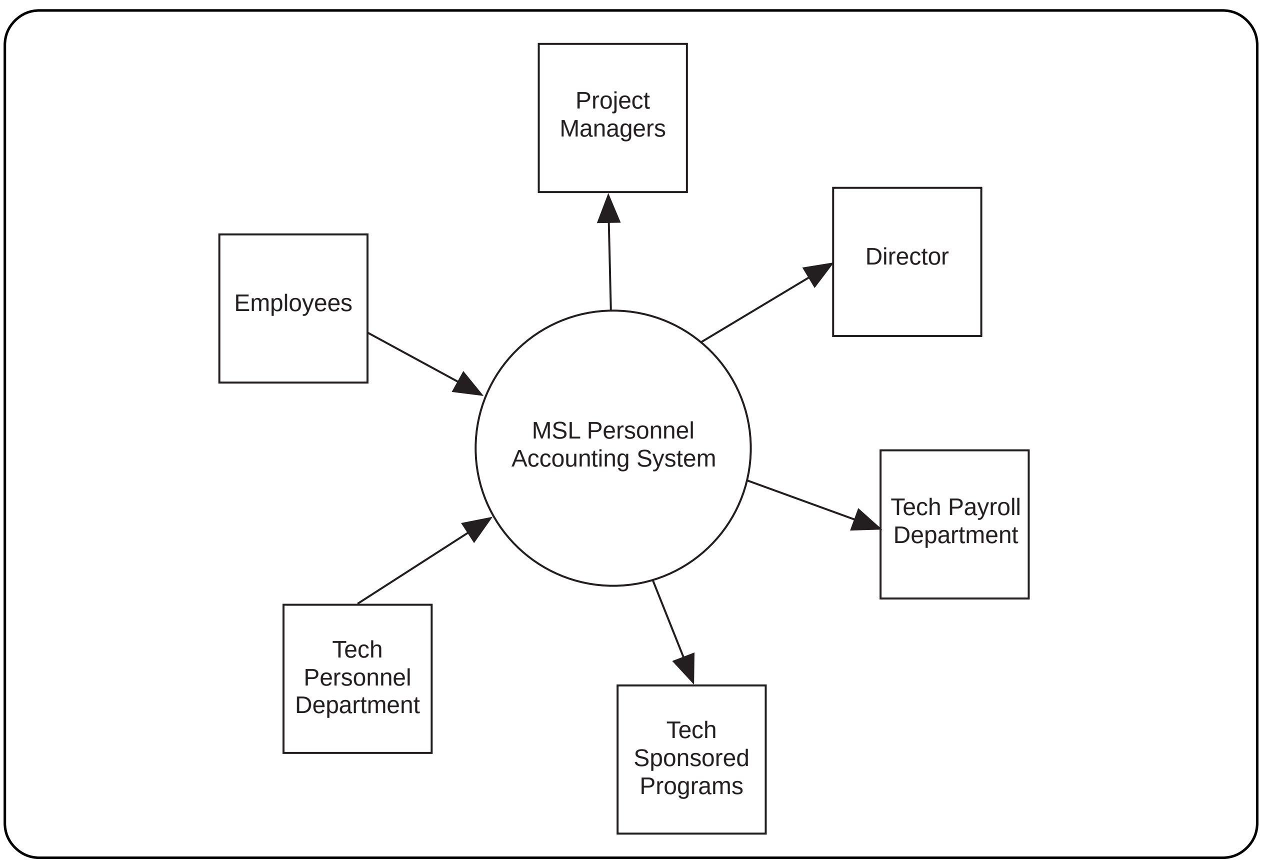

Figure 2.1.6.6.a. *Context diagram for MSL's accounting system.*

DAY	TASK CODE	HOURS		LETTER	MILESTONE	DELIVERABLE
M.	1-11-111	2.75	finished editing Citibank proposal		✓	
Tu.	77-77-777	14.5	gave presentation to Westinghouse			✓
W.	44-44-444	9.0	wrote management plan for Dept. of Energy			✓

Figure 2.1.6.6.b. *MSL's time sheet.*

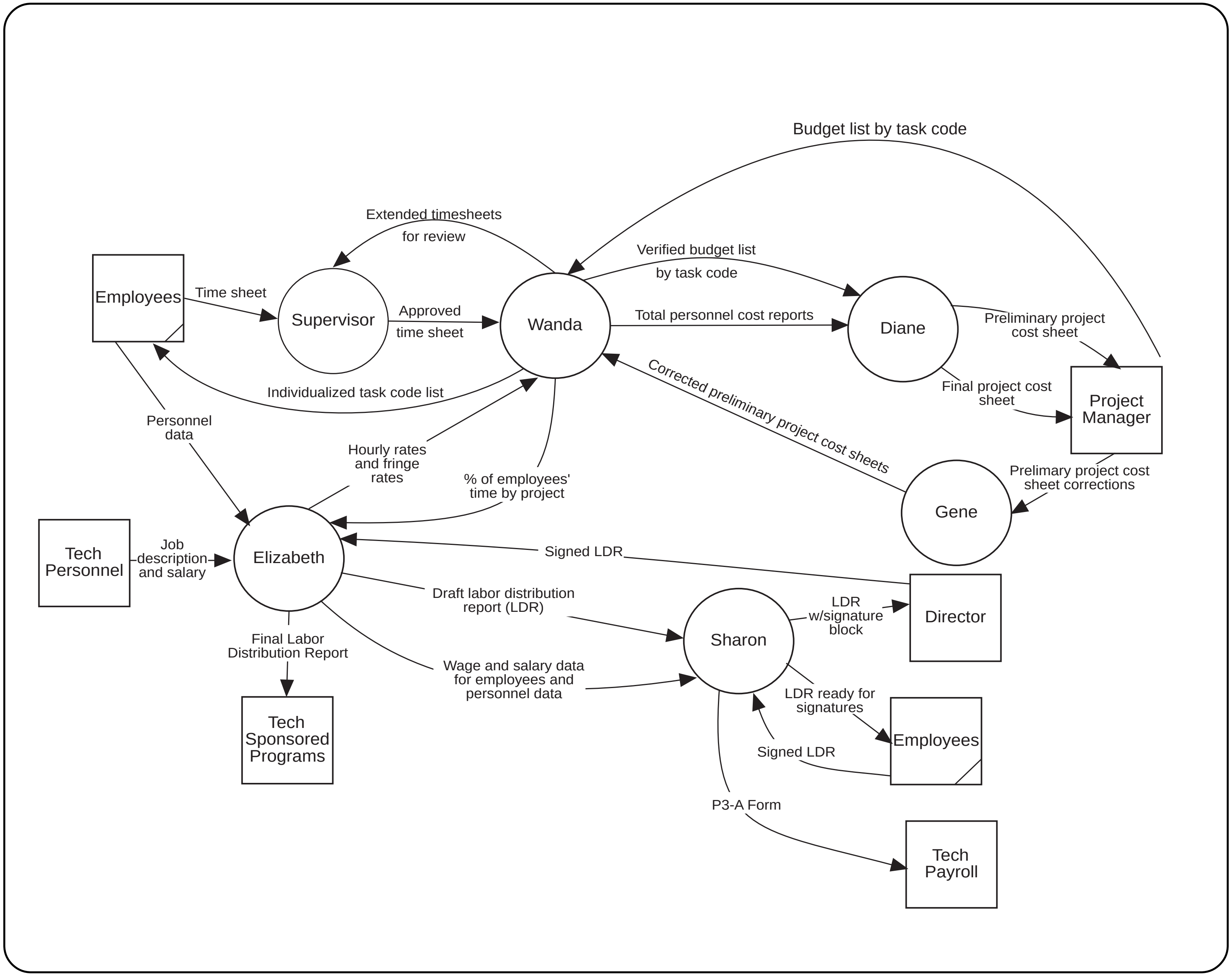

Figure 2.1.6.6.c. *Physical Information Flow Diagram of MSL's Personel Accounting System.*

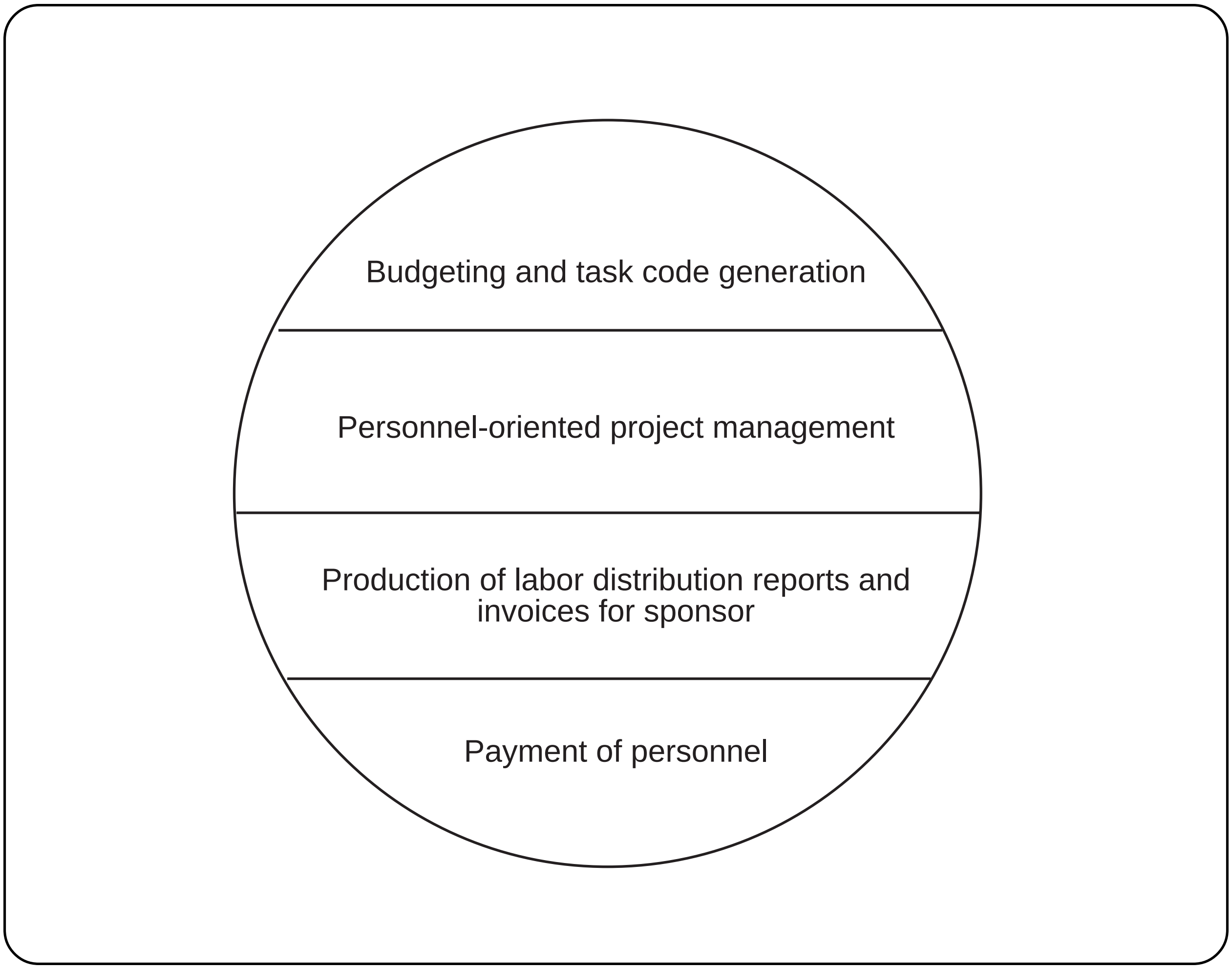

Figure 2.1.6.6.d. *Partitions for Context Diagram.*

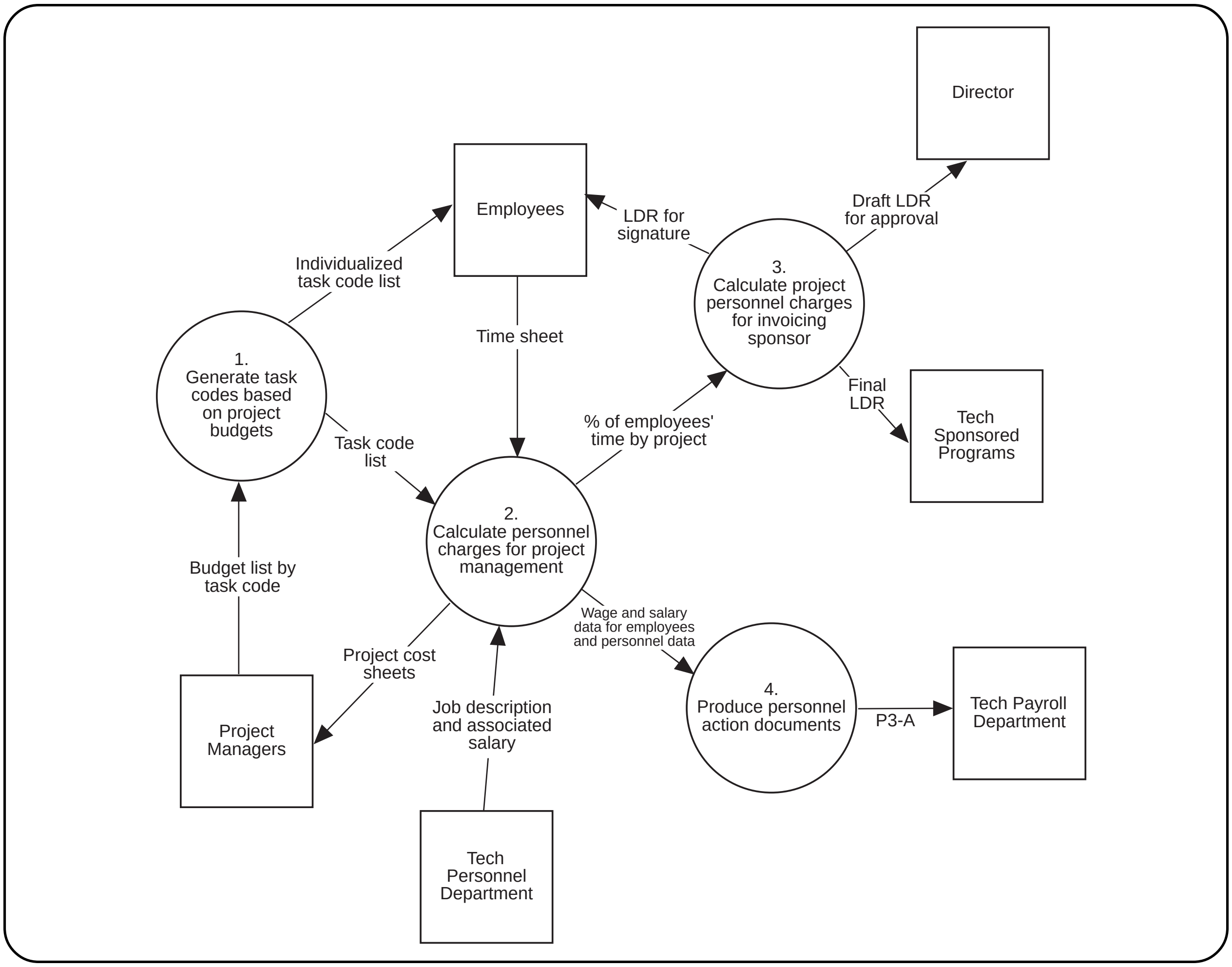

Figure 2.1.6.6.e. *Logical Information Flow Diagram of MSL's Personnel Accounting System.*

2.1.6.7. Exercise on Data Dictionary.

Explanation

In Module 1.1.18.10., you did a context diagram for a domain of responsibility. The context diagram is a zeroth-level DFD. In Module 2.1.5.4., you partitioned the domain of responsibility to produce more detailed DFD's. Now that you know each information flow, you can figure out the data carried along with each piece of information. The name of the game is to find the data requirements so you can find out how to acquire, store, retrieve, and manipulate only the needed data to later make information through comparing indicator data to reference data.

Situation Description

Sally and Bob graduated from Virginia Tech together five years ago. Sally, an engineering graduate, has been successful in technical sales for a major chemical company. Bob, a business graduate, has been an administrative officer for a small company.

Based on their success in working for others, they both wanted to go into business for themselves. They bought a small shoe store in Blacksburg, Virginia, close to their alma mater.

Bob and Sally agreed that Bob would invest 10% more than Sally and thus be the controlling partner in the business.

Sally does the inventory and customer end of the business and Bob does the purchasing and financial end of the business. Sally hired John to carry much of the day-in-day-out customer service. John has a flair for decorating and advertising.

Sally and Bob want to get their management started right. You've been hired as a management consultant to advise them.

Exercise

Write a data dictionary for three of the information flows from the domain of responsibility of the shoe store. Start with the DFD's you did in Module 2.1.5.4.. Choose three information flows and indicate which ones they are. For each information flow, write a data dictionary showing the data carried by the information flow.

2.0. Building Management Tools

2.1. Approaches for Building Tools

2.1.7. Logical Data Analysis

2.1.7.1. DATA, INFORMATION, AND IMAGE STORAGE—LILLA CABOT-PERRY

2.1.7.2. Images and Data are Part of Information Resource Management

2.0. BUILDING MANAGEMENT TOOLS

2.1. APPROACHES FOR BUILDING TOOLS

2.1.7. LOGICAL DATA ANALYSIS

2.1.7.3. NORMALIZING DATA BASES

2.1.7.3.1. ANALYZING DATA

To evaluate the roles data play in the organzation, we analyze the sources and sinks of data, the data stores, and the information flows.

In building any management tool, we ultimately must deal with data. Data is the stuff we make information from. We use information to support decision making. We've approached data from the starting point—from decisions. We used the management system model. Considering data and information, we'll step through the majority of the following steps.

1. Domain
2. Context
3. Analyze relationships (partitioning technique)
4. Information flows (DFD and data dictionary)
5. Output formats
6. Input methods
7. Information sources (and sinks)
8. Stores (files)
9. External entities
10. Conversion processes
11. Synthesize relationships (layering technique)
12. Design flows
13. Design sources
14. Design conversion processes
15. Test relationships

Notice several things from this list of steps. First, the steps are information and data flow oriented. That is, they don't include decisions. We must figure out what the decisions are we'll use the information for. And we do that by doing charts like logic charts and work flow diagrams. The decisions feed into the steps I've just listed at the point where we start dealing with analyzing the relationships internal to the domain of responsibility. Second, the analysis steps tend to carry us from a physical perspective to a logical one. Third, the synthesis steps tend to carry us from a logical perspective back to a physical one. That is, when we start, we use a physical perspective in learning what we need from the user. Then, when we're ready to turn everything back to the user, we must go back to a physical perspective again.

Looking at the 15 steps and thinking about what we've talked about so far, we're ready to start thinking about sources (and sinks) of data. Data are obviously generated either internal or external to the domain of responsibility. And they disappear either internal or external to it. Often, as we deal with data, we want to store them and save them for a while—maybe for a short while, maybe for a long while. So we can get data either from a source or from a store. And we can send them to either one. Figure 2.1.7.3.1. shows the sources and sinks of data as we make information.

In logical data analysis, we can look at three concepts:

1. Document analysis
2. External source/sink analysis
3. Data store analysis

In document analysis, you study the documents (or portrayal formats) in the domain of responsibility. They have data displayed on them. How good are the data? Are there redundant data? We can also ask questions like, "Are the data in the right place?" In logical data analysis, we're interested in the substance and redundancy of data, not the form of data.

In analyzing external sources and sinks, you study the veracity, timing, and use of data, based on where you get the data from or who you send them to. In all of this, we're interested in "data about data." Consider a piece of data indicating a milestone has slipped two months. Who got that datum (data about the data)? When did that datum get put in the system?

In data store analysis, you study the simplicity and redundancy of putting data into a place you can faithfully retrieve them from. Most of data analysis will focus on this analysis, but we can't overlook the others. We like to deal with data store analysis because it's easiest to define and describe.

These analyses can be carried out in great detail. The amount of detail depends on your objective when doing the analysis. A cursory or simple analysis will help find big overlaps or gaps in the data and will help you understand the management process, the domain of responsibility, and how the flow of information and the sources and sinks of data work. A detailed or complex analysis will help you design a more efficient and easy-to-use information system. Much like the management element (a concept I'll describe shortly), good analysis here tends to help us converge when things get complicated.

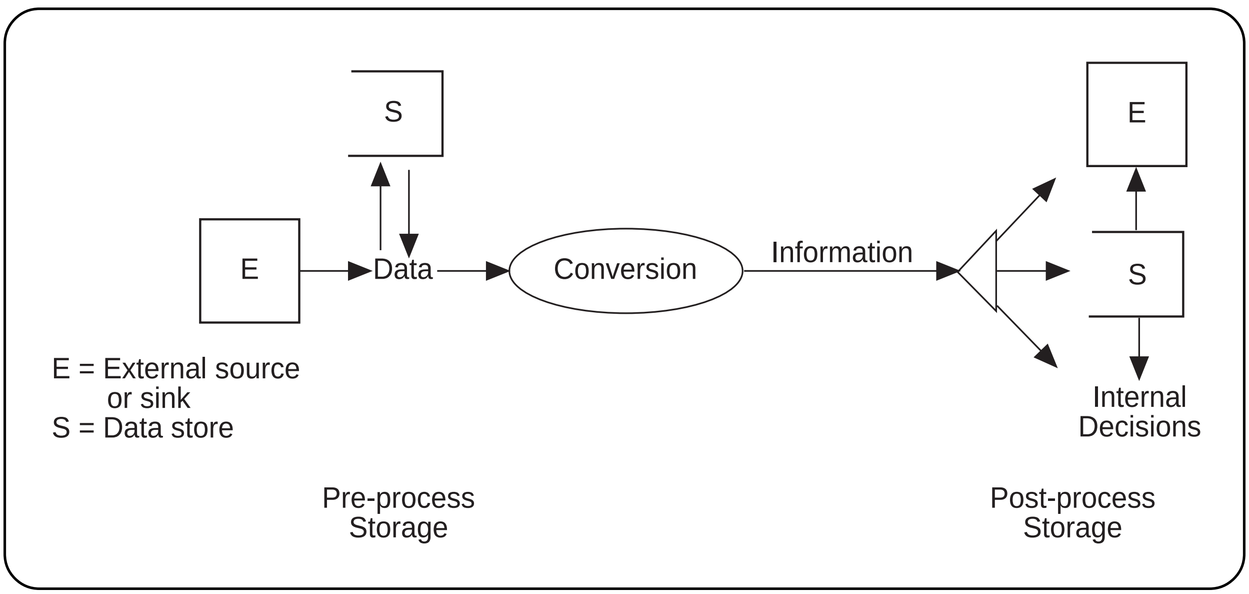

Figure 2.1.7.3.1. *The sources and sinks of data and the data stores fit into the data to information conversion process.*

2.1.7.3.2. Document Analysis

One quick way to improve data integrity and reduce steps in an organization is to study and streamline the many types of documents the organization has accumulated over the years.

In many organizations you'll find a large number of documents. Many of the data will be repeated from document to document. Some of the data will never be used. For most of the data, you'll know nothing about who put them there, or when, or how old the data are.

Most output formats in a domain of responsibility evolve. Also, the information system evolves as different output formats are needed.

Consider this example. While you're in college, you decide to sell tee-shirts on consignment. You start with an order form. That's all you need to keep track of what you're doing. So you make two data stores. One keeps track of the shirts you've sold (sizes, colors, etc.). The other keeps track of your customers (name, address, maybe color and size, etc.). From these data stores you can produce documents listing which shirts make up most of your business or listing your best customers so you can send them a Christmas card.

Then your business grows. You need some additional students (sales people) to keep up with all the business. You also have to keep some shirts on hand (the fast moving sizes, styles, and colors). Now you need data stores for sales people and inventories. You'll need merchandising and accounts payables documents. Soon you'll need to have payroll, accounts receivables (no longer cash on the barrel head), withholding taxes, and other documents. As you do business, you'll want to add to various data stores so when you need to aggregate data, you can. You'll have more data stores and more documents.

Someday, you'll have other personnel in addition to salespeople—secretary and stock clerks, for example. So you have different types of wages. Some get fringe benefits (insurance, paid vacation, etc.). How much vacation is accumulated? As you get bigger, some of your people will get perks (e.g., a company car).

You didn't analyze all this. It just happened. Your system evolved. You developed your information portrayal formats as you needed them. Many of your formats contain the same data. In some cases you get data for several documents from the same data store. In most cases, you don't. You need to do a document analysis to see what information you still need. In some cases, you don't need to know shirt color like you did when you operated your business out of the trunk of your car. When you developed the merchandising system, the shirt color was incorporated in the item number for the shirt. You're keeping redundant data—sometimes on the same document—or at least on several documents.

These redundant data beget problems with data integrity. Each time a datum changes, you have to find every place it occurs. Then you have to change that datum. Chances are you'll miss one or more occurrences of a changed datum. Then you won't know which value for the datum is the right one.

2.1.7.3.3. Data Store Analysis

If we don't eliminate redundancy and complexity in data stores, we'll surely reap data integrity problems.

In the shirt business example in Module 2.1.7.3.2., we talked about building separate tools for small functions in the bottom-up approach. We built one information system for one separate function. The information system had its own database. Then we did another information system for another function with another database. We used the classical bottom-up approach (see Module 2.1.4.) for developing our information system. With two databases we had update problems and data integrity problems—typical problems in the bottom-up approach. When we went to more systems for more functions, the problem increased.

Now, we'll look at a top-down approach where we do several functions simultaneously. We'll find several files in our one database (perhaps one, maybe a couple). The database will be kept in one mechanism—not a file cabinet and rolodex, but a computer database. Let's see what redundancy plagues us even now. We want to remove redundancy from any files, whether in a file cabinet, rolodex, and/or on a computer.

At Management Systems Laboratories, no one trusts the central filing cabinets—mostly because we don't lock them. Locked filing cabinets make people angry. Unlocked file cabinets mean we don't know what has been put in, removed, or replaced. We don't know how to share data. So everyone has their own filing cabinets. Things are filed in several places. Sometimes, a document is updated in one of the places. The others stay the same. Then, the document you get depends entirely on which filing cabinets you go to—not on which document is most current or accurate.

By studying the idea of normalizing data files (data stores), we'll learn a technique for eliminating redundancy and promoting integrity. The technique also makes the files simpler (always a valuable thing to do). We'll apply normalization to data stores, but we can extrapolate the ideas to document analysis and other issues where we want to eliminate redundancy.

Redundancy is bad in a computer because in the computer data are out of sight and we forget we may have some data (or derivatives of those data—e.g., hours, pay rate, and pay) in several places. Since we can't readily see the situation, we forget it.

We've studied information flows and information conversion processes. Now we'll study data stores.

We can apply two main criteria to data stores so we can see if their components and organization are best for the information system we're interested in. One of these criteria is simplicity. We want both the organization of and the access to a data store to be as simple as possible. Usually that means we'll implement the data store as a simple sequential or direct-access file. That is, the elements in the data store are referenced by a primary key and we have no repeating groups of data in the data store. A primary key consists of is one or more data elements that identify uniquely the occurrence of a data structure in a data store. Your social security number might be the key for a data store containing data about you. A data store is simpler if it doesn't have alternate keys or pointers to link records, and if it doesn't require implementation as variable-length records. The criterion for logical data organization is always simplicity over complexity.

The user thinks in terms of information files and records. The data processor thinks in terms of data, groups, records, and blocks. Before we discuss data stores in detail, we need some definitions to relate these terms. I've shown the definitions and the hierarchical nature of the terms in Figure 2.1.7.3.3.

The second criterion for logical data design is non-redundancy. We have redundancy, for the most part, when the same data element exists within two or more data stores. Redundancy can threaten the integrity of a system. If you change the value of a data component in one file, you must change the same element in all other files. We also have redundancy when the same data appear in different forms within the same data store—when two or more data components within a data store give the same information.

DATABASE - aggregate of files to meet information system requirements

- FILE - related records or blocks
  - BLOCK - two or more records retained in a particular storage medium such as a file cabinet or computer tape
    - RECORD - a collection of data elements related to a common identifier such as a person, machine, place, or operation
      - GROUP - two or more data elements that are logically related and must appear to form a complete unit of meaning (street number and name, first and last name of a person)
        - DATA ELEMENT - the lowest level of the data structure and the only one with which a specific value may be associated (age, part number, etc.)

Figure 2.1.7.3.3. *The convention for showing the aggregations of data into storage units helps us dig into a data store to find the datum we want.*

2.1.7.3.4. Normalizing Data Stores.

An example will help us track down the potential for data integrity problems and build a data store that has no redundency.

In the Management Systems Laboratories' personnel accounting system you saw when we discussed information flow diagrams, or data flow diagrams DFD's, in Module 2.1.6.6., we focused on information flows, information conversion processes, and external entities. We looked at that example from a physical perspective. Now let's look at a companion example—the system MSL uses to assign people to tasks and account for the time they spend on those tasks. We'll look at this example from a more logical perspective and we'll see more detail in flows and processes. And we'll see some data stores. I've shown the DFD for the personnel task assignment and execution system in Figure 2.1.7.3.4.a.

The domain of responsibility for this system is also in MSL's operations group. In Figure 2.1.7.3.4.a., you don't see much about people and places. This DFD is logical. You see three external entities to the domain. The group managers are responsible for their people. They hire and fire them, give them raises, and find contracts (or projects) for them to work on. The group managers negotiate with the contract managers to find the best place for their people to make a contribution to MSL's contracts. The contract managers are responsible to meet the requirements of certain contracts. MSL's people are one of the resources the contract managers need to meet those requirements. They divide their contracts into tasks and look for people to do the work of the task. The employees work for the group managers and are assigned to contracts under the direction of the contract managers. Usually the contracts they're assigned to are in their group.

Eight data stores are shown in Figure 2.1.7.3.4.a. The figure was produced by talking to (interviewing) the people involved. (We used our information gathering skill so we can get to the information flow diagramming skill and ultimately get to the skill for eliminating redundancy in data stores.) After doing this first-draft figure, I haven't yet reviewed it with those people and verified its accuracy. But the figure is good enough to analyze data stores. Knowing how this system has evolved over the years at MSL, I expect there's lots of redundancy in the files. Also the files aren't very simple. Usually, in a DFD, we don't label the flows out of and into a data store. I've labeled some of these flows in Figure 2.1.7.3.4.a. to help describe what's in the files. In this case, I've put those labels in parentheses. The flows between information conversion processes and external entities in Figure 2.1.7.3.4.a. are labeled as usual.

Generally speaking, what happens physically in this system is that the contract manager gets a new contract and defines tasks he or she wants people to work on. The group manager has people that need to be put to work. The manager of this domain identifies all tasks and puts them in a file. He or she also identifies all available people and puts data about them in a file. Then, on the advice of the group and contract managers, the employees are assigned to tasks and reports are sent to the group managers about what their people are working on and to the contract managers about who's working on their tasks. The employees get a report showing what tasks they can work on and charge their time to. As the employees work on their tasks, they fill in time sheets, which they submit to the manager of this domain each week. The assigning of people is the formulation side of the exercise. The charging to tasks is the execution side of the exercise. When employees are charged to tasks, the contract managers need to know exactly who and how many hours were charged to their tasks. The employees and their group managers need to know exactly what tasks the people were charged to and for how many hours.

Figure 2.1.7.3.4.b. shows a partial data dictionary for the data stores in Figure 2.1.7.3.4.a. Each data store is an iteration of a data structure. Thus, the normalization of data stores is essentially equivalent to the normalization of a set of data structures. You can glance at Figure 2.1.7.3.4.b. and see a lot of redundancy among the data stores. Look for task name for example.

We design data stores to support the information conversion processes. We need to derive the best logical design for this set of data stores. In this analysis, we'll replace the group of existing data stores by its logical equivalent. The result is a set of simple data stores containing no redundant elements.

The procedure used to derive this logical structure is called normalization. In general, normalization produces the simplest, most straightforward organization of data elements into component data stores. Normalization should produce a set of data stores containing nonredundant data elements accessible through use of unique primary keys. The keys are highlighted by showing them in bold type. I'll illustrate the procedure for MSL's personnel assignment and execution system.

STEP 1: PARTITION EACH DATA STRUCTURE THAT CONTAINS REPEATING GROUPS OF DATA ELEMENTS.

Take each repeating group of data elements and form two or more data structures without repeating groups. The newly formed data structures must accomplish the same purpose as the original repeating group of data elements. After we complete this step, the original data structures of Figure 2.1.7.3.4.b. will be converted into a state known as the first normal form. From Figure 2.1.7.3.4.c. you can see the result of step 1. For each data structure that contained a repeating group, the repeating group was removed and set up as a separate data structure. The key for the new structure was formed by concatenating the key for the original data store with the key for the repeating group. The key for the original file was retained as the key for the data structure without its repeating group. Again, in the figure the keys are highlighted by using bold type.

Figure 2.1.7.3.4.d. illustrates the original CONTRACT LOADING FILE. In Figure 2.1.7.3.4.d., I've displayed hypothetical data the way the data dictionary for the CONTRACT LOADING FILE indicates they should look. The first normal form yields three new data structures that accomplish the same purpose as the original. The new data structures are shown in Figure 2.1.7.3.4.e. They are the LOADED CONTRACT FILE, the CONTRACT TASKS FILE, and the CONTRACT EMPLOYEE FILE. I've tried to select meaningful names for the new files. The names are different from the original and from any other file. From Figure 2.1.7.3.4.e., you can see the new files are simple and are linked together through their keys.

STEP 2: VERIFY THAT EACH NONKEY DATA ELEMENT IN A STRUCTURE IS FULLY FUNCTIONALLY DEPENDENT ON THE PRIMARY KEY.

This step places the set of data structures in the second normal form. In doing this step, we deal only with those structures that are identified by concatenated keys. We accomplish the work of this step by verifying that each nonkey data element in a data structure is dependent on the full concatenated key, not just on a partial key. That is, each element should require the entire key as a unique identification. Instead, if a data element is determined uniquely by only a part of the key, the element should be removed from the structure and placed in a structure of its own. In some cases, one of the resulting structures contains only key information. This is both permissible and necessary.

From Figure 2.1.7.3.4.f. you can see the result of step 2. Figure 2.1.7.3.4.g. shows the CONTRACT TASKS FILE in the first normal form and then shows the results of changing to the second normal form. In the second normal form we've gotten the TASK 1 FILE and the CONTRACT POSITIONS FILE.

STEP 3: VERIFY THAT ALL NONKEY DATA ELEMENTS IN A DATA STRUCTURE ARE MUTUALLY INDEPENDENT OF ONE ANOTHER.

After we've converted the data structures to the second normal form, each structure is checked to verify that each non-key data element is independent of every other non-key element in the relation. We remove duplicate data elements or elements that can be derived from other elements to place the relation in the third normal form. The only redundant non-key data element in a data structure is "task duration" in the TASK DATA FILE. To get the third normal form, we must eliminate "task duration."

STEP 4: ELIMINATE REDUNDANT DATA ELEMENTS AMONG THE DATA STRUCTURES.

After we put the set of data structures in the third normal form, there are likely to be redundancies among the normalized structure. We simply remove redundant elements. In doing this, we have to use some judgment. In making the decision on which structures we should assemble into a composite structure, we are guided by a sense of what the object of a structure is and by what the attributes of that structure are. The object of a data structure is the entity to which the structure pertains. The attributes of an object are items of data characterizing that object. The data structure contains the attributes that pertain to one and only one object. No superfluous data elements appear in the relations, and no elements appear as attributes in any other relations. Figure 2.1.7.3.4.h. shows the results of steps 3 and 4. Three data structures are in the third normal form.

As a mechanical step, the revisions we've made to the set of data stores in Figure 2.1.7.3.4.a. must be reflected in the data flow diagram and data dictionary. The data flow diagram in Figure 2.1.7.3.4.i. is a redrawing of the original diagram from Figure 2.1.7.3.4.a. I've removed one of the information conversion processes because it dealt with creating a file we no longer need.

Advantages of the Third Normal Form

The following list summarizes the advantages of having data in the third normal form.

1. *Ease of Understanding.* In the third normal form, we present data structures in a way that operational and management users can easily understand them. The data structures are presented in simple, two-dimensional tables that do not require technical understanding on the part of the users and owners of the data.

2. *Ease of Use.* We can partition data structures further to represent any number of different logical viewpoints. Different structures can have different file organizations to allow efficient access for primary application, yet be accessible for many other secondary applications. Attributes from different files can be related with

little complexity.

3. *Ease of Implementation.* We can implement structures in the third normal form as simple files set up for either serial or direct access. Also, we can implement the structures within database systems.

4. *Ease of Maintenance.* Non-redundancies in the files reduce problems while keeping all files up to date. If we must add to, change, or delete an attribute from a file, we're sure that no other file will require the same maintenance. All nonkey attributes appear only one at a time in one place within the file structure.

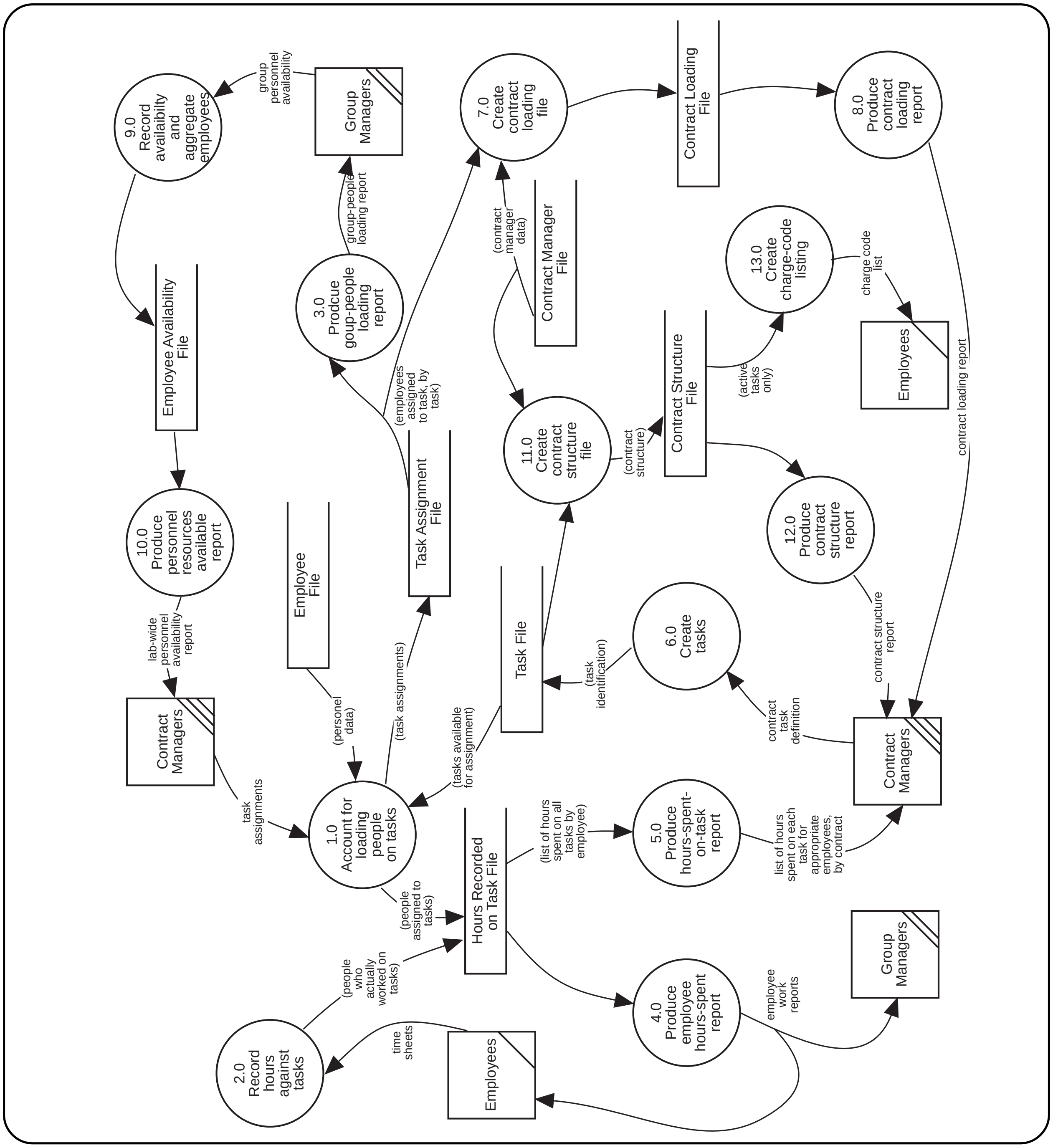

Figure 2.1.7.3.4.a. *Data flow diagram for MSL's personnel assignment system.*

EMPLOYEE FILE	=	{EMPLOYEE} All employees where
EMPLOYEE	=	**Employee-Number** + Employee-Name + Employee-Address + Employee-Start-Date + Employee-Group-Assignment + Employee-Qualifications + { Position-Title + Pay-Rate + Fringe-Rate + Pay-Start-Date } All pay rates for employee
TASK FILE	=	{TASK} All tasks available on a contract where
TASK	=	**Task-Number** + Task-Name + Task-Leader + Contract-Manager + Contract-Number + Task-Budget + Task-Start-Date + Task-End-Date + Task-Skill-Requirements
TASK ASSIGNMENT FILE	=	{TASK ASSIGNMENT} All tasks where
TASK ASSIGNMENT	=	**Task-Number** + Task-Name + Task-Leader + Contract-Manager + Contract-Number + Task-Budget + Task-Duration + Task-Start-Date + Task-End-Date + Number-of-Task-Position + { Employee-Number + Employee-Name + Employee-Qualifications + Employee-Group-Assignment } All employees on task
CONTRACT LOADING FILE	=	{CONTRACT LOADING} All tasks where
CONTRACT LOADING	=	**Contract-Number** + Contract-Manager-Name + Contract-Manager-Group + Number-of-Tasks-on-Contract + { Task-Number + Task-Name + Number-of-Task-Positions + } All tasks on contract { Employee-Number + Employee-Name } All employees on task

Figure 2.1.7.3.4.b. *Data Dictionary for Data Stores in MSL's Personnel Assignment System.*

CONTRACT MANAGER FILE = {CONTRACT MANAGER} All contracts where

CONTRACT MANAGER = **Contract-Manager-Employee-#** +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Contracts +
{ Contract-Number +
Contract-Name } All contracts assigned to contract manager

CONTRACT STRUCTURE FILE = {CONTRACT} All contracts where
CONTRACT = **Contract-Number** +
Contract-Name +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract +
{ Task-Number +
Task-Name +
Task-Status } All tasks on contract

EMPLOYEE AVAILABILITY FILE = {AVAILABILITY} All employees where

AVAILABILITY = **Employee-Number** +
= Employee-Name +
= Employee-Qualifications +
= Percent-Time-Available

HOURS RECORDED ON TASK FILE = {HOURS RECORDED} All tasks for all employees where

HOURS RECORDED = **Task-Number** +
Task-Name +
Task-Duration-in-Weeks
{ Employee-Number +
Employee-Name +
Week-Number +
Week-Name +
Hours-Spent +
Validity-of-Employee-on-Task } All employees on the task

Figure 2.1.7.3.4.b. (cont.) *Data Dictionary for Data Stores in MSL's Personnel Assignment System.*

DATA STRUCTURES IN FIRST NORMAL FORM

ORIGINAL DATA STRUCTURES

EMPLOYEE = Employee-Number +
Employee-Name +
Employee-Address +
Employee-Start-Date +
Employee-Group-Assignment +
Employee-Qualifications +
    Position-Title +
    Pay-Rate +
    Fringe-Rate +
    Pay-Start-Date

TASK = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Start-Date +
Task-End-Date +
Task-Skill-Requirements

TASK ASSIGNMENT = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Duration +
Task-Start-Date +
Task-End-Date +
Number-of-Task-Positions +
    Employee-Number +
    Employee-Name +
    Employee-Qualifications +
    Employee-Group-Assignment +

CONTRACT LOADING = Contract-Number +
Contract-Manager-Name +
Contract-Manager-Group
Number-of-Tasks-on-Contract +
    Task-Number +
    Task-Name +
    Number-of-Task-Positions +
        Employee-Number +
        Employee-Name

CONTRACT MANAGER = Contract-Manager-Employee-Number +
    Contract-Manager-Name +
    Contract-Manager-Group +
    Number-of-Contracts +
        Contract-Number +
        Contract-Name +

CONTRACT = Contract-Number +
    Contract-Name +
    Contract-Manager-Name +
    Contract-Manager-Group +
    Number-of-Tasks-on-Contract +
        Task-Number +
        Task-Name +
        Task-Status

AVAILABILITTY = Employee-Number +
    Employee-Name +
    Employee-Qualifications +
    Percent-Time-Available

HOURS RECORDED = Task-Number +
    Task-Name +
    Task-Duration-in-Weeks
        Employee-Number +
        Employee-Name +
        Week-Number +
        Week-Name +
        Hours-Spent +
        Validity-of-
          Employee-on-Task

DATA STRUCTURES IN FIRST NORMAL FORM

EMPLOYEE DATA = Employee-Number +
Employee-Name +
Employee Address +
Employee-Start-Date +
Employee-Group-Assignment +
Employee-Qualifications

POSITION = Employee-Number + Position-Title +
Pay-Rate +
Fringe-Rate +
Pay-Start-Date

TASK = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Start-Date +
Task-End-Date +
Task-Skill-Requirements

TASK DATA = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Duration +
Task-Start-Date +
Task-End-Date +
Number-of-Task-Positions

TASK EMPLOYEE = Task-Number + Employee-Number +
Employee-Name +
Employee-Qualifications +
Employee-Group-Assignment +

LOADED CONTRACT = Contract-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract

CONTRACT TASKS = Contract-Number + Task-Number +
Task-Name +
Number-of-Task-Positions

CONTRACT EMPLOYEE = Contract-Number + Task-# + Employee-# +
Employee-Name

MANAGER DATA = Contract-Manager-Employee-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Contracts

MANAGED CONTRACTS = Contract-Mgr.-Employee-# + Contract-# +
Contract-Name

CONTRACT DATA = Contract-Number +
Contract-Name +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract

TASKS ON CONTRACT = Contract-Number + Task-Number +
Task-Name+
Task-Status

AVAILABILITY = Employee-Number +
Employee-Name +
Employee-Qualifications +
Percent-Time-Available

TASK EXECUTION = Task-Number +
Task-Name +
Task-Duration-in-Weeks

HOURS = Task-Number + Employee-Number +
Employee-Name +
Week-Number +
Week-Name +
Hours-Spent +
Validity-of
  Employee-on-Task

Figure 2.1.7.3.4.c. *MSL's Personnel Assignment System Data Structures in First Normal Form.*

CONTRACT LOADING (Contract-Number + Contract-Manager-Name + Contract-Manager-Group + Number-of-Tasks-on-Contract + {Task-Number + Task-Name + Number-of-Task-Positions + {Employee-Number + Employee-Name}}

9-62	John Doe	Systems Group	3	9-62-01	Do Analysis	3	0138 Jim Young
							2156 Linda Steele
							1521 Susan Blank
				9-62-02	Evaluate Results	2	1356 George Smith
							0511 Betty Jones
				9-62-03	Write Report	1	0138 Jim Young
9-75	Peter Brown	Materials Group	2	9-75-01	Write Code	2	2156 Linda Steele
							3571 Henry Jordan
				9-75-02	Test Code	1	3571 Henry Jordan
9-81	John Doe	Systems Group	1	9-81-01	Write Report	1	0852 John Doe

Figure 2.1.7.3.d. *Original CONTRACT LOADING FILE.*

LOADED CONTRACT (Contract Number + Contract Manager Name + Contract Manager Group + Number of Tasks on Contract)

9-62	John Doe	Systems Group	3
9-75	Peter Brown	Materials Group	2
9-81	John Doe	Systems Group	1

CONTRACT TASKS (Contract Number + Task Number + Task Name + Number of Task Positions)

9-62	9-62-01	Do Analysis	3
9-62	9-62-02	Evaluate Results	2
9-62	9-62-03	Write Report	1
9-75	9-75-01	Write Code	2
9-75	9-75-02	Test Code	1
9-81	9-81-01	Write Report	1

CONTRACT EMPLOYEE (Contract Number + Task Number + Employee Number + Employee Name)

9-62	9-62-01	0138	Jim Young
9-62	9-62-01	2156	Linda Steele
9-62	9-62-01	1521	Susan Blank
9-62	9-62-02	1356	George Smith
9-62	9-62-02	0511	Betty Jones
9-62	9-62-03	0138	Jim Young
9-75	9-75-01	2156	Linda Steele
9-75	9-75-01	3571	Henry Jordan
9-75	9-75-02	3571	Henry Jordan
9-81	9-81-01	0853	John Doe

Figure 2.1.7.3.4.e. *Components of MSL's personnel assignment system in the first normal form.*

DATA STRUCTURES IN FIRST NORMAL FORM

EMPLOYEE DATA = Employee-Number +
Employee-Name +
Employee-Address +
Employee-Start-Date +
Employee-Group-Assignment +
Employee-Qualifications

POSITION = Employee-Number + Position-Title +
Pay-Rate +
Fringe-Rate +
Pay-Start-Date

TASK = Task-Number +
Task-Name +
Task-Leader +
Contract-Manger +
Contract-Number +
Task-Budget +
Task-Start-Date +
Task-End-Date +
Task-Skill-Requirements

TASK DATA = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Duration +
Task-Start-Date +
Task-End-Date +
Number-of-Task-Positions

TASK EMPLOYEE = Task-Number + Employee-Number +
Employee-Name +
Employee-Qualifications +
Employee-Group-Assignment

LOADED CONTRACT = Contract-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract

CONTRACT TASKS = Contract-Number + Task-Number +
Task-Name +
Number-of-Task-Positions

CONTRACT EMPLOYEE = Contract-Number + Task-# + Employee-# +
Employee-Name

MANAGER DATA = Contract-Manager-Employee-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Contracts

MANAGED CONTRACTS = Contract-Mgr.-Employee-# + Contract-# +
Contract-Name

CONTRACT DATA = Contract-Number +
Contract-Name +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract

TASKS ON CONTRACT = Contract-Number + Task-Number +
Task-Name +
Task-Status

AVAILABILITY = Employee-Number +
Employee-Name +
Employee-Qualifications +
Percent-Time-Available

TASK EXECUTION = Task-Number +
Task-Name +
Task-Duration-in-Weeks

HOURS = Task-Number + Employee-Number +
Employee-Name +
Week-Number +
Week-Name +
Hours-Spent +
Validity-of-
Employee-on-Task

DATA STRUCTURES IN SECOND NORMAL FORM

EMPLOYEE DATA = Employee-Number +
Employee-Name +
Employee-Address +
Employee-Start-Date +
Employee-Group-Assignment +
Employee-Qualifications

JOB = Position-Title +
Pay-Rate +
Fringe-Rate

PAY = Employee-Number + Position-Title +
Pay-Start-Date

TASK = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Start-Date +
Task-End-Date +
Task-Skill-Requirements

TASK DATA = Task-Number +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Duration +
Task-Start-Date +
Task-End-Date +
Number-of-Task-Positions

WORKER = Employee-Number +
Employee-Name +
Employee-Qualifications +
Employee-Group-Assignment

WORKER TASK = Task-Number + Employee-Number

LOADED CONTRACT = Contract-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract

TASK 1 = Task-Number +
Task-Name

CONTRACT POSITIONS = Contract-Number + Task-Name +
Number-of-Task-Positions

LOADING = Contract-Number + Task-# _ Employee-# +
Employee-Name

MANAGER DATA = Contract-Manager-Employee-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Contracts

PROJECT = Contract-Number +
Contract-Name

PROJECT MANAGER = Contract-Mgr.-Employee-# + Contract-#

CONTRACT DATA = Contract-Number +
Contract-Name +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract

TASK 2 = Task-Number +
Task-Name

STATUS = Contract-Number + Task-Number +
Task-Status

AVAILABILITY = Employee-Number +
Employee-Name
Employee-Qualifications +
Percent-Time-Available

TASK EXECUTION = Task-Number +
Task-Name +
Task-Duration-in-Weeks

RESOURCE = Employee-Number +
Employee-Name

TIME = Task-Number + Employee-Number +
Week-Number +
Hours-Spent +
Validity-of-
Employee-on-Task

Figure 2.1.7.3.4.f. *MSL's Personnel Assignment System Data Structures in Second Normal Form.*

CONTRACT TASKS (Contract Number + Task Number + Task Name + Number of Task Positions)

9-62	9-62-01	Do Analysis	3
9-62	9-62-02	Evaluate Results	2
9-62	9-62-03	Write Report	1
9-75	9-75-01	Write Code	2
9-75	9-75-02	Test Code	1
9-81	9-81-01	Write Report	1

TASK 1 (Task Number + Task Name)

9-62-01	Do Analysis
9-62-02	Evaluate Results
9-62-03	Write Report
9-75-01	Write Code
9-75-02	Test Code
9-81-01	Write Report

CONTRACT POSITIONS (Contract Number + Task Number + Number Task Positions)

9-62	9-62-01	3
9-62	9-62-02	2
9-62	9-62-03	1
9-75	9-75-01	2
9-75	9-75-02	1
9-81	9-81-01	1

Figure 2.1.7.3.4.g. *Components of MSL personnel assignment data structures in the second normal form*.

DATA STRUCTURES AFTER COMBINING COMMON ELEMENTS

EMPLOYEE = **Employee-Number** +
Employee-Name +
Employee-Address +
Employee-Start-Date +
Employee-Group-Assignment +
Employee-Qualifications +
Percent-Time-Available

TASK = **Task-Number** +
Task-Name +
Task-Leader +
Contract-Manager +
Contract-Number +
Task-Budget +
Task-Start-Date +
Task-End-Date +
Task-Skill-Requirements +
Number-of-Task-Positions +

CONTRACT MANAGER = **Contract-Manager-Employee-Number** +
Contract-Number +
Contract-Manager-Name +
Contract-Manager-Group +
Number-of-Tasks-on-Contract +
Number-of-Contracts

WORKER TASK = **Task-Number + Employee-Number**

HOURS = **Task-Number + Employee-Number** +
Employee-Name +
Week-Number +
Week-Name +
Hours-Spent +
Validity-of-Employee-on-Task

Figure 2.1.7.3.4.h. *MSL's Personnel Assignment System Data Structures in Third Normal Form.*

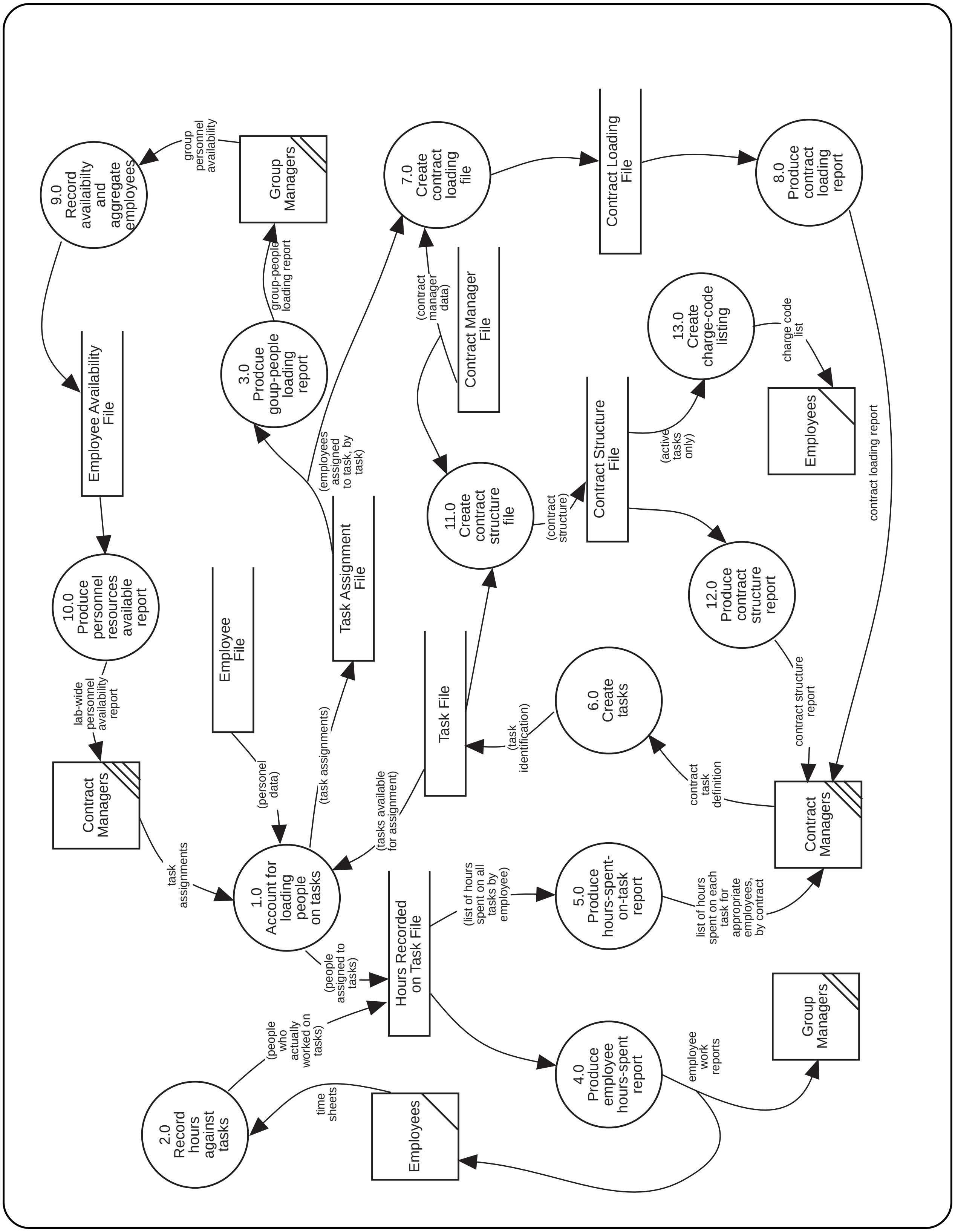

Figure 2.1.7.3.4.i. *Revised data flow diagram from MSL's personnel assignment system.*

2.0. Building Management Tools

2.1. Approaches for Building Tools

2.1.8. Logical Information Analysis

2.1.8.1. Focus on What You Manage—Winslow Homer

2.1.8.2. Choosing Your Management Element.

If you can focus on the entity you manage toward, your efforts for gathering, storing, and retrieving data will converge rather than diverge.

As we build management tools, the name of the game is to figure out what data we need to put into tools to get the information we need out of the tools. One way to get at the data in the organization for our management tools is to do DFD's and then develop data dictionaries for each information flow. There are other ways to get at the data elements we need. I'll describe another way here. The best way to use depends on the situation. The worst way is to make random guesses of the data you might need.

A management element is the entity you manage toward which your decision making efforts converge. Of all the things that may be in your domain—people, materials, activities, budgets, etc.—something is central. One entity is the hub the others rotate around. If you figure out what the hub is, your decisions and resulting actions and the information and data you use to support your decisions are more focused. Things seem to naturally fit together better. Not knowing your management element isn't a disaster. You can still do your work. However, things aren't so focused and your decision making efforts tend to diverge. You haven't distinguished the hub other entities rotate around.

The time you spend deciphering your management element pays rich dividends. Your thinking and decision making are more focused and streamlined. Your management tools perform better.

I've shown examples of management elements in Figure 2.1.8.2.a. This partial list is only the tip of the iceberg. You'll be able to think of some entirely different entries and some slightly different entities. Your management element is highly tuned to your domain.

Most of you will see aspects of your domain of responsibility that emphasize more than one, or even all, of the entities in Figure 2.1.8.2.a. You may think you have more than one management element. Indeed you may think all of these are your management elements. I'm asking you to choose one that is more your management element than any of the others. For your management element, you should be able to divide resources and assign accountability, and your management elements should have limits—be discrete.

This isn't easy, but it's worth it. Why? Because if you choose the right management element, information will be focused on your objective; if the wrong element, the information will be scattered and hard to consolidate. That's not a disaster if you're wrong, it's just more difficult.

Some years ago, Virginia Power came to me and wanted help with a methods-type management tool (See Modules 1.4.2.6.3. and 1.5.1.3.4.) called Critical Path Method (CPM). CPM is one of several types of network-based charting techniques used in project management. Any project management book describes CPM. CPM is a precedence diagramming technique showing the precedence of activities in a project. CPM requires that you know the endpoint of the collection of activities. CPM has some advantage over other networking techniques because "precedence is mathematically more precise and allows the user to exercise much more control over the relationships between activities in the schedule." (Daniel D. Roman, *Managing Projects: A Systems Approach*, Elsevier, 1986, p. 181.) Notice how CPM focuses on activities, one of the entities in Figure 2.1.8.2.a.

The managers from Virginia Power, who were responsible for producing batches of refuelling elements for their nuclear power plants, had recently studied project management at a workshop. They were armed with a tool in search of a problem. My first step was to understand their domain of responsibility.

A difficulty arose in that the managers represented two different endeavor levels: the strategic and the tactical. The strategic decision making in Virginia Power centered around the nuclear fuel cycle and their efforts in maintaining a presence in the mining, milling, conversion, enrichment, and fabrication stages. They had to make make-or-buy decisions for each stage and ensure they had adequate quantities of fuel material at each stage so when they needed to have material at a succeeding stage they didn't have to wait for feed material. In technical terms, they had a multi-stage, production-to-inventory problem with make-or-buy decisions at each stage.

The costs of waiting one day during the refuelling cycle in a nuclear reactor are astronomical. The corporate policy was to maintain a given quantity of uranium distributed among the inventories at the fuel cycle stages. At that time, uranium was quite expensive and the amount of money tied up in the large total inventory was enormous. (As an aside, keeping large inventories is a way of using the technique of slack resources in managing. If you can't nail down the process and the cost of failure is high, keep large amounts of slack resources—money, people, material, equipment, energy—available as contingencies. This is the opposite of Just-In-Time.)

The tactical decision making in Virginia Power centered around constructing the reload batch of fuel elements on time to refuel a given reactor during its refueling window.

My recommendation to the managers responsible for the strategic endeavors was that they needed a Material Requirements Planning (MRP) technique. William J. Stephenson defines MRP as "a computer-based information system designed to handle ordering and scheduling of dependent-demand inventories (e.g., raw materials, component parts, and subassemblies)." (William J. Stevenson, Production/Operations Management, Richard D. Irwin, Inc, 1990, p. 583.)

What happened in the nuclear fuel cycle and in each of the stages of the fuel cycle was that they did activities that yielded inventories. Of course, they used people and machines to do the activities to get the inventories. To figure out what tool to use and to figure out the focus of decision making, I needed to find the management element.

For the strategic endeavor, the management element was the inventories. In this case, other entities including the people, equipment, and activities aimed at the inventories. Therefore, the people doing the strategic endeavors would get the most benefit from an inventory-oriented management tool, namely MRP.

For the tactical endeavor, the management element was the activities. In this case, the people and equipment played roles in the activities and the inventories came out of the activities. Therefore, the people doing the tactical endeavors would get the most benefit from an activity-oriented management tool, namely CPM.

The managers doing the strategic endeavor could have used the CPM tool they came to me with. If they had, they would have dealt with inventories as attributes of certain activities. Whether they saw activities as attributes of inventories or inventories as attributes of activities may seem a trivial matter at first glance. But when they selected the tools they needed or they focused the information they used for decision making they'd go the long way if they saw activities as their focal point. Their thinking and effort would diverge. They'd have to search longer in their databases. They'd set up their output formats around activities. They could make activity-oriented decisions easier, quicker, cheaper, and better than inventory-oriented decisions. They'd eventually come upon the answer. I'd rather drive directly toward the answer I need by focusing on the right thing.

The management element is a concept I used to help select or build management tools. CPM and MRP are both methods-type management tools managers use to make decisions with. I quoted Stephenson's definition of MRP not just to define MRP but also to illustrate our common preoccupation with the computer. Both CPM and MRP can be done without the computer. In most cases, the computer helps us do more cumbersome problems quicker. However, if we lose sight of the principles behind the tools, we'll apply them improperly. Remember the caveman story in Module 1.4.5.2.2.

I'll now give you another example of choosing the right management element. In Figure 2.1.8.2.b., you see the classic dilemma for a teacher, who manages the classroom, which is the special student who needs the teacher's time. The teacher's ready to go to class on time. Two hundred people are waiting on him. If the teacher gives the time to the student, the class suffers. If the teacher scurries off to class, the student suffers. Therefore, the teacher's choice in this dilemma indicates the management element. Does the teacher focus on the student or the class? Possible management elements might be lesson plan (today's lesson), course (e.g., engineering economy), class (e.g., this particular section of engineering economy), the room, the student, a student group (if the students work in groups in that class), and many more. If the class is the management element, each student's name is an attribute of that class, as is the course number, the room number, the meeting days and times, the various lesson plans, and many more. If the student is the management element, the other entities are attributes of the students in the teacher's domain.

The right choice of management element helps you filter need-to-know information from irrelevant data. Information leading from other entities to the management element stand out more readily.

In the Management Systems Laboratories (MSL), project managers see people as resources to be spread over activities. The financial system focuses on transactions as opposed to dates, accounts, or balances.

If you haven't properly defined your management element, you're more likely to suffer from information overload.

CHOOSE YOUR MANAGEMENT ELEMENT FROM A REPRESENTATIVE SAMPLE.

- Inventory - a defined accumulation of a resource
- Activity - a timed effort to achieve a goal under single direction
- Transaction - a transfer of responsibility
- Budget - a comprehensive and specific plan for using resources
- Person - an individual
- Milestone - an important point in time

Figure 2.1.8.2.a. *What's your management element?*

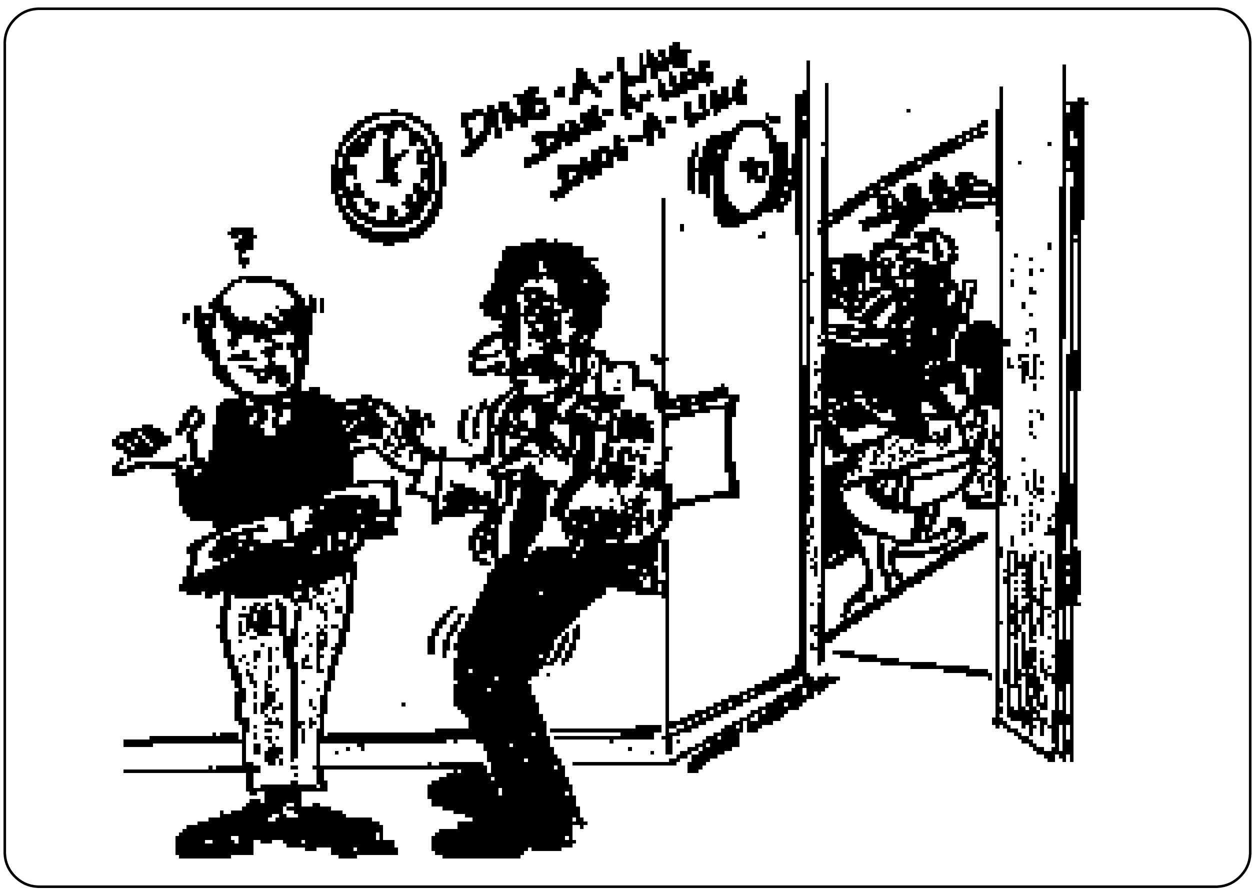

Figure 2.1.8.2.b. *"That answer's right—huh?"*

2.1.8.3. Characterizing and Accessing Your Management Element.

Another way to develop a list of data elements is to characterize your management element.

Attributes are the characteristics of your management element, and attributes lead to data elements.

In Figure 2.1.8.3.a., I've grouped attributes into five categories. The categories include the ideas of resources, schedule, and quality (or results) as well as relationships between your management elements and a catch-all I call identification. You saw the ideas of resources, schedule, and quality before when I discussed the project management pyramid.

The data-flow-diagram perspective of data elements works best when we know both ends of the information flows as in more certain environments. The management element perspective is best for more uncertain environments.

Each category in Figure 2.1.8.3.a. can be subdivided. The data elements appear when the attribute categories cannot be divided further.

Data are characteristics. When we use a reference point, we make information, and we include bias. Three of us may have the same characteristic. As shown in Figure 2.1.8.3.b., I'm persistent, you're stubborn, and he's pigheaded. The interpretation depends on the bias. Other examples of different perspectives of the same characteristic include: 1) consistent, predictable, and dull (boring), and 2) judicious, neutral, and indecisive.

Remember that we're looking at an abstract thing from several different perspectives to try to come to grips with it. When you do data flow diagrams, the natural progression is to identify information flows and determine the data elements that make up the flow. This technique gives you one list. Now we're looking at management elements and determining characteristics. This technique gives you another list. The lists won't be the same. However, one isn't better than the other. We need both to generate a complete list.

What we have with data elements is the ability to know what slots need to be filled with data and the appropriate data to fill those slots. We put values for the data elements into databases to retrieve when we want to make information.

Some attributes can be grouped into structures for accessing, monitoring, and controlling as shown in Figure 2.1.8.3.c. Attributes can continue simply to describe the management element or they may be elevated and structure the environment of the management element.

This elevation from attribute to structure is your choice but should respond to a need for greater accessibility or easier reporting, updating, and maintaining of data. The penalty for elevating an attribute is a more complex information system.

Consider an Hollarith card. (You may not remember Hollarith cards—the cards we punched to input data into and sometimes to output data from a computer.) The monitoring element is in the first field and attributes are in the following fields. The monitoring element might be last name or social security number.

Here's a story for understanding how to recognize environmental structures for characterizing and assessing a management element. In Figure 2.1.8.3.d., a newly married student has come to the departmental office in our university to have her marital status changed on her records. My department keeps student files by name. Someone asks the question, “Which students are married?” After looking through the files enough times, we mark married student files with red tape. Then someone asks the question, “Which students live in Virginia?” After looking through the files enough times, we mark Virginia-student files with blue tape. Now if someone asks the question “How many married students live in Virginia?”, the answer is easy to get We look for files with both red and blue tape. What I’ve described is a very simple instance of a modern database technique that allows two environmental structures.

We call the matrix in Figure 2.1.8.3.e. a schema, which is a diagrammatic presentation of your domain of responsibility. From this schema, database structures, information flows, and interaction points become clear—either as they exist or as they should exist. An example of an interaction point is whose office is next to whose office.

A primary purpose of the schema is to identify existing or potential gaps in responsibility or coordination. The schema is the starting point for defining data elements and information flows. Each axis on the matrix is a path into the data characterizing the management element.

It’s said that everyone wants to get to heaven, but nobody wants to die. You have begun to pay the price to understand what you manage well enough to fix automatic procedures according to a set structure. You know the phrase “Getting there is half of the fun.” In this case getting there is no fun at all. Certain things are better to have done than to do.

Think of one of the information documents you’d like to support one of your decisions. Whether it be text, checklist, table, or graphic, identify each data element on the document. You may have overlooked data elements. Any alpha-numeric unit on your document constitutes a data element. Ultimately we want to define data to access, store, and retrieve. Identifying the data elements in all the information documents for all the decisions is the other way to generate a representative list.

Relate the attributes of your management element to the data elements you identified on your document.

For any data element you must know the following:

> Who obtains the data? (Name of person)
> What is their source? (Name of agency or person)
> Who verifies the data? (Name of person)
> How frequently should the data be updated? (hours, days, weeks, months, etc.)

Data are expensive to maintain. You must identify the important pieces of data. Figure 2.1.8.3.f. shows a case of determining what should be measured to make data.

Two farmers with contiguous farms had horses they couldn’t tell apart. First, one of the farmers bobbed the tail of his horse. The other horse ran into a barbed wire fence and pulled off his tail so that again the farmers couldn’t tell the horses apart. The first farmer then notched the left ear of his horse. The other horse ran into the same fence and notched his same ear. Then the farmers decided to determine if the horses are of different height. Wouldn’t you know it, the black horse was two hands taller than the white horse.

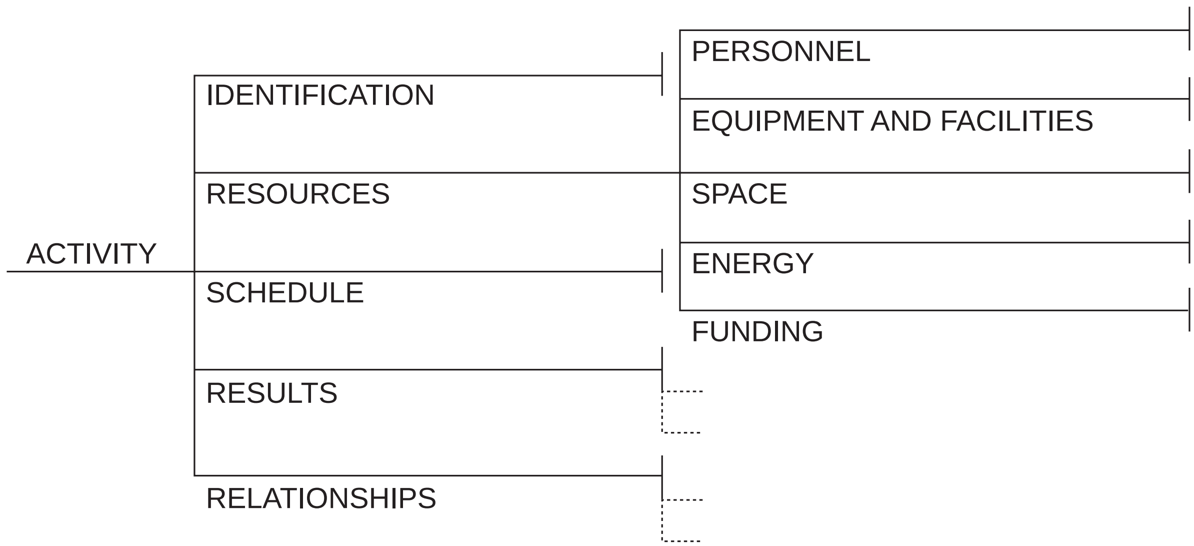

Figure 2.1.8.3.a. *Five attribute categories describe an activity.*

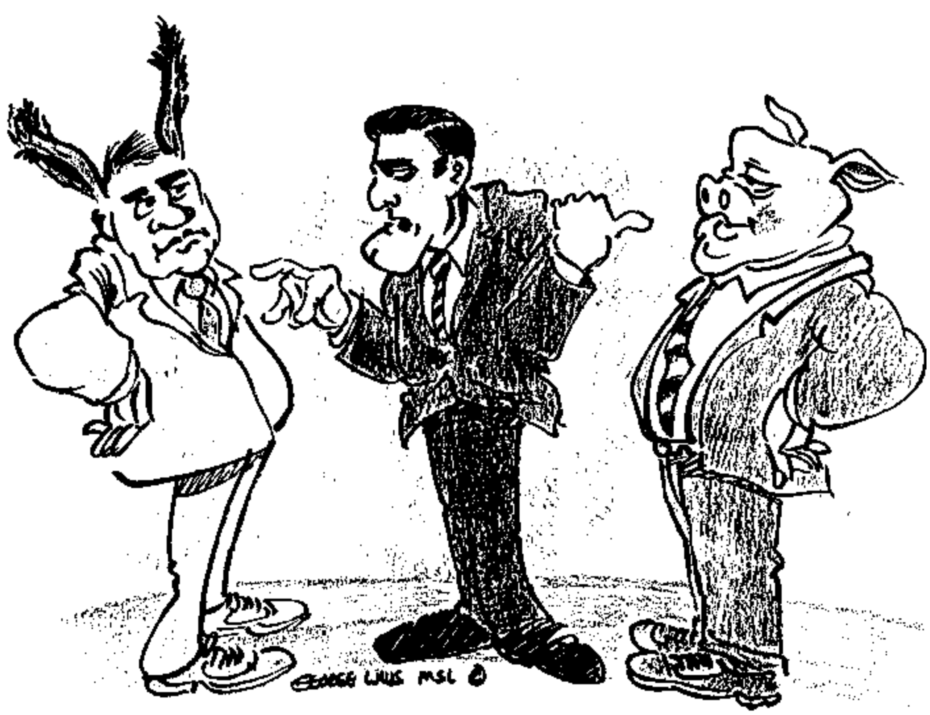

Figure 2.1.8.3.b. *"I'm persistent, you're stubborn, and he's pigheaded."*

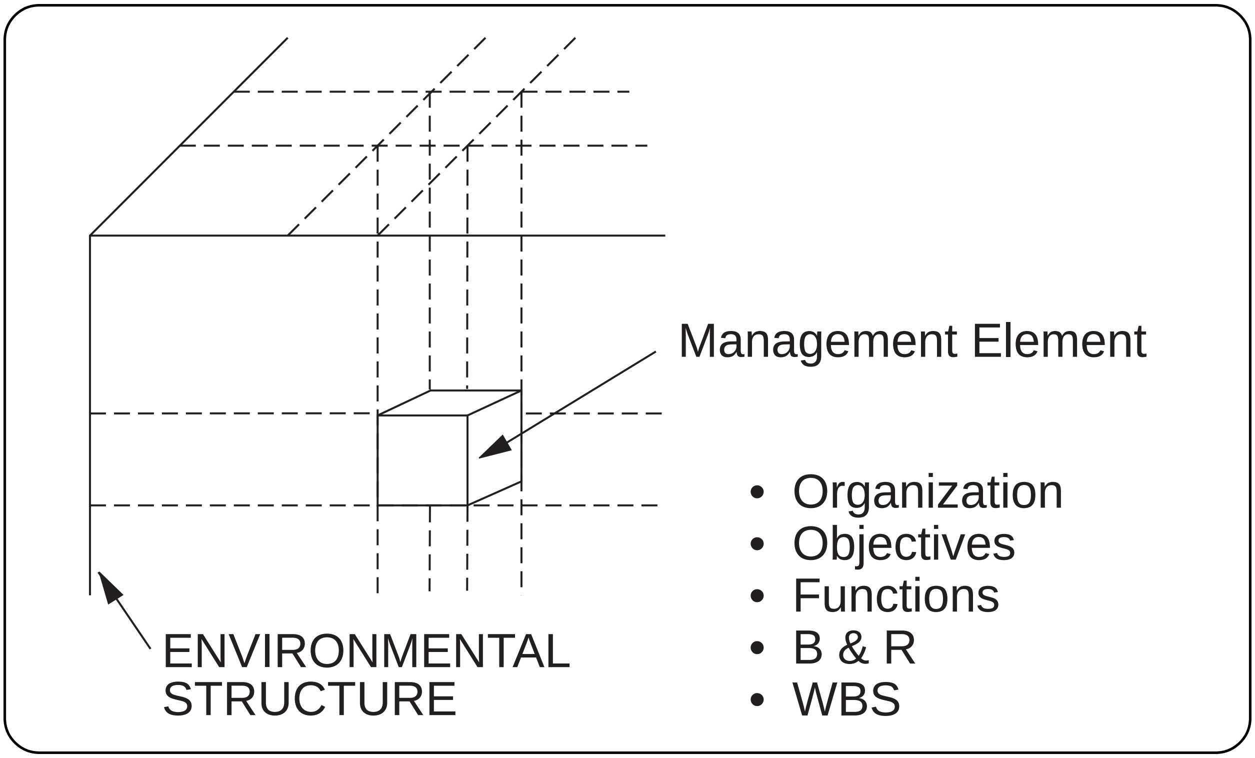

Figure 2.1.8.3.c. *Environmental structures allow ease of accessing, monitoring, and controlling information.*

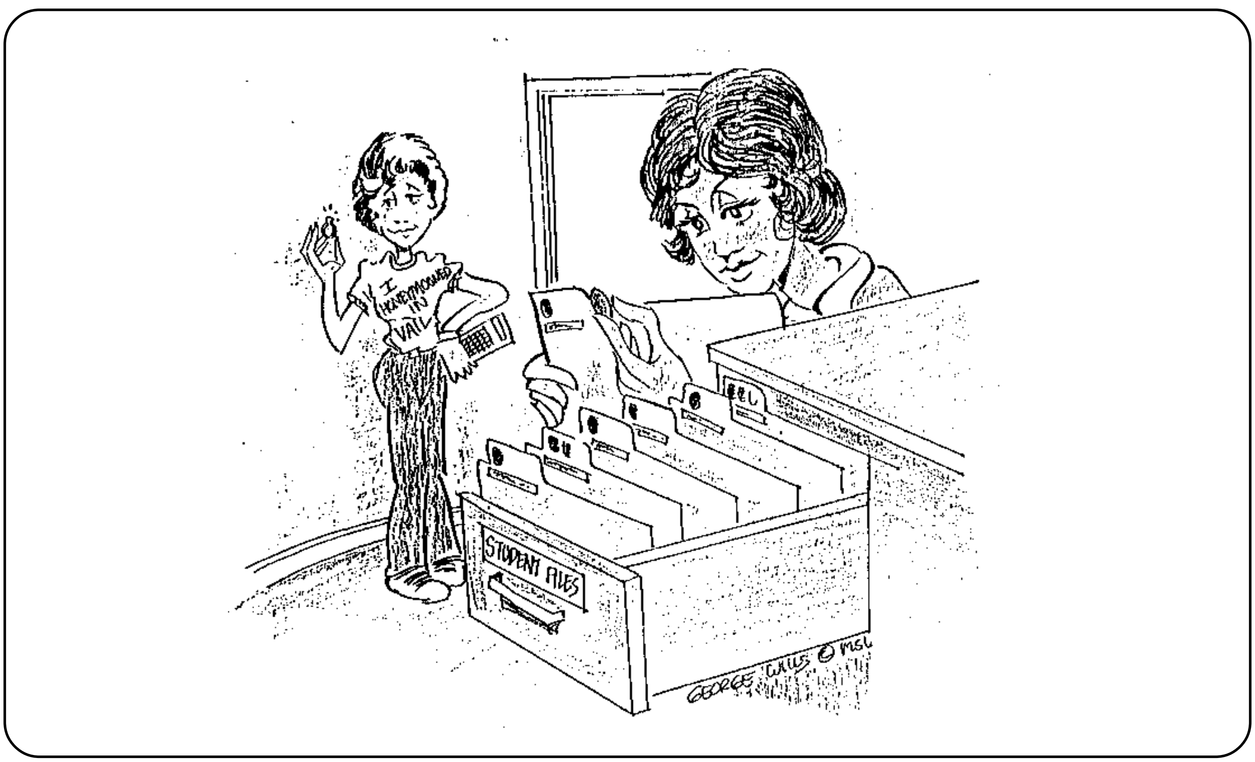

Figure 2.1.8.3.d. *"For the record, change my records."*

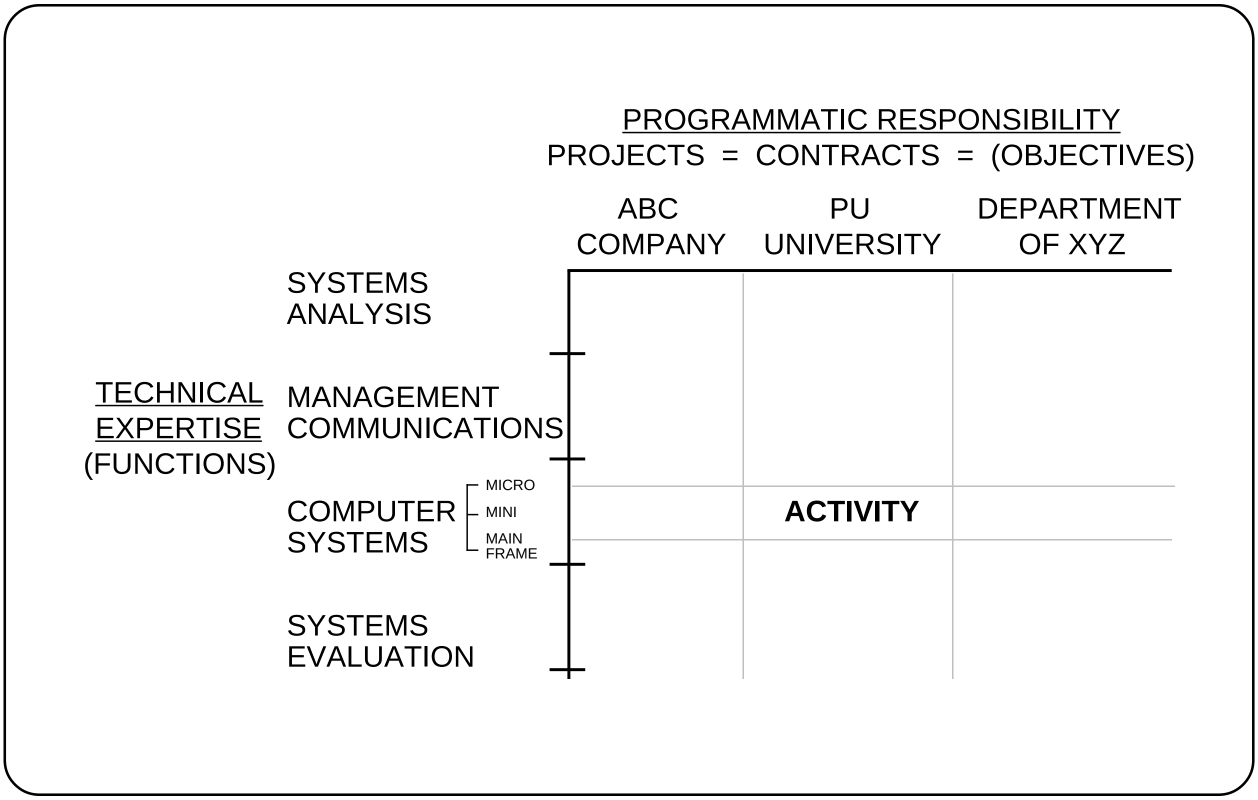

Figure 2.1.8.3.e. *"MSL manages activities in a project-management matrix organization."*

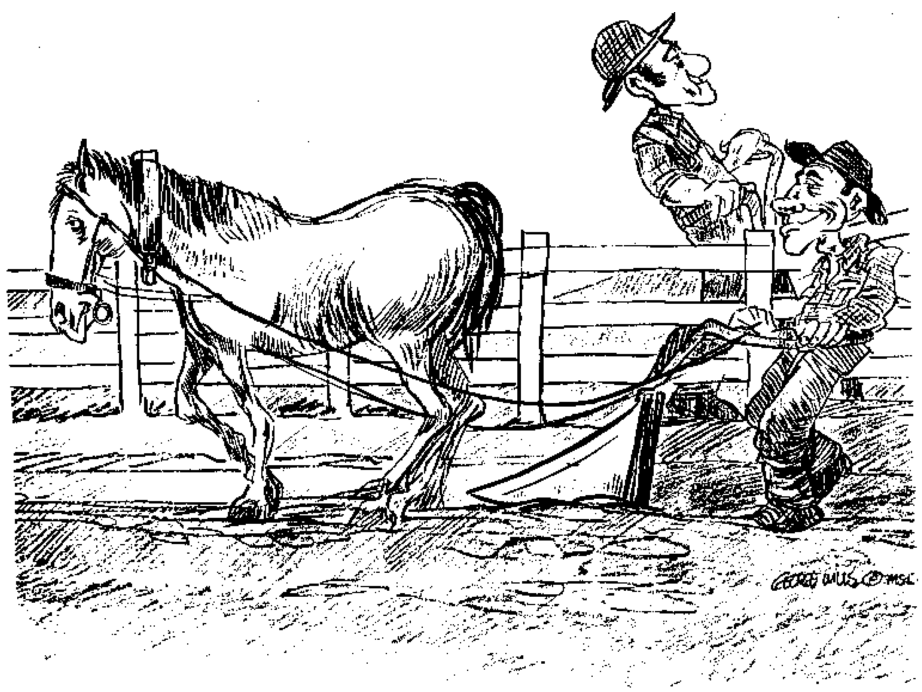

Figure 2.1.8.3.f. *"Whose horse is whose, Clem?"*

2.0. Building Management Tools

2.1 Approaches for Building Tools

2.1.9. Information Oriented Productivity

2.1.9.1. Choose Your Objectives–Thomas Gainsborough

2.1.9.2. Linking Domains for Productivity

We link domains to share information; and the better the performance of our management tools, the better we share.

Many people misuse the terms productivity and performance. So, I'll define what I mean here. When people use the terms interchangeably, they're trying to get at the idea of doing their jobs better. Typically, people associate productivity with this concept of doing a better job. However, the larger issue is performance, and performance is what most people mean when they use the term productivity.

My interest here is more specific than just productivity or performance. My interest is information-oriented productivity or performance. I'm considering the process for producing information from data. Good information is the product of our process. Bad information is the waste stream. Data are our feed materials. So, much like a chemical process, we have a multi-stage information conversion process.

Recall Figures 1.1.16.12.1 and 1.1.16.12.2. Raw data are our raw materials. We intend for management tools to help who manages get lots of good information (product) and little bad information (waste) from the smallest amount of raw data. Once the management tools of one who manages have converted data to information, we want the management tools of another who manages to refine that product as the feed material and make more-refined information. One manager's information (product) is the next manager's data (feed material). As the information passes up the chain of decision makers, the product hopefully becomes more refined (more valuable) and we're able to distinguish good from bad information. In this way, we share and enhance data and information through multiple stages. In Figure 2.1.9.2., I illustrate one link in the chain of decision makers. You saw this figure in Module 1.6.1.1.

For sharing information, we consider two or more domains of responsibility. Then we have two or more management systems and two or more connected Management System Models (MSM). The what is used to manage component is the information-oriented link between management systems, and the linkage occurs at the information portrayal/information perception interface. The linkage, as shown in Figure 2.1.9.2., is based on this relationship: audience plus purpose equals design. We can portray information to the who manages in our own domain of responsibility or to a who manages in any other domain. Any who manages is an audience and affects how the information *should be* portrayed and *is* perceived.

An audience outside our domain affects the linkage between domains by the audience's information needs and preferences in information perception. Your purpose for information transfer also affects the linkage through how you portray the information. You use the audience plus your purpose to design your information portrayal format. For convenience, I call the linkage within a domain the red loop. The blue loop is the linkage between domains, the linkage for shared information processing. The audience-plus-purpose-equals-design relationship applies to all information portrayal formats, including tables, graphics, checklists, and text.

Figure 2.1.9.2. represents an adaptation of the MSM to deal with the closed-system limitation of the MSM. We run a risk of misusing the MSM any time we adapt it. The value of this

adaptation is the identification of the concept of blue loop and red loop. Blue loop and red loop exemplifies the idea that we make different information from the same indicators. The difference depends on the different reference points (biases) we use for different purposes and audiences. A negative connotation of this concept is the idea of keeping two sets of books. We often keep more than one set of any kind of information. The negative enters the picture when we have something to hide. The idea is positive when we recognize the need to address different audiences and/or we have different purposes in producing information.

I used the idea of linked domains before when I talked about shared decisions. In that case, I link domains not only through the information portrayal/information perception interfaces but also through the decision/action interfaces.

With this idea of a multi-stage conversion process in mind, we can understand and measure factors for productivity and performance. Consider the ratio of good to bad information (product to waste). Consider the ratio of good information to good data (output to input). If we reduce the data a manager deals with to get the information he or she needs, we save time, effort, and money. Likewise, if we increase good information for the same input, we've saved even more.

Performance is the ability to fulfill a job or task. It is a multidimensional concept, which is evident when we try to measure performance. We can use several performance measures to see if our domain of responsibility is meeting its aim. Sink lists seven distinct, though not mutually exclusive, measures of organizational system performance. These are effectiveness, efficiency, quality, profitability, productivity, quality of work life, and innovation. (See Module 1.1.25.5.) Which measures are most important to you depends on your domain of responsibility.

For defining and measuring indicators to use in these measures, we can go many ways. For example, we can make an audit of a user's input (data) and output portrayal (information). We're auditing the user's material, but more specifically we're measuring the success of the mangement tools. So, we're not threatening the user. To start, let's sample input and output. Find out from the sample output how many data and information items are timely, accurate, and relevant and how many aren't. Now we have the ratio of good information to input data. Even if we don't know the absolute numbers, we do know if we get more good information or use less input data, the indicator will move in the right direction.

Once we define and measure performance indicators, we'll get the Hawthorne effect. That is, people will perform better just because someone is looking. Then, if we're not careful and haven't defined the indicators right, one of the performance factors will dominate. For example, productivity may go up at the cost of quality. And if quality goes down more than productivity goes up, the total performance goes down. By worrying about this problem and carefully considering all the performance factors and the interplay among them, we try to establish a closed set of measures. With a closed set, we're watching all the right things and making all the right moves so total performance goes up over the long haul and one factor doesn't gain at the expense of another without our planning it that way.

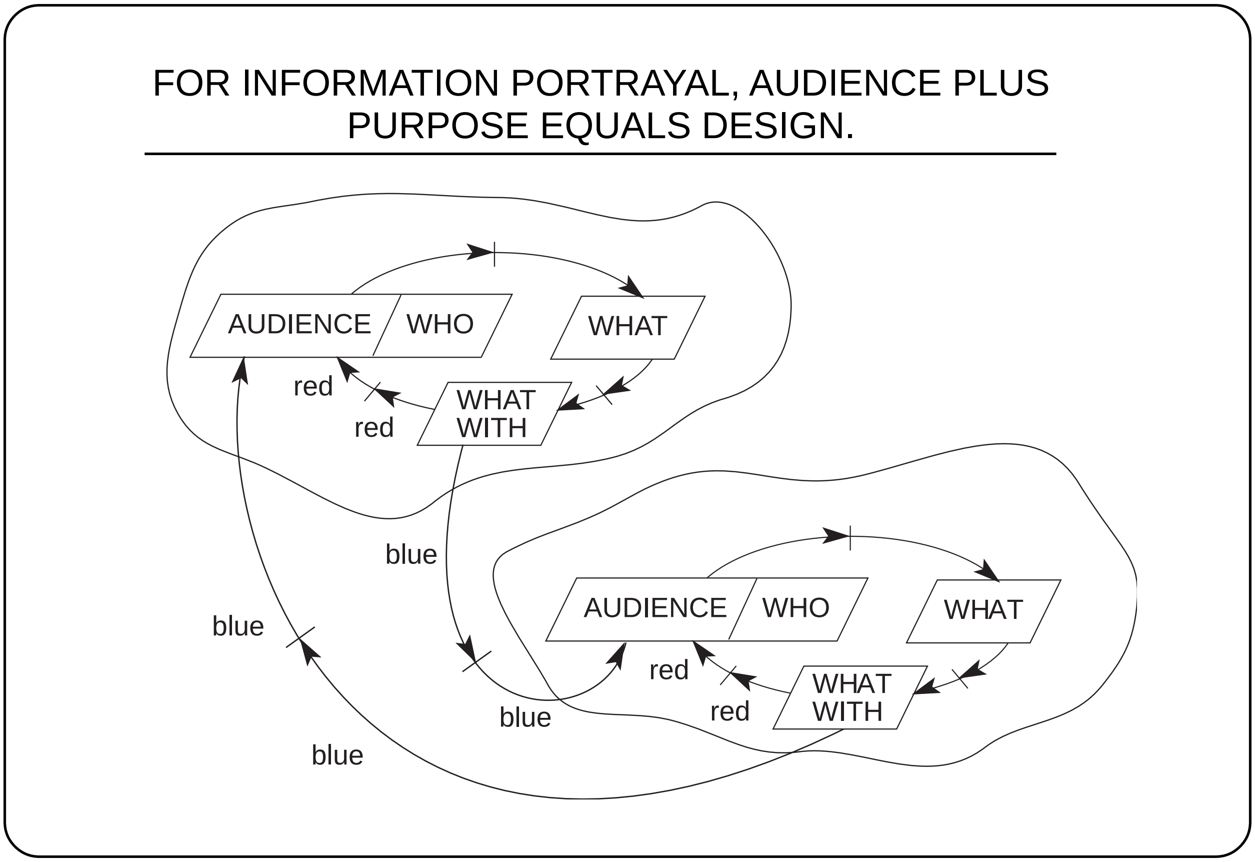

Figure 2.1.9.2. *Two domains are joined at their information portrayal/information perception interfaces.*

2.1.9.3. Measuring Information-Oriented Productivity and Performance

We can measure how well our management tools perform by looking at a number of ratios of bad, good, and relevant data and information.

The following discussion was adapted from *Measuring Information-Oriented Productivity and Performance* by Harold A. Kurstedt, Jr., and David T. Hill, Proceedings of the 24th Annual Meetings, Southeastern Chapter of the Institute of Management Sciences, October 1988, pp. 277-280.

Everyone talks about performance. But what kind of performance? The manager's performance? The performance of the operations (the people, facilities, and materials)? The performance of the management tools? The performance of everything taken together?

I first isolate what performance I'm concerned about. Many have studied personal performance. Others have studied operational performance. I'm studying the performance of management tools. How can we measure the performance of management tools? Why measure the performance of management tools?

We measure the performance of management tools to improve their performance. I'll borrow Sink's seven performance criteria discussed in Module 1.1.25.5. I'll adapt these criteria for operational performance into criteria for information-oriented performance. To develop measures (ratios) for the criteria, I define the differences among good, bad, and relevant information and data. Then I can quantify the ratios by measuring the amount, cost, and value of the different kinds of information and data. To measure performance, I address the issue of how or whether to combine the criteria. Later, I'll discuss an instrument to tally the quantities of the different kinds of information and data for a given information document. You can use the instrument to evaluate and improve the performance of an information document.

From the Management System Model (MSM), we know that management tools convert data to information. A manager converts information to action. For information-oriented performance, I concentrate on the management tools.

In Module 1.1.18.5., I divided the MSM into three areas of performance: personal/professional, operational, and information-oriented. I call the performance of the whole organizational performance. (See Figure 1.1.18.5.) Operational performance corresponds to Sink's organizational system performance. I'm going to use Sink's organizational system performance criteria to develop measures of information-oriented performance. I define information-oriented performance as the measure of how well a process for producing information from data (management tool) meets its goals and objectives. I believe Sink's criteria are comprehensive and, with slight modification, will suit my needs best.

Operationalizing Performance Measures

For now, I'll describe each performance measure in terms of information (INFO) and data (DATA). Information is biased data. The bias occurs when data are compared to reference points to generate information. INFO includes GOOD, RELEVANT, and BAD INFO. DATA include GOOD, RELEVANT, and BAD DATA. RELEVANT is necessarily GOOD, but GOOD is not necessarily RELEVANT.

Later, I define what I mean by GOOD, RELEVANT, and BAD.

Keep in mind I'm measuring the performance of what is used to manage (management tools), not who manages or what is managed. However, the boundary conditions of the performance measures are the projections of who manages and what is managed on their respective interfaces with what is used to manage. (See Figure 1.1.18.1.3.) RELEVANT INFO matches the interface with who manages. RELEVANT DATA match the interface with what is managed.

Productivity: a Measure of Output over Input

Productivity is the ratio of outputs over inputs for a system over a period of time. I don't think the output has to be good as Sink defines it in his productivity equation. (D. Scott Sink. *Organizational System Performance: Is Productivity a Critical Component?* IIE Annual Conference Proceedings, Institute of Industrial Engineers, 1983.) I'll be more concerned with measuring good output when I talk about quality. I measure information-oriented productivity by (amount of INFO out from our tools/amount of DATA into our tools).

Quality: an Input Measure and an Output Measure

"Quality is the degree to which the system conforms to requirements, specifications, or expectations" (D. Scott Sink. *Productivity Management: Planning, Measurement and Evaluation, Control and Improvement*. New York, NY: John Wiley & Sons, Inc., 1985.). I use two quality checkpoints: one for inputs and one for outputs. I measure quality at these two checkpoints in terms of GOOD DATA and GOOD INFO. GOOD DATA and GOOD INFO can include accuracy, timeliness, and other attributes I'll define later. I need a reference point, so I'll measure the amount of GOOD DATA over the total amount of DATA, GOOD and BAD. The ratio for information-oriented input quality is then (amount of GOOD DATA into our tools/amount of DATA into our tools). Likewise, I'll measure the amount of GOOD INFO over the total amount of INFO, GOOD and BAD. The ratio for information-oriented output quality is then (amount of GOOD INFO out from our tools/amount of INFO out from our tools).

Effectiveness: an Output Measure

Effectiveness is accomplishing the right things. We want our tools to produce the right information for our decisions. I call the right information RELEVANT INFO. Since RELEVANT is necessary GOOD, but GOOD is not necessarily RELEVANT, I measure the amount of RELEVANT INFO over the amount of GOOD INFO. Therefore, the ratio for information-oriented effectiveness is (amount of RELEVANT INFO out from our tools/ amount of GOOD INFO out from our tools).

Efficiency: an Input Measure

Efficiency is using the right things. We want our tools to use the right data to produce information. I call the right data RELEVANT DATA. I measure information-oriented efficiency by (amount of RELEVANT DATA into our tools/amount of GOOD DATA into our tools).

Relative Value (Profitability): a Measure of Outcome over Input

Profitability is the ratio of total revenues over total costs. Revenue isn't an output; it's an outcome, or a perception. Value is also a perception. I measure the value of the INFO out from our tools, whether it's GOOD, RELEVANT, or BAD, over the cost of the DATA into our tools, whether it's GOOD, RELEVANT or BAD. I call the ratio "relative value," since it measures value relative to cost. I can measure information-oriented relative value in terms of dollars and cents by the equation (present unit value of INFO out from our tools/present unit cost of DATA into our tools).

Innovation: a Measure of Successful Adaptation

Innovation is the creative process of successfully responding to pressure, demands, and opportunities. These changes can occur either upstream (caused by new technology) or downstream (caused by managers). Two measures of innovation are adaptation to internal needs and adaptation to external competition. I'll write a ratio for each measure of innovation in terms of the value of the output from our tools. First, I'll look at adaptation to external competition. Our tools are innovative if they successfully adapt to external competition from similar (standard) tools. I can measure this by (present value of INFO out from our tools/ present value of INFO and from similar tools). Now I'll look at adaptation to internal needs. Our tools are innovative if they successfully adapt to the changing needs of the user. I can measure this by (present value of INFO out from our tools/original value of INFO out from our tools). The internal measure of information-oriented innovation may be more appropriate for my purposes since the other performance measures are also internal to the MSM.

Quality of Work Life: a Measure of Response to the Environment

Quality of work life is the affective response of employees to the overall work environment. Quality of work life is closely related to employee satisfaction. I obviously can't measure how satisfied our management tools are with the quality of their work life, but I can measure the affective response of our management tools to the physical work environment. Our management tools may have some specifications that must be followed for them to function properly. Their performance won't improve if we adhere to the specifications, but it will decrease if we don't. Information-oriented quality of work life is then the extent to which the environment violates the design specifications of our management tools, or the relationship of our tools' environment to their limits (what they can stand). I can measure this by (our tools' environment/our tools' limits).

One Measure or a Family of Measures?

Now that I've written an equation for each performance measure, I need to decide if I want to use them as a set, if I want to aggregate them into one performance indicator, or if I want to group them into several indicators. The Multi-Criteria Performance Measurement Technique (MCPMT) can be used to aggregate multiple measures into one performance indicator. Using this technique, the measures are prioritized, assigned relative weights, multiplied by their respective relative weights, and summed into one indicator (Scott D. Sink. *Productivity Management: Planning, Measurement and Evaluation, Control and Improvement*. New York, NY: John Wiley and Sons, Inc., 1985.). I could also use this technique to group the measures into several indicators. For now, I'll group the performance measures into input, transformation, and output combinations by multiplying them together since multiplication is a logical "and." I want to try to make sense of how the measures work together.

Information-Oriented Input Performance

There are two input measures: efficiency and input quality. The input combination is then (amount of RELEVANT DATA into our tools/ amount of DATA into our tools).

Information-Oriented Transformation Performance

There are four transformation measures: productivity, relative value, innovation, and quality of work life. The transformation combination is then (present value of INFO out from our tools/present cost of DATA into our tools) and (our tools' environment/our tools' limits) and either (present value of INFO out from our tools/present value of INFO out from similar tools) or (present value of INFO out from our tools/original value of INFO out from our tools).

Information-Oriented Output Performance
There are two output measures: effectiveness and output quality. The output combination is then (amount of RELEVANT INFO out from our tools/amount of INFO out from our tools).

Information-Oriented Performance
Now I should be able to describe information-oriented performance. Some of the measures have like terms, so I'll apply dimensional analysis. If I multiply (since multiplication is a logical "and") productivity by effectiveness by output quality and divide by efficiency and input quality, I get (amount of RELEVANT INFO out from our tools/amount of RELEVANT DATA into our tools). This makes sense because we want our management tools to use only relevant data and produce only relevant information. Notice also I'm taking a measure of output over input (productivity), multiplying it by two output measures (effectiveness and output quality), and dividing it by two input measures (efficiency and input quality) to get a new measure of output over input. Now I multiply this by relative value to get (present value of RELEVANT INFO out from our tools/present cost of RELEVANT DATA into our tools). I multiply this by one of the two measures of information-oriented innovation to add a measure of successful adaptation. Finally, I multiply that by (our tools' environment/our tools' limits) to add a measure of response to the work environment. Trying to come up with one number may not be important. I just want to make sense of how the measures work together.

The Good, The Bad, and the Relvant
Now I'll define what I mean by GOOD, RELEVANT, and BAD INFO and DATA. I define GOOD and BAD INFO by two attributes: accuracy and timeliness. If the information portrays a situation or status as it really is, the information is accurate. If the information is available when needed and hasn't become outdated through delay, the information is timely. If the information is both accurate and timely, it's GOOD INFO. If the information lacks accuracy or timeliness or both, it's BAD INFO.

Information must be both accurate and timely to be RELEVANT INFO, but it must also be relevant. If the information is useful or needed by the user in making a particular, immediate decision, the information is relevant. Relevant information fulfills the decision maker's unique requirements.

I define GOOD, RELEVANT, and BAD DATA by the same attributes. If the data represent a situation or status as it really is, the data are accurate. If the data are available when needed to produce information and haven't become outdated through delay, the data are timely. If the data are useful in producing or needed to produce information about a particular, immediate situation, the data are relevant. GOOD DATA are both accurate and timely. BAD DATA lack accuracy or timeliness or both. RELEVANT DATA are accurate, timely, and relevant.

I think accuracy, timeliness, and relevance are the criteria I need to define GOOD, RELEVANT, and BAD INFO and DATA. "The quality of information rests solidly on three pillars—accuracy, timeliness, and relevancy. These are the key attributes of information." (Burch, John G., and Grudnitski, Gary. *Information Systems: Theory and Practice*, fourth ed. New York, NY: John Wiley & Sons, 1986.). Keep in mind I want to classify the information and data as GOOD, RELEVANT, or BAD, so I'm not interested in how accurate, timely, and relevant the information and data are. I just want to know whether or not the information and data are accurate, timely, and relevant so I can put them in one of the three classes.

2.1.9.4. The Automation Objectives Model

From many potential objectives for automation, we need to chose one or more objectives to address for improving information supply and flow in our domain.

Our ultimate goal in designing an information system is to improve our information-oriented productivity or performance to get better information faster. Timely, accurate, and relevant information will help us, as managers, make better decisions.

Most organizations today see office automation as more than word processing, teleconferencing, and scheduling. They see automation as applying to all management responsibilities of your office. As such, automation is really just a mechanization for information management. You have undoubtedly heard that "the computer is the forcing function of the age of information." Fortunately, this statement is incorrect and misleading. Clearly, we're in the age of information. Think of today's parlor games (e.g., Trivial Pursuits) and television games (e.g., Jeopardy). But computers aren't the forcing function. The forcing function is the need for more and rapidly-changing information. Computers merely reduce our technical contraints on getting the information. Today's managers don't want computerization, they want information. You need to decide how, or if, automation will best help you achieve the goal of getting good information to make good decisions.

Before deciding how automation can best help, you need to understand and identify your domain of responsibility—that is, know where you are. Management system analysis, based on the Management System Model (MSM), can help you understand your domain. The Automation Objectives Model illustrates the various automation objectives available to you and alternate routes you can take to achieve these objectives. It helps you decide where you want to be. You can then use the MSM to understand the domain you want to get to.

The Model

We all want personal computers and other automation techniques to improve our management tools. I'm interested in three variables to describe objectives for automating some of the tools. Taken together, the variables form a three-dimensional matrix. I'll use the matrix to pinpoint where we want to be after we apply automation techniques such as shared information processing and personal computers.

The three variables for automation objectives are:

1) the number of data types and the degree of interrelatedness we've captured among them, or moving from task automation toward broad decision support;

2) the range of impact of automation, or moving from just doing right the things we know to do toward doing more of the right things; and

3) the number of users, or moving from personal productivity toward corporate performance.

You need to decide where improved management tools and automation will help you do better. What in your domain of responsibility will benefit from automation? Each of the variables for describing automation objectives either directly or indirectly alludes to performance measures.

I've shown the variables in the three-dimensional matrix in Figure 2.1.9.4.1. The subcubes in Figure 2.1.9.4.1. simplify the range and continuous character of the variables. For example, I show only personal productivity (one user) and corporate performance (many users) for the number-of-users axis.

Management Systems Laboratories (MSL) uses this cube as a simple device for helping managers figure out where they want to be with their management tools. The model allows us to look at what our automation objectives are and to see several alternatives for getting to where we want to be from where we are. Before discussing the meaning of the subcubes in Figure 2.1.9.4.1., let's look at the axes.

The first axis I'll discuss is the "Interrelatedness of Data Types." To do this, let's define data types, data representations, and interrelatedness. Data types include financials (budget), production, project (milestones), and personnel. These data types can be represented or portrayed in image, text, or numerical form. When we talk about the interrelatedness of data types think about it in the following way: who (personnel) works on what task (project) and how much (financials) does it cost? As a manager, systems analyst, or automation specialist you'll have to deal with data interrelatedness as you work toward the goal of transforming the data into information.

Many organizations function as information processors. Indeed, one concept of organizational design considers any organization as an information processor. Many of the inputs and outputs to your domain are data and information: plans, targets, guidelines, and more. As such, many of your activities relate to the data-to information chain, one of the tools we use to manage with.

Figure 2.1.9.4.2. shows the links in the data-to-information chain. Each link represents a technical discipline for the information specialist. As an information processor, you can view your information activities in relation to the links in this chain. In Figure 1.5.1.3.7. you saw a version of Figure 2.1.9.4.2. without the arrow at the bottom.

The starting point in the chain is data. Raw materials put into the system are data; data are facts and meanings. People and machines transform the data to produce an output: information. We transform data into information when we compare data against a reference point. We'd like to think data are pure so when we transform them into information, we get lots of good information to make sound decisions. Data, however, are always biased. Bias is introduced at every link in the chain. We introduce bias through the methods we use to acquire data (the measurement/data interface in the MSM) and at the end of the chain through information portrayal.

The more physical activities occur on the side of the chain closest to the source of data; typing, drawing, mail, and scheduling meetings. As you progress through the chain you get into more complex activities like analysis and synthesis. This progressing complexity is shown in Figure 2.1.9.4.2. as well as in Figure 2.1.9.4.3.

Automation terminology follows this progression, with task automation dealing with the more physical activities and decision support the more complex or abstract activities.

Strictly speaking, images, text, and numerical values are all different representations of data. When choosing our automation objectives, we should consider specific examples within data representations. For example, we can use specific numerical values to portray different qualitative concepts such as resources and evidence of progress. When considering resources, the numerical values could be funding levels or energy requirements. Numerical values for progress could be completion amounts and dates for project milestones or production indicators.

Let's look at the data interrelatedness variable and consider an example of the interrelationship between data types and how the interrelationship can be portrayed. We'll take funding (financials) and milestones (project) for a task as our data types. Funding can be portrayed as funding level in a table and as description in text. Milestones can also be presented in tables and text. To point out interrelatedness, let's consider a situation where the funding for a task is cut. How does that affect the milestones? We need a system where funding level is automatically related to the milestones for a given task so when funding is cut, we automatically know what milestones won't be met. A change in funding not only affects the data type, milestone, but also the representation or portrayal of those data. For example, in a document, when the funding level is cut we have to know what entry in the budget table and what sentences in the text are affected. And since funding affects milestones we have to know what entries for milestones are affected. This example demonstrates how data types and data representations are interrelated.

As you think about data types, remember there are many tools or supporting devices with which you manage. Automation can play an important role in any of the tools.

If you're looking at one data type (e.g., financials) and that data type isn't related to other types, you have a relatively simple situation. You're probably dealing with automating a single task. We call this task automation on the "Interrelatedness of Data Types" axis.

Task automation isn't a new idea, but the manager's office is late in getting into task automation. The idea came into being with the assembly line. Early automation was accomplished with mechanical devices and has now progressed to total-plant process-control systems with robotics that rely heavily on computers. Task automation in white-collar jobs started with accounting and payroll tasks, moved into the engineering department with CAD/CAM and has now been generalized into automated office support systems.

If you're relating two or more data types, you're dealing more with bringing several pieces of information together to support a broad requirement. We call this decision support on the "Interrelatedness of Data Types" axis.

You'll need to choose where you want to start. Review the information supporting your structured decision and identify critical or widely-used data. You may choose to start with a particular type of data, like budget data, production data, or milestone data. Do you gain the most by automating budget data or milestone data? Picking a type of data and/or one domain as a starting point may help narrow the scope of your attack and allow you to set achievable objectives. You also need to decide whether your objective has more to do with task automation or decision support, effectiveness or efficiency, and personal productivity or corporate performance. The choices aren't always obvious and depend on your domain of responsibility and where you are and where you want to be.

The Range of Impact axis includes efficiency and effectiveness. Efficiency has to do with using the right data and information to accomplish specific goals. Efficiency leads to productivity. Improving efficiency is a commendable objective for operational-level and clerical-level endeavors.

For strategic-level and tactical-level endeavors, the question is more a matter of doing all the right things on time; this is effectiveness. Effectiveness leads to performance.

The “Number of Users” axis has to do with personal productivity and corporate performance and confronts the problem of sharing. As we add users to our management tools, we have to deal with sharing. We must share the data that goes into the tools and the information that comes out of them. We must share the decision mechanisms we use the information for and the processors we get the information from.

In short, just looking at the axes forces us to face up to the problems—and the value—of automating our management tools. But where are we? Where do we want to be?

If you apply automation to achieve a personal efficiency gain with a particular type of data, you can achieve visible results quickly. The type of automation is task automation more so than decision support. You can buy a personal computer and a spreadsheet package, and with a little training you’re there.

Trying to be effective with sharing corporate data, all interrelated to support decision making, is like standing at the bottom of a huge cliff figuring out how to get to the top. We want to figure out how to get, by any path or mechanism, to the top. The first task is to be effective with corporate data of any one type. Then we can scale the cliff along any one type of data at a time. When you’re able to connect the several types of data, then you’ll not only be able to get up the cliff, but you’ll have a measure of control over where you are on the cliff (Figure 2.1.9.4.4.)

As you move toward decision support, you must define the interrelationships among the various types of data. You must answer questions like, “Where does this letter fit within the budget-and-reporting structure?” and, “Which milestones go with which budget-and-reporting number?”

Placing numbers on the three axes in Figure 2.1.9.4.1. gives us a numbering convention to identify the boxes. I refer to the personal, efficiency, task automation box as box 1, 1, 1.

Take a minute and review the boxes, moving from one box to another. If your objective is box 1, 1, 1 for narrative data (text), you want to buy a word processor. If your objective is 1, 2, 1, meaning you want more users, you want to buy several word processors or a multi-user version that can share data.

If the objective is box 2, 2, 1, meaning you not only want efficiency but effectiveness, you should have word processors that share a common disk with some administrative functional capability like searching, indexing, and filing. If you move from the personal level to the corporate level, it means you must be able to at least share data. If you move from efficiency to effectiveness, it means you must be able to manage the data and information.

Moving to box 2, 2, 2, from task automation to decision support, means the narrative data is related to other data more and more tightly as we progress into box 2, 2, 2. The automation becomes less generalized and routine—the automated systems become more complex and specific to the domain. In box 2, 2, 2 (and others) we must worry about “data about data.”

Trying to use new technology to get up the cliff can be frustrating. Usually we don’t understand the machinery and it isn’t easy for us to use effectively and we can hurt ourselves or the machinery. The fact is that automation for effective, corporate decision support is no easy task. To get there, you must be able to effectively manage data and information.

The bottom line is that the choice and investment are yours. As a decision-maker, for your domain, your job is to make effective corporate decisions. You may decide, however, that the place to spend you automation dollars is in meeting box 1, 1, 1 objectives.

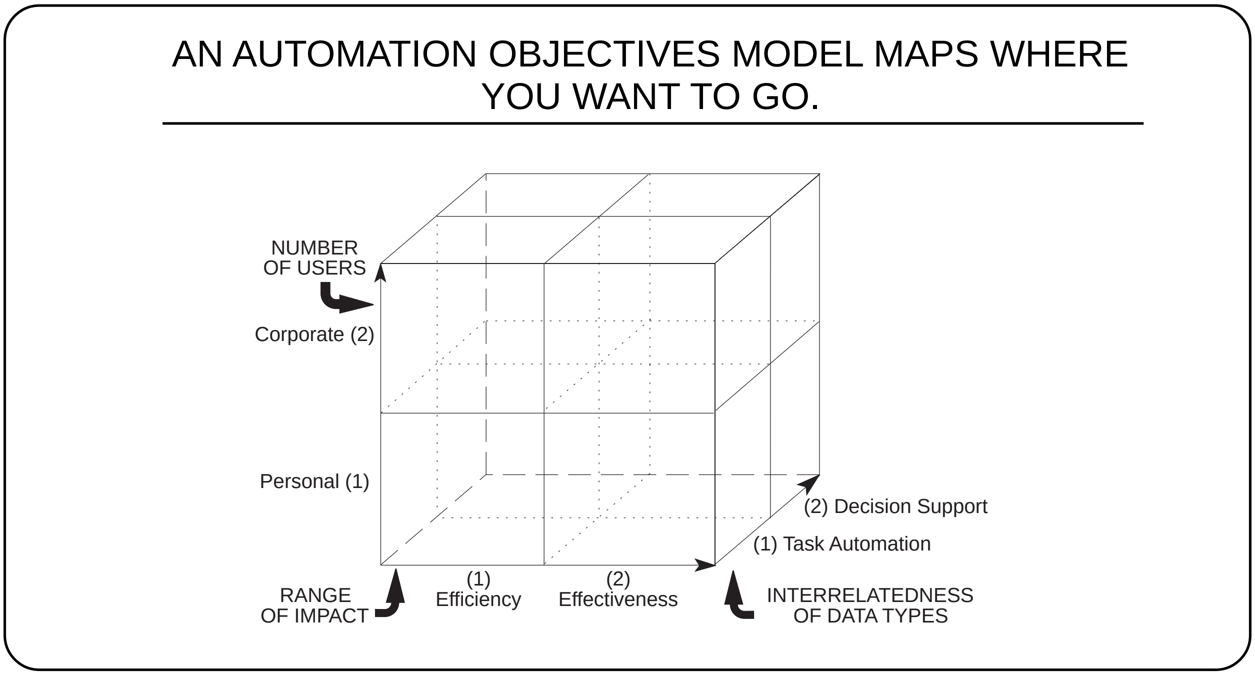

Figure 2.1.9.4.1. *Use the automation objectives cube as a map to find out where you are, where you want to be, and how to get there from here.*

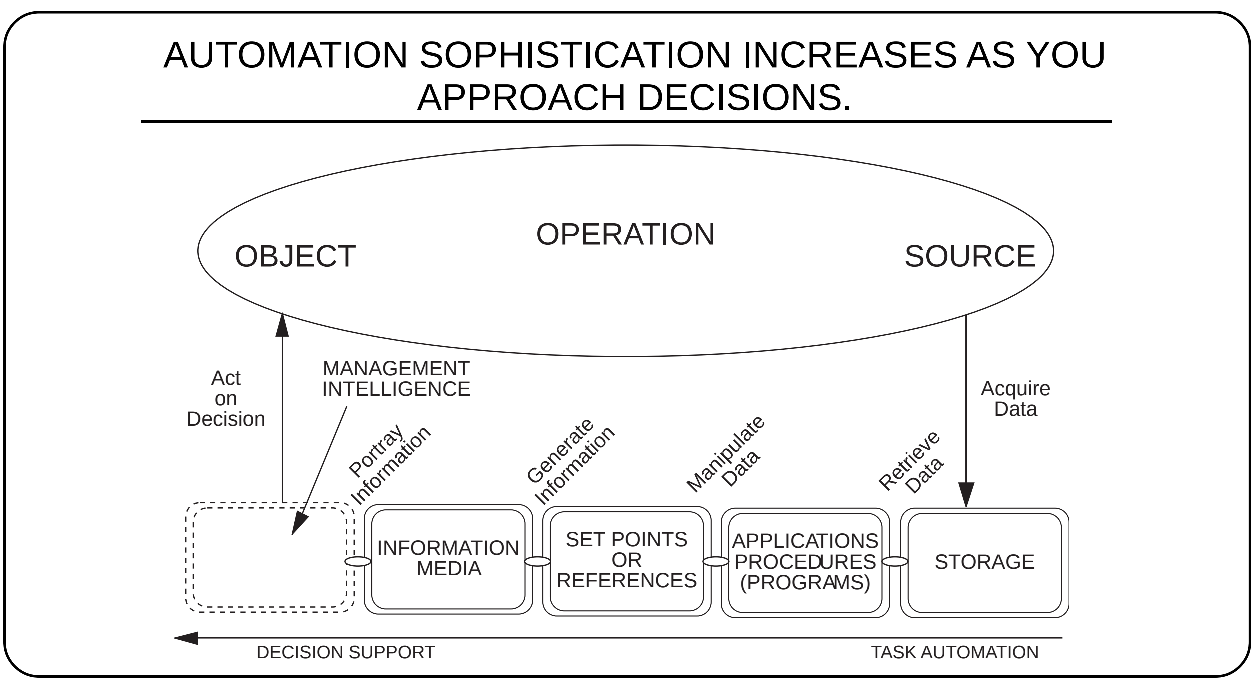

Figure 2.1.9.4.2. *We can see the progression from task automation to decision support on the data-to-information chain.*

YOUR INFORMATION PROCESSING ACTIVITIES RELATE TO THE DATA-INFORMATION CHAIN.

- Physical tasks - typing, drawing, calculating, measuring
- Communication - voice, mail, briefings
- Scheduling - meetings, tasks
- Data selection - filter, develop patterns
- Manipulation - aggregate, convert
- Analysis - comparison, contrast, trend
- Synthesis - relationships
- Information portrayal

Figure 2.1.9.4.3. *As we progress through the links of the data-to-information chain, we do more complex activities.*

SHARING CORPORATE DATA FOR EFFECTIVENESS IS A HIGH CLIFF TO SCALE.

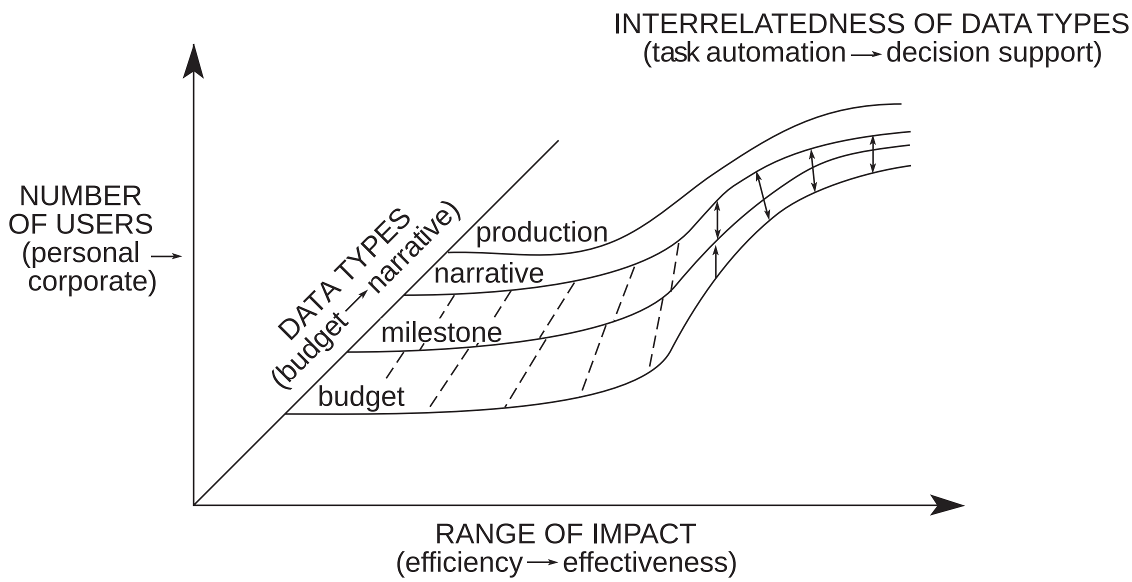

Figure 2.1.9.4.4. *The sharing corporate data cliff shows how hard it's going to be to take the next steps compared to the steps we've just taken.*

2.1.9.5. Exercise on Automation Objectives

What are measurable objectives for initiatives or evolving automation in the organization?

Situation Description

The ISE Department participates in the three land-grant-university missions: teaching, research, and public service. The Department administratively supports the missions. Faculty are involved in all three; undergraduate students primarily in teaching; and graduate students primarily in research and teaching.

The administration must 1) schedule classes and assign faculty; 2) operate the financial business of the Department; 3) support space requirements for offices, class rooms, laboratories, and other space like conference rooms, lounges, and the copier room; 4) prepare for university-level and college-level accreditation reviews; 5) support travel, procurement, and personnel needs of the administration, faculty, and students; 6) support document preparation needs like, papers, presentations, books, class materials, memos, and letters; 7) interface with the University on student information and registration, class room allocations, and other activities; 8) set up and operate support functions for the Department like advisory groups, alumni interest, and industrial and individual gifts; and 9) provide information to prospective students and their parents.

Faculty members 1) generate documents like papers, presentations, class assignments and tests, and letters; 2) monitor student progress in class and in research; 3) interact with government and industry for public service requests, research proposals and reports, senior design projects, and others; 4) solicit, conduct, and report research activities; 5) set up, attend, or give seminars or special lectures; 6) participate in university, college, and department committees and task forces; and 7) serve their country, state, industry, and profession through professional societies, government commissions, and consulting.

Students 1) attend class and carry out assignments in lecture and laboratory settings; 2) participate in research for thesis and non-thesis objectives; 3) support their studies through gathering library and other academic information; 4) direct and participate in University, College, and Department social and professional groups; 5) participate in extracurricular activities like fraternities, sororities, the United Fund, and others; 6) work on placement and job search activities and graduate school opportunities; and 7) take specialized exams like EIT, MEDCAT, LSAT, GMAT, GRE, and others.

Exercise

Assume you're responsible for an automation plan for the ISE Department. Ultimately, your plan will guide the acquisition (over time) of hardware, software, laboratory equipment, space, and procedures for Department automation activities. What are your automation objectives? What are their priorities? How do they fit in the Automation Objectives Model? What is the logical sequence of actions (related to the model) to meet your objectives?

2.0. Building Management Tools

2.1 Approaches for Building Tools

2.1.10. Evaluating Management Tools

2.1.10.1. Evaluation—Peter Paul Rubens

2.1.10.2. Evaluating Life Cycle Stages

You have important evaluation activities or documents at all steps and stages in the system life cycle.

Why Do We Evaluate?

In the system life cycle in Figures 1.1.20.1.1.a. and 1.1.20.1.1.b., evaluation is shown or implied throughout the cycle. Also, remember the process flow diagram in Figure 2.1.3. for developing any management tool. Remember the funny box in Figure 2.1.3. with all the arrows on it? That box was labeled documentation and evaluation. The arrows mean you always do documentation and evaluation at each and every step of the process flow. Hence, all the arrows. I'm interested in evaluation now and I'll discuss documentation later.

To be successful, evaluation must not be post facto. Don't evaluate only after you've developed a management tool. I could discuss evaluation as it applies to each step of the system life cycle; but, you'll get the picture if I just relate evaluation to the four sequential stages: analysis, design, implementation and follow up.

The Analysis Stage

In analysis, you must decide what you're going to evaluate your management tool against. You and the user must agree on what's expected of the tool and what criteria the tool must meet. Most people don't like to pin themselves down so tightly at such an early stage (or any stage, for that matter). You'll suffer less in the long run if you do pin yourself (and your client or customer) down early.

The user will expect something! And those expectations will change over time. When you agree on what you're to do for a user, he or she will have in mind some outcome and will expect results. The expectation may be specific or quite general. You may or may not agree on those expectations. In any case, you must write the expectations down in some non-ambiguous way. I promise you that after you agree on expectations (written or not), the user's ideas, recollection, and expectations will change. And I've never seen them change to be something less or something easier to do than what was agreed. If you haven't written down those expectations, you'll produce something the user doesn't want (at worst) or end up arguing about what you were really supposed to do (at best). Your customer or client probably should write down their expectations and their criteria for evaluating you and your product. But, they won't. So, to serve your customer and to protect yourself, you must.

In the analysis stage, figure out what the tool is supposed to do. Set evaluation criteria, both tangible and intangible, and agree on them with your customer. Now you know what you're working against. You have landmarks out there on the horizon to move toward. The tool requirements (expectations) document out of the survey step in the analysis stage represents the formal documentation from evaluation. Keep evaluation in mind at all steps.

The Design Stage

In the design stage, keep track of your evaluation criteria. Use them as guideposts to make sure you're going in the right direction. If you're not going to achieve what's expected of you or if you find different or better criteria, immediately review the situation with your customer. (Many of the comments I'm making here about evaluating management tools apply to evaluating people as well. I'm thinking about things like talking with the person evaluating you as soon as you recognize you're not going to live up to expectations.) If the user is involved both in what he or she will get in the form of a tool and in what the tool will be measured against, you're keeping his or her expectations realistically tuned to what he or she will get and assuring your success. When designing the management tool, you can add or subtract features or capabilities. But, in the final analysis, the user is going to focus on what he or she expects and not on something else added or missing.

During the design stage you want to formalize and document the bases for evaluating the management tool while in use (in the operation step of the follow-up stage). You find out the success factors for the tool and the evaluation criteria in the acceptance and evaluation bases step in the design stage. When both you and your client know how the management tool will be evaluated, you'll design the tool to successfully meet the evaluation criteria. Keep evaluation in mind at all steps in the design stage.

The Implementation Stage

In the implementation stage, make sure you build the management tool to meet the expectations identified in the analysis stage and the criteria set during the design stage. And make sure the user sees and knows what you've done in relation to meeting expectations. Test the management tool against the evaluation criteria. Remember that the criteria will include both operations and physical features. You cover the operations in the training step. Keep evaluation in mind at all steps.

The Follow-up Stage

Press for a formal evaluation. Take the initiative here, because the user probably won't. This step is the most important one for your professional development. Learn what the user likes and dislikes. Learn the difference between what you think are the most important hits and misses of the tool and what the user thinks is important. By keeping evaluation in mind at all steps of the follow-up stage, you ensure the maintenance and upgrade activities continuously improve your success.

2.1.10.3. Evaluating Anything

If you experience something, you'll evaluate it. So will anyone else.

Evaluating a Product, Service, or Person
From the Management System Model (MSM), we realize the management tool's success depends on how well it fits with who manages and with what is managed. So, the management tool is like both a product and a service. It will be evaluated like both. Product evaluation is easier than service evaluation. And both are easier than personnel evaluation.

Personnel and program evaluation usually look at the wrong things or take a wrong look at the right things. Often we don't define the right measures of performance. We end up ranking people instead of coaching them.

Product evaluation has the great advantage of maturity. You're probably familiar with product evaluations, like in Consumer Reports, where products are ranked by quality. The strongest specific area of product evaluation is in automobiles. The physical part (or product part) of your management tool will be the easiest to evaluate. For example, we can evaluate computer hardware— the monitor, the keyboard, the printer.

"Specialized independent product evaluators practiced their trade many centuries before the industrial revolution. The tang of ancient Japanese swords often bears the signature, not only of the maker, but of a respected independent sword evaluator." (This story is taken from Michael Scriven in Nick Smith's book *New Perspectives in Evaluation*.) "Sometimes—in the case of blades from the master swordsmiths, which have always been worth a prince's ransom and sometimes comprised one—this annotation would include a reference to some applied performance testing data, usually obtained from carefully conducted tests on hapless prisoners. Very good blades, in the hands of the 'standard reference swordsman' would be rated as single-stroke whole-torso cleavers, slightly less good ones as leg-loppers, and so on. These product evaluators were part of a hereditary vocational system, which did a great deal for their independence; not only would any loss of integrity reflect on one's own future job prospects, but also on one's children's career options—and on one's ancestors' reputations. Modern job mobility has considerably weakened the feasibility of this particular system of bias control, and it is not certain we have developed a replacement that is as good."

Product evaluation is relatively easy; and, relatively speaking, people and evaluation laboratories do a lot of it. Service evaluation, people evaluation, system evaluation and evaluating combinations of these things is seldom done. In Figure 2.1.10.3.a., you'll enjoy a facetious look at evaluating people. Since people are our most important resource, performance appraisal may be our most important management responsibility. Too bad most of you will go out to work and won't have your performance appraised. You'll probably reflect this experience (or lack of it) and won't appraise the work of your people. (Maybe once a year you'll fill in some boxes and check some squares on some annual appraisal sheet for the personnel department.)

You need evaluations to manage success. Here, I mean manage in the sense of plan, direct, and control. And I mean making the needed decisions so the thing to be evaluated will be a success.

The Impact of Evaluation

To experience something is to evaluate it. The person in Figure 2.1.10.3.b. is pretty clear in his evaluation of the presentation he's hearing. But I wonder what he'll put down on his evaluation sheet when the talk is over.

Let's think about your evaluation—not when you're evaluated in this course or in school, but when your work is evaluated on the job. You'll probably take the concepts I present here more to heart if you think of them in relation to your work being evaluated. These concepts apply both to your work being evaluated and to a management tool being evaluated.

When you experience and evaluate something, you'll make that evaluation informally or formally. The difference in the formality of the evaluation is in how you present or communicate it. You may just think the presentation is boring (like Figure 2.1.10.3.b.), or you may write it down on the evaluation sheet. Writing it down is much more formal than thinking it. And the formality of how you make the evaluation will influence the effect your evaluation has on what you're evaluating. Figure 2.1.10.3.c. shows three factors that influence the effect your evaluation may have.

I define evaluation impact as the significance of action resulting from the evaluation. The impact is high if the evaluation results in highly visible or consequential action. Examples of this kind of action are reorganizing or redesigning something, making a purchase, bargaining or negotiating something, awarding or cancelling a contract, and so on. The impact is low if the resulting action has low visibility and consequence. An example of this kind of action is when evaluations are conducted to meet routine legal requirements or when the findings aren't used at all.

Three factors affect the impact of the evaluation. The factors are formalities of reporting, the significance of the evaluator or the source of the evaluation, and the significance of the impact or of the evaluation criteria. Formality of reporting varies with how the evaluation findings are communicated, written reports being the most formal. If I only *think* about the good job you did, the impact on you is low. If I *tell* you or your boss or the "big boss" that you did a good job, the impact is higher. The more specific I am in what I say, the greater the impact. I'll remember what I thought longer and someone else will share in my evaluation. If I *write* you or someone else that you did a good job, the impact is even higher. Whoever receives the written evaluation can keep it, and, even if they don't, the impact is greater. In personnel evaluations, written comments (either good or bad) usually end up in your personnel file.

I define significance of evaluator (the source of the evaluation) as the evaluator's willingness and ability to initiate important action involving the evaluand. In personnel evaluation, the evaluand is the person being evaluated. I extend the definition to include anything, whether person, service, or product, being evaluated. The most significant evaluators are those who have a stake in, and the power to, directly make critical decisions involving the evaluand. For example, in evaluating software for possible purchase, the buyer, not the salesperson, is the significant evaluator. Of course, significance of evaluator is strongly affected by his or her professional competence as an evaluator.

Significance of criteria (or significance of impact) has to do with how critical to the success of the evaluand the attribute is that's being evaluated. Some attributes, or characteristics, are more important to the success than others. If you're trying to be a movie star, good looks are more significant than if you're trying to be an engineer. In the early stages of design and implementation of a management tool, utility criteria are often more significant than quality criteria.

By looking at Figure 2.1.10.3.c., you can make the following observations. First, impact is highest when formality of reporting, significance of evaluator, and significance of criteria are all high, and impact is lowest when all three factors are low. Second, a low value on one factor can be compensated by high values on the other two. Thus, an evaluator with low significance can cause high impact by using significant criteria and making a formal report.

GUIDE TO PERFORMANCE APPRAISAL

Performance Factors	Excellent (1 out of 15)	Very Good (3 out of 15)	Good (8 out of 15)	Fair (2 out of 15)	Unsatisfactory (1 out of 15)
	Far Exceeds Job Requirements	Exceeds Job Requirements	Meets Job Requirements	Needs Some Improvement	Does Not Meet Minimum Standards
Quality	Leaps tall buildings with a single bound	Must take running start to leap over tall building	Can only leap over a short building or medium one without spires	Crashes into building	Cannot recognize buildings
Timeliness	Is faster than a speeding bullet	Is as fast as a speeding bullet	Not quite as fast as a speeding bullet	Would you believe a slow bullet?	Wounds himself with the bullet
Initiative	Is stronger than a locomotive	Is stronger than a bull elephant	Is stronger than a bull	Shoots the bull	Smells like a bull
Adaptability	Walks on water consistently	Walks on water in emergencies	Washes with water	Drinks water	Passes water in emergencies
Communications	Talks with God	Talks with angels	Talks to himself	Argues with himself	Loses the argument with himself

Figure 2.1.10.3.a. *This performance appraisal has a standard form. The entries are nonsense. However, some descriptions of job requirements are almost this ridiculous. (I don't know where I found this chart. I found a similar version in Kurt Hanks, Up Your Productivity, William Kaufmann, Inc., 1986, pp. 56-57. Hanks notes, "I would like to give credit to the person who created the above chart, but I've been unable to track him or her down.")*

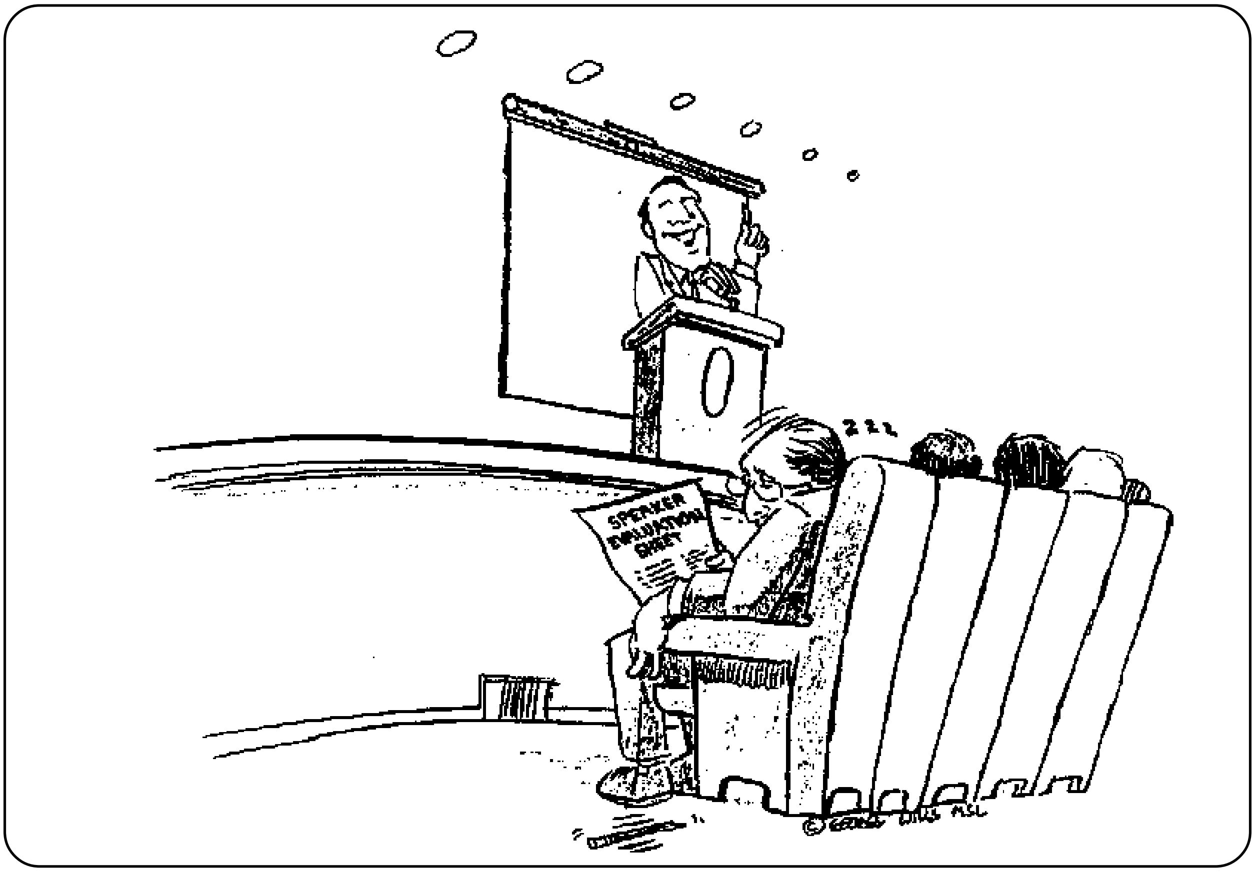

Figure 2.1.10.3.b. *To experience something is to evaluate it.*

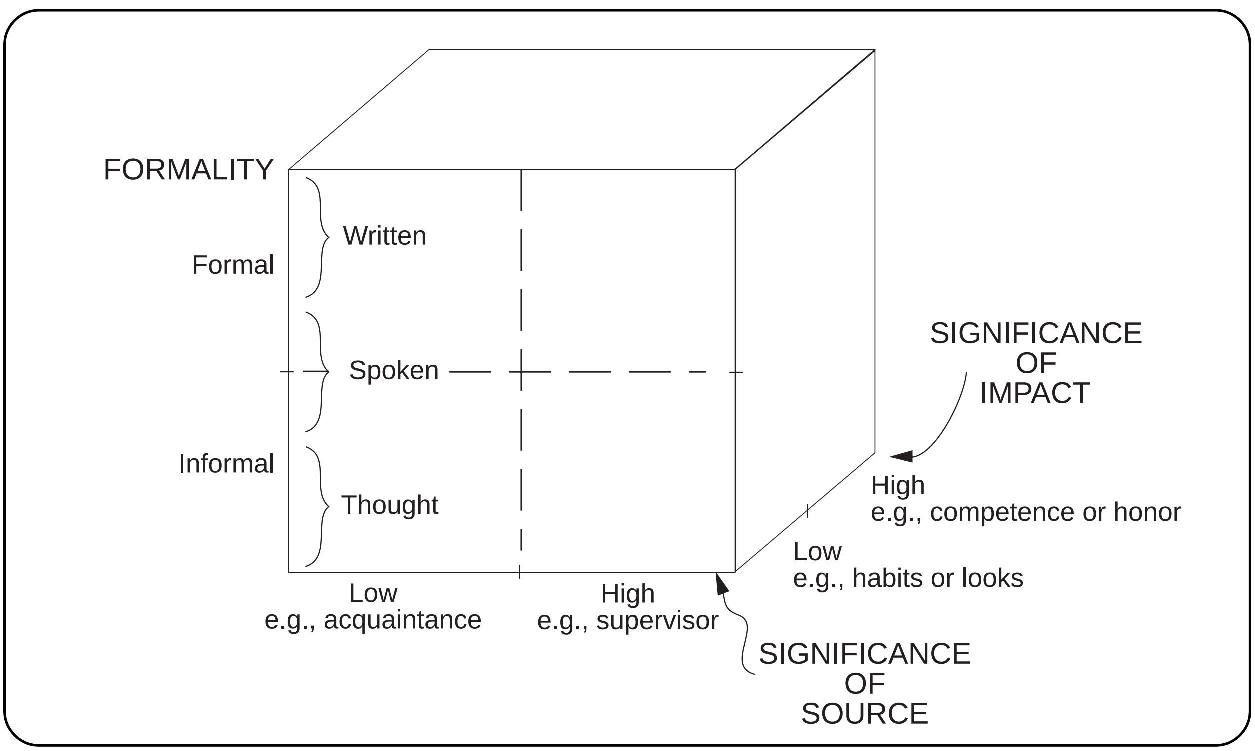

Figure 2.1.10.3.c. *Three factors influence the effect of evaluation.*

2.1.10.4. You Can Manage Your Evaluation

You can manage your evaluation. You can get an evaluation by asking someone (your boss, for instance) about how you're doing or about something you did. By asking the right questions, you can cause the evaluation to be specific. Being specific helps you more and cements what is said more firmly in the mind of the evaluator. You can even ask for a written evaluation—if in no other way than by making a written request.

If your evaluation is important to you, you should manage it. Try not to manipulate it. Ask about what you did poorly as well as ask what you did well. Always get specifics, not only when you did your best. Use your evaluation to improve your performance and to get a handle on the expectations of your evaluator.

You first manage your evaluation by setting expectations.

Determine the tests for your product or service before you complete the design of the product or service.

2.1.10.5. Management Tool Success

If you perform at the margin, your success depends on what your evaluator will tolerate at the moment he or she evaluates you.

Criteria for Management Tool Success

Let's switch our thinking for a moment back to developing a management tool. I'll discuss management tool evaluation criteria (not as easily compared to criteria for evaluating people); then I'll discuss how we judge something to be a success. For judging success, I can talk about you and your evaluation again.

A management tool is successful in a given domain of responsibility if it meets reasonable expectations of the person managing that domain who will use the tool. This definition explicitly recognizes that the tool (what is used to manage) must fit the operation (what is managed) and the manager (who manages). So, a management tool that fits a given manager and operation can't be assumed to succeed for a different manager in a different operation. By requiring the expectations to be reasonable, I've allowed us to be logical about evaluation criteria (leaving out politics and prejudice, for example).

I'll use two types of criteria for evaluating the success of a management tool. They are utility criteria and quality criteria. For utility criteria, we identify specific uses of the tool, while quality criteria specify management tool characteristics that improve its functioning. Utility criteria depend on who manages and what is managed and quality criteria depend on the management tool itself (what is used to manage). A management tool successful in quality criteria alone is of no use, and thus is a failure.

Consider four functional needs for utility criteria:

1) criteria met by a particular management tool,

2) criteria defined uniquely according to each manager,

3) criteria dependent on the business environment and the context of use, and

4) criteria reflecting flexibility to change as the business environment and the manager's needs change.

Consider four qualities for quality criteria:

1) criteria generally desirable in all management tools,

2) criteria defined by industry-wide norms,

3) criteria as tool properties, independent of specific business environments, and

4) criteria reflecting flexibility to change as technology advances and industry changes.

Since quality criteria are defined by industry-wide norms, the evaluator can pick the most important quality criteria from a list. However, utility criteria can only be defined by a person very familiar either the specific domain of responsibility the tool will be used for. The utility criteria highlight the need to involve the user in defining desirability standards.

Judging Success and Failure

Now let's think about our own evaluations and whether we're succeeding or failing in what we're doing. These concepts apply to the success and failure of a management tool as well as our own success or failure.

When all is said and done, the evaluator must come to some conclusion about the overall worth of the evaluand. Are you worth promoting? Are you doing a good job? Are you doing an adequate job? This worth is often expressed as a bottomline pronouncement of success or failure, acceptance or rejection. However, if the goal of the evaluation is to *cause* success, instead of simply identifying its presence or absence, the judgment process is often tempered by optimism. This optimism is embodied in the evaluator's toleration for less than acceptable performance. Three entities are critical to the judgment process, which by its very nature, is subjective. (See Figure 2.1.10.5.a. for the three entities.) The three entities are performance, expectation, and toleration.

I define performance as the actual performance of the evaluand, measured relative to predefined standards or criteria. Expectation is the level of performance the evaluator considers fair and due. And toleration is the capacity for enduring a performance level below what is expected. In your job, you'll be expected to accomplish certain things. I expect my project managers to satisfy the customer and to meet the scope of work of their project, within cost and on time. I can measure their performance against the project statement of work. However, if they're young, inexperienced, and don't get paid very much, I'm pretty tolerant of them doing less than I expected. On the other hand, if they're mature, experienced, and get paid a lot, I'm not very tolerant of much. You see, there's something to be said for not getting paid a fortune early in life.

You can see another example of tolerance in Figure 2.1.10.5.b. In this case, I've bought a car. I'm not into luxury or beauty. But, regardless of what I've bought, I expect it to get me to class every day, no matter what. If I didn't expect that, there's no need for the car. In one case, I've bought a 15-year-old clunker for $200. When it doesn't start on a cold winter morning, I say "What do you want from such a car?" I tolerate its not starting. But I still don't change my expectation. I still have to get to class every day. I'll live with it until I can afford a better car. In another case, the case in Figure 2.1.10.5.b., I've bought a brand new Mercedes for $64,985. No matter how cold or bad the weather, if it doesn't start, I throw a tantrum. I call the dealer. I threaten to sue. I won't live with it for one minute.

Human judgment can logically relate the three evaluation considerations of Figure 2.1.10.5.a. I've shown the relationships in the logic diagram of Figure 2.1.10.5.c. Clearly, when actual performance equals or exceeds expected performance, the evaluand is judged successful, and there's no need to measure toleration. That's the situation you want for yourself and for what you do. Know what is expected. Exceed that, and then do what you think is important. Don't exceed that, and what you think is important is going to be lost in trying to hang on or hoping for toleration. However, if performance doesn't meet or exceed expectation, the evaluator compares the *deficiency* against his or her toleration. The determination of success or failure is based not only on actual and expected performance, but also on toleration.

An important point can be made here. If you perform at the margin of what's expected, you must depend on toleration. I try to tell a young faculty member concerned about tenure that if he or she performs well above expectations, he or she has nothing to worry about. If he or she performs at the margin, he or she must depend on the rather undependable tolerance of their evaluator.

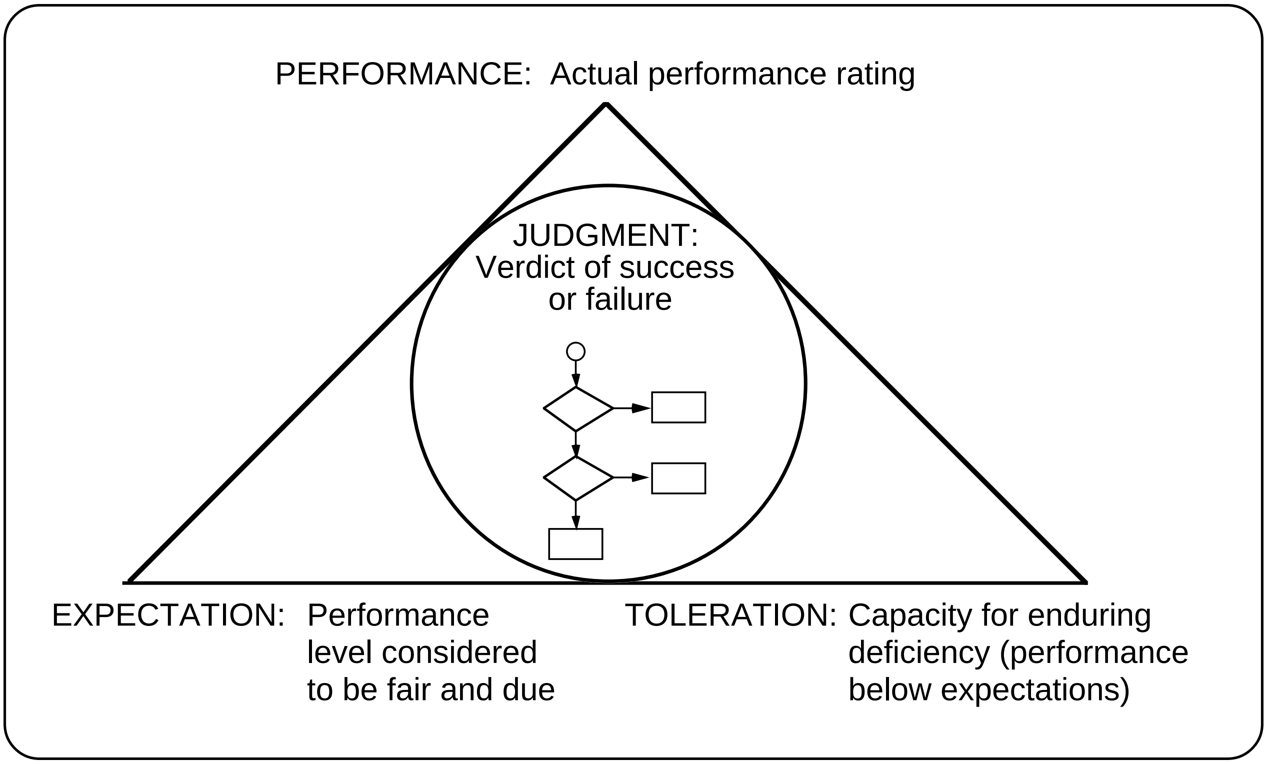

Figure 2.1.10.5.a. *Success is a judgment call affected by three considerations. (This chart was developed during my interaction with Amod Singhal during his master's degree work at Virginia Tech.)*

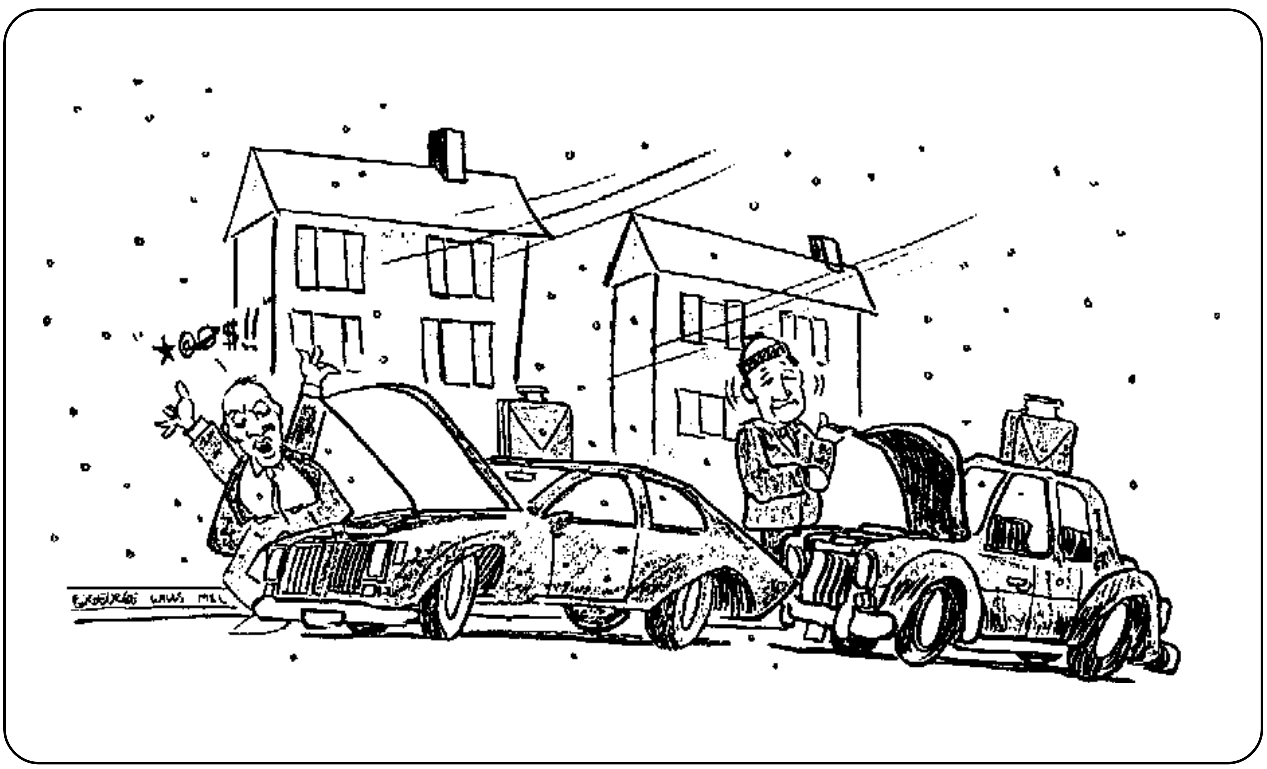

Figure 2.1.10.5.b. *"I have no tolerance for this!"*

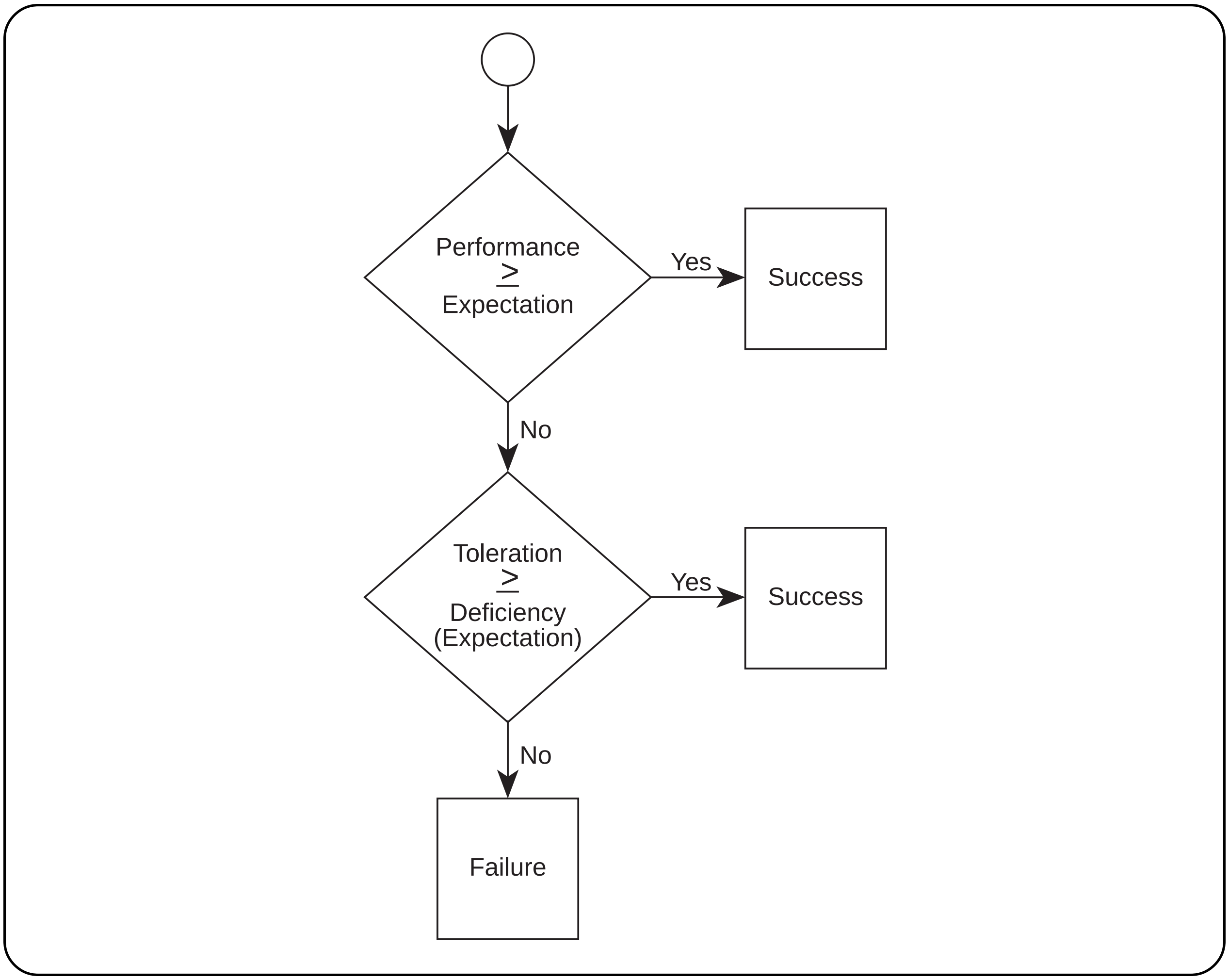

Figure 2.1.10.5.c. *Judgment can logically relate the three evaluation considerations.*

2.1.10.6. Return on Investment

Identifying, verifying, and balancing costs and benefits for a management tool depend a lot on what Deming calls the unknown and unknowable.

Relating Cost, or Investment, and Benefits, or Return

As engineers, we like to forecast (for future projects) or measure (for existing projects) costs and benefits. When we know what the costs and benefits are, we compare them to see if we want to do something or if we're glad we did something. We talk about trade-off decisions or break-even analysis. In break-even analysis, we're looking for the point (break-even point) where the identifiable benefits equal identifiable costs. In trade-off decisions, we want the benefits to equal, or preferably exceed, the costs.

So, we have to figure out what the benefits and costs are. Unlike most of the problems in engineering economy, we can't assign a dollar value to all the benefits or costs of a management tool. What about the ability to hire better young people out of college because they think that if the organization has a big computer, it's better? What about the frustration when the information system gives the user every piece of information in the world except the one they want?

We say that management tool development involves two types of costs and benefits: tangible and intangible. Management tool development is harder to evaluate than most things because it involves so many intangible costs and benefits. In many ways, evaluating management tools is like evaluating innovation. You have to have it; but, based on tangible benefits alone, most innovation or management tool projects would never be started.

Tangible Costs, or Investment

Tangible costs include the cost of new equipment, stated either in terms of purchase price or payout over the useful life of the system. Remember payback analysis and present value and all of that from engineering economy? We can convert tangible costs to operational terms. For example, if a piece of equipment costs $2 million and handles 5 million transactions over a three-year period, the tangible cost is 40 cents for each transaction.

We can also measure human factors in terms of tangible costs. Other tangible costs include payroll costs associated with developing or using the management tool.

Tangible Benefits, or Return

We realize tangible benefits when a management tool is projected to make money or save money for the domain of responsibility or to contribute in some other quantifiable way. Typically, we look for savings in time, steps, or paperwork, all of which are translated to cost.

Incrementally, a management tool may save some money for the organization; but, by and large, the tool usually shows more tangible costs than tangible benefits. Remember before we had copying machines? To get a copy, you either had to get a photograph of the original or make carbon copies when you made the original. The copy machine would obviously save lots of time, right? We wouldn't need such a large secretarial staff. What happened? We used to make two or three copies of things. We now make thousands of copies of them. Do we really need all those copies? The machines are noisy. The copy machine has its own private office. Think of the number of maintenance people we employ just for copy machines. I'm sure that if you figured out how much an office pays for all its copies today compared to all its copies years ago, the economics wouldn't, in most cases, warrent getting the machine. But, are we better off with all those copies? How much better off? In what ways? What's it worth?

Intangible Costs, or Investment

Intangible costs can't be easily pinpointed in terms of money. Yet we can readily identify intangible costs. For example, when employees are apprehensive about changes in their job content, their work output can decline. Decreased output like this represents an intangible cost of converting from the old management tool to a new one.

When first converting to a new management tool, error rates are likely to be higher than they'll be once employees learn the new tool and become comfortable with it. Frightened employees may blame the computer (or whatever mechanism), rather than themselves, for delays or incorrect outputs delivered to customers. This is another intangible cost of a new management tool.

Intangible Benefits, or Return

Intangible benefits are return you get that is qualitative, such as satisfaction, comfort, prestige, and joy. We try, but we are seldom successful, to assign value to these benefits. One of the challenges of systems analysis is to identify these benefits and to put a value to them in offsetting the cost of a new management tool.

For example, assume that a particular department converts from using typewriters to using word processors. Employees report a more pleasant workplace since they've eliminated typewriter noise. Further, the word processors provide a status symbol, giving the operators added respect among their peers.

Simple benefits such as these can reduce employee turnover. If your employees stay longer, you reduce training cost. To calculate the value of these benefits, you estimate (based on experiences with similar systems) the decrease in turnover. You then calculate the savings in new employee training and apply the savings to the cost/benefit analysis.

Cost Avoidance

In an effort to justify a new management tool, some people calculate cost avoidance—and many misuse the calculation or the result. In cost avoidance, you figure how much it costs to do something now. You figure how much you save by doing that thing using the new tool. *Then* you assume you want to do that thing many more times than you do now. For example, it now costs $500 in a person's time to make three iterations at forecasting the organization's budget each month when we do it by hand. With a new computer-based tool, we can do those three iterations for $200 of the budget analyst's time. But that's all we use the computer for and the cost of purchasing or leasing the computer is $600 per month. If three iterations are sufficient, it's cheaper to do the forecasts by hand. But, let's assume we really should be doing 30 iterations. The cost of doing the iterations by hand is evenly spread. The cost of doing the iterations by the computer is a one-time cost regardless of the number of iterations. To do 30 iterations by hand costs $5000 and with the computer $200 plus the $600 lease. Now, even with the cost of the computer we're saving a bundle—that is, we're avoiding the cost of $4200.

The Relationship between Quality and Cost

Increasing the quality of information generally costs more in verifying and updating the data. Generally, the direct cost of information increases with increasing quality, but at an accelerating rate. This is shown in Figure 2.1.10.6. as the cost of information. Be careful of simple curves like this one because the indirect costs in increasing quality can decrease. (Such an indirect cost might be customer complaints.)

Now, we'll consider a common situation where we get better and better information—quality wise. There will come a point where we don't really need such high-quality information to make the decisions we have to make. Figure 2.1.10.6. shows the situation where the value of information increases with increasing quality, but at a declining rate. This is shown as the value of information.

From the curves in Figure 2.1.10.6., we see that the quality of information received from a management tool is a trade-off between the cost of the tool and the value of the information received for that cost. This cost/benefit relationship is shown in Figure 2.1.10.6. The intersection is the break-even point. That point represents the best tool the organization can afford. That is, the break-even point represents the highest quality of information that can be justified economically.

In fact, the break-even point probably isn't the best or optimum solution from a business viewpoint. The level of information quality at which the gap between the two curves is widest is (theoretically) the optimum solution. The value received is not as great as it would be at a higher level of quality. However, any increase in quality beyond this point would increase costs more than it would increase value. Therefore, the point at the widest gap is the most cost-effective solution. Beyond a certain point, improvements in quality may not be worth the increased cost of achieving them.

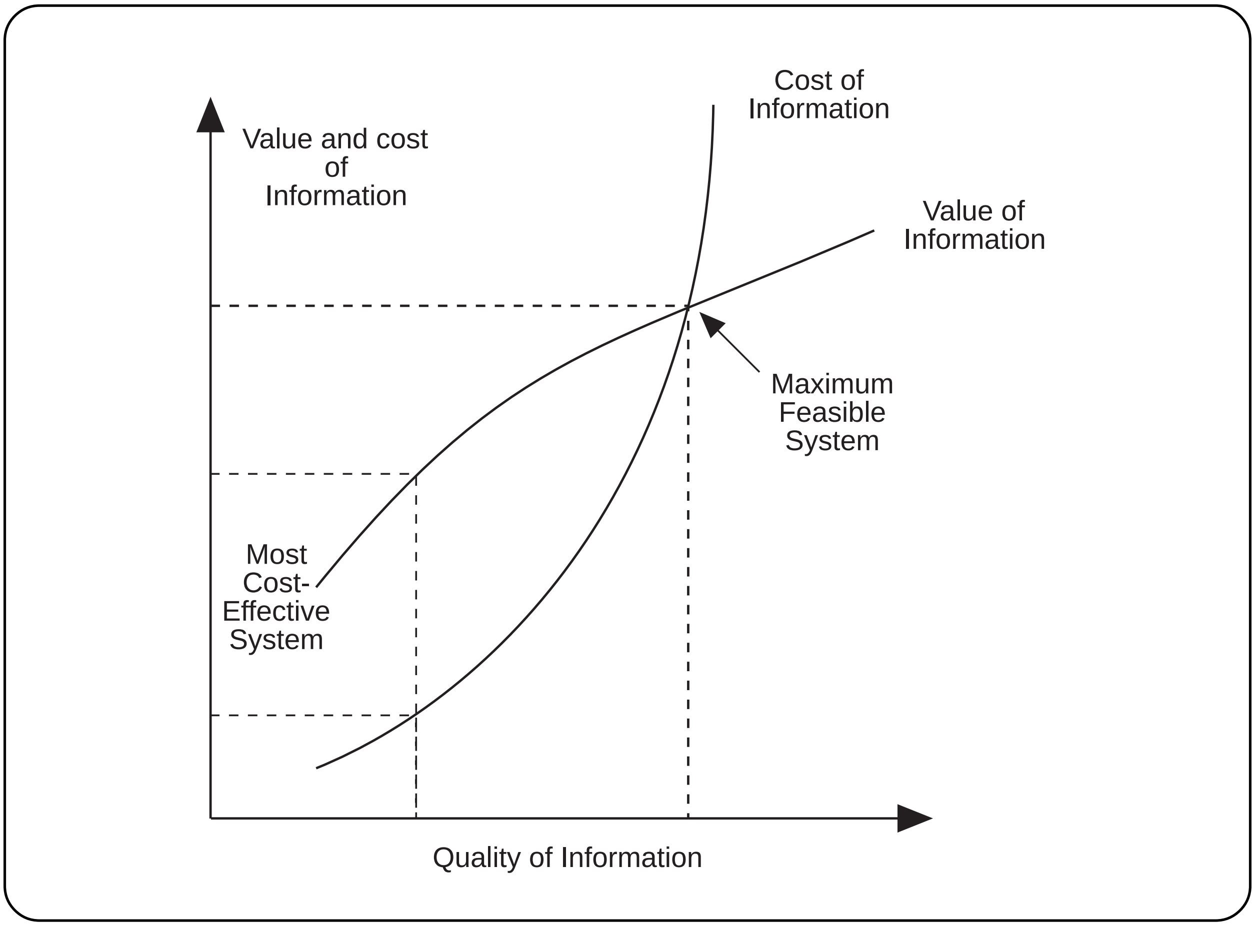

Figure 2.1.10.6. *The optimum, most cost-effective system produces the most favorable ratio of information value to information cost.*

2.1.10.7. Benefits

Most benefits in MIS development can't be quantified in a bottomline figure.

Conceptualizations of Management Tool Success

We can think of a successful management tool in various ways. The management tool can:

1. bring economic value,
2. generate intangible benefits,
3. improve decision making,
4. help train new people,
5. advance business objectives, and
6. satisfy its users.

These ideas of success are neither mutually exclusive nor comprehensive. One or more of these notions, and perhaps many others, may define the success of a management tool in a given management system.

Bring Economic Value

The idea that a successful management tool brings economic value is central to cost/benefit and similar techniques, which attempt to measure the monetary worth of management tools. The major shortcoming of this widespread idea is the assumption that all costs and benefits of a management tool can be quantified in terms of dollars.

We've found our attempts to quantify benefits that are largely seen as qualitative to be inaccurate and unsatisfactory. One reason is that quantification is often accomplished by imposing an analytic model on the data. The three major problems with cost/benefit analyses are that costs and benefits are often miscalculated or overlooked, it's difficult to quantify costs and benefits, and the expected benefits sometimes fail to materialize. These problems happen because unrealistic expectations, poor design or implementation, internal opposition to the management tool, bad guesses, and poor information bring about miscalculation and omission of costs. When we evaluate a management tool, we can't rely too easily on quantification or on any single economic analysis model. We must, instead, give the manager the best tools for dealing with qualitative concerns in a rational, structured manner.

Generate Intangible Benefits

A management tool does give us many intangible benefits. The term intangible is commonly used in Management Information System (MIS) literature to describe benefits whose dollar value can't be readily found, that are otherwise difficult to quantify numerically, or that are unanticipated. The intangible category is used as a catch-all for benefits that can't be adequately dealt with by commonly used evaluation techniques such as cost-benefit, return-on-investment, and multi-attribute utility analyses.

From the users viewpoint major benefits in a management tool are flexibility, improved communication, insight, and learning. Peter G. W. Keen identifies twelve benefits in MIS development, ten of which can't be quantified in a bottomline figure. They are:

1. increase in the number of alternatives examined,
2. better understanding of the business,

3. fast response to unexpected situations,

4. ability to carry out ad hoc analysis,

5. new insights and learning (e.g., better sense of true costs),

6. improved communication,

7. control (better tracking of cases),

8. better decisions,

9. more effective team work, and

10. better use of data resources.

Intangible benefits are important when we evaluate a management tool. We must relate all benefits of the tool to the value it brings to the organization and to the manager.

Improve Decision Making

Many people have tried to relate management tools and improve decisions. People working on productivity and performance especially need this relationship. However, techniques for measuring decision improvements because of a new management tool have had varying degrees of success. People usually rely on surrogate measures.

Help Train New People

Since a management tool contains structures and processes for converting data about the management work processes into information, both final and intermediate presentations of the data and information about the organization will help train people. For example, a work flow diagram, a relationships and structures tool, is a wonderful aid for showing someone how the work process flows and identify his or her role in the process. The MIS shows both indicators and reference points (voice of the process and voice of the customer) for the work process.

Advance Business Objectives

A good management tool puts an organization in a more competitive position. For that reason, management tools are often worked into an organization's business strategy. Information technology can improve the business because it changes the way people do business.

Satisfy Its Users

User satisfaction is critical measure in management tool success. User satisfaction can be measured in terms of response time, accuracy, distribution, timeliness and quality of output, as well as response to problems and attitude and cooperativeness. Evaluation approaches based on user perception seek to measure these perceptions but don't give us a systematic way for users to develop realistic expectations and definitions of success.

Hierarchy of Evaluation Criteria for MIS

"The fundamental purpose of the MIS is to bring the organization closer toward achieving its primary objectives more efficiently. Profit and return on investment are generally accepted objectives. Service to society and workers' satisfactions are others. The problem in measuring the contribution to these objectives is that so many other factors act upon the organization at the same time."

"[Figure 2.1.10.7.a.] shows a continuing breakdown of factors that might serve as criteria for evaluating an MIS. Examples of variables to be measured to evaluate each factor are also shown. Although measuring many of the variables poses difficulties, this hierarchy can be used for crude evaluations."

"G. B. Davis divides the MIS into functional subsystems. They are the strategic planning information system, the managerial control information system, the operations information system, and the transaction processing system."

“Evaluation of the MIS could be based on criteria established for each of these four systems. For example, the transaction system could be in terms of:

1. throughput—total transactions processed over the evaluation period,

2. throughput rate—amount of work processed per unit of time, and

3. throughput rate capability—the maximum throughput rate possible for the system.

Unfortunately, measuring the MIS contribution to the other three systems presents the same difficulties as in the hierarchical approach. Measures of effectiveness closely corresponding to the MIS activities listed by Davis, have been developed by W. A. Smith, Jr. These are shown in [Figure 2.1.10.7.b.].” (I quoted this section in part from Robert G. Murdick with John C. Munson, *MIS Concepts and Design*, Prentice-Hall, 1986, pp. 598-600.)

ACTIVITY		DOMINANT ISSUES	EXAMPLE OF MOE's (Measures of Effectivenss)
Clerical Function:		cost displacement, task execution	Units per labor hour, backlog
	System:	efficiency, speed of operation, economy	Throughput, capacity utilization, data preparation cost per unit
	Information:	accuracy	Percent error transactions
Operational	Function:	monitoring and control over activity and resources	Inventory level, yield rate, messages delivered/received, missed shipping dates
	System:	maintainability, sustainability, availability, sensitivity	Percent downtime, time between failures, frequency of service, percent requests with special handdling
	Information:	timeliness, reliability	Response time
Tactical	Function:	decision quality, functional objectives	Return on investment, volume orders per district, unit cost, overtime/regular hours, percent returned product, delivery time
	System:	auditability, compatibility, flexibility, security, scope	Actual users vs. intended users, percent service of total cost, reports returned vs. delivered
	Information:	sufficiency, conciseness, discovery	Percent file used when appropriate, volume of inquiries
Strategic	Function:	organizational mission, planning, outcome of decisions	Share of market, new products, earnings/share, change in risk, percent R&D of total expense
	System:	user satisfaction[a]	Number of accesses per inquiry, time to formulate inquiry, percent compliments vs. complaints
	Information:	relevance	Percent responses appropriate

[a] Access ease, available period, dependable source, suitability to purpose, personal convenience.
Source: W. A. Smith, Jr., *Effectiveness of Information Systems* (Bethlehem, Pa.: Lehigh University, Dept. of I.E., June 1972) (AD744027), National Technical Information Serivice.

Figure 2.1.10.7.a. *Characteristic performance indicators. (taken from Murdick, p. 600)*

	Hierarchy in the MIS	Change that is Measured
Level 1	Company profit, return on investment	Dollars
Level 2	Company costs, revenues	Dollars
Level 3	Planning	Specificity, quantification, degree to which plans are achieved, time required to produce plans, number of alternative plans made available for consideration, cost.
	Control	Degree of control by exception, selection of activities to be controlled, forewarning of activities going beyond acceptable limits, managerial time required for control, automation of control of repetitive situations, cost.
Level 4	Decisions	Quality of decisions, frequency of reversal of decisions by superiors in the organization, number of alternatives examined in arriving at decisions, sophistication of "What if...?" questions permitted, time required for decisions, automation of repetitive decision situations, cost.
Level 5	Information	Validity, accuracy, clarity, distribution, frequency, appropriateness of detail for each level of management, timeliness, format, availability on demand, selectivity of content, disposition method, retention time, cost.
Level 6	System characteristics	Number of people required, equipment and facilities, response time, frequency of breakdowns, inputs, outputs, number of forms, number of operations, number of storages, sizes and quality of data bank, size and quality of model bank, flexibility, simplicity, degree of automation, scope of business components that are related by the MIS, user satisfaction, error rates, persistent problem areas, ease of maintenance and modification, unplanned-for impact on comany performance, savings, cost etc.

Figure 2.1.10.7.b. *Measurement hierarchy. (taken from Murdick, p. 599)*

2.1.10.8. Qualitative and Quantitative Data

To get closer to balancing costs with benefits, we must work on quantifying the qualitative data we have for benefits.

When we gather information about the domain of responsibility for setting the criteria and evaluating a management tool, the data will be found in many forms. We'll find a lot of qualitative data—from "war stories" to gossip. Usually the qualitative data are most valuable, if we could just make them useful. In some cases, we'll want to make quantitative data out of qualitative data.

The quantitative methods we have don't adequately handle many aspects of evaluating management tools. We can trace the emphasis on quantification in evaluations to the misperception that quantification provides reliable, bias-free results. However, both qualitative and quantitative data may be biased. Bias, defined as distortion in findings due to the adoption of a given perspective, can manifest itself at all stages in our evaluation. Thus bias is inherent in choices regarding what is studied, the method used, the sample selected, and the measures used in gathering data. Bias may also be manifested in data analysis and reduction, as well as in reporting the findings. Quantification does reduce one form of bias—idiosyncratic variations between the people who conduct observations and gather information. However, we can make qualitative descriptions more reliable by carefully choosing the criteria for classification. Contrary to popular belief, the problem with qualitative data isn't bias or reliability, but that more effort is required to reduce and summarize them.

We can use formal techniques to quantify qualitative data. To understand how we make the conversion, I'll define two categories of qualitative data. *Impressionistic or descriptive data* are those data where most of the available facts haven't been placed into categories, or for which the categories are broad and loosely defined. Examples are: anecdotal reports, handwritten notes from an interview, and general impressions from observations. Nearly all informal communication (personal encounters, telephone conversations, and gossip) is classified as descriptive data. Data may be considered to be *systematic data* if most of the available facts have been categorized, especially where elaborate and precisely defined rules are used for assigning instances to categories. Frameworks using typologies, taxonomies, coding schemes and variables are examples of systematic data. My frameworks for pursuits, endeavors, maturity, and decisions are specific examples.

Figure 2.1.10.8. shows how impressionistic or descriptive data are quantified by first converting them into systematic data through categorization (defined as the assignment of instances to categories according to rules). Systematic data are then converted into numeric data by quantification (defined as the assignment of numbers to attributes according to the rules). Formal techniques of categorization include the constant comparative method, typology development, analytic induction, and content analysis. Techniques for quantification include the use of rating and ranking scales and of weights.

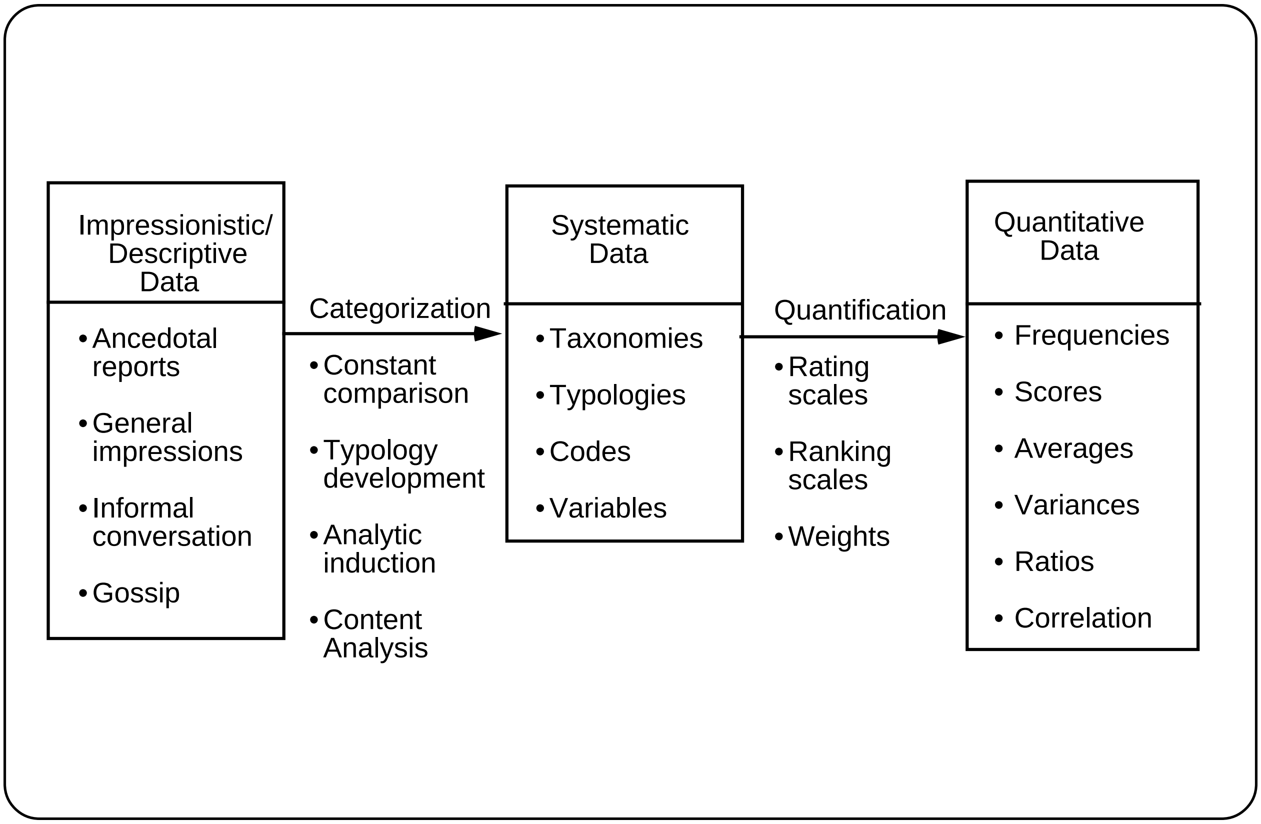

Figure 2.1.10.8. *Qualitative data can be reduced to quantitative data.*

2.0. Building Management Tools

2.2. Example Types of Tools

2.2.1. Project Management Tools

2.2.1.1. Paintings as Projects–Canaletto

2.2.1.2. A Selected Sequence of Project Management Tools

With a set of management tools for stepping through a project planning effort, we can figure out how to get from the production process we have to the one we want.

Introduction

I'll present a group of modules containing a ten-step process for planning a new project and monitoring your progress against that plan. Each module contains one step of the process. Each step is introduced with a purpose and discussion of why and how we use that step's tool. Following the discussion, I'll include definitions you'll need and a procedure to lead you through the development of the information required by the tool. The first figure in each module contains forms for producing the tool. Then, I'll use two additional figures to show real-world examples for using the tool. The first example is for a multimedia design and development project. The second example is for the re-engineering of MSL. These examples will help you understand the final form of each tool.

The project planning process is iterative. Later steps will identify gaps and overlaps in earlier steps. You'll iterate until you have your plan "tight enough" to satisfy your needs and objectives as a manager. Project planning takes time up front when you're most eager to get started on the work. However, this is definitely a "pay me now or pay me later" situation. Up-front planning will save you time, money, and improve quality throughout the project.

Multimedia Project Scenario

Virginia Tech's College of Engineering is improving its curriculum through a number of innovations. One of those innovations is multimedia courseware. Multimedia courseware is a computer-based product combining text, animation, audio, video, and photographs to provide self-paced tutorials for students. This courseware supplements lectures, discussions with the professor, class discussions, and the required textbook.

Developing new courseware is expensive, both in professional time and in equipment. Several corporate partners provide grants to the College to further develop courseware. Northern Telecom is especially interested in helping Virginia Tech's College of Engineering develop courseware to supplement freshman and sophomore classwork on total quality management. Pamela Kurstedt and Patrick Koelling wrote a proposal to Northern Telecom proposing a new two-credit elective class, The World of Quality, supplemented by a multimedia courseware product devoted to total quality management principles and examples. The grant for $25,000 was approved. The grant will support the development of the multimedia product. The course, World of Quality, and the direction of the multimedia product will be developed as a normal activity of the college and require no outside funding. The grant will pay for equipment, travel, a graduate student for approximately 800 hours, and a graphic artist for 360 hours. Students will be used to test the product. The project will use additional resources in the University, including the Learning Resource Center experts on video production and the Multimedia Laboratory experts and equipment for editing the final product.

Pamela Kurstedt has two part-time support staff dedicated to this project. Lisa Connelly is a graphic artist and will be responsible for text input and artistic design of the computer screens. Wayne Neale is a Ph.D. candidate in human factors. He is responsible for determining the equipment needs; editing video, audio, and stills; and coordinating with Lisa on final design.

The Multimedia Laboratory is a college resource with equipment available for training or production. Pamela Kurstedt can consult with the director on hardware and software issues.

The project will cover 12 months, however the project management tools look at the initial phase of the courseware development during September 1 through December 31, 1992. Before January 1, 1993, additional project management tools will be completed for the time period January 1, 1993 through August 31, 1993. Improvement of the product, the course, and selection of the packaging for the product will occur during the second stage in 1993.

MSL Re-engineering Project Scenario

MSL is undergoing a reorganization from four independent research laboratories to an overall product-by-project matrix. This reorganization will require training, mentoring, and a realignment of support systems and processes. This new structure should improve the organization's performance to its research sponsors and enhance its ability to achieve the strategic direction set by top management (Harold Kurstedt and Ron Simpson).

MSL decided its lack of a unifying theme and purpose has created a barrier to closer cooperation and teamwork within MSL. Harold wants MSL to understand, refine, and demonstrate management systems engineering (MSE) in the interest of developing this common theme and purpose.

At the same time, MSL recognized MSE closely resembles the total quality management (TQM) fundamentals taught by W. Edwards Deming and others. One key to this organization's uniqueness and vision could be understanding and applying MSE, a TQM approach to developing tools for management. Harold and Ron wrote a strategic plan to document this new direction.

Here are some key features:

a. Harold and Ron created the position of Director of the Management Engineering Laboratory. This position will serve as master architect of the matrix and "mentor" for MSE/TQM. This position is a temporary transition position (about one year). As the matrix grows and matures, the Projects, Resources, and Business Directors will change to directly reporting to the Deputy Director. Dr. Brian Kleiner will be Director of the Management Engineering Laboratory (MEL).

b. Three positions report to the MEL Director: the Director of Projects, the Director of Resources, and the Director of Business. The Director of Projects will provide direction and coordination for designated project managers and will be responsible for continued development of work for existing sponsors. The Director of Resources will organize and manage the placement of MSL staff in four core product concentrations and will be responsible for "technical" or "product" development and marketing. Finally, the Director of Business will manage all the laboratory support services. Jyl Smithson-Riehl will be Director of Projects, John Imholz will be Director of Resources, and John Garrison will be Director of Business.

c. The Marketing Director will serve as the focal point for new ventures and high-level contacts within existing and potential sponsor organizations. This position will also give leadership to special projects, which represent potential core products. Dr. Anne Doss will be Director of Marketing.

The first task for the MEL leadership is to develop an implementation plan for the new direction as written in the strategic plan. The implementation plan should take three to four weeks to complete. The initial design and implementation should span a 12-month time period. Implementation will begin July 1, 1993 after the plan has been developed. It should take about one year to fully transition MSL into a matrix organization with a respective culture change, realignment of research products and services, and realignment of processes.

2.2.1.3. Scoping Agreement

With a scoping agreement, you can initiate a project so the responsible person knows what's expected.

The purpose of the *scoping agreement* is to define expectations of the project's work, responsibility, and accountability.

In a *scoping agreement*, the doer and the receiver agree on the scope of the doer's work. The agreement is a crisp 250-word statement (easily read in one minute). The *scoping agreement* is the beginning or definition phase of the management process and gives a firm point of reference for project efforts. An important part of the *scoping agreement* is to transfer or assign responsibility and accountability of an effort to the person doing the work.

The *scoping agreement* gives the project manager a defined agreement of what he or she is to do. The key is for both doer and receiver to agree on the time, requirements, and content of the effort.

We define the form of the *scoping agreement* by identifying four specific paragraphs and a total of ten specific pieces of information required for the paragraphs. By writing a sentence or so for each of the required pieces of information, you'll end up with the right information at the needed level of detail.

After doing one or two *scoping agreements* and using the outline, the preparation of the agreement can easily be done in fifteen minutes. You need to think through the content of the agreement anyway to effectively manage.

Definitions:
Doer - Person managing project, task etc.
Receiver - Person receiving the results

Using the outline in Figure 2.2.1.3.a., consider a *scoping agreement* to define the work agreed on between the doer and receiver for any project. For reference, review the multimedia example *scoping agreement* in Figure 2.2.1.3.b. and the MSL re-engineering example *scoping agreement* in Figure 2.2.1.3.c. You can use Figure 2.2.1.3.a. as a form for developing a *scoping agreement* for any project.

When considering the outline in Figure 2.2.1.3.a., also consider the following statement requirements for each item in the outline.

I. Identification of general information
   1) Identify parties of agreement including doer and receiver.
   2) Identify the task to be done or the result of the agreement.
   3) Identify what initiated the agreement (e.g., contract, management plan, update meeting).
   4) State what tangible outcome is needed and/or expected by receiver.
   5) Identify the funding vehicle or path.

II. Description of task and what is to follow the task
   1) Describe what the task or result looks like (be physical).
   2) State what follows from completing the task—what the task leads to.

III. Description of doer and receiver responsibilities
   1) Describe what is provided by doer.
   2) Describe what is needed from receiver.

IV. Description of background and supporting information
   1) Describe how the project relates to the

strategic plan or direction.

Helpful Hints:

- Supplier and customer sign scoping agreement.
- Keep agreement visible.
- Use agreement to audit your actual activities.
- Use supporting document.

SCOPING AGREEMENT

Project Name:____

Project Manager:____

I. Identification of general information.

II. Description of task and what is to follow the task.

III. Description of doer and receiver responsibilities.

IV. Description of background and supporting information.

Figure 2.2.1.3.a. *The scoping agreement is a crisp statement of expectations and work used to initiate a project.*

SCOPING AGREEMENT

Project Name: Multimedia Product for World of Quality, EF 2984
Project Manager: Pamela Kurstedt

I. Identification of General Information

Pamela Kurstedt and Patrick Koelling will work together to develop a free-elective course entitled, World of Quality, EF 2984, and a multimedia product to support that course and to support presentations on quality in EF 1005. The work was initiated by a request by Northern Telecom to propose a project allowing Northern Telecom and Virginia Tech interaction. This work is supported by Northern Telecom ($25,000) and the College of Engineering. The outcome for Spring Semester, 1993 is teaching the course for the first time with a pilot multimedia product (without video). (91)

II. Description of Task and What is to Follow the Task

The World of Quality course will be a 2-credit course offered to freshmen and sophomore students. The course will cover management philosophies, tools, and examples of Total Quality Management. The multimedia product will provide tutorial assistance in learning the major principles of the philosophy and examples of using quality tools in industry and in sample problems. The course will be improved and the multimedia product will add video for the fall semester, 1993. (73)

III. Description of Doer and Receiver Responsibilities

Pat Koelling will be responsible for developing the course syllabus and preparing the course material. Pamela Kurstedt will be responsible for developing the multimedia product to supplement the lectures and readings in the course. Northern Telecom will provide examples from industry and interviews for video production. (46)

IV. Description of Background and Supporting Information

The College of Engineering has committed to teaching Total Quality Management/Continuous Performance Improvement to students throughout the undergraduate program and to develop multimedia teaching tools for student-owned computers. This project will be an important step in advancing the college in both areas. (43)

Figure 2.2.1.3.b. *The multimedia example scoping agreement shows how to address the statement requirements for each item in the outline.*

SCOPING AGREEMENT

Project Name: Management Engineering Laboratory (MEL) Design and Implementation
Project Manager: Kleiner

I. Identification of General Information

Brian Kleiner, Jyl Smithson-Riehl, John Imholz, and John Garrison will work together to design, develop and implement the Management Engineering Laboratory (MEL). This reorganization is to be funded primarily with returned overhead funds. MEL is a reorganization of five former laboratories and/or groups into an integrated, matrix organization, operating under TQM/Continuous Process Improvement principles. This implementation is designed to achieve the strategic direction provided by Harold Kurstedt and Ron Simpson in support of their strategic plan. This plan won't change for the implementation period.

II. Description of Task and What is to Follow the Task

The design, development, and implementation of the MEL will involve a reorganization of personnel into four technical areas, serving one or more project managers. The four technical areas are TQM/MSE training, planning, communications, and management information systems. In addition to a restructure, the project will entail a culture change, alignment of products and a reengineering of processes. This reorganization will require training, mentoring, and a realignment of support systems and processes. The MEL will improve performance for sponsors on a number of dimensions.

III. Description of Supplier and Customer Responsibilities

Brian Kleiner will be responsible for the overall project. Jyl Smithson-Riehl will be responsible for projects; John Imholz will be responsible for resources; and John Garrison will be responsible for supporting the MEL with necessary services. Harold Kurstedt and Ron Simpson will support, protect and nurture the MEL. In addition, Anne Doss will direct the marketing effort, designed to bring in new sponsors to the MEL. In this regard, the MEL is her customer.

IV. Description of Background and Supporting Information

Harold Kurstedt and Ron Simpson are committed to implementing their strategic plan. The MEL is the major implementing force behind the strategic plan. The implementation of MEL is complemented by an institutionalization plan, a marketing plan, and several supporting documents including position descriptions and operating principles.

Attached is a list of operating principles and objectives for MEL design and implementation.

Figure 2.2.1.3.c. *The MSL re-engineering example scoping agreement shows how to address the statement requirements for each item in the outline.*

OPERATING PRINCIPLES and OBJECTIVES

Physical Layout/Facilities Design Requirements
- classroom to support 20-25 people with screen, good acoustics
- maximize staff in same location
- locate four MEL managers in same proximity, especially the resource director (RD) and the project director (PD)
- locate managers near a “war room,”
- no perceptions of downgrade (e.g.staff with fixed offices get fixed offices; if staff has a window, they get a window etc.)
- TQM group located near MEL director
- RD located near most staff
- PD located near project managers
- project managers have adequate project room
- adequate hardware/software support as determined by users

Reward/Recognition
- reward is based primarily on satisfying customers, and doing so according to the principles of TQM/MSE and related principles and norms of the MEL

Communication
- MEL management and staff should exhibit open, honest, regular and constructive communications
- Decisions and plans should be fully communicated and if in process, an honest report of status should be shared with staff

Research
- According to Harold and Ron’s direction, research will be part of MSE and the way we do business.

Behavioral Norms
- Everyone has paradigms which will need to change to be successful in the MEL.

Leadership
- Create constancy of purpose
- adopt the new philosophy
- cease dependence on inspection for quality
- develop long term relationship with University, sponsors, other suppliers
- improve constantly
- institute training
- institute leadership
- drive out fear
- break down barriers
- eliminate slogans and exhortations
- remove barriers to pride of workmanship

Figure 2.2.1.3.c. (cont.) *The MSL re-engineering example scoping agreement shows how to address the statement requirements for each item in the outline.*

Management

- decision making should be performed with input from those affected by the decision
- power should be shared vertically and horizontally
- resource units should perform as teams
- project units should perform as teams
- managers should facilitate, support, empower the teams
- Harold/Ron will handle MSL pre-existing problems
- only staff who commit to support Harold's and Ron's strategic direction should enter the new organization
- maintain open financial records
- learn, practice, and teach continuous process improvement
- align everyone with development and commitment to shared vision
- lead and empower others
- build a critical mass
- create and maintain a continuous improvement culture
- eliminate special causes of variation
- improve the system
- learn, apply, and teach the tools of quality management
- champion empowerment activities by ensuring personnel have knowledge to be empowered; ensuring the team is ready to be empowered; supporting the team once empowered.
- decisions based on accurate understanding of data
- focus on the process/manage improvement efforts
- focus on long-term improvements
- measure improvements
- manage projects according to project management (PM) principles, using appropriate PM tools

Operations

- system provides capability on a consistent basis, to meet the needs and desires of customers
- system is highly capable of meeting both internal and external customer needs
- obsession with quality
- optimize the system not subsystems
- understand processes, re-engineer and/or replace processes

Figure 2.2.1.3.c. (cont.) *The MSL re-engineering example scoping agreement shows how to address the statement requirements for each item in the outline.*

2.2.1.4. Task List

With a task list, you can see that you have no gaps and overlaps in the tasks you need to complete to successfully accomplish your project's objectives with scoping agreement.

The purpose of the *task list* is to identify the tasks required to complete the project, their durations, and the important outcomes (milestones) of some of the tasks.

The *scoping agreement* defined the expectations of both the doer and the receiver for the project. The next step in project planning is brainstorming to create a list of all project tasks. (A task is a defined piece of work with start and end dates and is assigned to a responsible person). All tasks end in an event. Milestones are events with the following characteristics: 1) They're events you wish to highlight and follow. 2) They're events that have clear results or ending points. 3) They're events that are significant; they give you a feel for whether or not you're behind schedule. 4) They're events that should not be more than 10 days apart. For example, a good milestone might be to turn in an important weekly report. This is good because it meets all four criteria. A monthly report could be a poor milestone because it may not satisfy the last two criteria. List project tasks as you think of them on the *task list*. Include all tasks, both big and small, necessary to complete the project. Then record the duration of each task using your best time estimate. Complete the *task list* by denoting all milestone events with a capital M. You'll now have a checklist of all the project's tasks; and they can be collected into activities.

Using the outline in Figure 2.2.1.4.a., consider a *task list* to outline the tasks you can find in or extrapolate from any project. Don't forget to distinguish the more important events (task endings) by designating them as milestones.

For reference, review the completed *task list* for the multimedia project in Figure 2.2.1.4.b. and notice which tasks constitute milestones. Also review the completed *task list* for the MSL re-engineering project in Figure 2.2.1.4.c. You can use Figure 2.2.1.4.a. as a form for developing a *task list* for any project.

Note that at step 2 (the *task list* step) you're constrained only by the *scoping agreement* (the project boundaries from step 1). In step 2, you'll define your activities, tasks, task durations, events, and milestones. A decision you'll need to make is: How small should I divide up activities and tasks?

Definitions:

Task **-** A defined piece of work

Follow these guidelines as you complete your *task list*:

1) What are the tasks for this project? List them randomly as you think of them under task. All tasks end with an event.
2) What is the duration of each task? Record under duration.
3) Are any events important enough to be milestones? If yes, put an M in the milestone column.

Helpful Hints:

- Consider scoping agreement boundaries and constraints.
- Don't think of duration starting today.
- First list major milestones, then iterate for more detailed ones.

TASK LIST

Project Name:____

Project Manager:____

Task	Duration	Milestone

Figure 2.2.1.4.a. *The task list is a simple listing of everything you need to complete to accomplish the project objectives.*

TASK LIST

Project Name: Multimedia Product for World of Quality, EF 2984
Project Manager: Pamela Kurstedt

Task	Duration	Milestone
Investigate and select software	5 days	M
Identify equipment needed	5 days	
Purchase software	5 days	
Purchase equipment	10 days	M
Learn new software	6 days	
Design outline of multimedia product	10 days	M
Review of literature for quotes and history	10 days	
Input of multimedia screens	20 days	
Input and edit text screens	6 days	M
Input and edit animation screens	6 days	M
Unforeseen problems	8 days	
Review available videos on TQM topics	19 days	
Request copyright permission if needed	43 days	
Arrange visit to Northern Telecom	1 day	
Visit Northern Telecom for examples and interviews	2 days	M
Edit video from Northern Telecom	3 days	
Identify location of video	2 days	
Select stills for multimedia product	6 days	
Input and edit stills	3 days	M
Test multimedia product with students	15 days	M
Identify test group	5 days	
Reserve room for test	1 day	
Invite students	1 day	
Conduct test	5 days	
Analyze test comments	3 days	
Final edit of multimedia product	5 days	M
Review progress of course material with multimedia	1 day	M
Review progress of course material with multimedia	1 day	M
Review progress of course material with multimedia	1 day	M

Figure 2.2.1.4.b. *The multimedia example task list shows how to include all tasks to accomplish the project objectives.*

TASK LIST

Project Name: MEL Design and Implementation
Project Manager: Kleiner

Task	Duration	Milestone
Scoping Agreement	1 week	M
Operating principles	3 weeks	
Operationalize values	3 weeks	
Decision making process	1 week	
Position descriptions	1 week	
Current layout/assignments	1 week	
Current equipment allocations	2 weeks	
Determine equipment needs	3 weeks	
Create design alternatives	3 weeks	
Select and approve design	1 week	
Implement new design	8 weeks	M
Select project managers	2 weeks	M
Select product managers	3 weeks	M
Pre-train managers	4 weeks	M
Analyze skill/interest mix	2 weeks	
Interview staff	3 weeks	
Select staff	4 weeks	M
Define current funding/staff mix	2 weeks	
Create forecast	3 weeks	M
Identify funding gap	3 weeks	
Secure overhead for gap	3 weeks	M
Marketing Plan	3 weeks	M
Monitor Marketing Plan	ongoing	
Academic Institutionalization Plan	3 weeks	M
Business Institutionalization Plan	3 weeks	M
Monitor Institutionalization plan	ongoing	
Proposal Development process	3 weeks	
Test MSE against TQM	6 weeks	
Test MSE against research	6 weeks	
Recommendations re:viability of MSE	1 week	
Decision regarding MSE	1 week	M
Design and Develop Training	3 weeks	
Develop Training schedule	1 week	
Implement training	8 weeks	M
Develop mentoring process	ongoing	
Develop success factors	2 weeks	

Figure 2.2.1.4.c. *The MSL re-engineering example task list shows how to include all tasks to accomplish the project objectives.*

Task	**Duration**	**Milestone**
Define performance measures	3 weeks	
Collect “before” data	2 weeks	
Collect data	ongoing	
Review results weekly then monthly	ongoing	
Document/analyze compensation levels	2 weeks	
Develop compensation plan	2 weeks	
Implement first phase compensation	2 weeks	M
Develop/implement recognition process	3 weeks	
Develop int. promotional materials	3 weeks	
Develop ext. promotional materials	3 weeks	
Develop publications process	3 weeks	

Figure 2.2.1.4.c. (cont.) *The MSL re-engineering example task list shows how to include all tasks to accomplish the project objectives.*

2.2.1.5. Work Breakdown Structure

The work breakdown structure serves as the basis for all following project management tools by organizing project tasks into related groups.

The purpose of the *work breakdown structure* is to group tasks logically into activities, and identify subtasks, etc.; develop identifiers for them.

The next planning step is to logically group into activities those tasks you identified in doing the *task list*. An activity is a logical grouping of tasks. A structured grouping of tasks into activities is called a *work breakdown structure (WBS)*. The *WBS* is a tree diagram of the task list and is either in an outline format or an organizational-chart type format. The *WBS* shows the relationships between the individual tasks and gives structure to the *task list*. After listing the tasks in an activity, look for tasks you may have missed. If a task can be divided in time and responsibility, break it into subtasks. Divide the tasks into as many subtasks as necessary to reduce tasks to manageable size. Each subtask should be small enough to control, but not so small it's trivial. If you find more than nine subtasks under a task or nine tasks under an activity, you have too great a span of control. Ten or more subtasks should be logically divided into two or more tasks each containing some portion of the original number of subtasks.

The *WBS* specifies the tasks, their estimated durations, and those tasks ending in a milestone. If the project is simple, only a few project divisions are required. For complex projects, construct a detailed *WBS*. Composing a good *WBS* is an important planning step, because it's the basis for the rest of the steps. If in doing a following project management step, you discover a task you missed, come back to this step and add it.

Using the outline in Figure 2.2.1.5.a., consider a *WBS* for any project. For reference, review the completed *work breakdown structure* for the multimedia project in Figure 2.2.1.5.b. and for the MSL re-engineering project in Figure 2.2.1.5.c. You can use Figure 2.2.1.5.a. as a form for developing a *work breakdown structure* for any project.

Note that at step 3 (the *WBS* step) you have tasks from your *task list*. In step 3, you'll add groupings to the tasks so you can find gaps and overlaps. This step runs a sanity check on your *task list* and sets up the next sets of tools. You'll want your *WBS* to be as good as you can make it at this point. In later tools, you'll match the *WBS* against time, people, materials and equipment, funding, and specifications.

Definitions:

Activity - Logical grouping of tasks

Follow these guidelines as you complete your *work breakdown structure*.

1) What are the main activities to accomplish?

2) What tasks and subtasks fall under each main activity? List these tasks in an outline format (or organization-chart type format) to show activities and tasks and subtasks. If needed, break subtasks into sub-subtasks and so on.

3) Develop an identifying number for each

activity, task and subtask by numbering the project 1. and the activities 1.1, 1.2, etc. The tasks under activity 1.1 are numbered 1.1.1, 1.1.2, etc. Use this scheme for numbering all entries in you *work breakdown structure*. (Actually a project may need to start with a number like 2., 3., etc. so several projects can be monitored together). Based on the span of control management principle, if you approach ten (double digit) tasks under an activity, subtasks under a task, sub-subtasks under a subtask, etc.; then you should set up another level in your hierarchy.

Helpful Hints:

- List major categories of tasks first, then subtasks.
- Use short identifiers with task numbers.
- Modify the task list as needed.

WORK BREAKDOWN STRUCTURE

Project Name: ____
Project Manager:____

Task #
1.1. ____
1.1.1. ____
1.1.2. ____
1.1.3. ____
1.1.4. ____
1.1.5. ____
1.1.6. ____
1.1.7. ____
1.1.8. ____
1.1.9. ____
1.2. ____
1.2.1. ____
1.2.2. ____
1.2.3. ____
1.2.4. ____
1.2.5. ____
1.2.6. ____
1.2.7. ____
1.2.8. ____
1.2.9. ____
1.3. ____
1.3.1. ____
1.3.2. ____
1.3.3. ____
1.3.4. ____
1.3.5. ____
1.3.6. ____
1.3.7. ____
1.3.8. ____
1.3.9. ____
1.4. ____
1.4.1. ____
1.4.2. ____
1.4.3. ____
1.4.4. ____
1.4.5. ____
1.4.6. ____
1.4.7. ____
1.4.8. ____

Figure 2.2.1.5.a. *The work breakdown structure organizes tasks into related groups.*

WORK BREAKDOWN STRUCTURE

- 1.4.9. ____________________
- 1.5. ____________________
  - 1.5.1. ____________________
  - 1.5.2. ____________________
  - 1.5.3. ____________________
  - 1.5.4. ____________________
  - 1.5.5. ____________________
  - 1.5.6. ____________________
  - 1.5.7. ____________________
  - 1.5.8. ____________________
  - 1.5.9. ____________________
- 1.6. ____________________
  - 1.6.1. ____________________
  - 1.6.2. ____________________
  - 1.6.3. ____________________
  - 1.6.4. ____________________
  - 1.6.5. ____________________
  - 1.6.6. ____________________
  - 1.6.7. ____________________
  - 1.6.8. ____________________
  - 1.6.9. ____________________
- 1.7. ____________________
  - 1.7.1. ____________________
  - 1.7.2. ____________________
  - 1.7.3. ____________________
  - 1.7.4. ____________________
  - 1.7.5. ____________________
  - 1.7.6. ____________________
  - 1.7.7. ____________________
  - 1.7.8. ____________________
  - 1.7.9. ____________________
- 1.8. ____________________
  - 1.8.1. ____________________
  - 1.8.2. ____________________
  - 1.8.3. ____________________
  - 1.8.4. ____________________
  - 1.8.5. ____________________
  - 1.8.6. ____________________
  - 1.8.7. ____________________
  - 1.8.8. ____________________
  - 1.8.9. ____________________

Figure 2.2.1.5.a. (cont.) *The work breakdown structure organizes tasks into related groups.*

WORK BREAKDOWN STRUCTURE

Project Name: Multimedia Product for World of Quality, EF 2984
Project Manager: Pamela Kurstedt

- 1.1 Complete equipment set-up
    - 1.1.1 Investigate and select software
    - 1.1.2 Identify equipment needed
    - 1.1.3 Purchase software
    - 1.1.4 Purchase equipment

- 1.2 Design product content
    - 1.2.1 Learn new software
    - 1.2.2 Design outline of multimedia product
        - 1.2.2.1 Review literature for quotes and history
    - 1.2.3 Input of multimedia screens
        - 1.2.3.1 Input and edit text screens
        - 1.2.3.2 Input and edit animation screens
        - 1.2.3.3 Unforeseen problems
    - 1.2.4 Review available videos on TQM topics
    - 1.2.5 Request copyright permission if needed

- 1.3 Design media components
    - 1.3.1 Arrange visit to Northern Telecom
    - 1.3.2 Visit Northern Telecom for examples and interviews
    - 1.3.3 Edit video from Northern Telecom
        - 1.3.3.1 Identify location of video
    - 1.3.4 Select stills for multimedia product
        - 1.3.4.1 Input and edit stills

- 1.4 Test and edit phase
    - 1.4.1 Test multimedia product with students
        - 1.4.1.1 Identify test group
        - 1.4.1.2 Reserve room for test
        - 1.4.1.3 Invite students
        - 1.4.1.4 Conduct test
        - 1.4.1.5 Analyze test comments
    - 1.4.2 Final edit of multimedia product

- 1.5 Coordination of course planning
    - 1.5.1 Review progress of course material with multimedia
    - 1.5.2 Review progress of course material with multimedia
    - 1.5.3 Review progress of course material with multimedia

Figure 2.2.1.5.b. *The multimedia example work breakdown structure shows how tasks are grouped.*

WORK BREAKDOWN STRUCTURE

Project Name: MEL Design and Implementation
Project Manager: Kleiner

1.1 Set expectations
- 1.1.1 Scoping Agreement
- 1.1.2 Operating principles
- 1.1.3 Operationalize values (behavioral norms)

1.2 Roles and Responsibilities
- 1.2.1 Decision Making process
- 1.2.2 Position Descriptions

1.3 Facilities
- 1.3.1 Current Layout/staff assignments
- 1.3.2 Current equipment allocations
- 1.3.3 Determine equipment requirements
- 1.3.4 Create design alternatives
- 1.3.5 Select and approve design
- 1.3.6 Implement new design

1.4 Selection
- 1.4.1 Select project managers
- 1.4.2 Select product managers
- 1.4.3 Pre-training for managers
- 1.4.4 Analyze skill/interest mix from surveys
- 1.4.5 Interview staff
- 1.4.6 Select/assign staff

1.5 Business Plan
- 1.5.1 Define current project/funding/staff mix
- 1.5.2 Create forecast
- 1.5.3 Identify funding gap
- 1.5.4 Secure overhead funds for gap
- 1.5.5 Marketing Plan
- 1.5.6 Monitor Marketing
- 1.5.7 Academic Institutionalization Plan
- 1.5.8 Business Institutionalization Plan
- 1.5.9 Monitor institutionalization
- 1.5.10 Proposal development process

1.6 Test and Evaluation
- 1.6.1 Test MSE against TQM
- 1.6.2 Test MSE against research
- 1.6.3 Recommendations regarding viability of MSE
- 1.6.4 Decision regarding MSE

1.7 Training
- 1.7.1 Design and Develop Training
- 1.7.2 Develop training schedule

Figure 2.2.1.5.c. *The MSL re-engineering example work breakdown structure shows how tasks are grouped.*

1.7.3 Implement training
1.7.4 Develop mentoring process

1.8 Measurement
1.8.1 Develop success factors
1.8.2 Define performance measures
1.8.3 Collect "before" data
1.8.4 Collect data
1.8.5 Review monthly

1.9 Reward and Recognition
1.9.1 Document and analyze compensation levels
-managers
-staff
1.9.2 Develop compensation/performance mgt. plan
-managers
-staff
1.9.3 Implement first phase in July
1.9.4 Develop and implement recognition process

1.10 Communication support
1.10.1 Develop internal promotional materials
1.10.2 Develop external promotional materials
1.10.3 Develop publications process

Figure 2.2.1.5.c. (cont.) *The MSL re-engineering example work breakdown structure shows how tasks are grouped.*

2.2.1.6. GANTT CHART

With the gantt chart, you see how the tasks from the work breakdown structure layout against a time line so you can look for conflicting needs for resources.

The purpose of the *gantt chart* is to place tasks and activities as horizontal bars against a time line to show start and end dates. Sometimes milestones are superimposed on the horizontal bars. (Note: The *gantt chart* doesn't show precedence).

All projects must have a time schedule. Scheduling forces us to figure out the sequence of tasks and the time to complete them. *Gantt charts* are useful in scheduling a project. They're easy to develop and use and give us a quick overview of the project.

A *gantt chart* is a bar chart to graphically portray *WBS* task duration. A *gantt chart* might be called a graphical *WBS*.

A *gantt chart* shows whether the project team is meeting the schedule or not. The chart can be color coded to note who is responsible for what task. You can include symbols to depict starting and ending dates, milestones, or other relevant information. The strength of the *gantt chart* is its simplicity. Include only information readily depicted on the chart. You've now sequenced and scheduled the project's tasks. (If you're responsible for a number of projects, you can do a multi-project *gantt chart* by putting projects in the stub (y-axis) of the chart. You can also add vacation and training periods. What you get is a master schedule.)

Using the outline in Figure 2.2.1.6.a., consider a *gantt chart* for any project. For reference, review the completed *gantt chart* for the multimedia project in Figure 2.2.1.6.b. and for the MSL re-engineering project in Figure 2.2.1.6.c. You can use Figure 2.2.1.6.a. as a form for developing a *gantt chart* for any project.

Note that at step 4 (the *gantt chart* step) you have duration from your *task list* and tasks and groupings from your *WBS*. In step 4, you'll add start and end dates to your tasks.

Follow these guidelines as you complete your *gantt chart*.

1) What is the total length of the project? Let that time be the length of the time axis (x-axis).

2) How long is the shortest task? Let that time help you set the divisions on the x-axis. (Use your judgment if you have a few tasks much shorter than most. They'll show up as points in time--or vertical lines).

3) What are the tasks of the project? List them sequentially along the y-axis (either by short title or identifying number). Also, you can choose to list your tasks sequentially by starting date or by number.

4) Use the duration from your *task list*. When does the task begin? Represent starting time and duration by an empty bar horizontal to the x-axis for each task.

Note: When you use the *gantt chart* during the project to see how well you're doing, you'll include a solid bar above each empty bar. Draw in the solid bar to show the progress (percent completed) of each task. So the empty bar shows plan and the solid bar shows actual. For a short-duration task, shown as a vertical line on the *gantt chart*, draw a vertical line under the original line to show the task was completed. You'll read about the use of triangles for milestones in the milestone log.

Helpful Hints:

- List short identifiers with numbers.
- Don’t get in the habit of slippery slope scheduling.
- Use weeks for first iteration.

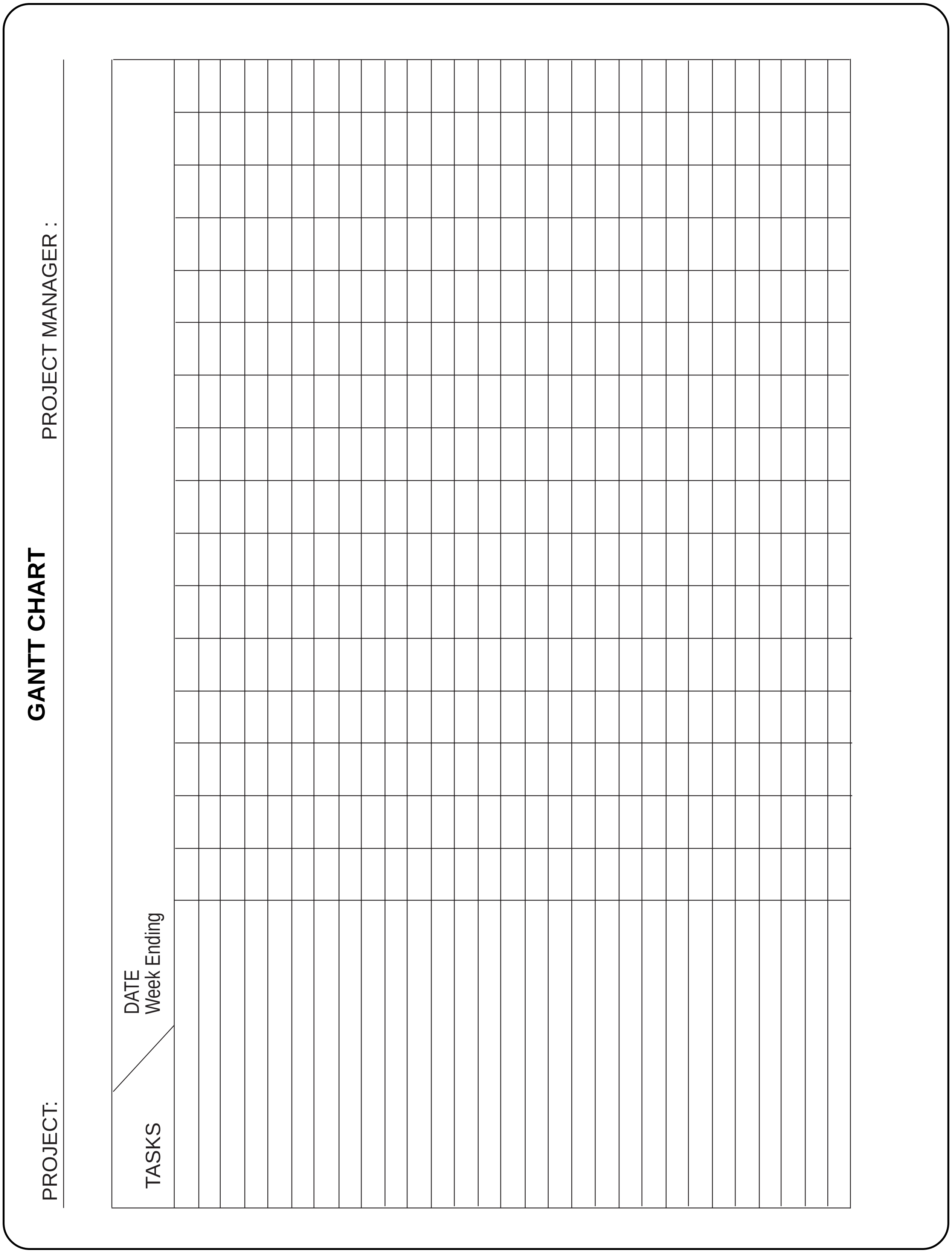

Figure 2.2.1.6.a. *The gantt chart schedules tasks against time.*

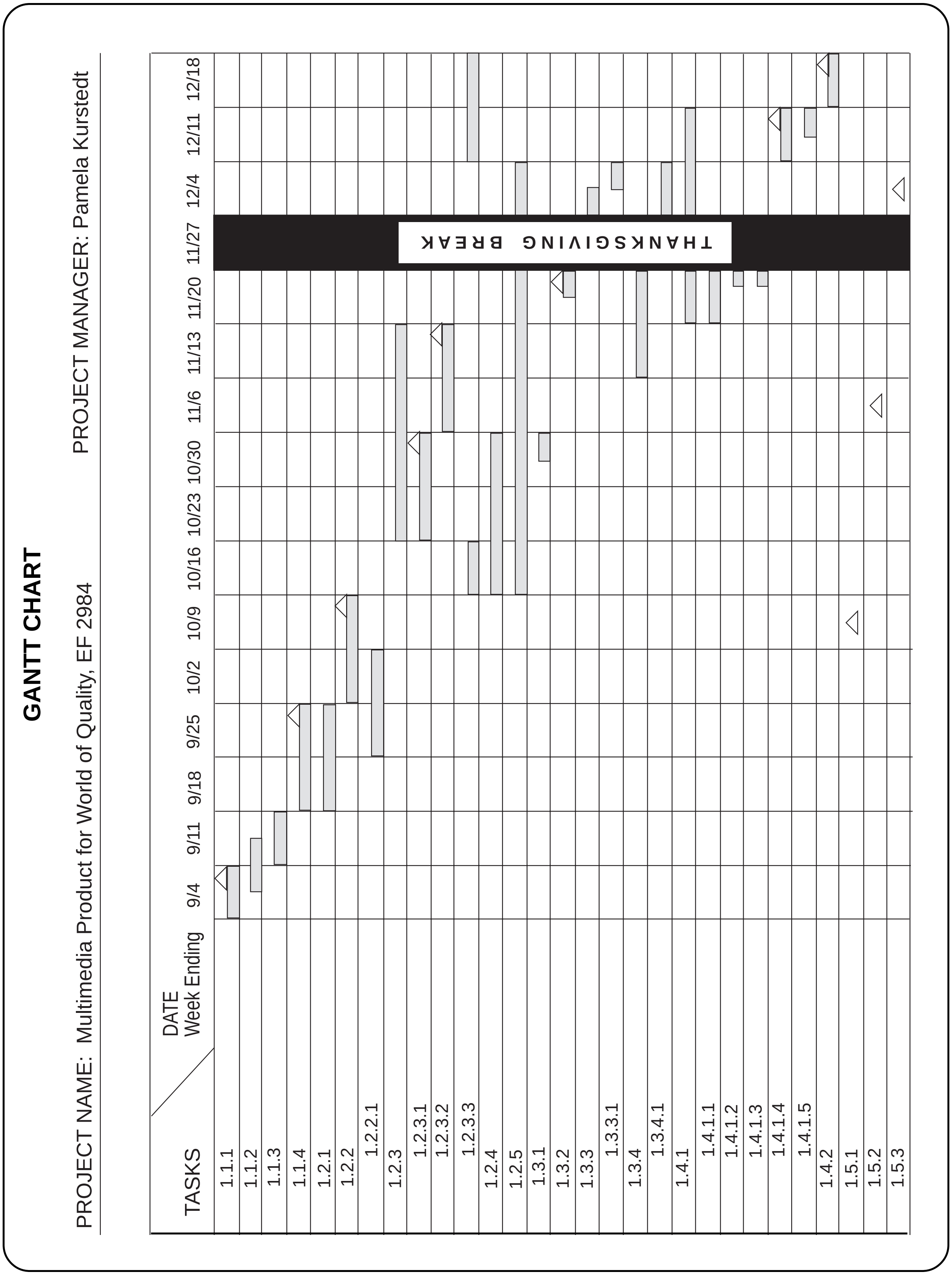

Figure 2.2.1.6.b. *The multimedia example gantt chart shows tasks as a function of the weeks in the project.*

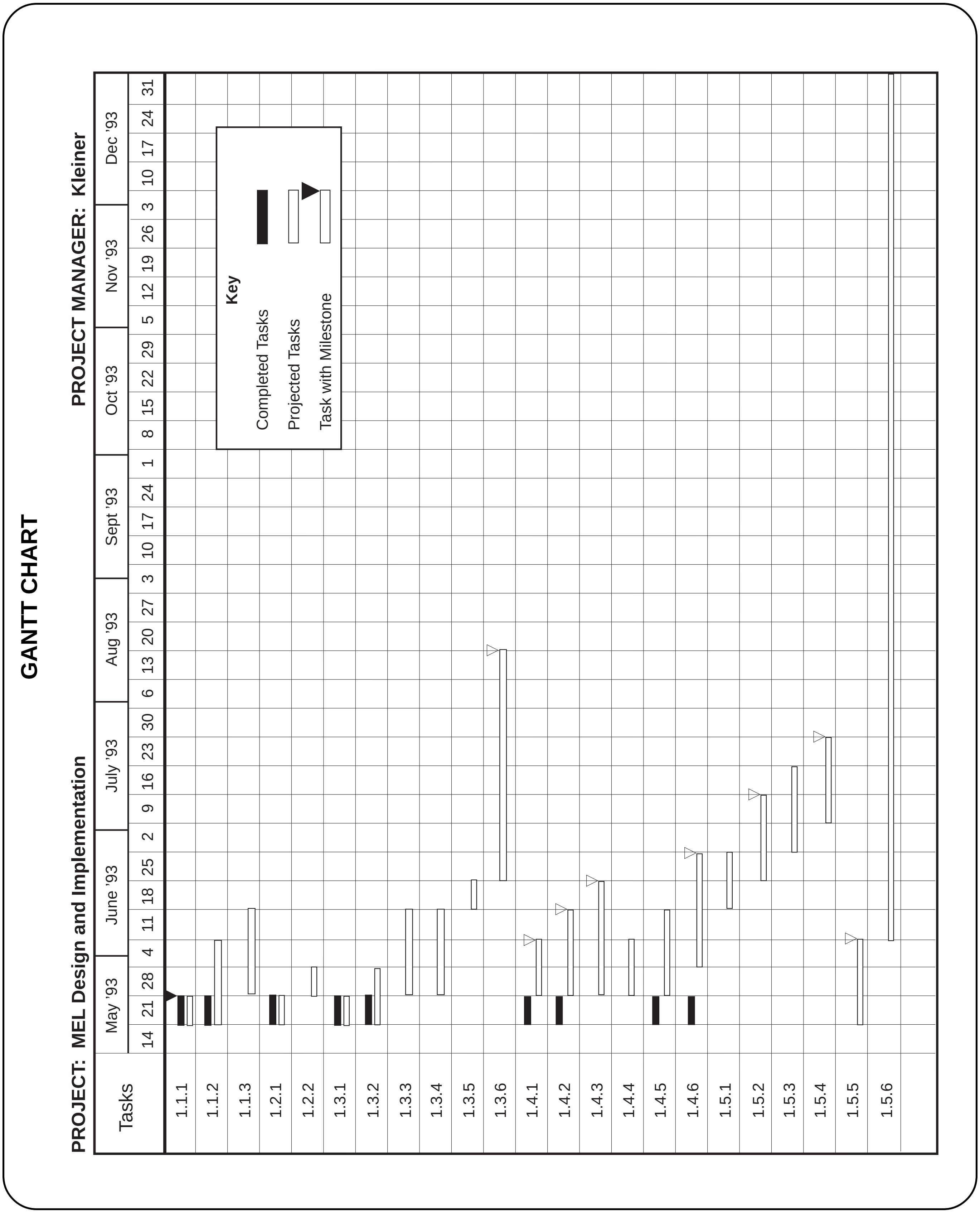

Figure 2.2.1.6.c. *The MSL re-engineering example gantt chart shows tasks as a function of the weeks in the project.*

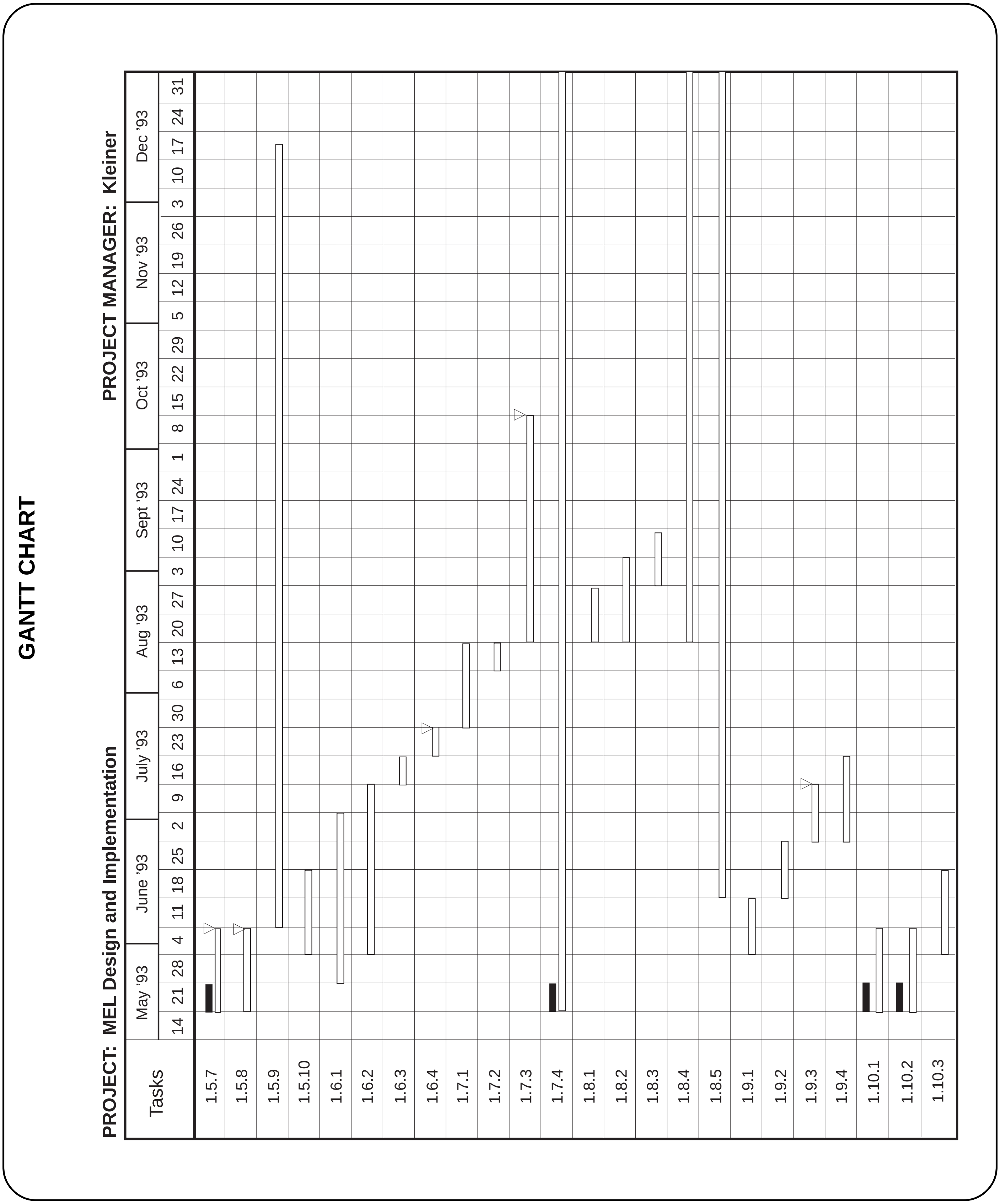

Figure 2.2.1.6.d. *The MSL re-engineering example gantt chart shows tasks as a function of the weeks in the project.*

2.2.1.7. MILESTONE LOG

With the milestone log, you can concentrate on the due dates of important events marking the end points of activities or tasks.

The purpose of the *milestone log* is to list the milestones with their due dates and identify the people responsible for achieving the milestone.

The activities of a project show effort and input to the system. The events related to the activities show physical evidence and output from the system. You want to monitor physical evidence, not effort. Events the project manager wants to highlight are milestones. The characteristics and some examples of milestones are repeated here for your convenience. Milestones are events with the following characteristics: 1) They're events you wish to highlight and follow. 2) They're events that have clear results or ending points. 3) They're events that are significant; they give you a feel for whether or not you're on schedule. 4) They're events that should not be more than 10 days apart. The *milestone log* contains more detailed milestone information such as the responsible people, event descriptions, and due dates. All milestones are characterized by physical evidence. Upon completing the *milestone log*, you'll have regular and frequent indications of the project's progress.

Using the outline in Figure 2.2.1.7.a., consider a *milestone log* for any project. For reference, review the completed *milestone log* for the multimedia project in Figure 2.2.1.7.b. and for the MSL re-engineering project in figure 2.2.1.7.c. You can use Figure 2.2.1.7.a. as a form for developing a *milestone log* for any project.

Note that at step 5 (the *milestone log* step) you have milestones from your *task list* and end dates from your *gantt chart*. In step 5, you'll verify end dates and add the person responsible for each milestone.

Follow these guidelines as you complete your *milestone log*.

1) What are the milestones from your *task list*? Using the *gantt chart* starting dates, list them in sequential order.

2) What physical evidence shows the milestone is reached? Describe it under event description.

3) Who's responsible for the milestone? When is it due? Record these in the corresponding columns.

4) Now go back to you *gantt chart* and show milestones as triangles, the point-down along the top edge of the bars. Empty triangles are planned milestones, filled-in triangles completed ones.

Helpful Hints:

- Project deliverables should be creative and should meet customer needs and wants.
- Project deliverables should be visible and should facilitate communication.
- Have task list handy for reference.

MILESTONE LOG

Project Name: ______________________________

Project Manager: ______________________________

Milestone	Event Description	Person Responsible	Due Date

Figure 2.2.1.7.a. *The milestone log highlights important events you set expections for during the course of the project.*

MILESTONE LOG

Project Name: Multimedia Product for World of Quality, EF 2984
Project Manager: Pamela Kurstedt

Milestone	Event Description	Person Responsible	Due Date
1.1	Investigate and select software	PSK	9/4
1.1.4	Purchase equipment	PSK	9/25
1.2.2	Design outline of multimedia product	PSK	10/9
1.2.3.1	Input and edit text screens	LGC	10/30
1.2.3.2	Input and edit animation screens	LGC	11/13
1.3.2	Visit Northern Telecom for examples and interviews	PSK	11/17
1.4.1.4	Test multimedia product with students	PSK	12/11
1.4.2	Final edit of multimedia product	PSK	12/18
1.5.1	Review progress of course material with multimedia	PSK/CPK	10/5
1.5.2	Review progress of course material with multimedia	PSK/CPK	11/6
1.5.3	Review progress of course material with multimedia	PSK/CPK	12/4

Figure 2.2.1.7.b. *The multimedia example milestone log shows the due dates for important events.*

MILESTONE LOG

Project Name: MEL Design and Implementation
Project Manager: Kleiner

Milestone	Event Description	Person Responsible	Due Date
1.1.1	Signed Scoping Agreement	BMK	5/21
1.3.6	New Offices/Layout	JLG	8/13
1.4.1	Position Announcements	JSR	6/4
1.4.2	Position Announcements	JJI	6/11
1.4.3	Training for Managers	BMK	6/18
1.4.6	Assignment Announcement	JJI	6/25
1.5.2	Forecast Disseminated	JSR	7/9
1.5.4	Budget Announcement	BMK	7/23
1.5.5	Plan Disseminated	ARD	6/4
1.5.7	Plan Disseminated	HAK	6/4
1.5.8	Plan Disseminated	RDS	6/4
1.6.4	Decision Communicated	BMK	7/23
1.7.3	Training for Staff	BMK	10/8
1.9.3	Salary Increases	JLG	7/9

Figure 2.2.1.7.c. *The MSL re-engineering example milestone log shows the due dates for important events.*

2.2.1.8. Program Management–Camille Pissarro

2.2.1.9. Responsibility Matrix

With the responsibility matrix, you'll assign human resources to each task.

The purpose of the *responsiblity matrix* is to identify task responsibility, participation, and approval.

People are the most important resource you'll manage. Coordinating the activities of a large group of people can be a major effort. Even for smaller projects, we often have trouble assigning people to various tasks. Each individual may be working on several tasks. Additionally, people may have a different level of responsibility on each task. The project manager must coordinate the duties of all the people in these tasks and activities.

An efficient way to link people to specific tasks is the *responsibility matrix*. The matrix's y-axis lists the project's tasks, the x-axis lists the people involved in the project. By using the symbols:

R: Person responsible for the task,
P: Person participating on the task
A: Person who approves the task, and
S: Person playing a key supportive role

in the matrix cells, you can show who's working on what task in what capacity. To construct a *responsibility matrix* you must first list all names of people involved with the project's tasks across the top of the form (including your name). Then you must list the tasks involved in your project in the column titled tasks. Finally you assign the letter R, P, A, or S to each person who is involved with each corresponding task. When the matrix is complete, you'll have allocated all human resources (project team members) to tasks. (If you're responsible for a number of projects you can do a multi-project *responsibility matrix* by putting projects on the stub (y-axis) of the matrix.)

Using the outline in Figure 2.2.1.9.a., consider a *responsibility matrix* for any project. For reference, review the completed *responsibility matrix* for the multimedia project in Figure 2.2.1.9.b. and for the MSL re-engineering project in Figure 2.2.1.9.c. You can use Figure 2.2.1.9.a. as a form for developing a *responsiblity matrix* for any project.

Note that at step 6 (the *responsibilty matrix* step) you have tasks and groupings from your *WBS* and the responsible person *for milestones* from your *milestone log*. In step 6, you'll verify responsible person and add roles for other people.

Follow these guidelines as you complete your *responsibility matrix*.

1) What are the project's tasks? List along the y-axis.
2) Who'll be working on the project team? List along the x-axis.
3) Who's responsible for each task? Who'll participate in the tasks? Whose approval is needed for the tasks? Who plays a key supportive role? Show them in the matrix cells using the letters R, P, A, and S.

Helpful Hints:

- This tool helps empower others if used correctly.
- Each task should have only one 'R'.
- Don't confuse 'A' and 'R'.
- Use many 'P's'.

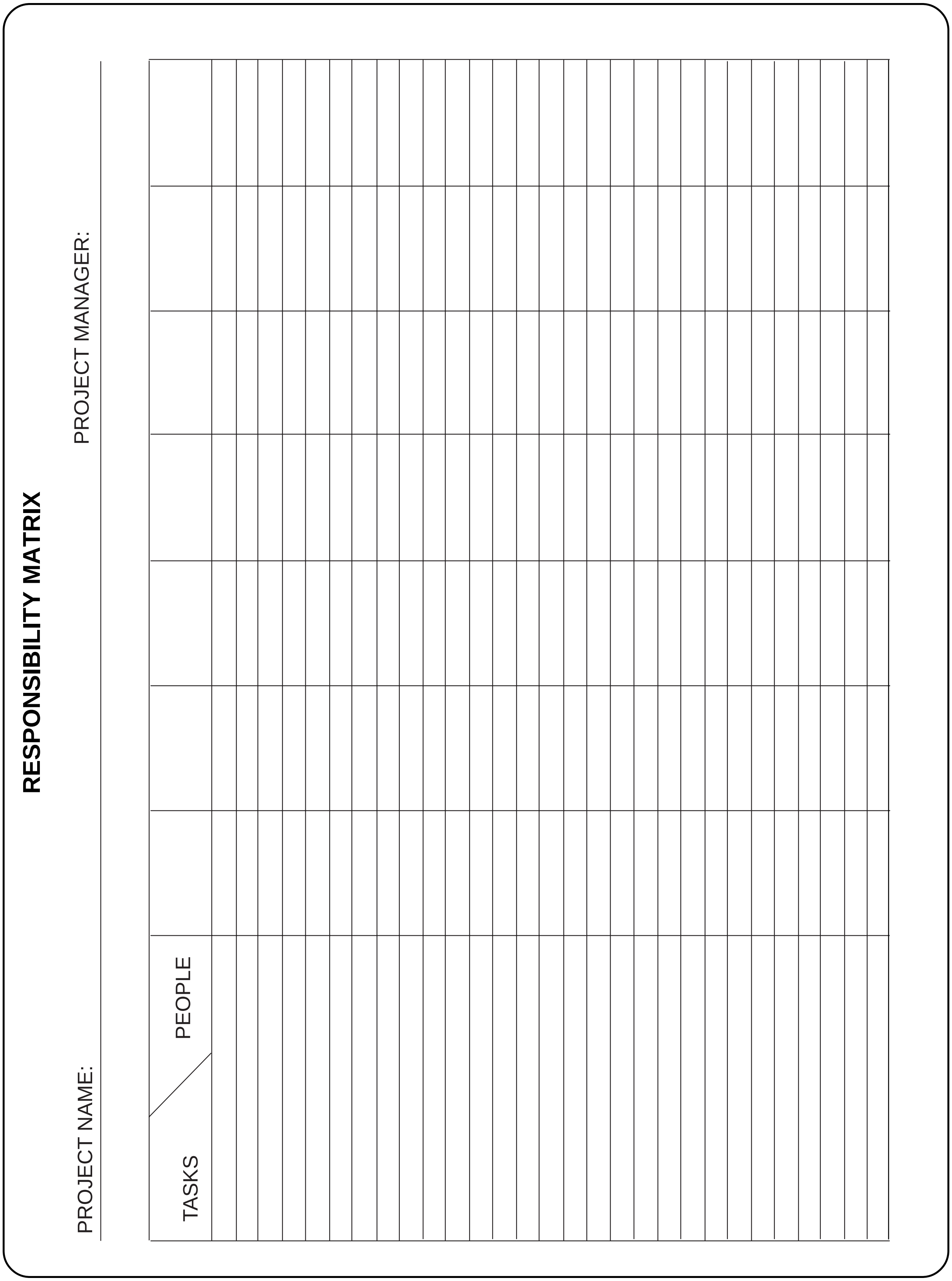

Figure 2.2.1.9.a. *The responsibility matrix identifies the responsibilities for each person working on a project.*

RESPONSIBILITY MATRIX

PROJECT NAME: Multimedia Product for World of Quality, EF 2984

PROJECT MANAGER: Pamela Kurstedt

TASKS \ PEOPLE	PSK	CPK	LGC	GRAD STUDENT	STUDENT REVIEWERS	TELECOM	OTHER
1.1.1	R						
1.1.2	R						
1.1.3	R						
1.1.4	R						
1.2.1	P		R				
1.2.2	R						
1.2.2.1	A			R			
1.2.3	A		R	P			
1.2.3.1	A		R	P			
1.2.3.2	P		P	P			
1.2.3.3	P		P	P			
1.2.4	A			R			
1.2.5	A			R			
1.3.1	R			P		P	
1.3.2	R	P		P		P	
1.3.3	A						R
1.3.3.1	R						
1.3.4	R						
1.3.4.1	A		R				
1.4.1	A			R			
1.4.1.1	A			R			
1.4.1.2	A			R			
1.4.1.3	A			R			
1.4.1.4	A			R	P		
1.4.1.5	A			R			
1.4.2	R		P	P			
1.5.1	R	P					
1.5.2	R	P					
1.5.3	R	P					

Figure 2.2.1.9.b. *The multimedia example responsibility matrix shows who's working on what and in what capacity.*

RESPONSIBILITY MATRIX

PROJECT NAME: MEL Design and Implementation PROJECT MANAGER: Kleiner

TASKS \ PEOPLE	BMK	JSR	JLG	JJI	HAK	RDS	ARD
1.1.1	R	P	P	P	A	A	P
1.1.2	R	P	P	P	S	S	P
1.1.3	R	P	P	P	S	S	P
1.2.1	R	P	P	P			P
1.2.2	A	P	P	P	R	S	P
1.3.1	P	P	R	P			P
1.3.2	P	P	R	P			P
1.3.3	P	P	P/S	R			
1.3.4	P	P	R	P		A	P
1.3.5	R	P	P	P			P
1.3.6	P	P	R	P/S	S	S	P
1.4.1	P	R	P	P	S	S	P
1.4.2	P	P	P	R			P
1.4.3	R	P	P	P			P
1.4.4	P	P	P	R			P
1.4.5	P	P	P/S	R	S	S	P
1.4.6	P	P	P/S	R			P
1.5.1	P	R	P/S	P			P
1.5.2	P/S	R	P/S	P/S			P/S
1.5.3	P/S	R	P/S	P/S	A	A	P/S
1.5.4	R	P/S	P/S	P/S			P/S
1.5.5	P	P/S	P/S	P/S			R
1.5.6	P	P/S	R	P			P
1.5.7					R	P	
1.5.8					P	R	
1.5.9	R	P	P	P			P
1.5.10	P	R	P	P			P/S
1.6.1	R			P/S	S	S	
1.6.2	R			P/S	S		
1.6.3	R			P/S	S		
1.6.4	R	P	P	P	S	S	
1.7.1	R	P/S	P/S	P/S			P
1.7.2	P	P/S	P	R			P

Figure 2.2.1.9.c. *The MSL re-engineering example responsibility matrix shows who's working on what and in what capacity.*

RESPONSIBILITY MATRIX

TASKS \ PEOPLE	BMK	JSR	JLG	JJI	HAK	RDS	ARD
1.7.3	R	P	P/S	P/S			P
1.7.4	R	P	P	P			P
1.8.1	R	P	P	P	A	A	P
1.8.2	R	P	P/S	P			P
1.8.3	R	P	P/S	P			P
1.8.4	R	P	P/S	P			P
1.8.5	R	P	P	P	P	P	P
1.9.1	P	P	R	P			P
1.9.2	P	P/S	R	P/S	A	A	P
1.9.3	P	P	R	P			P
1.9.4	P	P/S	P/S	R			P
1.10.1	R	P	P	P/S			P
1.10.2	A	P	P	R			P
1.10.3	A	P	P	R			P

Figure 2.2.1.9.c. (cont) *The MSL re-engineering example responsibility matrix shows who's working on what and in what capacity.*

2.2.1.10. PERSONPOWER LOADING CHART

With the personpower loading chart, you identify when project needs could exceed resource availability.

The purpose of the *personpower loading chart* is to identify the number of people working on each of the tasks at any given time during the project.

Once you assign your people to tasks (shown in the *responsibility matrix*), you'll want to know how many workers are needed for each task each day. The *personpower loading chart* combines information from the *gantt chart* and the *responsibility matrix* to determine daily (or any other time unit) personpower requirements for each task. The average personpower requirement is the sum of the daily (or other) requirements divided by the project's length. You'll now have a schedule for your human resources.

When you consider number of people on tasks you won't always have a person full time on a task during the full period of your time unit. For example a person doing a fifteen minute task on a certain day or week is neither full time nor total duration. You can choose to count FTE (full time equivalents) or body count in terms of bodies, calendar-days involved by a person on a task, or person weeks. Note that in body count, when you total bodies across all the tasks during a given time unit you will multiple count people who work on more than one task during that time unit.

Using the outline in Figure 2.2.1.10.a., consider a *personpower loading chart* for any project. For reference, review the completed *personpower loading chart* for the multimedia project in Figure 2.2.1.10.b. This example uses FTE in terms of days of the week. Review also the *personpower loading chart* for the MSL reengineering project in Figure 2.2.1.10.c. This example uses manager-days per week. You can use Figure 2.2.1.10.a. as a form for developing a *personpower loading chart* for any project.

Note that at step 7 (the *personpower loading chart* step) you have people who participate from your *responsibility matrix*, tasks and groupings from your *WBS*, and time periods and start and end dates from your *gantt chart.* In step 7, you'll add person-days (FTE) each week (or another option for loading people).

Follow these guidelines as you complete your *personpower loading chart.*

1) List tasks from *gantt chart* along the y-axis.
2) What is the time unit on *gantt chart*? Fill in the time on the x-axis.
3) What are the task starting and ending times (from *gantt chart*)?
4) How many people are working on each task (from *responsibility matrix*)? Assume each person works uniformly over the duration of the task.
5) Fill in the *personpower loading chart* cells in the matrix.
6) Sum the labor requirements vertically for each time unit to get the total labor requirements. (Note whether your labor requirements are FTE's or body count).

Helpful Hints:
- Decide on unit of analysis—managers, staff, overall.
- For ongoing tasks, allocate weekly or monthly.

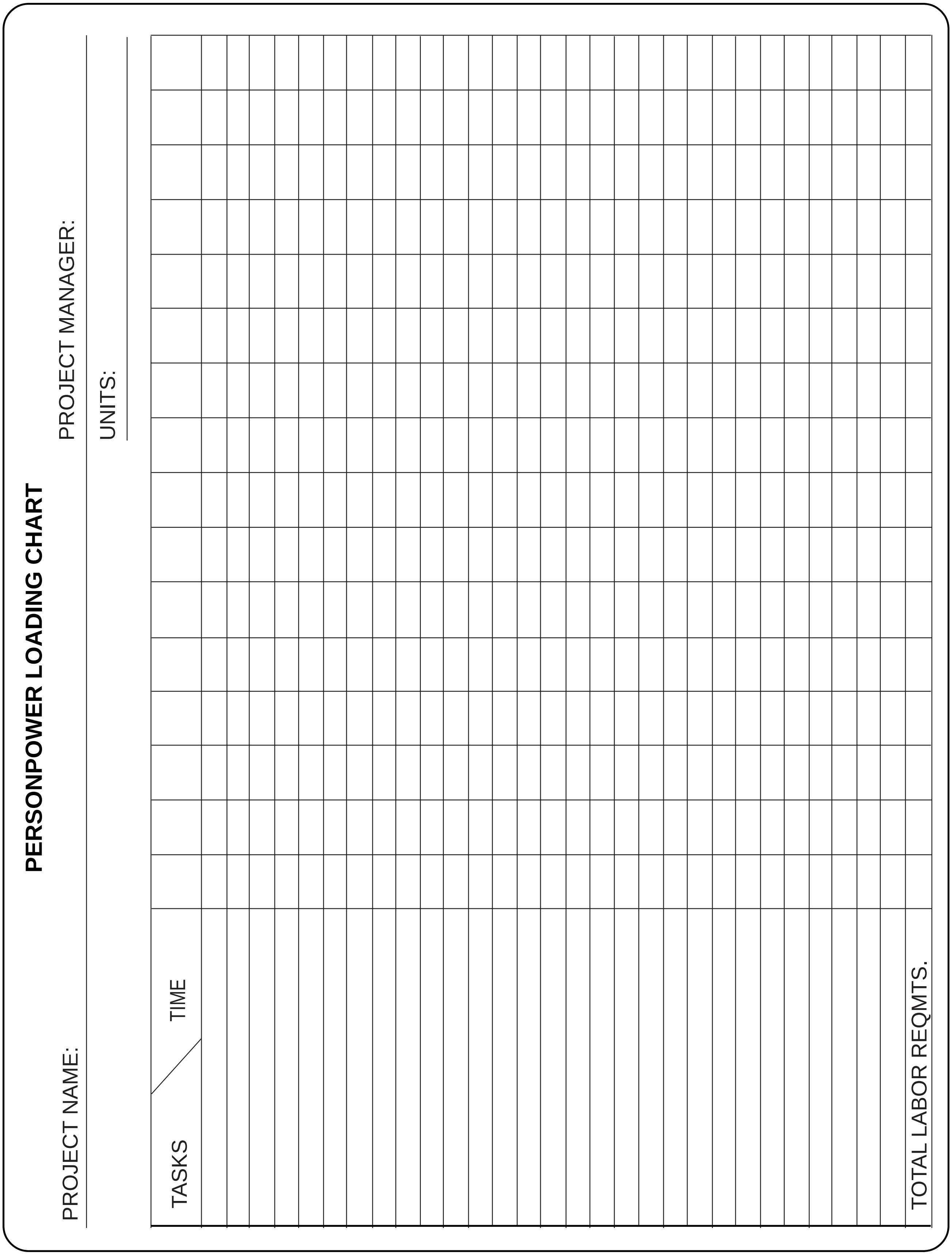

Figure 2.2.1.10.a. *The personpower loading chart identifies human resource requirements by time period (e.g., week) for each task.*

PERSONPOWER LOADING CHART

PROJECT NAME: Multimedia Product for World of Quality, EF 2984

PROJECT MANAGER: Pamela Kurstedt

UNITS: Person-Days

TASKS / TIME	9/4	9/11	9/18	9/25	10/2	10/9	10/16	10/23	10/30	11/6	11/13	11/20	11/27	12/4	12/11	12/18
1.1.1	2															
1.1.2	3															
1.1.3		1														
1.1.4			1	1												
1.2.1			3	3												
1.2.2					3	3										
1.2.2.1				2	2											
1.2.3								3	3	3	3					
1.2.3.1								3	3							
1.2.3.2										3	3					
1.2.3.3							3								3	3
1.2.4						2	2	2								
1.2.5							0.5	0.5	0.5	0.5	0.5	0.5		0.5		
1.3.1									1							
1.3.2												2				
1.3.3														3		
1.3.3.1														2		
1.3.4											3	3				
1.3.4.1														3		
1.4.1												5		5	5	
1.4.1.1												5				
1.4.1.2												1				
1.4.1.3												1				
1.4.1.4															3	
1.4.1.5															3	
1.4.2																5
1.5.1						1										
1.5.2										1						
1.5.3														1		
TOTAL LABOR REQMTS.	5	1	4	6	5	5	5.5	8.5	7.5	7.5	9.5	17.5		14.5	14	8

Figure 2.2.1.10.b. *The multimedia example personpower loading chart shows conflicts for human resources among the tasks at any time.*

PERSONPOWER LOADING CHART

PROJECT: MEL Design and Implementation

PROJECT MANAGER: Kleiner

Time / Tasks	May		June				July					August				September				October					November				December				
	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10	17	24	31
1.1.1	1																																
1.1.2	1	1	1																														
1.1.3			1																														
1.2.1	0.5																																
1.2.2		0.5																															
1.3.1	0.5																																
1.3.2	0.5	0.5																															
1.3.3		0.5	0.5	0.5																													
1.3.4		1	1	1																													
1.3.5					0.25																												
1.3.6					0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5																				
1.4.1			0.5	0.5																													
1.4.2			0.5	0.5																													
1.4.3		0.5	0.5	0.5	0.5																												
1.4.4		0.5	0.5																														
1.4.5		0.5	0.5	0.5																													
1.4.6		0.5	0.5	0.5	0.5	0.5																											
1.5.1					1	1																											
1.5.2						0.5	0.5	0.5																									
1.5.3							1	1	1																								
1.5.4										.25																							
1.5.5	1	1	1																														
1.5.6			1				1					1				1				1					1				1				
1.5.7	1	1	1																														
Subtotal Labor Requirements	5.5	7.5	9.5	4	2.75	2.5	3	2	1.5	0.75	0.5	1.5	0.5	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	1	0	0	0	

Figure 2.2.1.10.c. *The MSL re-engineering example personpower loading chart shows conflicts for human resources among tasks at any time.*

PERSONPOWER LOADING CHART

PROJECT: MEL Design and Implementation PROJECT MANAGER: Kleiner

Time / Tasks	May		June				July					August				September				October					November				December				
	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	3	10	17	24	31
1.5.8	1	1	1																														
1.5.9			1				1					1				1				1					1				1				
1.5.10			0.5																														
1.6.1		0.25	0.25	0.25	0.25	0.25	0.25																										
1.6.2			0.25	0.25	0.25	0.25	0.25	0.25																									
1.6.3									0.25																								
1.6.4										0.25																							
1.7.1											1	1	1																				
1.7.2													0.25																				
1.7.3														2	2	2	2	2	2	2	2												
1.7.4			1				1					1				1				1					1				1				
1.8.1														1	0.25																		
1.8.2														1	0.5	0.5																	
1.8.3															0.5	0.5																	
1.8.4															0.5					0.5					0.5				0.5				
1.8.5																0.5				0.5					0.5				0.5				
1.9.1			0.25	0.25																													
1.9.2					1	1																											
1.9.3							1																										
1.9.4							1	1	1																								
1.10.1		1																															
1.10.2		1																															
1.10.3			1																														
Subtotal	1	3.25	5.25	0.75	1.5	1.5	4.5	1.25	1.25	0.25	1	3	1.25	4	3.75	5.5	2	2	2	5	2	0	0	0	3	0	0	0	3	0	0	0	
Total Labor Requirements	6.5	10.75	14.75	4.75	4.25	4	7.5	3.25	2.75	1	1.5	4.5	1.75	4	3.75	6.5	2	2	2	6	2	0	0	0	4	0	0	0	4	0	0	0	

Figure 2.2.1.10.c. (cont) *The MSL re-engineering example personpower loading chart shows conflicts for human resources among tasks at any time.*

2.2.1.11. PERSONPOWER LOADING HISTOGRAM

With the personpower loading histogram, you can level out your human resources.

The purpose of the *personpower loading histogram* is to identify peak resource requirement periods and level them.

The *personpower loading histogram* is a graphical version of the *personpower loading chart*. Since the data are visually represented, you can easily see peaks and valleys in labor requirements. You should attempt to reschedule tasks from peak time periods to those time periods with little labor demand. This is called leveling.

Represent the average labor requirement (rounding up to nearest whole number) by a dotted line on the histogram. Select those tasks with float time (tasks with flexible starting dates). Then level the labor requirements by rescheduling those tasks during the "valleys." (If you want, redraw the histogram to show this leveling.) You'll now have efficiently allocated your human resources to the individual tasks.

Note that you must remember to revise your *gantt chart* and *milestone log* if you reschedule any tasks.

Using the outline in Figure 2.2.1.11.a., consider a *personpower loading histogram* for any project. For reference, review the completed *personpower loading histogram* for the multimedia project in Figure 2.2.1.11.b. This example uses body count, not FTE, in terms of bodies for the week. Review also the *personpower loading histogram* for the MSL re-engineering project in Figure 2.2.1.11.c. This example uses number of manager-days per week. You can use Figure 2.2.1.11.a. as a form for developing a *personpower loading histogram* for any project.

Note that at step 8 (the *personpower loading histogram* step) you have time periods and start and end dates from your *gantt chart* and total labor requirements from your *personpower loading chart*. In step 8, you'll add a week-by-week allocation of effort.

Follow these guidelines as you complete your *personpower loading histogram*.

1) Fill in time units from *gantt chart* on horizontal axis.
2) What are the *total labor reqmts* for each time unit? Plot them on the *personpower loading histogram*. Use these labor points to draw a histogram of the labor requirements.
3) What are the labor requirements for each task? Plot them on the chart. Draw horizontal lines to show the portion of labor needed for each task and label each section of the graph with its associated task number.
4) What is the average labor requirement? Refer to the *personpower loading chart*. Sum the total labor requirements horizontally and divide by the project length (in time units). Draw a horizontal dotted line on the chart to reflect this and label it accordingly.
5) Which tasks have float time? Reschedule them in time periods having less than average labor requirements.

Helpful Hints:

- Compare project work load to your other activities (non-project).
- Decide whether and when people will be needed to backfill project personnel.

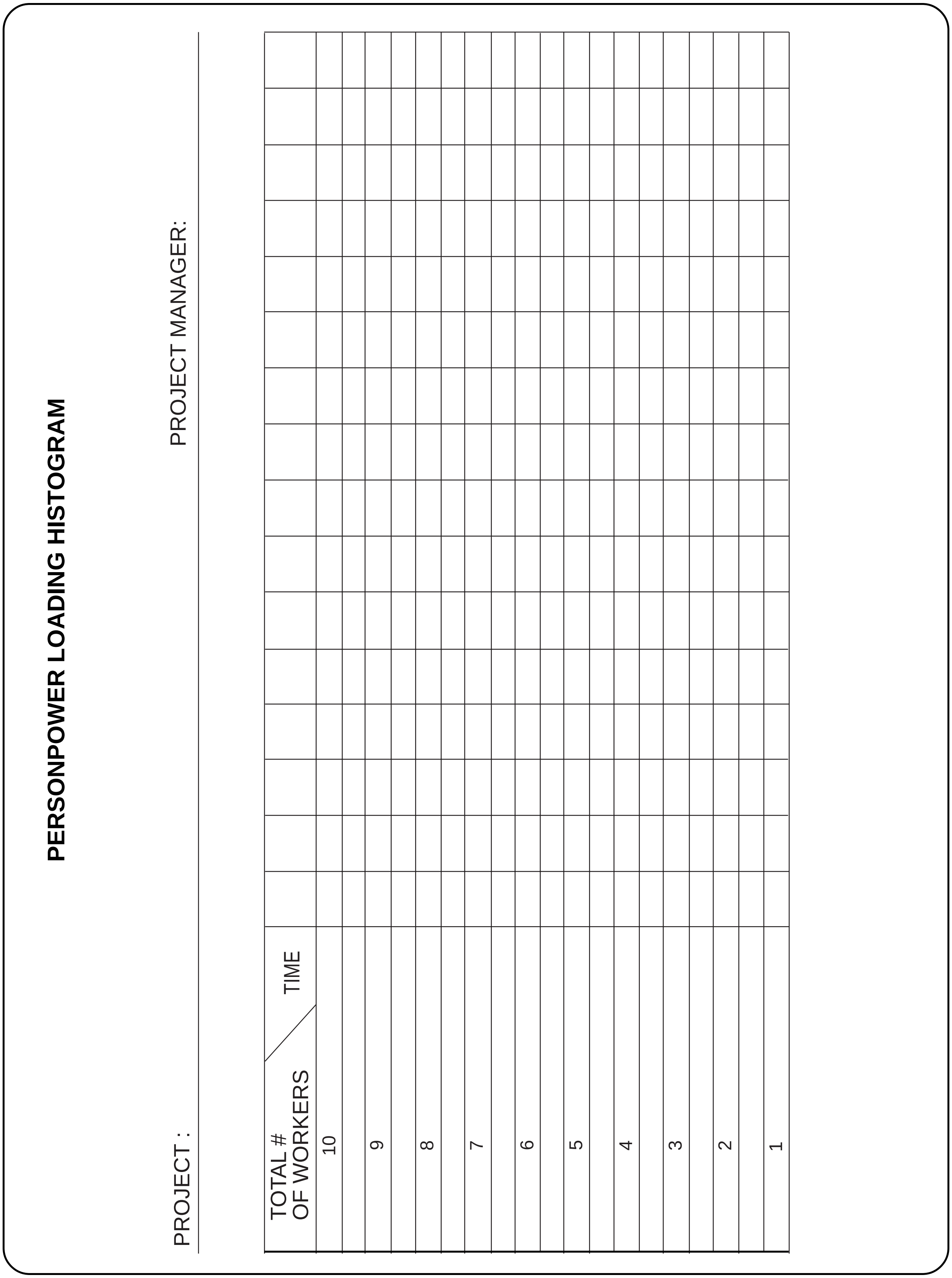

Figure 2.2.1.11.a. *The personpower loading histogram identifies uneveness in distributing human resources to tasks over the project lifetime.*

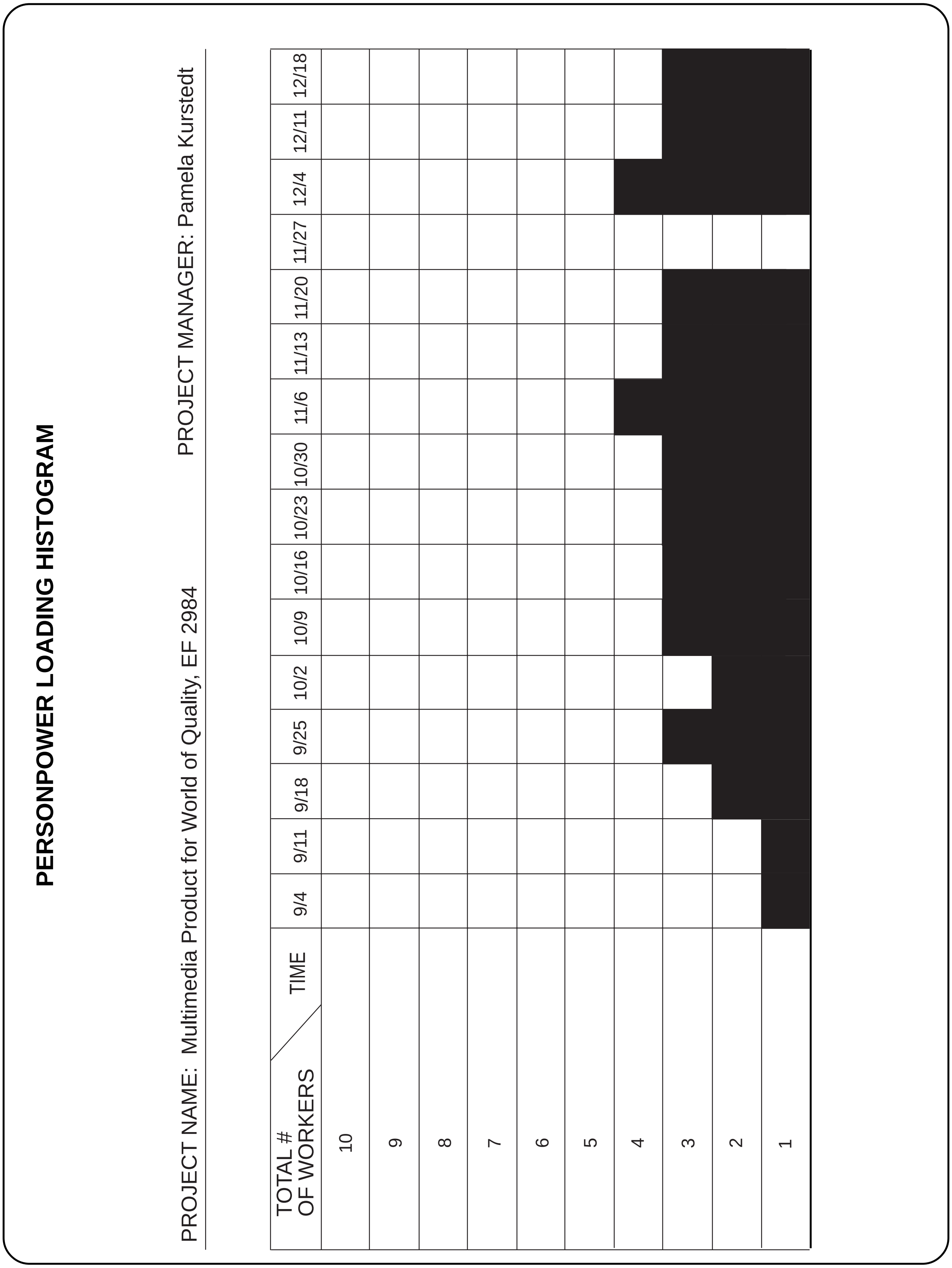

Figure 2.2.1.11.b. *The multimedia example personpower loading histogram shows uneveness in human resource needs and availability during the project (including holidays).*

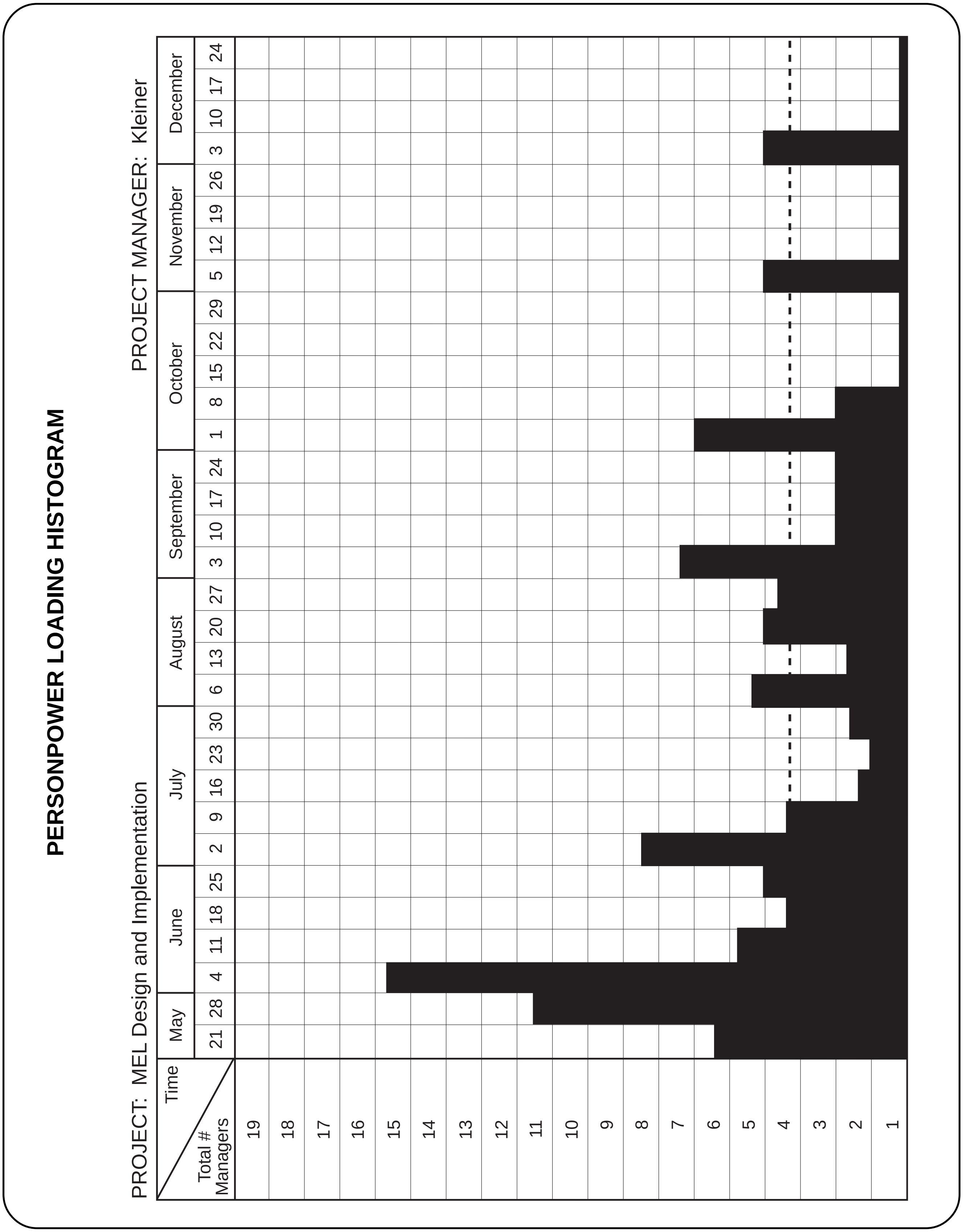

Figure 2.2.1.11.c. *The MSL re-engineering example personpower loading histogram shows uneveness in human resource needs and availability during the project.*

2.2.1.12. EXPENDITURES CHART

You need the expenditures chart to identify the financial resources needed to accomplish the project's tasks.

The purpose of the *expenditures chart* is to describe each expenditure and estimate its dollar cost for each task.

As the project manager, you must develop the project's budget. Success or failure often hinges on whether or not you adhere to your budget. The first budgeting step is to estimate task costs. Include materials costs, labor costs, overhead costs, and any auxiliary expenses in each task estimate. Also, describe each expenditure when completing the *expenditures chart.* Often project managers build some "fat" into their cost estimates by multiplying realistic estimates by a "fudge factor" (doubling estimates is not uncommon). As Murphy's Law states, "Anything that can go wrong will go wrong," so take this into account in your cost estimates.

Using the outline in Figure 2.2.1.12.a., consider an *expenditures chart* for any project. For reference, review the completed *expenditures chart* for the multimedia project in Figure 2.2.1.12.b. and for the MSL re-engineering project in Figure 2.2.1.12.c. You can use Figure 2.2.1.12.a. as a form for developing an *expenditures chart* for any project.

Note that at step 9 (the *expenditures chart* step) you have the total funding from your *scoping agreement* and the tasks and groupings from your *WBS*. In step 9, you add the division of funding by task.

Follow these guidelines as you complete your *expenditures chart*.

1) What are the project tasks from you *gantt chart*? List them (by identifying numbers) in the task column.

2) What must you purchase (what expenses will you incur) for each task? Describe each expenditure under expense description.

3) What is the cost (in dollars) for each task? Record each task's cost under task expenditures.

Helpful Hints:
- Budget conservatively.

EXPENDITURES CHART

Project Name: ______________________________

Project Manager: ______________________________

Task	Mgt. Labor	Staff Labor	Other (descrip.)

Figure 2.2.1.12.a. *The expenditures identify what it costs to accomplish the project's tasks, sometimes categorized by labor type, materials, and so on.*

EXPENDITURES CHART

Project Name: Multimedia Product for World of Quality, EF 2984, 9/1-12/31,1992
Project Manager: Pamela Kurstedt

1.1	Complete equipment set-up	
1.1.1	Investigate and select software	
1.1.2	Identify equipment needed	
1.1.3	Purchase software	75.00
1.1.4	Purchase equipment	3000.00
1.2	Design product content	
1.2.1	Learn new software	270.00
1.2.2	Design outline of multimedia product	2600.00
1.2.2.1	Review literature for quotes and history	
1.2.3	Input of multimedia screens	
1.2.3.1	Input and edit text screens	
1.2.3.2	Input and edit animation screens	
1.2.3.3	Unforeseen problems	
1.2.4	Review available videos on TQM topics	
1.2.5	Request copyright permission if needed	
1.3	Design media components	
1.3.1	Arrange visit to Northern Telecom	
1.3.2	Visit Northern Telecom for examples and interviews	1000.00
1.3.3	Edit video from Northern Telecom	3000.00
1.3.3.1	Identify location of video	
1.3.4	Select stills for multimedia product	
1.3.4.1	Input and edit stills	
1.4	Test and edit phase	
1.4.1	Test multimedia product with students	1000.00
1.4.1.1	Identify test group	
1.4.1.2	Reserve room for test	
1.4.1.3	Invite students	
1.4.1.4	Conduct test	
1.4.1.5	Analyze test comments	
1.4.2	Final edit of multimedia product	300.00
1.5	Coordination of course planning	
1.5.1	Review progress of course material with multimedia	
1.5.2	Review progress of course material with multimedia	
1.5.3	Review progress of course material with multimedia	
TOTAL BUDGET		$11,245.00

Figure 2.2.1.12.b. *The multimedia example expenditures chart shows how much the tasks cost to execute.*

Project Name: MEL Design and Implementation Plan
Project Manager: Kleiner

Task	Mgt. Labor	Staff Labor	Other (descrp.)
1.1 Set Expectations			
1.1.1 Scoping Agreement	$145.00		
1.1.2 Operating principles	435.00		
1.1.3 Operationalize values (behavioral norms)	145.00		
1.2 Roles and Responsibilities			
1.2.1 Decision Making process	72.50		
1.2.2 Position Descriptions	72.50		
1.3 Facilities			
1.3.1 Current Layout/staff assignments	72.50		
1.3.2 Current equipment allocations	145.00		
1.3.3 Determine equipment requirements	217.50		
1.3.4 Create design alternatives	435.00		
1.3.5 Select and approve design	36.25		
1.3.6 Implement new design	652.50		$10,000.00 (software/hardware)
1.4 Selection			
1.4.1 Select project managers	145.00		
1.4.2 Select product managers	145.00		
1.4.3 Pre-training for managers	290.00		1,000.00(materials)
1.4.4 Analyze skill/interest mix from surveys	145.00		
1.4.5 Interview staff	217.00		
1.4.6 Select/assign staff	362.50		
1.5 Business Plan			
1.5.1 Define current project/funding/staff mix	290.00		
1.5.2 Create forecast	217.50		
1.5.3 Identify funding gap	435.00		
1.5.4 Secure overhead funds for gap	36.25		
1.5.5 Marketing Plan	435.00		
1.5.6 Monitor Marketing	1015.00		
1.5.7 Academic Institutionalization Plan	435.00		
1.5.8 Business Institutionalization Plan	435.00		40,000.00(consultant)
1.5.9 Monitor institutionalization	1015.00		
1.5.10. Proposal development process	72.50		
1.6 Test and Evaluation			
1.6.1 Test MSE against TQM	217.50		
1.6.2 Test MSE against research	217.50		
1.6.3 Recommendations regarding viability of MSE	36.25		
1.6.4 Decision regarding MSE	36.25		
1.7 Training			
1.7.1 Design/develop training	435.00		
1.7.2 Develop training schedule	36.25		
1.7.3 Implement training	2320.00		500.00(materials)
1.7.4 Develop mentoring process	1015.00		
1.8 Measurement			
1.8.1 Develop success factors	181.25		
Subtotal	$12614.50		$51500.00

Figure 2.2.1.12.c. *The MSL re-engineering example expenditures chart shows the task expenditures by cost category.*

EXPENDITURES CHART

Task		Mgt. Labor	Staff Labor	Other (descrp.)
1.8.2	Define performance measures	290.00		
1.8.3	Collect “before” data	290.00		
1.8.4	Collect data	290.00		
1.8.5	Review monthly	290.00		
1.9	**Reward and Recognition**			
1.9.1	Analyze compensation levels (managers/staff)	72.50		
1.9.2	Develop compensation/performance plan	290.00		
1.9.3	Implement first phase in July	145.00		
1.9.4	Develop/implement recognition process	435.00		
1.10	**Communication support**			
1.10.1	Develop internal promotional materials	145.00		1000.00(materials)
1.10.2	Develop external promotional materials	145.00		1000.00(materials)
1.10.3	Develop publications process	145.00		
Subtotal (this page)		**2537.50**		**2000.00**
Subtotal (page 1)		**12614.50**		**51500.00**
Total				**$68,652.00**

Figure 2.2.1.12.c. (cont.) *The MSL re-engineering example expenditures chart shows the task expenditures by cost category.*

2.2.1.13. Cumulative Budget

You use the cumulative budget to plan total costs and then monitor how well your project will meet the cost estimate.

The purpose of the *cumulative budget* is to graph the forecasted expenditures over the project's life.

Plotting a *cumulative budget* will help you (as the project manager) visualize project expenditures over the life of the project. A common method of projecting expenses is to graph cumulative expenditures. To do this, add each time period's expenditures to the previous time period's expenditures. Plot these estimates for each time period and connect the points with a solid line to generate a smooth increasing curve. The result will be a curve starting at zero dollars at time zero and ending at the total forecasted budget estimate at the project's conclusion. You can now visualize the project's planned expenditures for any time period. Once the project is underway, you can represent actual budget expenses by a dotted line. Then you can easily see whether or not you're adhering to your planned budget.

Using the outline in Figure 2.2.1.13.a., consider a *cumulative budget* for any project. For reference, review the completed *cumulative budget* for the multimedia project in Figure 2.2.1.13.b. and for the MSL re-engineering project in Figure 2.2.1.13.c. You can use Figure 2.2.1.13.a. as a form for developing a *cumulative budget* for any project.

Note that at step 10 (the *cumulative budget* step) you have division of funding by task from your *expenditures chart* and time periods and start and end dates from your *gantt chart*.

In step 10, you add a week-by-week allocation of funds.

Follow these guidelines as you complete your *cumulative budget*.

1) What is the total forecasted budget? (Sum the task expenditures from the *expenditures chart*). Let the total forecasted budget (in dollars) be the maximum value of the y-axis.

2) What is the smallest expenditure (from *expenditures chart)*? Let the smallest expenditure (in dollars) be the units for the y-axis (Use your judgment for a few expenditures much smaller than most).

3) What is the project's overall length (from *gantt chart*)? Let that time be the length of the x-axis.

4) When is each task expenditure incurred? (Use task starting dates from *gantt chart* for reference points). Plot the *cumulative budget* by adding each time period's task expenditures to the previous time period's task expenditures. Connect points with a smooth curve to complete the graph of the *cumulative budget*.

Helpful Hints:

- Track acutal against budget.
- Use variance to check assumptions for the future.

CUMULATIVE BUDGET

PROJECT :

PROJECT MANAGER:

TOTAL EXPENDITURES / TIME																		

Figure 2.2.1.13.a. *The cumulative budget shows the accumulating costs over time during the project.*

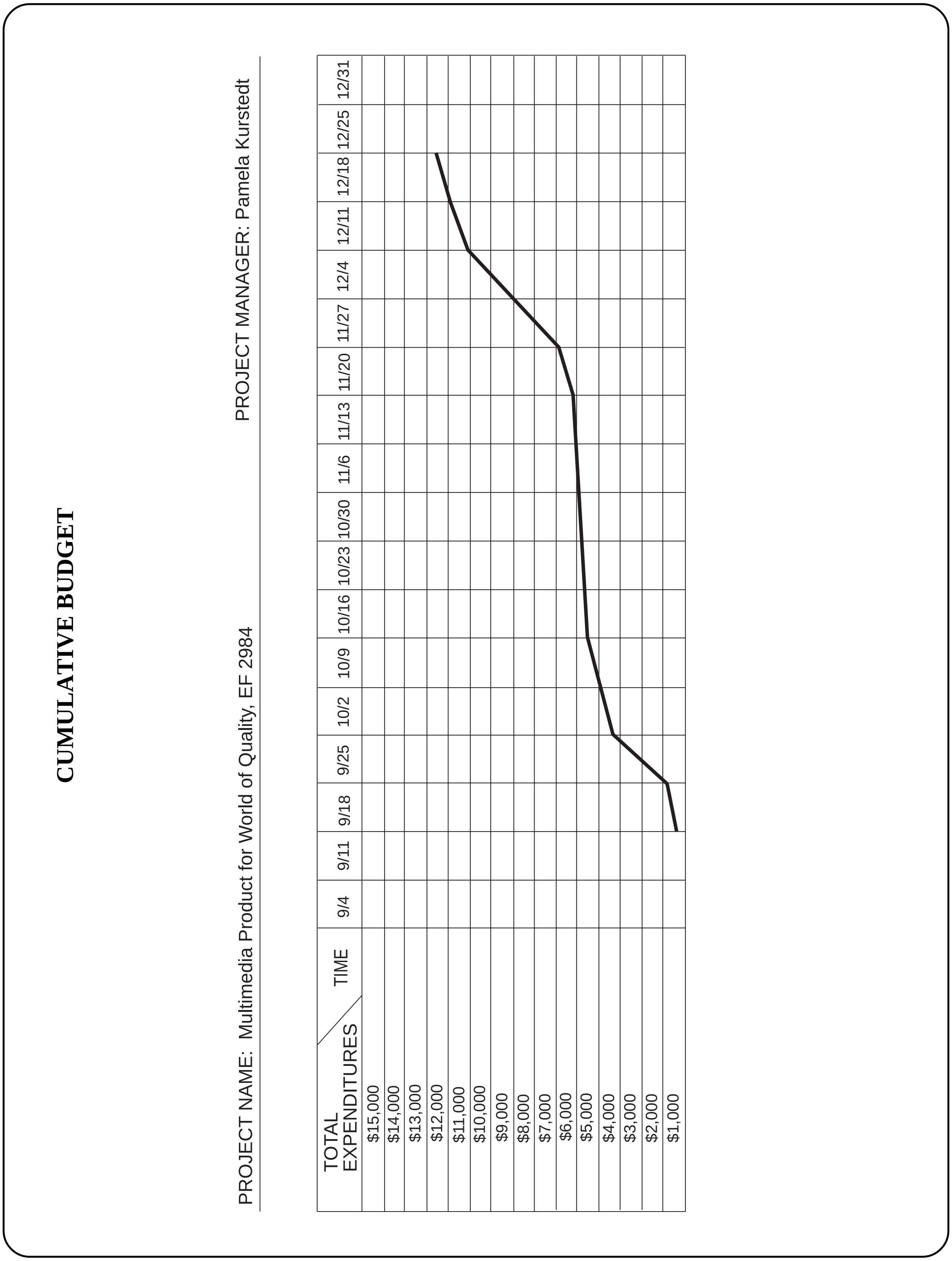

Figure 2.2.1.13.b. *The multimedia example cumulative budget shows the rates and amounts of expenditures over time.*

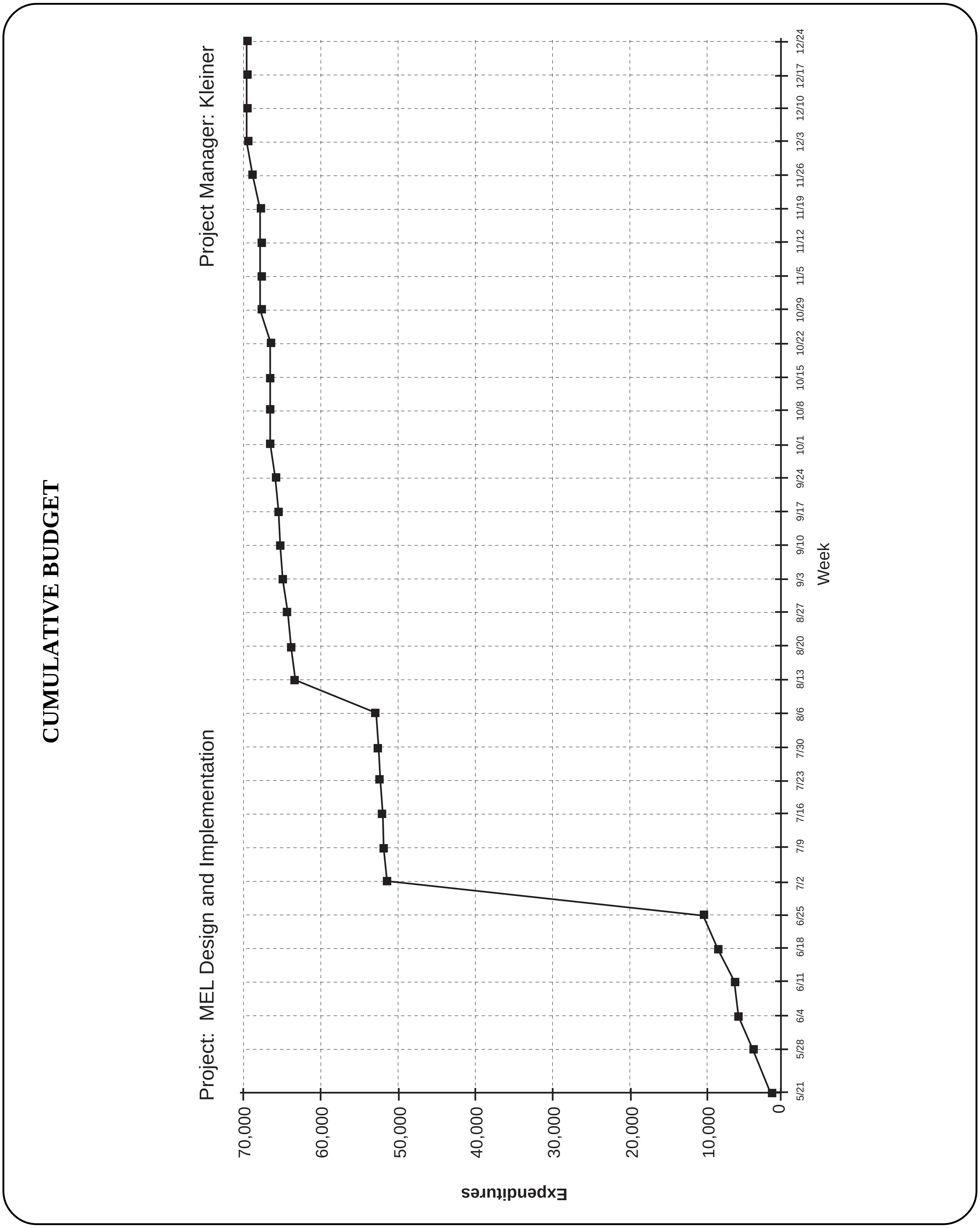

Figure 2.2.1.13.c. *The MSL re-engineering example cumulative budget shows the rates and amounts of expenditures over time.*

2.0. Building Management Tools

2.2. Example Types of Tools

2.2.2. Program Management

2.2.2.1. Goal-Oriented Planning

2.0. Building Management Tools

2.2. Example Types of Tools

2.2.3. Emergency Management

2.2.3.1. Managing Change—Jean-Auguste-Dominique Ingres

2.2.3.2. NEED FOR EMERGENCY MANAGEMENT TOOLS

For their responsibility in managing uncertainty, emergency operations organizations need management tools that stand up to today's heightened scrutiny, increased openness, the resultant great expectations, and demand for accountability during emergency situations.

When an emergency strikes, will the organization be *ready* to protect life, property, and the environment? Will the appropriate response resources be available? Will the right information be available at the right time? Will the hard work of the emergency operations organization (EOO) facilitate the prompt and effective management of this emergency?

An EOO is the foundation of the emergency management structure because it orchestrates the preparedness, response, recovery, and mitigation activities of line organizations, emergency management teams (EMTs), and their own staffs before, during, and after emergency conditions. EOOs are required to ready, coordinate, and sustain sudden shifts from normal operations to emergency conditions.

EOOs face more demands from their constituencies than ever before. Coupled with increased scrutiny is the difficulty of managing sudden changes in roles, responsibilities, and resources inherent in emergencies and exacerbated in potential multiple incidents. In switching between managing routine operations and emergency conditions, EMT personnel must suddenly transform their managing skills and information and resource requirements to meet the fast-paced emergency context. The EOO must possess the skills and tools to successfully make the shift to and facilitate the management of emergency conditions.

EOOs also experience considerable pressure because an unknown *potential* emergency is a perplexity. Perplexities are extreme management pursuits characterized by ill-defined, complex, unique, and unpredictable situations with potentially severe consequences. For a fuller treatment of the term *perplexity*, please see Modules 1.4.5.2.1. and 2.2.3.5. Because perplexities involve uncertainty, they require sudden changes in the amounts, types, and means of delivery of information to support decision making. EOOs manage the amounts, types, and means of delivering information before an incident, so when the incident occurs, managers have the information they need.

The EOO provides the right information to support emergency management teams and line organizations when they participate in any of the four activities: emergency preparedness, response, recovery, and mitigation shown in Figure 2.2.3.2. The figure also shows the relative responsibilities of the EOO, line organizations, and EMT. EOO responsibility is constant and is the foundation for all four activities and thereby supports and provides continuity through all emergency management roles and responsibilities. The line organization performs those emergency activities germane to their operations utilizing the foundation developed, maintained, and coordinated by the EOO. Emergencies occur suddenly as does a lightning bolt (jagged arrows in the figure). The response role of the EMT appears in a flash. The EOO role of readying, coordinating, and sustaining line organizations and the EMT in its response role is subject, before and after-the-fact, to intense external and internal scrutiny. Such scrutiny is important to developing the ability of the EOO to deliver the right information and tools at the right time to the EMT for decision making in preparedness, response, recovery, and mitigation. Balancing external scrutiny with internal scrutiny, as shown in Figure 2.2.3.2., helps managers be responsive to external scrutiny by anticipating (foresight) rather than looking back (hindsight). Because of public scrutiny and sudden shifts into emergency conditions, EOOs need the proper set of tools and guides, so when an emergency happens, their constituencies are confident the best decisions are made based on the best information.

Emergency management tools can be defined by starting with successful management tools, proven in managing routine operations. We can generate new sets of tools based on the principles underlying the successful tools but constrained to suit emergency management responsibilities. A sufficient set of emergency management tools and guides doesn't exist.

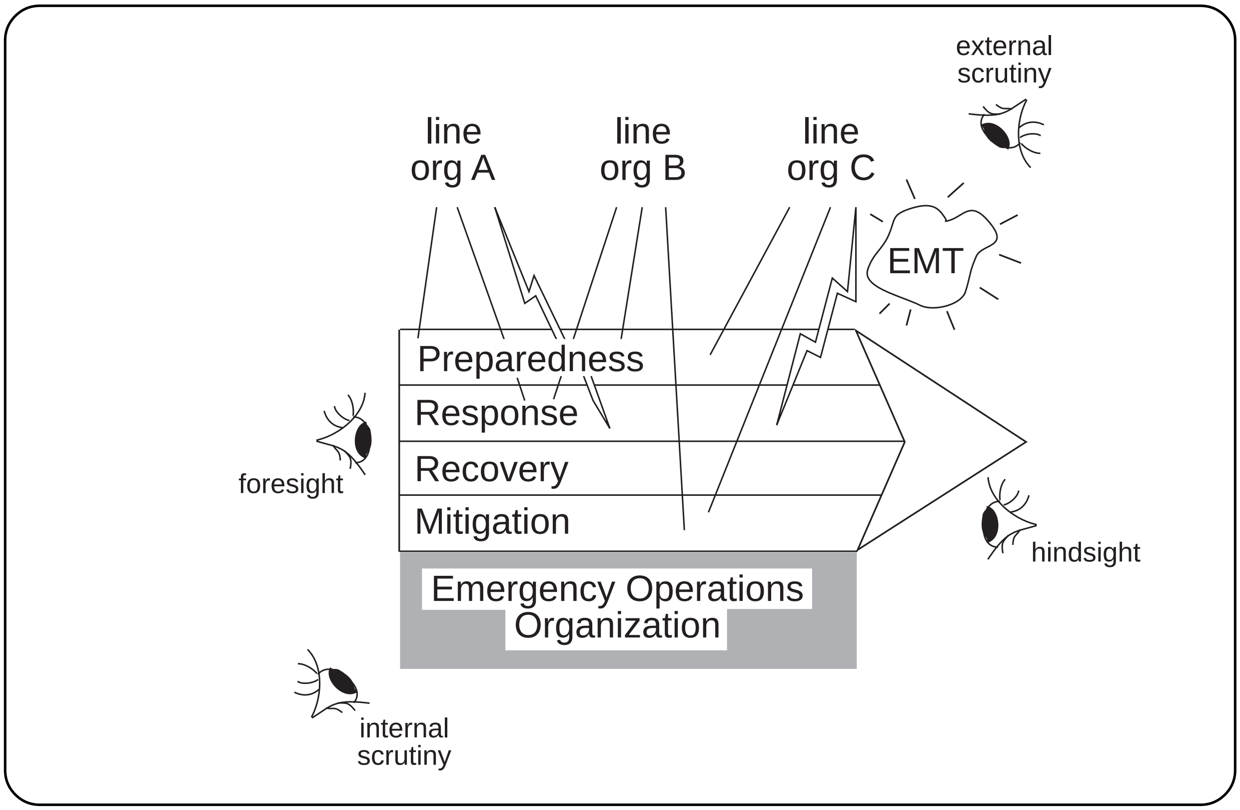

Figure 2.2.3.2. *In the face of scrutiny from all directions, the EOO needs the means for providing information and support as it sustains and coordinates the emergency preparedness, response, recovery, and mitigation activities of all participants.*

2.2.3.3. A New Approach to Tools Aimed at Perplexities

So the EOO can respond to information needs for sudden shifts from routine operations to emergency conditions, we need a new approach to understanding, developing, and using synergistic tools working through effective guides aimed at perplexities. The tools and guides of this new approach must help EOOs consistently get, store, retrieve, see, and communicate information selectively aimed at the appropriate emergency management activity.

We need a new approach to tools aimed at perplexities so we can assist EOOs in their efforts to ready, coordinate, and sustain line organizations and EMTs as, together, they manage emergencies. For the new approach to succeed, it must help EOOs cope better with perplexities and their associated uncertainty and unique information requirements. What is the nature of an emergency from a decision-making and information-requirement perspective? What principles guide the selection and use of the right information? Can we figure out management tools for converting raw data into useful information as well-suited to perplexities as we have for our more routine pursuits?

Throughout the four emergency management activities (preparedness, response, recovery, and mitigation), EOOs have relative continuity in roles, responsibilities, and resource requirements compared to line organizations and EMTs. Line organizations switch from routine operations to any of the emergency management activities when called upon. And EMTs make the most dramatic switch. The switch involves different information and different tools for recording, verifying, storing, arranging, and accessing data to make information by comparing data to different reference points.

By selecting and applying the appropriate tools working together, EOOs can give EMT personnel acting in emergency management roles the information they need when they need it. Management tools and the guides through which they work must function within a synergistic integrated package if they are to work effectively in perplexities. Tools designed for use in routine operations and those tools currently used in emergency management won't necessarily work for emergency conditions *unless we understand the underlying principles* behind the tools' use, and adapt the tools for use in perplexities.

What's more, emergencies require a lot more information than non-emergencies. The closer the ratio (information EMT personnel need/ information they have) is to one, the more effectively they can confront perplexities.

The classical management principle (Tushman & Nadler, "Information Processing as an Integrating Concept in Organizational Design," *Academy of Management Review*, July 1978, pp. 613-624.) for information requirements for organizations facing different degrees of uncertainty is illustrated in Figure 2.2.3.3. and is adapted to highlight the situation encountered by EOOs. Classically, good management in certain conditions means relatively low information requirements and in uncertain conditions means relatively high information requirements. As shown in Figure 2.2.3.3., the problem with an emergency is that the change in information requirements is a large and abrupt step function. The sudden change in information requirements includes the amount of information; timeliness, accuracy, and relevance characteristics of the information; and the resources (equipment and trained people) for delivering the information. The extreme time factor means it's crucial to be ready with the necessary information.

We can help EOOs gain better control of perplexities by helping them to know: 1) what tools work best in perplexities; 2) what guides govern the most effective use of those tools; and 3) how to get, store, retrieve, portray, and communicate the right information. When EOOs manage effectively day-to-day, if an emergency hits, the right tools and information are ready.[1]

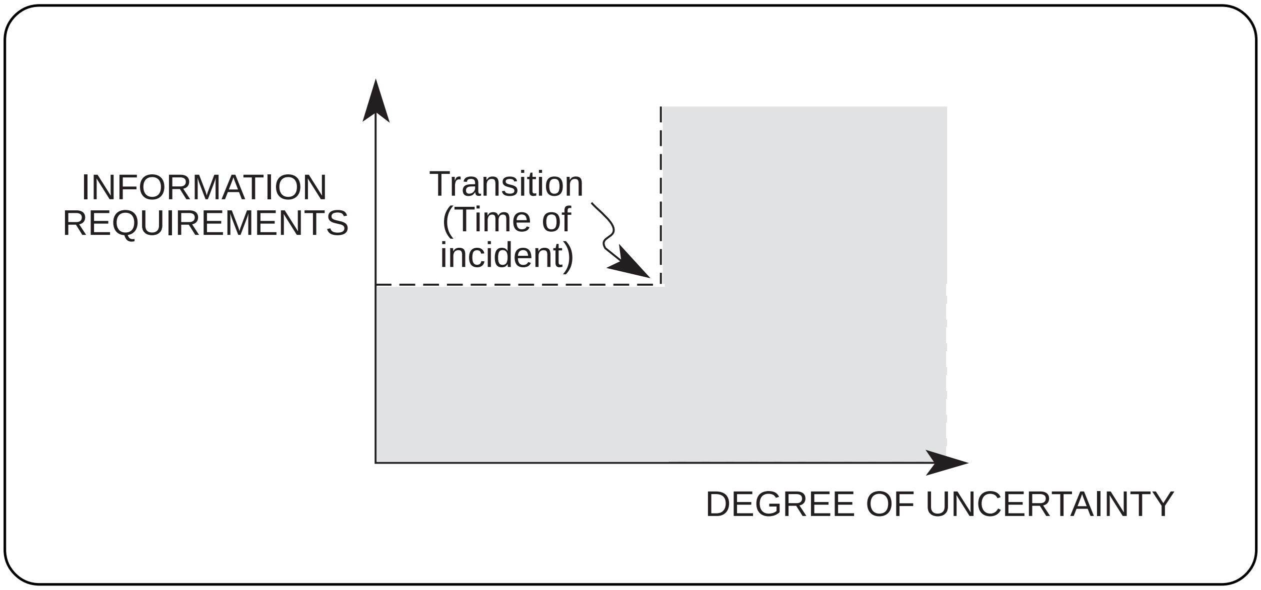

Figure 2.2.3.3. *When uncertainty increases dramatically, so do information requirements for effective management. EOOs need management tools to provide information for EMTs during situations of high uncertainty and sudden shifts to uncertainty.*

[1] The emergency manager is like a stage director who must orchestrate preparedness, response, recovery, and mitigation. Stage directors set the stage, the actors, and support people by producing, coordinating, and directing all props, cues, script, lighting, sound, and rehearsals for a successful production. When the director pulls all the tools and arrangements together with the ability and talents of the actors, their audience and critics respond favorably. We need to know what tools the emergency operations manager needs, how the tools should be used, and why the tools do what they're supposed to do so the audience (the public) and critics (surrogates of the public—the media and legislative bodies) provide superlative reviews. The difference is that the emergency operations manager doesn't know what the play is, where it's being put on, who the actors are, or when curtain time is.

2.2.3.4. THE FOUR ACTIVITIES OF EMERGENCY MANAGEMENT

To effectively address the important issues and information within the context of urgent conditions, EOOs must direct and channel information using tools well-suited to the unique characteristics of emergency activities to assist line organizations and EMTs in their managing of perplexities in real-world settings.

For EOOs, emergency management is more than response. Over all four activities of emergency management, EOOs need to address important issues to help deal with urgent issues. EOOs want to help managers in emergency conditions work smart, not work frenetically. They particularly need tools so they can attend to what's important before it becomes urgent.

In terms of addressing the needs of EOOs, emergency management is much like dealing with a leaky roof. When you have a leaky roof and it's sunny, nobody worries about fixing it. That's because, when it's sunny, people often aren't concerned about preparing for a rainy day. But when the rain comes, it's too late. So it is in emergencies. During normal, non-emergency operations the line organization is concerned with normal activities, but the EOO is concerned with improving the database and other emergency management needs. When an emergency strikes, suddenly circumstances require extensive information. In an emergency, without good programs and adequate planning (foresight), good data may be unavailable, ineffectively integrated, or inadequately portrayed. Although EOOs work very hard, new leaks are constantly developing. An integrated set of emergency management tools will help EOOs address their leaky roof problem.

Figure 2.2.3.4. shows the cyclic and recursive nature of the four activities for emergency preparedness, response, recovery, and mitigation. Figure 2.2.3.4. also shows the integrated set of synergistic tools as being central to feeding the information, decisions, and understanding from one activity into any of the other activities. EOOs want to plan for the important to help mitigate the urgent.

To implement emergency management tools, we must understand: 1) what roles, responsibilities, and resources EOOs need for the four activities of emergency management to ready, coordinate, and sustain sudden shifts from normal operations, including potential multiple incidents; 2) the reason why EOOs require the information they do to meet their responsibilities; 3) the principles behind the selection of an integrated set of tools to provide that information; and 4) why those tools work, by applying the principles of decision making and information support and designing the tools for emergency preparedness, response, recovery, and mitigation. Emergency management tools must:

1) recognize the unique qualities of perplexity management;

2) obtain, integrate, and portray necessary information through an integrated package of tools to support decision making by EOOs facing sudden change from normal operations to emergency conditions;

3) facilitate the coordination and integration of efforts among multiple layers of

emergency responsibility—incident scene, line responsibility, and senior management; and

4) provide a support system to handle the compound effects of multiple emergencies within hierarchical organizations.

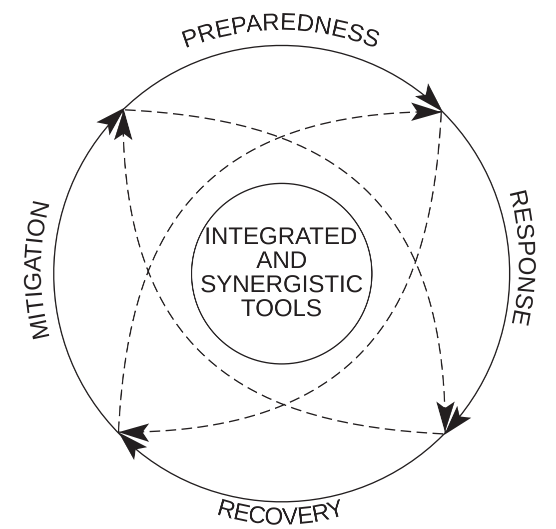

Figure 2.2.3.4. *We need to develop tools well-suited to use in the four activities of emergency management.*

2.2.3.5. Concept of Perplexity Management

EOOs need to address perplexity management to achieve success; that is, they must prepare information sources and delivery systems, the decision environment and the decision makers, and use management tools to achieve high information richness to assist the decision makers in reducing uncertainty by driving ill-defined or emergency conditions toward well-defined or normal operating conditions.

What are perplexities? Perplexities are the most uncertain of all management pursuits. Uncertainty is the ratio of the information we need to the information we have (See Module 1.4.5.2.1.). Emergency preparedness is the classical example of a perplexity. The EOO doesn't know until the event occurs what the emergency conditions might be or what outcome the unknown event might lead to. If problem-solving is knowing: 1) where we are (WWA), 2) where we want to be (WWWTB), and 3) how to get there (HTGT), then the emergency preparedness problem is certainly a perplexity because we don't know WWA, WWWTB, and HTGT. To solve perplexities, we not only need information about where we are going and how to get there, we also need information about where we are at any point in time. We need detective information as well as corrective information.

When the emergency incident occurs we know more: We know WWA. Then we have a management pursuit called a problem, which is more certain than a perplexity. The EOO then has the first information on the type, severity, and scope of the emergency and can bring the tools and information systems to bear as the perplexity unravels. Managing perplexities and problems is what EOOs are all about. Figure 2.2.3.5. shows perplexities and problems as high on an uncertainty spectrum, while routine operations, like R&D programs, projects, and processes, tend to be lower in uncertainty. To achieve success, EOOs must manage information so the amount of quality information needed by decision makers equals the amount of information available. Inequality of information needs and information availability requires EOOs to adjust information needs or the amount of information possessed. EOOs need uniquely designed management tools, high in information richness, to help reduce uncertainty. Richness is defined as the potential information-carrying capacity of data (See Module 1.4.4.2.).

Figure 2.2.3.5. illustrates how we manage uncertainty. In managing emergency preparedness (perplexities) we assume a number of different types of incidents (problems) and plan, gather resources, and exercise for a possible chemical release, terrorist attack, computer crime, radiological release, or other type of incident. We make a perplexity into a series of possible problems. In emergency response (problems), we work to achieve alternate possible qualitative outcomes to a given incident. For the example problem of a chemical release, qualitative outcomes could be: stop the chemical release, contain the chemical release, evacuate away from the chemical release, or clean up the chemical release. We make a problem into the next, more certain, pursuit in Figure 2.2.3.5.

EOOs must address the need for rich information (e.g., complex, on-the-scene, oral communication) and the fact that scrutiny and accountability require simple, structured and emotionless information interpretation (e.g., written status boards and press releases).

So what tools can EOOs provide to support the four characteristic activities in emergency management? How about the management tools we use every day in routine operations? We use Management by Objectives (MBOs) in managing production and Critical Path Method (CPM) in managing projects. (Production, or processes, and projects are the two most certain management pursuits in Figure 2.2.3.5.) MBOs and CPM require knowing what the end of the management pursuit is (WWWTB). So do two other tools we use every day: life-cycle costing and resource loading. In processes and projects we know the end (WWWTB). But perplexities and problems aren't like that. In short, the tools we learn to use for success in the processes and projects of our routine operations will not necessarily work for emergency preparedness, response, recovery, and mitigation. (They will work, however, for a project like building an Emergency Operations Center.) Most tools for process and project management were neither designed nor tested against the unique characteristics of perplexity management.

Two traditional approaches for finding tools that will work for emergency preparedness, response, recovery, and mitigation are: 1) to try tools we use in routine operations (with the potential for failure just discussed) and 2) to develop any tool we perceive to be well-qualified for emergency management. The new approach is to address emergency preparedness, response, recovery, and mitigation by developing a comprehensive, integrated set of synergistic tools, all of which incorporate the information requirements and unique characteristics of perplexity management.

Uncertainty

PERPLEXITY	–	Can specify neither the start nor the end.
PROBLEM	–	Can specify the start but not the end.
PROGRAM	–	Know the start and have qualitative fix for the end.
PROJECT	–	Know the start and have specifications for the end.
PROCESS	–	Repeatedly achieve the same known end.

Figure 2.2.3.5. *EOOs address the uncertain end of the spectrum of management pursuits, whereas the tools we know best are proven in our routine operations at the lower end of the spectrum.*

2.2.3.6. A Support System for Managing Perplexities

Understanding what constraints are unique to perplexity management and systematically applying these constraints to the fundamental principles underlying management tools proven in process and project management is the first step in understanding how to build an Integrated Perplexity Management System.

We manage emergency preparedness, response, recovery, and mitigation by using information media capable of providing high information richness to reduce equivocality (differing interpretations). That is, we want to work down the spectrum to reduce the equivocality in what we manage, and work up the spectrum to increase the capacity of our management tools in providing rich information in uncertain conditions. EOOs want tools for managing uncertain conditions that are at least as effective as those they use for normal operations.

Management tools convert data to information. Decision makers convert information to actions. We often suffer from a data-rich, information-poor situation because we don't understand what information we need for the decisions we make. We end up with not enough good information from credible primary sources.

We can, however, look at tools successful in routine operations, the processes and projects at the lower end of the uncertainty spectrum in Figure 2.2.3.6. and identify five types of management tools effective in converting data to information: 1) relationships and structures; 2) methods; 3) guides and rules; 4) precedents; and 5) the data-to-information chain (Module 1.4.2.6.3.). These management tool types are shown across the top of Figure 2.2.3.6. Examples of the types (together with emergency response examples) are: 1) organizational structure (EMT organization), 2) hazard analysis (e.g., plume model), 3) plans or procedures, 4) social system or culture, and 5) management information system.

The effective tools in *certain* management pursuits (e.g., projects) are those that have been heavily constrained to meet the specific needs of the decision maker. But, the more a management tool is constrained to do a job well in a specific situation, the less useful that tool will be when used for a different situation.

Let's consider a single management tool like a calendar. To make the calendar work well, Manager A heavily constrains his or her calendar to be pocket-sized, to have a page for each month, and to show weekly staff meetings, travel dates, important milestones, and much more. However, this calendar won't work very well for Manager B, who wants a wall calendar showing a year at a glance. We need to remove the constraints of Manager A, generate the general principles of a calendar, and apply the constraints of Manager B.

Starting with management tools that are successful for projects or processes is smart, because managers have invested a large amount of time and effort in developing and understanding these tools. But, similar to the calendar example, we believe tools heavily constrained to work well for projects won't necessarily work well for perplexities. We have to remove the project constraints, identify the general principles, and apply the constraints specific to perplexities.

For the Critical Path Method example discussed in Module 2.2.3.5., the constraint for using CPM in projects is that projects have a defined and known end. By removing the constraint, we discover the basic management principle of focusing management attention on bottlenecks. Now we have to figure out how to constrain managing bottlenecks for perplexities, because emergency managers have bottlenecks too. In effect, we're working from using CPM as a structure tool for projects, up the uncertainty spectrum to perplexities, as shown in Figure 2.2.3.6.

The way to develop an Integrated Perplexity Management System (IPMS) is to start with proven management tools constrained for processes and projects, carefully investigate and strip away the constraints to reveal the basic management principle the tool was conceived to support, and then develop new constraints based on our research into perplexity management. The result will be a new tool reflecting the basic principle constrained to perplexity management.

The key to working tools up the spectrum in Figure 2.2.3.6. is that we can consider a comprehensive synergistic set of tools through the complementary management principles the package represents, and constrain this set to perplexities; thus we will have an IPMS.

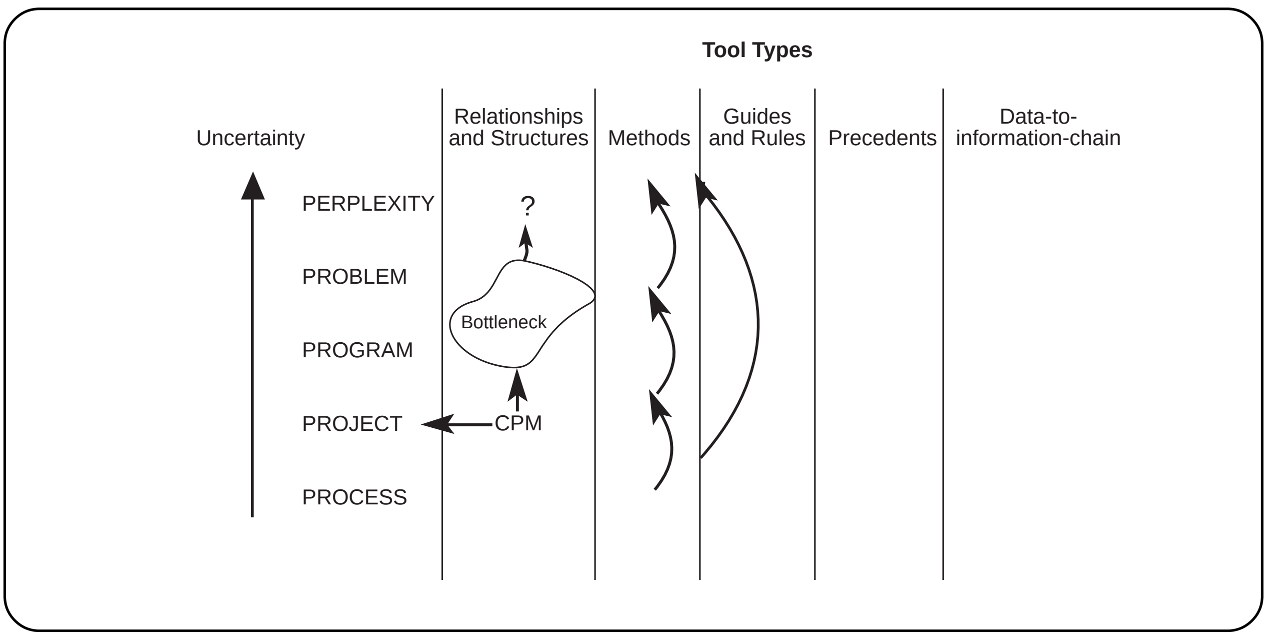

Figure 2.2.3.6. *The IPMS will include an integrated set of tools covering the five tool types and investigated by identifying and using tools we have in normal operations, detecting the basic management principles upon which they are based, and remodeling the perplexity management tool based on the principle and constrained to perplexities.*

2.2.3.7. The Structure behind the IPMS

Tools that make up the IPMS, no matter how effective or efficient, are only as valuable as their ability to reduce the amount of time programmable decisions compete for an emergency response manager's attention.

Behind the IPMS is the realization that for the EMT to be most effective in times of emergency, EOOs must be effective both in times of calm and in times of emergency. EOOs work in process, project, and program pursuits, as well as in perplexity and problem pursuits. The information needed for managing pursuits at one end of the spectrum is different from information needed at the other. When managing at the *certain* end of the spectrum, decisions are called programmable (Herbert A. Simon, "The Executive as Decision Maker," *The New Science of Management Decision*, Harper and Brothers, 1960, pp. 1-8.) and are best made on clear, structured, logical, and verified information. At the uncertain end of the spectrum, non-programmable decisions (Simon, 1960) are made based on experience, judgment, and intuition. The information supporting these bases is ambiguous, changing, and incomplete. EOOs must manage information for both programmable and non-programmable decisions in all activities to affect the mix of programmable and non-programmable decisions during response.

The difficulty of managing the mix of programmable and non-programmable decisions in emergency preparedness, response, recovery, and mitigation activities is most acute during response because of the relative urgency of tasks. By managing the mix during other activities and linking the programmable decisions and information through the activities, EOOs manage the mix in response.

To support these differences in decision making and different information requirements during response, the IPMS must have a two-pronged approach: 1) make the clear, structured, logical, and verified information as crisp, focused, and accessible as possible, 2) make best use of the increased time for non-programmable decisions by improving and supporting the access, storage, retrieval, integration, and portrayal of information for decisions that count the most and are scrutinized so closely.

Figure 2.2.3.7. illustrates the objective of the IPMS. Because of the high uncertainty and importance of external information during the response activity, EMT personnel *need to spend* most of their time concentrating on the non-programmable decisions (part (a) of Figure 2.2.3.7.) and to have the right information to support non-programmable decisions. But, often EMT personnel don't have enough time. Because of ineffective and inefficient information concepts and tools supporting programmable decisions, EMT personnel often spend too much time on programmable decisions (as shown in part (b) of Figure 2.2.3.7.). One crucial problem is that the size of the pies in parts (a), (b), and (c) of Figure 2.2.3.7 is fixed. We aren't going to generate more time for EMT personnel, we can only help them with the time they have. Part (c) of Figure 2.2.3.7. shows if we can reduce the time demanded by programmable decisions even a small amount, the increase in time available for crucial non-programmable decisions can be increased several-fold.

In developing emergency management tools, we need to know how we can slice the pie better and how we can make best use of the pie we have. We must learn the environments and support for programmable decisions before, during, and after an emergency condition. We need to find and address the processes and projects in emergency management, especially in mitigation and recovery, so EMT personnel can concentrate on the problems in emergency management.

Barnard (1938) and later Simon (1987) found that in decision-demanding situations (uncertain end of spectrum) we use intuitive and judgmental responses for: 1) bringing the right decision makers together in the right environment supported by the best available information and 2) using planning and information tools before, during, and after the emergency condition to reduce the distractions and equivocality posed by the myriad small-but-necessary issues on the decision maker's attention. In short, EMT personnel must sort out the urgent from the important.

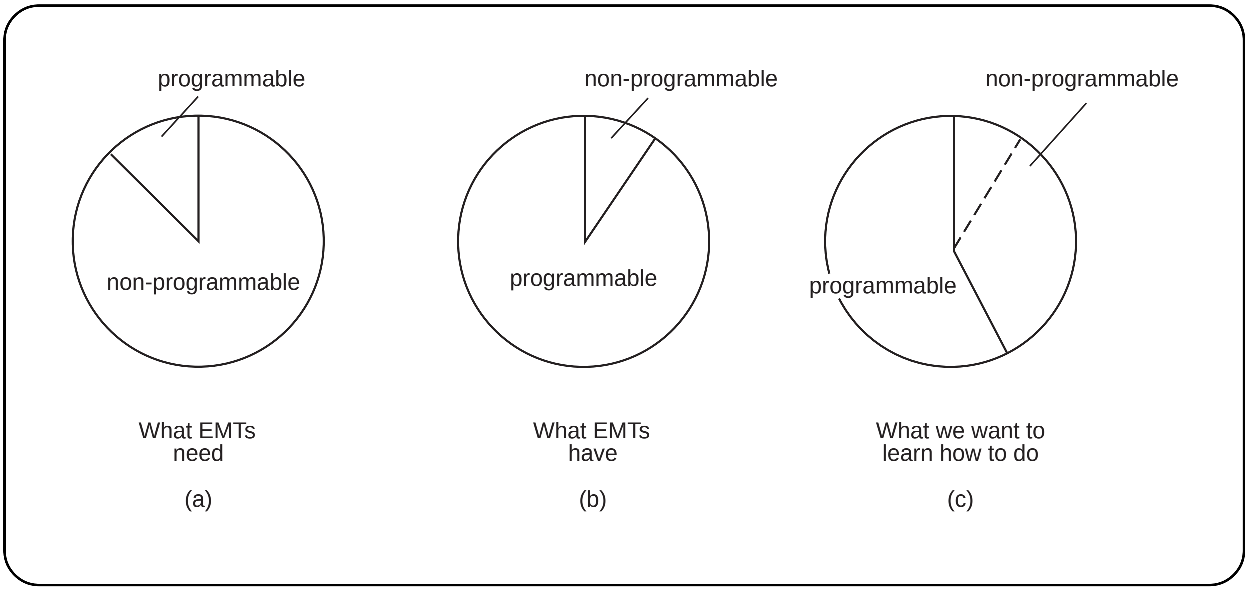

Figure 2.2.3.7. *During emergency response, EMTs need as much time as possible for dealing with non-programmable decisions, but they have so many urgent programmable decisions the important non-programmable decisions get squeezed out of the time available. We want to learn how to increase time for non-programmable decisions showing the huge leverage of good tools for programmable decisions.*

2.2.3.8. THE EOO'S ROLE AS INTEGRATOR

The role of the integrator is one of the most difficult, important, and ill-defined roles in perplexity management because of the variety of activities and the diversity of information needing coordination at many levels of the organizational complex.

EOOs provide continuity throughout the four emergency management activities of preparedness, response, recovery, and mitigation. The EOO is the one organization involved in all emergency activities and functions and in all types of incidents. It's responsible for maintaining continuity from one activity to another when needed. The EOO also ensures that lessons learned from one type of emergency are evaluated and, where appropriate, are incorporated into the management tools for entirely different types of emergencies. In short, the EOO facilitates the management of emergencies.

The most demanding part of the EOO's responsibility is to balance the leaky roof problem mentioned in Module 2.2.3.4. That is, the EOO enters into a maintenance role when the management tools are in place. This role instantly changes when an incident occurs from that of routine maintenance and operations to full organizational and resource support. Maintaining the balance between the maintenance and development role and the full-on role required by an incident highlights the EOOs role as integrator.

We've shown the emergency management activities to be interdependent (Figure 2.2.3.4.). The EOO has the ultimate responsibility for integrating the interdependent activities while meeting the sharply changing information requirements of line organizations and EMTs. As indicated in Module 2.2.3.3., the emergency manager is like a stage director who sets the stage, the actors, and support people by producing, coordinating, and directing all props, cues, script, lighting, sound, and rehearsals for a successful production.

The EOO needs much more than management tools aimed at a specific need in one activity or one incident type; it needs an integrated package of tools able to carry over from one activity or incident to another and to selectively fit whatever situation arises. This selectivity, synergy, and focus demands a comprehensively thought-out, tested, and generalized set of management tools.

EOOs have two information tasks that, during emergency response, compete for the same time and resources. One information task is to reduce equivocality so the organization shares a common view of events and alternatives. We call this task external interpretation (Weick, 1979). The other task is to process enough information to coordinate the organization's activities and manage performance. We call this task internal coordination (Galbraith, 1973). EOOs in the role of integrator provide media high in information richness to reduce equivocality and large amounts of information to handle interdependence in the organization. Effective integration and portrayal of information facilitates both external interpretation and internal coordination.

Multiple emergencies bring a special problem in that we must be able to balance separating rapidly-changing information about more than one event to partition and focus resources with combining the information to reduce redundancy and make most effective use of the resources we have—including the time and energy of the EMT.

The integrator role underscores the importance of getting, storing, and portraying just the right information for a given situation in any emergency management activity and any incident. EOOs must maintain data integrity throughout an organizationally and geographically disparate group of managers and to reduce conflicting information, decisions, and actions.

Figure 2.2.3.8. shows the inter-relationship of all four emergency management activities. In Figure 2.2.3.8. the EOO is responsible for increasing the time available to EMTs for non-programmable decisions in emergency management activities. The EOO does this by effectively integrating and portraying information from tools. Thus, the EOO supports EMTs well despite the increased demands upon it (e.g., requirements for more openness, and strict compliance).

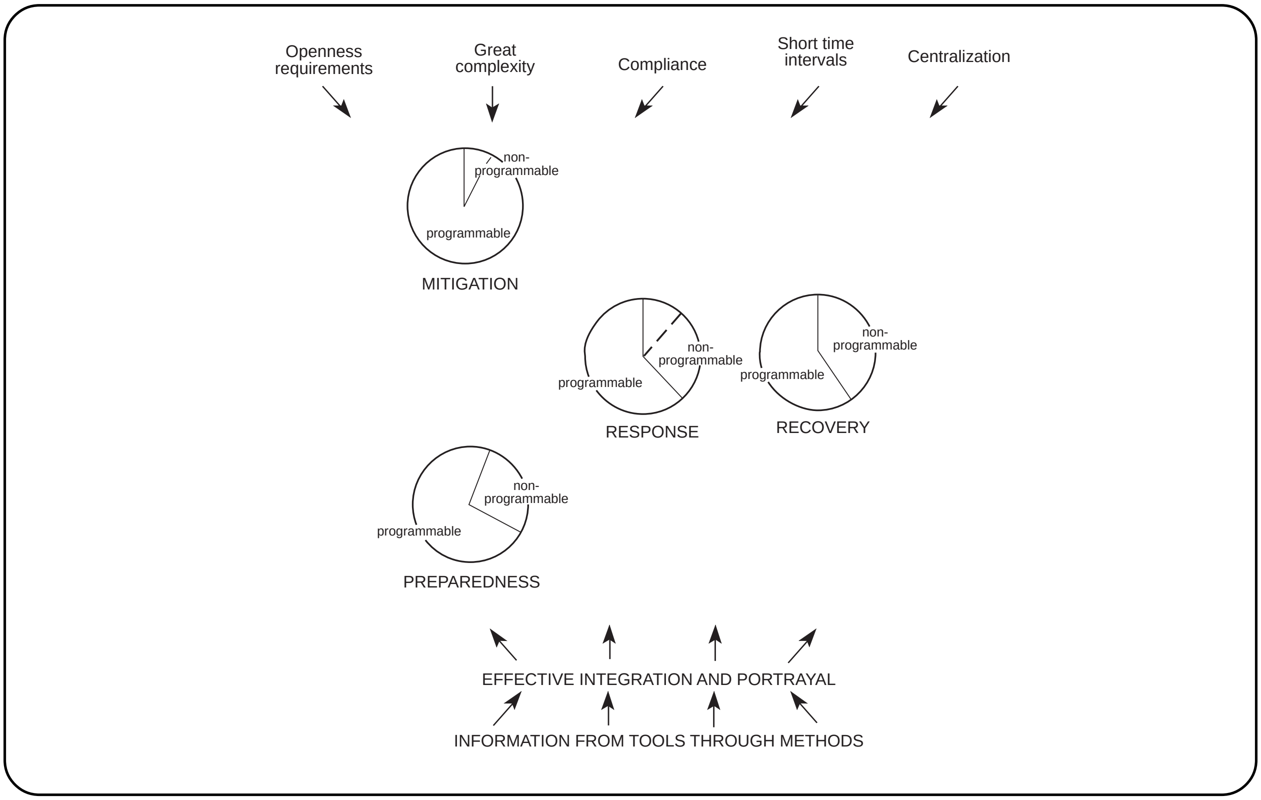

Figure 2.2.3.8. *By making best use of time for programmable decisions during all four emergency management activities, EOOs can make significant improvements in the time EMTs have available.*

2.2.3.9. CRISES AMIDST PROJECT MANAGEMENT

When dealing with crises related to a project, the project manager must have available and be able to use emergency management tools, which are somewhat different from the project management tools he or she is familiar with.

This module is adapted from Kurstedt, H. A., Jr., G. R. Patzak, L. A. Mallak, and E. M. Howard, "Crises Amidst Project Management: Strategies for Managing Better," *Proceedings of the 11th INTERNET World Congress on Project Management*, June 1992, Vol. 2, pp. 35-45.

Project managers can't always foresee every contingency when planning and managing their projects. Many spurious events affecting project milestones and resource allocations can surface once the project is underway. Experienced project managers find crises, miscommunications, mistakes, oversights, and disasters must be managed as part of successful project management. Project managers need effective tools for managing crises. These are tools project managers may not use everyday, yet they need these tools to serve them in time of an emergency.

The scope of application for emergency management tools will vary based on the size of the project. The tools can be quite elaborate, such as volumes for a risk analysis or reserved space for an Emergency Operations Center (EOC) with many dedicated phone lines. The tools can also be quite simple, such as a 1-2 page list of risks in priority order or a designated office or conference room (to function as a mini-EOC) with the ability to bring in portable phones. All the tools should be used, even if just in simple form. In a small project, using one hour of a staff meeting to assign roles in the event of a crisis may suffice for more elaborate means (i.e., formal EOC) in a larger project. The elaborateness of tools should be balanced with the cost and time required for preparation.

Projects have characteristics that make the design and preparation of elaborate tools difficult. First, many projects lack the permanence of a large plant, mine, or government installation. Second, emergencies in smaller projects tend to be more constrained to the site, while larger projects must deal with emergencies of greater scope and impact, such as chemical and radiological releases. Third, in a plant, a large number of people are affected by an emergency—especially the public as opposed to the workers. When the public or a large number of workers are involved, the organization's confidence in safe operations has a heavy influence, and this begets elaborateness. A simple tool can afford us most of the protection we need (for example, 70% of maximum), while a more elaborate tool will buy us more confidence and protection (perhaps up to 99% of maximum). The more elaborate tool is worth the investment when confidence is at stake.

I've chosen five types of tools used primarily in emergency management to help project managers manage their crises better. I'll describe and show how to apply: 1) risk analysis and vulnerability assessment, 2) logic charts, 3) tabletop exercises, 4) notification, and 5) crisis organization and communication.

Risk Analysis and Vulnerability Assessment
The primary tool for mitigation is risk analysis. Risk analysis helps us find out: 1) what can go wrong, 2) what's most probable, and 3) what has the greatest impact. The combination of an event's probability of occurrence

and severity of consequences (e.g., catastrophic failure) determines priorities. Incident analysis can also help us understand the lessons learned in an actual crisis and develop plans to mitigate the effects of similar incidents in the future.

One key strategy for managing better is to properly prepare for crises in projects and take steps to reduce the occurrences of crises. Engineering analyses support this process of risk analysis and make up the quantitative portion of mitigation. Cause-and-effect analyses make up the qualitative portion of mitigation and help us assess the systematic effects both forward and backward.

In emergency management, we use risk analysis to find out the risks beforehand. My use of risk analysis should be differentiated from a probabilistic risk analysis. Establishing the consequences of accidents or incidents by deterministic or risk analysis provides effective tools in emergency management. In project management, we concentrate on planning and sequencing activities to maximize our efficiencies and effectively schedule resources.

Project managers need to sit down and ask "What can go wrong with my project?" Once identified, the project manager has a list of risks associated with a particular project—the output of a risk analysis. Then they should ask, "Which of these risks are most likely to happen?" and "Which of these will have the greatest impact?" "On what or whom?" This last question implies the vulnerability of the organization to the identified risks. Project managers should develop plans which use the data from a risk analysis to prepare them and their organizations for the broadest range of emergencies. Risk analyses support planning by helping project managers pick the most probable and most severe events combined with a vulnerability assessment to see who or what is vulnerable and what will be affected. Therefore, when the crisis happens, the project manager has thought about the crisis and what can be affected. Plans incorporating this thinking help the project manager be ready when the crisis occurs and do what is necessary to fix it. If a manager is responsible for a project, he or she should require someone to conduct a risk analysis. The risk analysis improves early recognition of warning signs; the vulnerability assessment helps identify whom to notify and how to start support to them early.

Logic Charts

Logic charts employ project flow logic to show the project flow with all dependencies in an extremely flexible, time-scale independent diagram. Logic charts are a form of expert system because they embody the decision making knowledge of the expert in a system that can be followed procedurally. Project flow logic is the basis for any personal computer-assisted project management tool. Project managers are skilled at charting. But, in times of crisis, the charts used are different.

When a crisis occurs, people need procedures to follow. Logic charts form the basis for writing these procedures. In project management, the most commonly used charts are Gantt charts for looking at activities against time and networks for looking at precedence. Emergency logic charts depend heavily on logic because of branching due to chained contingencies (e.g., "if event X and event Y happened, then event Z is likely").

Logic charts force project managers to think through the critical decisions necessary in a crisis. Project managers won't have time to go through the logic chart when the actual emergency occurs—we're counting on the project manager learning from the preparation and thinking required to construct a logic chart and feeding this into or reinforcing it through a tabletop exercise (described later). When the crisis occurs, the project manager isn't thinking as clearly as usual, and the more that's been done before the crisis occurs, the better action the project manager can take.

Tabletop Exercises

Tabletops and other exercises use the information from the risk analysis in the mitigation phase to simulate the decision making and action taking occurring in an actual crisis. A tabletop is where we bring a group of people together and they act out the roles for a given scenario. These same techniques can help project managers prepare for possible crises that may occur in their projects.

The events or crises occurring to project managers won't be the things we're tracking. It's what we don't track that will go wrong. The need for tracking illustrates the use of a structured management process to catch the small problems through a thorough, systematic, and frequent review of relevant indicators (Kurstedt, Mallak, & Pacifici, 1992).

Tabletops are generally used in the beginning and focus on managerial information flows—who we talk to, what we do, who needs what information, etc. Issues surface in tabletops. Tabletops are a training device used to elicit understanding by carefully guiding the participants through a simulated emergency requiring a response. Although tabletops are typically less expensive to conduct than drills or field exercises, they cannot substitute for the simulation of actual emergency events available through drills and exercises.

I recommend conducting tabletop exercises every quarter to keep the emergency plans, procedures, and necessary thinking fresh in project managers' minds. Thinking through the decisions beforehand in an evaluative session such as a tabletop pays off when the real crisis occurs.

Tabletop exercises force managers to think through the decisions made during a crisis in advance, thereby reducing the need for decision making during the crisis and reducing the time needed to make those decisions. "A tabletop is accomplished in controlled phases to allow discrete, individual answers, which focuses group attention on each point and thereby promotes a common understanding of roles and responsibilities and the entire response sequence by all participants" (Walker & Middleman, 1988). The tabletop exercise is a versatile tool that can be applied to all phases of project management. The overarching benefit of tabletops is they require response system elements to pay attention both during development and as the system evolves (Walker & Middleman, 1988).

Notification

Emergency managers often have elaborate plans for notification in the event of an emergency. They've thought out and provided for consensus decisions on who to notify and in what order. Project managers, once they have completed a risk analysis and identified the types of crises that may occur, should convene a group of representatives from the affected parties (e.g., neighborhood, city council, media, police, fire, medical, rescue squad) to come to a consensus on who should be notified and in what order they should be notified. The political consequences of calling in the wrong sequence can be severe and each party should know and agree on its standing in the notification.

Crisis Organization and Communication

Crisis organization and communication concerns internal communication about the crisis while the crisis is occurring. Communications to and from the field must be reliable and quick. The technologies chosen for communication must be robust to crisis conditions and must have enough range to cover the distance between the emergency operations office and the furthest point in the field from which we'd expect to receive communications.

An emergency operations center (EOC) coordinates and organizes communications and information to and from the field. Each person has a telephone, often with direct access to key response units. For example, the medical person may have a direct line to the hospital and the technical person's telephone may be linked to the laboratory.

A single status board gives everybody the same information at the same time at the same place. This reduces equivocality and improves quality of response. The EOC houses backup information, such as slides of the facility. The EOC gives managers rapid access to many different types of information, based on the expert models, to support real-time decision making throughout the course of a complex project.

When the crisis occurs, those who respond must know their roles and responsibilities and learn where to go to exercise them. The responsible people are pre-identified as an emergency management team (EMT) and they gather in the EOC to respond in ways they've learned and exercised before.

An effective crisis communication system design will take into account: 1) who must talk to whom, 2) how they should communicate, 3) what the requirements are for speed of communication, 4) how potential crises might interfere, 5) the distances we want covered by such a system, and 6) what to do in the event of system failure (e.g., backup systems, battery power). Consideration of these issues beforehand will increase the likelihood of communication needs being met during the crisis.

A crisis communication system is only as strong as its weakest link. If part of the communication system involves hand-carried messages, then electronic sophistication will only help us marginally. We should plan ahead to ensure the communication system meets our needs. We should test the communication system frequently to ensure it works properly.

A related type of communication, risk communication with the public, plays a significant role in managing the risks and perceived risks associated with a project. Effective risk communication to the public is critical. The public must feel they have some influence over managing or controlling the risk conditions. The public must have the feeling that they've supplied input considered by project managers in their risk analyses. The public must be invited and empowered to participate in decisions that affect them. During a crisis, the project manager must put good information in the public's hands immediately (a public information task). For large projects, the project manager or spokesperson should have a place (not the EOC) to meet with the media and other public stakeholders.

2.2.3.10. Strategies for Project Managers to Manage Crises Better

To manage crises better, the project manager needs to adapt emergency management tools and practices for his or her use and fit those tools and practices to the characteristics of his or her project.

This module is adapted from Kurstedt, H. A., Jr., G. R. Patzak, L. A. Mallak, and E. M. Howard, "Crises Amidst Project Management: Strategies for Managing Better," *Proceedings of the 11th INTERNET World Congress on Project Management*, June 1992, Vol. 2, pp. 35-45.

While I don't have a closed set of comprehensive strategies to offer other project managers to manage crises better, I do have several recommendations I can offer based on my experience in emergency management. Considering the uncertainty involved in crisis management, I would be wary of any closed set of strategies. Crisis management, by definition, is perplexing, constantly changing, full of uncertainties, and challenging to any manager, especially the project manager. There is no simple solution to the complex problems posed by crises. Here are my recommendations.

1. Even for small projects, assign the job of developing at least a two-page risk analysis and vulnerability assessment before the project begins.

2. Assign somebody the job of producing a notification sequence.

3. Use logic charts to design procedures that won't go awry during a crisis.

4. Use tabletop exercises because few people will look at a logic chart or even a procedure when a crisis occurs. Project managers will depend on what they've practiced, and this underscores the need and value of tabletops.

5. Decide on a gathering place for decision makers to congregate in the event of a crisis. Backup gathering places should be arranged in case the primary gathering place is involved in the crisis. Gathering sites should have information and communication systems ready for immediate use.

6. Establish authority for crisis management before the crisis. The project manager isn't always the best emergency manager, so choose a person who has greatest knowledge of the operational issues associated with the crisis.

7. Establish an emergency operations center (EOC) and an emergency management team (EMT). The EOC should coordinate the communications to and from the field and provide information on key indicators of the crisis. The EMT mobilizes at the crisis onset to provide specialized personnel and resources for effective response and to minimize the consequences of the crisis.

8. Follow the steps used by emergency managers to progress from risk analysis to emergency management: risk analysis, problem identification, scenario development, response training, and emergency operations.

9. Design effective, accurate, and timely feed-

back systems to provide early warning signs of failure and impending crises. A structured management process mentioned earlier can help in focusing attention on regular tracking of relevant and critical indicators to surface the little problems before they become big ones.

10. Be mindful of the social and political consequences of crises or events. Critics, or stakeholders, bear significant influence on project success regardless what the indicators of cost, schedule, and quality show. Learn how to satisfy stakeholders (cf. Mallak, Patzak, & Kurstedt, 1991). Identify one spokesperson as a liaison with the public and prepare a procedure for quick dissemination of information to all affected parties.

11. Become sensitive to indicators of impending project failure. Pay special attention to untracked indicators because these are the most likely to go wrong. Develop antennae and know when the project is going wrong.

12. Adopt a systems view and separate the crisis from the origin of the crisis. Consider the basic good performance principles now popularized as total quality management. Look forward and backward to assess the potential overall effects of the crisis.

13. Choose a project manager indigenous to the country where the project is being conducted. An indigenous project manager will be sensitive to the social and political aspects of the project and its peripheral issues and will catch more problems while they're small or otherwise undetectable to the outsider.

A valuable contribution of a professional society or association (at the committee level) would be to organize a team to design generic tools with directions for customizing each tool to a specific project manager's needs. I believe such a committee would be the appropriate group for effective tool design because they wouldn't have the proprietary concerns that a corporate consortium would have. These tools, such as a checklist for producing a rank-ordered risk analysis, wouldn't give organizations a competitive advantage—they would be shareable commodities. The development of generic tools would improve the quality, access, and cost of emergency management tools used in project management. All organizations must prepare themselves for potential emergencies, and this preparation is scrutinized by the public who expect socially responsible corporate behavior.

These are just a few of my recommendations or strategies for project managers to manage their crises better. The more we focus on the mitigation and preparedness phases of the emergency management model, the less we'll have to deal with the response and recovery phases. And that, I believe, is the best strategy for managing better.

2.2.3.11. Emergency Management Tools Applied to Difficult Management Problems

When we discover our domain is a perplexity, we then know we need to adapt emergency management tools to help us manage.

What we typically term emergency management tools are tools we use to support decisions in uncertain pursuits: perplexities and problems. Once we determine a domain of responsibility is a perplexity or problem, we have an indication we should customize typical emergency management tools to that domain. This module addresses a situation where a holding company (I call it Holding Company) is responsible for a number of divisions, each of which is responsible to operate a government reservation. (I call the divisions Herbert, Sandy, Frances, William, Wesley, and Ingrid.) The term GOCO (Government Owned-Contractor Operated) stands for an organization that operates a government site. I call a previous GOCO at the Sandy site the Chemical Company. I call a comparable site not the responsibility of the Holding Company Ronald. The following discussion explains a real situation and how we should distinguish where emergency-management-type tools (tools designed for problems or perplexities) will help in situations not typically considered emergencies. The discussion is adapted from a letter written to the Holding Company person responsible for all the GOCO sites who asked the question: How do I distinguish management approaches among such vastly different sites?

Summary of the Philosophical Perspective
A crisp statement of the difference in management challenges among the Holding Company GOCO sites is: The sites differ in degree of uncertainty. Herbert (and Sandy) are relatively more uncertain than Frances, William, Wesley, and Ingrid. I define uncertainty as the ratio of the information you *need* for managing well to the information you *have*. So, Herbert has a greater disparity between what you need and have than do the others. More obvious causes of uncertainty at Herbert (higher number of workers, diversity of operations, scrutiny, etc.) increase the numerator of the ratio. Less obvious causes of uncertainty (lower quality information systems, communication, networks, etc.) decrease the denominator of the ratio.

The easy answer to the more uncertain challenges (i.e., Herbert) is to improve information richness up and down the line through better communications and networking, thereby driving up the information you have in relation to the information you need. The difficult answer to the more uncertain challenges is *how* to improve information richness. The how relates to management tools we use to provide information for decision making. Our more-familiar management tools have been developed for managing relatively more-certain responsibilities, like projects and processes. These should work well for Wesley and Ingrid and perhaps for Frances and William. But to manage Herbert, you need management tools similar to those that work for more-uncertain responsibilities, like emergencies or research and development programs. My discussion will focus on tools for 1) improving information and communication, 2) designing complex organizations, and 3) responding to chronic emergencies.

GOCO Sites and Uncertainty
Consider the Holding Company GOCO sites on an uncertainty scale shown in Figure 2.2.3.11.1. As we evaluate each site more,

we'll improve our guess of the relative position of the sites on this scale.

Now consider management's problem-solving task as knowing 1) where we are (WWA), 2) where we want to be (WWWTB), and 3) how to get there (HTGT). Our involvement with different management responsibilities suggests the combinations of knowledge for dealing with uncertainty shown in Figure 2.2.3.11.2.

I've coined terms for the five combinations of knowledge in Figure 2.2.3.11.2. and shown these terms in Figure 2.2.3.11.3.

The key point in all of this is: The management tools managers need for each of these different pursuits (perplexity, problem, etc.) are *different*; and, of course, vastly different at the extremes. So, tools for managing perplexities (where the ratio for uncertainty is high) are very different from tools for managing processes (where the ratio for uncertainty is low).

For any given pursuit, to be successful, we use well-suited management tools to drive the pursuit to a more-certain condition. For example, in a perplexity, we consider and prepare for potential problems. (We help prepare for an unknown emergency by writing plans for alternative possible occurrences and our responses to them.) Likewise in a research and development program, we render the program into one or more projects to get the understanding and results we want. Therefore, if the Herbert site is more like a problem, we want to use well-suited tools to render it more like a research and development program, then one or more projects, and ultimately a process.

Successful leadership styles differ for the pursuits. Task-oriented leadership is more effective at the top and bottom of the scale for pursuits, and relationship-oriented leadership is more effective in the middle. In short, by knowing where our management responsibility is on the scale in Figure 2.2.3.11.3., we get clues to the types of management tools we need and how to best use them.

Causes of Uncertainty

Let's examine the sources of uncertainty at the Herbert site. Start with three factors affecting the numerator in the ratio of information you need to information you have. First, the number of employees you manage at Herbert is large. The increase in number of interactions and therefore the decrease in quality of communication changes significantly as you increase people. Second, the diversity of operations you manage at Herbert is large. There are many different simultaneous operations to manage at Herbert, while sites like William and Ingrid are more focused toward a single mission. Third, the scrutiny you receive from the government and relevant stakeholders at the Herbert site is large. The Holding Company has better relations with stakeholders around the Ingrid site than they do around Frances or Herbert. Factors like these influence each other. For example, great scrutiny of diverse operations means the media's penetration into a problem in one operation at Herbert affects public opinion about an entirely different operation at the Herbert site.

Management Tools for Uncertainty

I believe the Holding Company's GOCO sites range from Herbert being more like a problem to Ingrid being more like a project as shown in Figure 2.2.3.11.4.

The management tools that work for perplexities and problems that we can consider using or modifying for Herbert are: risk assessment, vulnerability analysis, crisis communications, notification schemes, Emergency Operations Center (EOC), table-top exercises, and others. As an example, we can translate the idea of a notification scheme into the need for rapid and effective dissemination of information to the right people in the right sequence about the right subjects, which is another way of saying notification in a timely fashion. You may need such a tool at Herbert. As an example of another tool, the Management Systems Laboratories at Virginia Tech (MSL) is building an emergency-operations-center-like facility, called an Intelligent Information Center, to support large-scale project management.

In learning about managing emergencies, we've found some are acute (poof emergencies) and some are chronic (plume emergencies). The plume emergency applications are more in tune with Herbert. These tools emphasize information richness and communication needed for plume emergencies.

Dealing with Interaction and Communication

As we consider specific tools and tasks for increasing information richness and communication for Holding Company management and for the Holding Company's stakeholders, we ask the following sorts of questions. How is the communication best done? What information is rich? Communicate with whom? How often? For what purpose? We sort questions like these into what we believe is a closed set by using Figure 2.2.3.11.5. The *precipitator* motivates or causes a need for interaction. The *purpose* defines the expected outcome for the interaction by the *people* who interact. *Participation* describes how people intend to interact on a *problem* of common concern. These five elements set up the physical *process* for interaction and communication we use to get a physical *product* as a result of the interaction. As we consider tools for communicating rich information, often we gather people together and, in so doing, we must factor the elements of Figure 2.2.3.11.5. into the design and use of our tools.

Organization Structures for Supporting Communication

We know characteristics of organization structures that can either reduce the need for information or increase the capacity to provide information, either of which would contribute to improving the uncertainty ratio through organizational design. To reduce the need for information, we can create slack resources or set up self-contained tasks. To increase the capacity to provide information, we can develop vertical information systems or create lateral relations. The easiest thing to do with the greatest return is to create lateral relations. And when we consider affinity groups, field coordination meetings, or other interactions increasing communication across the organizational hierarchy, we're considering creation of lateral relations. One of the objectives of the infamous matrix organization is to have a multi-directional organization so more information flows more quickly in more directions to the people who need the information.

The challenge in implementing lateral relations is two-fold. The first is that you have to gather, store, retrieve, and disseminate rich information quickly and effectively, which means you must have good support systems. The second is that once you start dancing with a bear you can't quit just because you're tired. That is, if you set up lateral relations or use a field coordination meeting, you must get support systems in place and you must follow through or you'll suffer backlash. One management tool for effectively helping manage any pursuit is organizational structure, but the characteristics you place in the organizational structure must be designed to accomplish what you want. For the Herbert site, we want good and timely communication of rich information to the people who need it.

The Holding Company's Management Perspectives

One of the types of tools we consider for increasing information richness and communication is interactions for lateral relations—one-on-one, group, informal, and/or formal interactions. As we consider lateral relations, information richness, and communications through different interactions, we'll focus on Herbert and the special needs there. When thinking about the Herbert site, we'll consider both Herbert and Sandy to help us keep from overlooking something. We first look at similarities and differences between the Sandy and Herbert sites.

<u>Similarities between the Herbert and Sandy Sites</u>

Similarities between the Herbert and Sandy sites influence management strategies:

1. Herbert and Sandy have many diverse missions resulting in multiple government headquarters organizations having a vested interest (management and budget functions), which increases the opportunities for turmoil, confusion, and disunity. William, Wesley, Frances, and Ingrid have single missions and single government headquarters points of contact, allowing management to be more focused and manage external factors more effectively.

2. Herbert and Sandy are more difficult to manage than the other Holding Company GOCO operations because they have a much larger number of employees.

3. Herbert and Sandy, with large land areas, are always prospects for new government projects or programs and therefore new missions. A new project can be placed at Herbert or Sandy and be a good drive away from all other projects at those sites.

4. Herbert and Sandy have many missions from which they receive constant guidance and direction from a number of federal government agencies. The larger sites receive more attention because they're larger assets for the government. The new government emphasis on centralization is a change in the rules. In the past Herbert and Sandy were more independent of day-to-day government headquarters directions.

   The Holding Company needs to have unified management at Herbert and at Sandy. The missions need to be separated so a problem with one doesn't affect another. For the public who is going to create problems for these missions, how does the Holding Company 1) separate them so a problem with one doesn't affect another and 2) at the same time organize the missions in a unified way?

<u>Differences between the Herbert and Sandy Sites</u>

Differences between the Herbert and Sandy sites also influence management strategies:

1. Herbert has traditionally been the site of multiple prime contractors. A few years ago they pared down from about seven to three. Even today, Herbert has more prime contractors than the Sandy site.

2. There is a greater degree of employee-contractor loyalty at Sandy than at Herbert. The Herbert site has historically had a turnover in prime contractors approximately every ten years. The employees have no loyalty to a contractor, but rather to the site. The employees have learned to be flexible when it comes to what contractor affects their paychecks. By contrast, Sandy was built and operated solely by the Chemical Company, so it became part of the employee culture to be loyal to the contractor. So far, this loyalty has carried over to the Holding Company. At Herbert, the lack of loyalty or unity of purpose could be a barrier to communicating effectively.

3. Herbert is unique because of the number of "whistle blowers." This is a reflection of

the lack of employee trust. At Sandy and Ronald, problems are dealt with internally, not in the media or a politician's office. The Herbert site has such a high number of these incidents that the government agreed to support an independent and unbiased review of whistle blower complaints.

4. At the Herbert site, most of the surrounding population moved to the area and has grown with Herbert. They take interest in and scrutinize everything Herbert does. At Sandy, the surrounding population was sparse and generally poor. They have benefited economically from Sandy and view Sandy as a positive influence in their lives. The way Herbert and Sandy have evolved has caused two differences in management style. First, Herbert managers must be more involved in local community affairs. Herbert management budgets for much larger goodwill expenditures to their surrounding communities than Sandy budgets for theirs. Second, because the surrounding communities display more confidence in Sandy than Herbert, there is a much greater need to involve stakeholders in decisions at Herbert. To make sure stakeholders participate in the right way in the process, techniques such as flow charts can be used to plan and track stakeholder involvement.

5. The Herbert site's mission has changed from production to remediation. The Herbert people are probably having difficulty accepting the new role and change in mission. Employees will not enthusiastically back a mission if they feel completion of the mission means they'll lose their job. There's a lack of understanding among government and Holding Company top management on what's necessary to retain interest and enthusiasm for the new mission. Also, the politicians in Washington, D.C. and at the state level, as well as the public, probably don't have a clear understanding of what's happening at Herbert. The Holding Company should work against a "plant shutdown" mentality.

6. The reassignment of Herbert from one governmental program responsibility to another may be confusing to both the government and the Holding Company. They now have to deal with a new hierarchy of government "landlords" and new lines of communication and direction.

7. The Sandy site has many groups focused on it. The Herbert site has only one group looking at it. That may help Herbert.

<u>Centralizing Authority at Government Headquarters</u>

The government's efforts to centralize authority at headquarters also presents some management issues:

1. The government field office role is being reduced and changed. Traditionally, official communication and program direction to the contractor came through the field office manager. In the past, contractors rarely talked to government headquarters personnel unless they had a field office representative with them. Now, as the government headquarters directly communicates with the contractor, the contractor asks the field office for interpretation, but the field office may be out of the loop and may interpret what the government headquarters wants incorrectly.

   An effort should be made to increase information shared among the Holding Company, the field office, and the government headquarters. There needs to be more of the right kinds of interfaces. The government headquarters information should be shared with the field office and the Holding Company. If not, the Holding Company may head in one direction and find out months later that the government headquarters has changed direction. Also, the government headquarters may be months behind on important issues the contractor has identified. This lack of sharing of information leads to increased opportunity for miscommunication at all levels.

2. An effort should be made to increase face-to-face contact between the Holding Company and the government headquarters. The Holding Company needs more-direct communication lines at all levels of management.

3. Since the government headquarters has recently reorganized, there is confusion at headquarters, and that confusion simply passes down. There are new government managers trying to make their own mark. New relationships between the government and the Holding Company should be defined soon to result in greater stability in the government management process.

4. The atmosphere of fear and suspicion between the government headquarters and contractors contributes to disunity. The Holding Company position against the recent reorganization initiative by the government further exacerbated the poor relationship between the Holding Company and government people.

<u>Things to Be Considered</u>

There are several things to be considered that might assist the Holding Company management:

1. Improve communication within the Holding Company: more emphasis on the new mission at Herbert; focus on morale and unifying employees (i.e., constancy of purpose); drive out fear; emphasize opportunities for cooperation.

2. Improve communication with the government: focus groups; scheduled meetings for communication; Holding Company representative at government headquarters.

3. The Holding Company should consider bringing together one or more groups to improve information sharing:

   a. Field Coordination Meetings—bring together government program officials, field office managers, and Holding Company officials to discuss responsibilities, expectations, status, and progress (programmatic and budget). Discuss specific problems and solutions. Use status and planning presentations from specific sites. These meetings would help the field office managers in their roles as much as the Holding Company. Another purpose of these meetings is to have the Holding Company and the government redefine their relationships at all levels.

      You should not jump right into a full-scale field coordination meeting, but rather take one step at a time. You may want to begin by using an existing regularly scheduled gathering of your site managers to set up the foundation or the preliminaries to making this field coordination meeting concept work well. Then investigate the possibilities of government headquarters participation.

      Consider coordination meetings for Herbert, at first separate from the other sites. Contractors and government participants in these meetings have special considerations different from the other sites. Then bring all sites together for a joint coordination meeting. Perhaps the other sites should meet together prior to the joint coordination meeting.

b. Focus Groups—maybe a group like the State and Tribal Government Working Group (STGWG) to look specifically at Herbert. Talk about plans and the mission of Herbert and share frustrations. Try to build trust among government headquarters, the Herbert site, and local political subdivisions like the Indian tribes and the state and local governments.

c. Quarterly Meetings—have the Holding Company GOCO site managers meet quarterly to discuss their problems and lessons learned. Have the meetings rotate among the sites, so they visit every site every year and a half.

Once participants for the groups are identified, the real challenge is to convince the various levels in government headquarters that information sharing is a good thing to do.

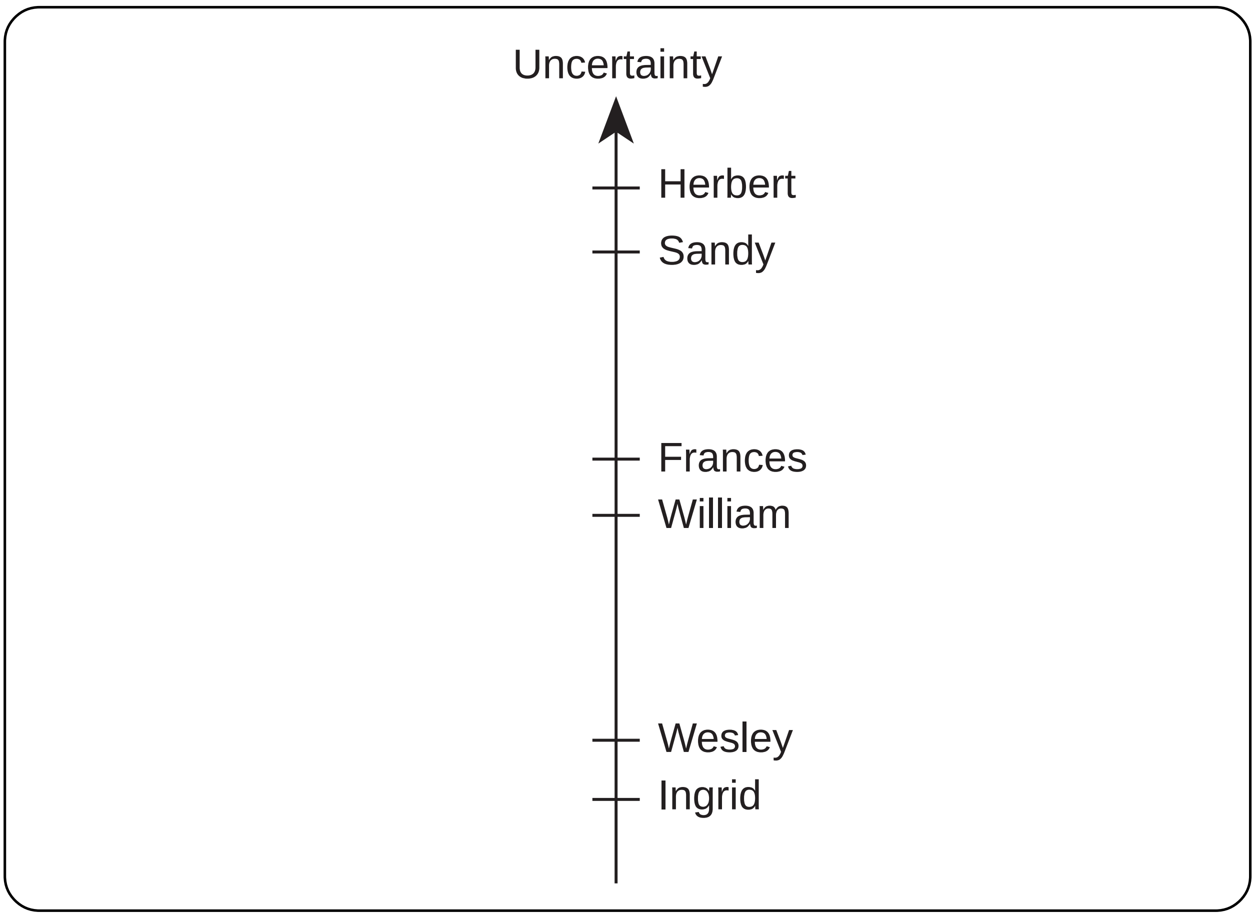

Figure 2.2.3.11.1. *We can contrast the types of management tools best suited to a particular site by comparing the sites according to their uncertainty.*

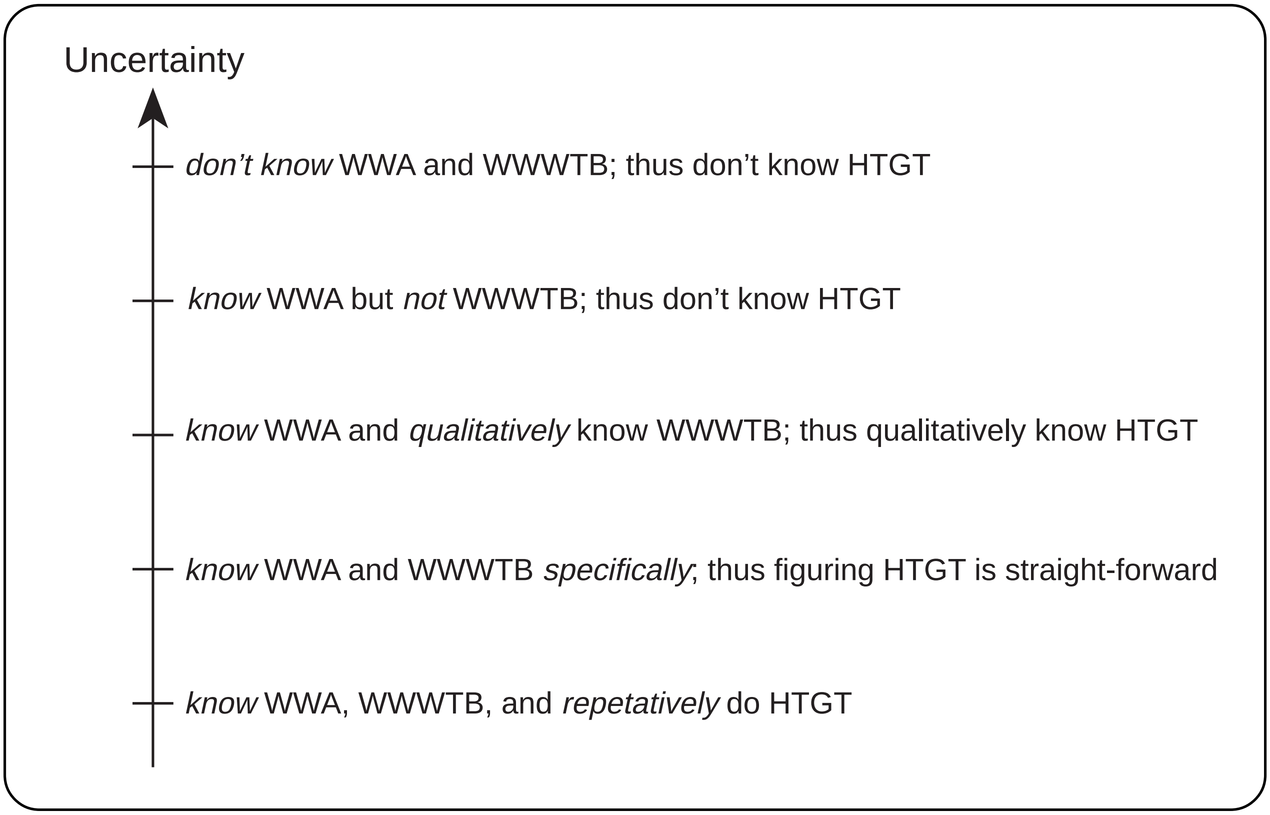

Figure 2.2.3.11.2. *We can convert the uncertainty scale to divisions reflecting how much we know about a domain of responsibility in terms of information needed for problem solving.*

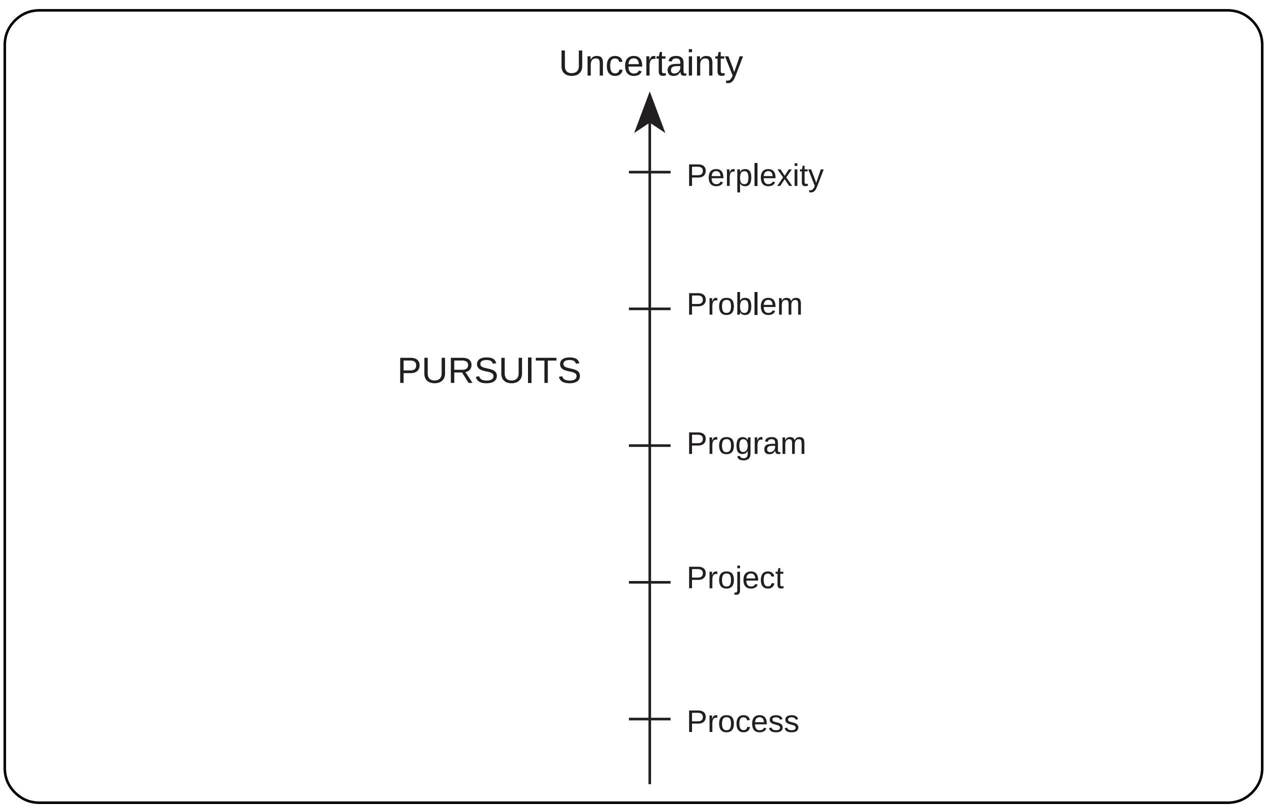

Figure 2.2.3.11.3. *The different pursuits reflect what you know and what you don't.*

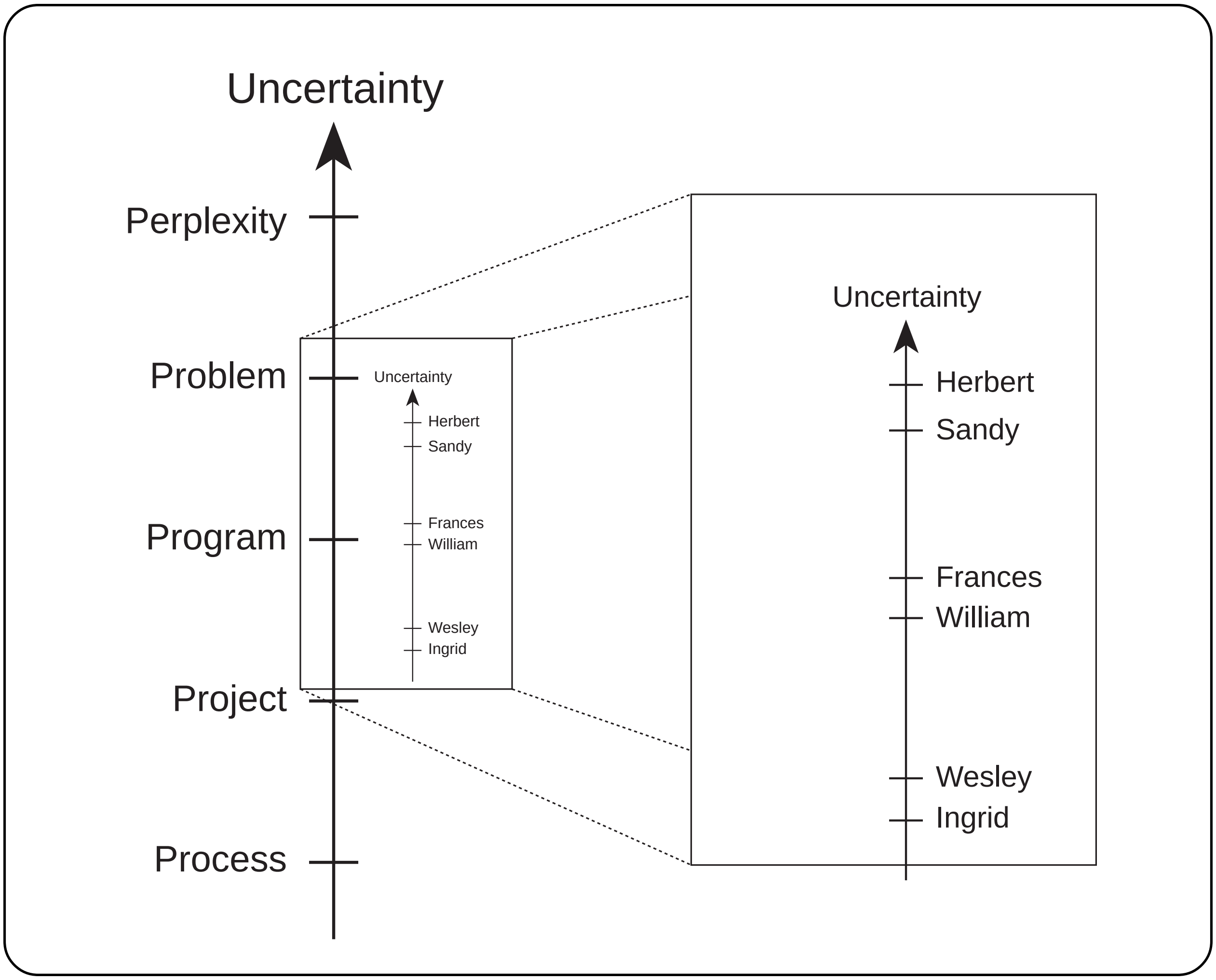

Figure 2.2.3.11.4. *The Holding Company's sites are fit in the pursuits framework.*

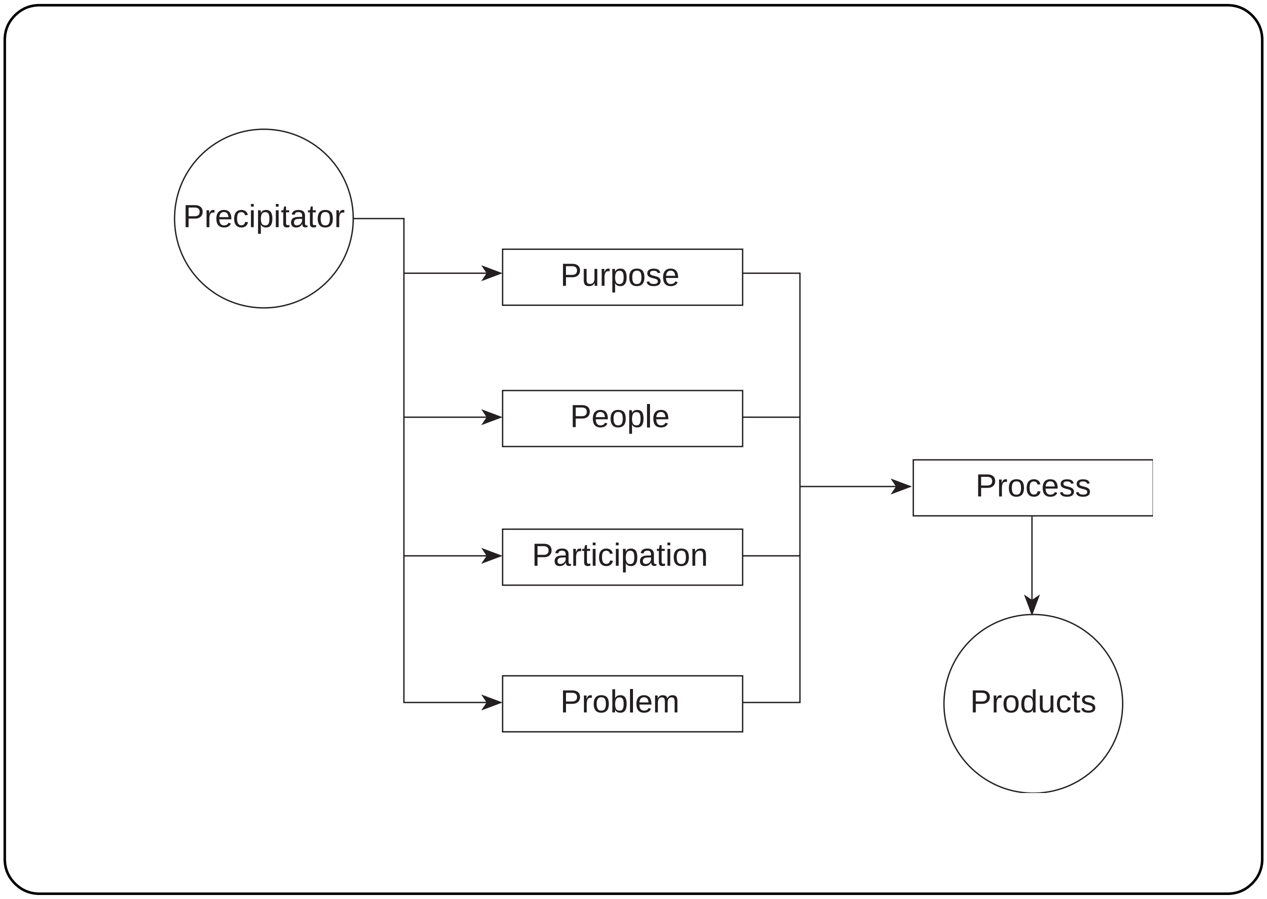

Figure 2.2.3.11.5. *We model group interaction or communication using seven components.*

2.2.3.12. The Management of Risk.

We can manage risk by applying management system analysis and management system synthesis.

This module was taken from "The Engineer's Approach to the Management of Risk," *American Nuclear Society's Embedded Topical Meeting on Risk Management.*

From a management perspective, I see risk management, vulnerability analysis, and risk assessment in simple terms. Risk management involves vulnerability analysis, risk assessment, and the relationship between the two. The decisions relating to where you're vulnerable and where you want to assess risk constitute a vulnerability analysis. Morale problems, communication issues, and other influences diverting employees' attention from their work produce areas of vulnerability. Risk assessment concerns the determination of types and related probabilities of an emergency. We can't assess risk on everything everywhere. That's why we do a vulnerability analysis first—so we can focus our risk assessment efforts on our vulnerabilities. I link vulnerability and risk through the evaluation of the consequences of a particular risk applied to a given vulnerability.

In a vulnerability analysis, a manager decides which elements in the domain of responsibility are vulnerable to the effects of any type of potential incident. Decisions for specifying and quantifying the risks to which the domain is vulnerable constitute the risk assessment. In a vulnerability analysis we identify where our domains are open to risk—the weaknesses. The dictionary definition of vulnerable includes "open to attack or damage." Risk, as opposed to vulnerability, suggests exposure to dangerous elements or factors. The vulnerability analysis doesn't tell us what we're vulnerable to; it just tells us where we're vulnerable. I'm addressing risk management decisions in terms of the Management System Model. The risk manager will first want to delimit his or her domain of responsibility. I'll describe a procedure for building and using risk management tools based on the Management System Model (Figure 2.2.3.12.1.).

The processes for risk management are closed-loop processes. See the control loop in Figure 2.2.3.12.1. We first identify where we're vulnerable (domain decision [plant in the control loop]). We follow with assessing types and probabilities of risks associated with those vulnerabilities (disturbance decision [disturbance in the control loop]). Then, we relate these by examining the effect (consequences) of the risk on the situation where we first conducted the vulnerability analysis (disturbances on the plant in the control loop). The linkage between vulnerability analysis and risk assessment is the disturbance on the plant. The disturbance is the risk and the plant is where you're vulnerable. In risk management, managers use and improve vulnerability analyses, risk assessments, and their linkage through testing, evaluating, and modifying their domains under the consideration of a crisis to form a feedback loop (the rest of the control loop). Later, I'll extend the management process cycle of Plan-Do-Study-Act, so popular today in managing quality, to risk management based on the cyclical relationship of risk management processes.

Applying the Engineer's Approach to Risk Management

I focus on two fundamental techniques used by management systems engineers that can help risk managers better understand their domains of responsibility and therefore practice higher-quality, more-comprehensive risk management. The first technique involves delimiting your domain of responsibility to understand what you manage and what tools you use to manage. I'll introduce the Management System Model and briefly cover the steps involved in management system analysis and management system synthesis.

We all make decisions affecting what we manage. By my definition, then, anyone who makes decisions affecting what they manage is a manager. Managers must know what they manage and what tools they use to manage with. We use the Management System Model (MSM) to define the domain of responsibility for an individual manager (Figure 2.2.3.12.1.). The MSM balances the interfaces between the three components of who manages, what is managed, and what is used to manage. A vulnerability analysis asks you to identify which of your responsibilities is vulnerable. Failure to gain a good understanding of your responsibilities prior to the vulnerability analysis means you'll overlook some vulnerabilities or you'll confuse some vulnerabilities—it all starts with knowing where you're vulnerable.

Once we've defined our domain, we use management system analysis to build management tools for risk management (i.e., decisions about vulnerability or decisions about risk). Management system analysis represents a counterclockwise progression through the MSM, starting at what is managed (Figure 2.2.3.12.2.). Management system analysis has five steps: 1) delimit your domain, 2) determine decisions and actions, 3) define information for decisions, 4) outline data for information, and 5) list measurements for data. When we delimit our domains, we carefully specify what is in the domain and what is not. For example, if what is managed is office supplies, the risks tend to be minimal: paper cuts, thumbtack stabs, etc. But if what is managed is a nuclear power generation station, the components of what we manage present known risks to health and safety (e.g., leakage of underground waste storage tanks; discharge of harmful effluents into the biosphere) that should be characterized in a risk assessment.

In management system analysis, once we've delimited the domain, we should determine what decisions we should make and what actions we should take to manage the domain. The range of decisions we make defines the scope of our responsibilities. We can refer to a formal job description to get an idea of what types of decisions are expected to be made, but there's usually no good substitute for asking the incumbent or having him or her log the decisions made and actions taken for a specified period of time. Work sampling procedures may prove useful for collecting these data.

Identifying the decisions made and actions taken in a domain leads to the next step in management system analysis: determine the information required to support the manager's decision making. Determining information requirements to support decision making depends to a large part on who manages. The manager's cognitive style bears implications for how the information should be portrayed to best suit the manager and support decision making.

Once we've defined the information needed to support the managers's decision making, we must outline the data needed to develop the information by developing the data requirements to generate the desired information. In management system analysis, I view the what is used to manage component as a process converting data into information for decision making.

This leads us to the fifth management system analysis step—listing measurements to obtain the data from what is managed. We must design measures to capture the data we need in an efficient and timely manner.

Cycling through the management system analysis steps helps you build effective management tools for converting data into information. Risk managers have much to gain from management system analysis if they can use the process to mitigate crises.

Management system synthesis gives us the functions for using management tools. Nine functions, working clockwise around the MSM, characterize management system synthesis (Figure 2.2.3.12.3.). These nine functions make up a structured management process. I group the nine functions into three groups: planning functions, executing functions, and comparing functions. Planning functions address what you want to do; executing functions address what you did; and comparing functions address whether you did what you wanted to do.

The planning functions are: setting expectations, surveying your work, and determining indicators and reference points. Risk assessment and vulnerability analysis work heavily into the planning functions. For setting expectations, we try to identify what could happen and what the consequences would be. Both risk assessment and vulnerability analysis are very strong in setting expectations. For surveying our work, we flowchart potential risks and use cause-and-effect charts for consequences. Defining indicators gives us early warning and detection of incidents.

The executing functions include collecting and logging data, converting data to information, and organizing and presenting information. A tabletop exercise is an example of an executing function. When you look at cause and effect, what you do during that incident is part of the cause-and-effect linkage. You can reduce the effect of the cause by taking the right action. You can increase or make worse the effect of the cause by taking the wrong action.

The comparing functions include reviewing status and progress, exercising personal effectiveness, and verifying performance. In my context, comparing functions encompass learning, improving, and updating risk assessment and vulnerability analysis.

What is the engineer's approach to risk management? I say it's Deming's Plan-Do-Study-Act (PDSA) cycle. *Plan* includes the management system synthesis planning functions; *Do* includes the executing functions; *Study* includes the comparing functions; and *Act* makes the sequence an iterative cycle—the basis of continuous performance improvement.

In risk management, vulnerability analyses and risk assessments make up the *Plan*. Hypothesizing what will happen as a result of the risks is the *Do*. Risk managers using tabletop exercises combine *Do* and *Study* to generate information to improve their risk management processes. Improving the processes for dealing with the risk is *Act*. Then the cycle starts over: What is the vulnerability and risk now that we've taken action to improve our processes?

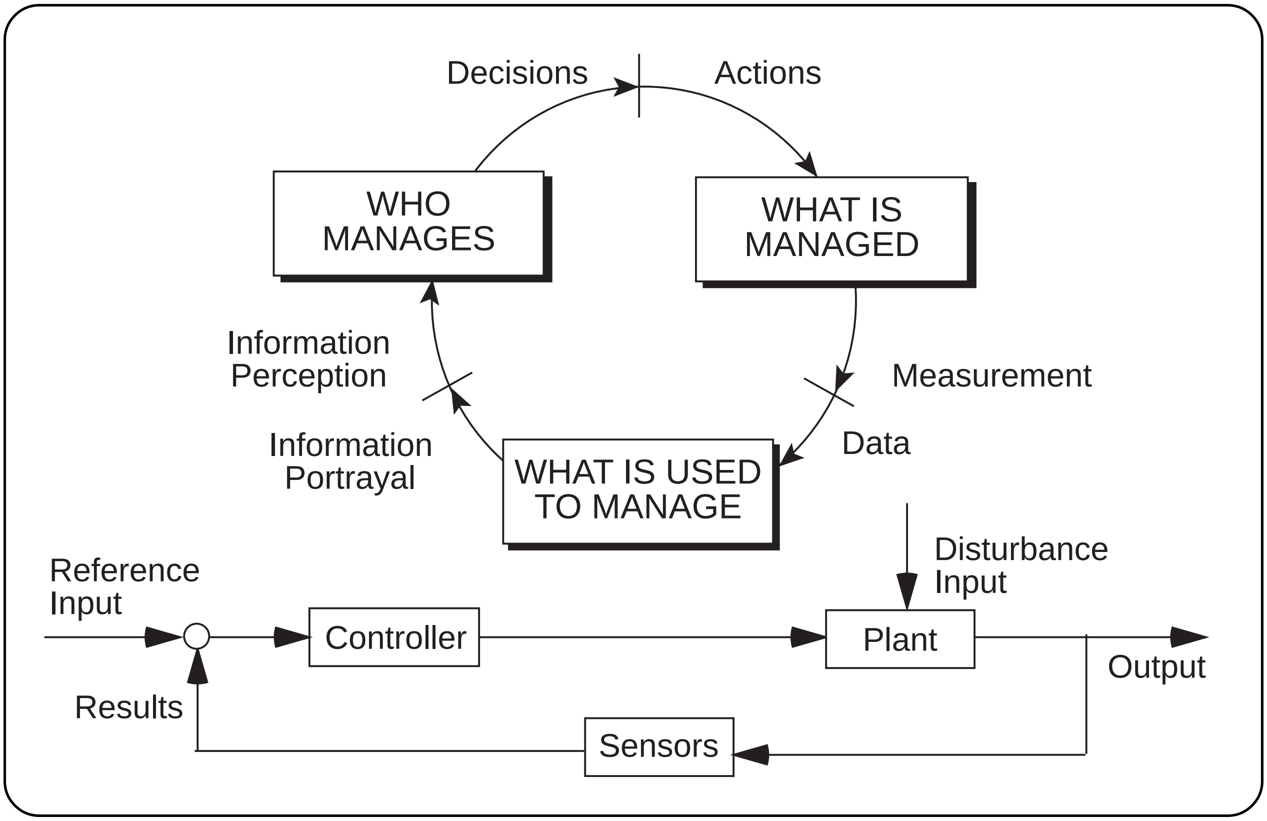

Figure 2.2.3.12.1. *A control loop is analogous to the Management System Model.*

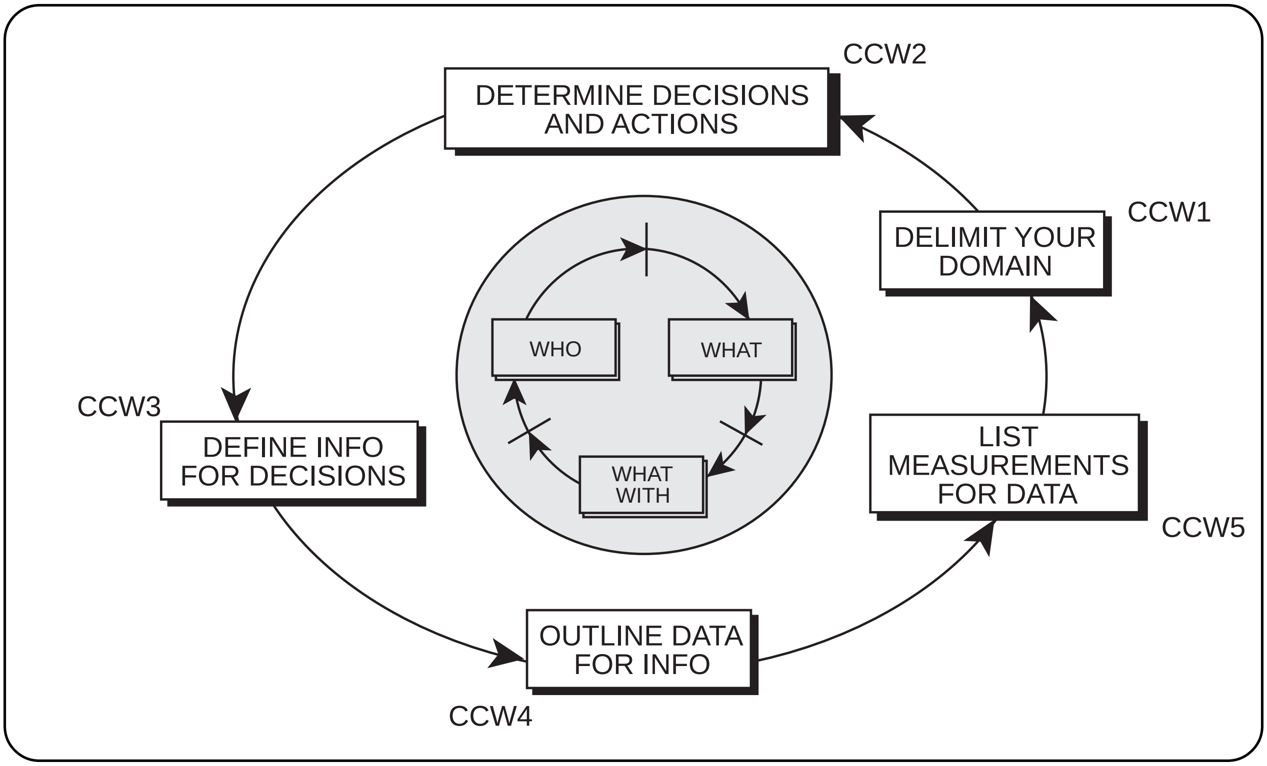

Figure 2.2.3.12.2. *Management system analysis has five steps working counterclockwise around the MSM.*

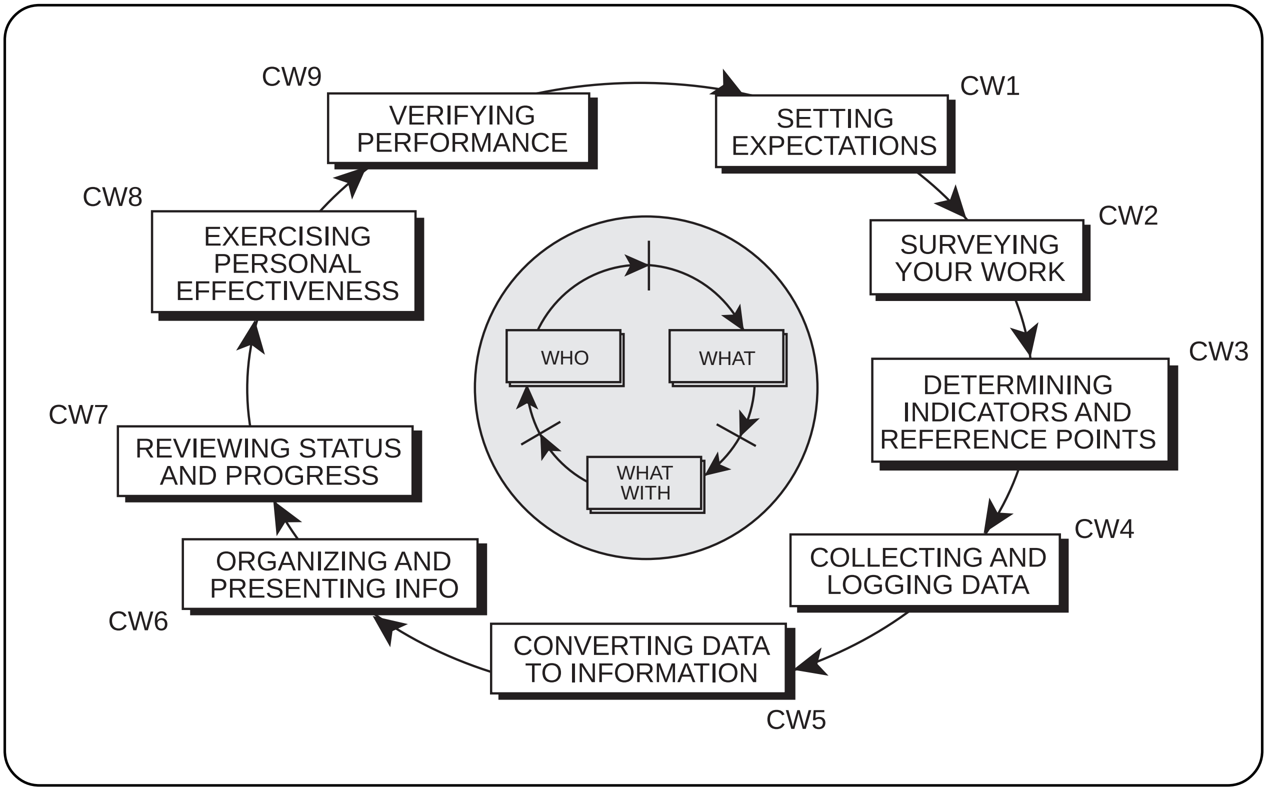

Figure 2.2.3.12.3. *Management system synthesis has nine steps working clockwise around the MSM.*