Part 1

Understanding Engineering Process Management

1 The Holistic Approach to Managing Engineering Operations

This book is intended to help you implement a more rigourous approach to the practice of engineering management. In our consulting work, we have seen many attempts to improve this management process. Mostly we have been called in when previous initiatives have failed. We believe that these initiatives have failed for one simple reason. They were narrow, one-dimensional solutions to problems that had many facets. Additionally, the people who offered the consulting services quite often had very little practical background in engineering. In this book, we will look at the engineering process from a holistic approach.

Typically, we see the scenario play out as follows: a firm finds that its development projects are taking too long or costing too much money to complete. A senior manager in engineering has read a book, attended a course, or acquired considerable experience in one particular approach and recommends that the organization simply implement this new way and the problem will be solved. In the best case, a year later the performance in the one area at which the solution was aimed has improved, but there is no broad-based financial measure of improvement. In the worst case, the organization is in upheaval with pockets of resistance firmly entrenched against the change.

The reason for this failure is the application of improved methods in isolation from one another. These solutions typically originate from one of six bodies of knowledge. A *body of knowledge* is an inclusive term that describes the sum of knowledge within a profession or management practice. A body of knowledge includes knowledge of proven, traditional practices, which are widely applied, as well as knowledge of innovative and advanced practices, which may have seen more limited use. The six bodies of knowledge that we examine are fundamentally sound and broadly accepted in modern management theory. In this book, we will look at how to integrate them into a cohesive approach to making quantum improvements in your product definition process.

In this first chapter, we will examine the six bodies of knowledge that we will integrate to form our approach. We will look at the motivation that led us to take this tack. That discussion will lead us to examine the benefits of the holistic approach. Then we will look at some of the critical success factors that will make the difference as you move to implement it in your organization. Finally, we

will introduce what we call the Integrated Enterprise Architecture as a model for managing broad based change programs.

1.1 SEPARATE BODIES OF KNOWLEDGE

Top managers have two perspectives that separate them from the middle managers. First, the language of middle managers is "things," whereas the language of top managers is dollars. Certainly, top managers have a way of looking at issues from a financial perspective. However, top managers also have a wide breadth of perspective. Managers will usually rise to the top on their ability to synthesize the input from many different perspectives. They lead their organization on a path that will optimize many, many different variables. This book was written to help give you that breadth. It will help you look at improvements to your product development process from the same perspective as the most successful executive. Then it will help you set a course of action that optimizes all the variables and constraints. It will be particularly useful for engineers and scientists who aspire to executive management. The traditional education and training of engineers is based on the applied sciences. Scientific training has tended to create people with black-and-white or right-and-wrong thinking. This thinking works well when dealing with equations and the design of things, but it falls apart when dealing with people. Unlike things, people exhibit unpredictable behavior. The interaction of politics and emotions is the greatest challenge management faces. And the transition from engineer/scientist to manager is a major challenge. This transition can work only if the executive takes a holistic approach at applying what are traditionally separate disciplines. We will develop a practical approach that can be implemented readily.

This approach, while broad, draws its strength from a grounding in six long-trusted management bodies of knowledge (see Figure 1-1). In the past middle managers have tended to treat them as separate entities possible because they each have their own professional bodies that promote them. Middle managers have tended to lock onto one body of knowledge to call their own and then to develop an expertise in that area. For example, they may have led a crusade to implement business process reengineering, concurrent engineering, systems engineering, or project management. Our approach in this book, however, is to integrate these previously separate disciplines. We believe that this approach has not been documented in management literature.

Let's first examine the foundation, the six bodies of knowledge upon which we base our approach.

Integrated product development

Integrated product development (IPD) was the brainchild of the U.S. defense industry in the late 1980s. In the IPD approach, engineers form multidisciplinary

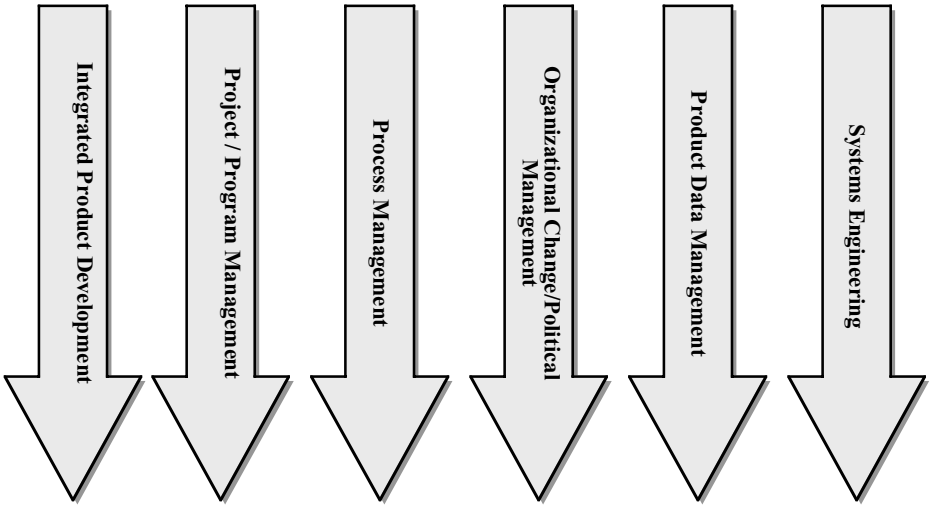

Figure 1-1: The six management bodies of knowledge

teams with the mandate to deliver a product that optimizes all the individual constraints placed upon it. These constraints could include budgets, materials, speed, strength, and functionality, among others. The list could go on indefinitely. However, for the purposes of this book, and to promote a common understanding of IPD, we have adapted the definition provided in the U.S. Department of Defense *Guide to Integrated Product and Process Development*.

Integrated product development is "[a] management process that integrates all activities from product concept through production/field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing and sustainment processes to meet cost and performance objectives."

IPD replaces the serial or "over-the-wall" approach in which a designer completes a design and throws it over the wall to someone in an analytical discipline who, in turn, throws it back saying something like, "It needs to be stronger." As ridiculous as it seems, most design departments still operate this way. IPD utilizes integrated product teams (IPTs) to allow all affected areas to provide their perspective up front. The IPD approach allows the specialists to collaborate on the design and collectively present a finished product to a manufacturing team that already knows exactly what it will be receiving.

Concurrent engineering is at the heart of IPD. The IPTs are multifunctional teams organized around the major components of the product (or product structure). These teams have responsibility for developing a fully functional, producible, highly reliable product that meets or exceeds customer requirements, program budget, and schedule constraints. The teams have authority over all technical, cost, schedule, and quality aspects of their products. They are accountable to the respective program manager. All IPT team members represent the expertise of their functional discipline and are able to provide input to team decisions based

on the processes and procedures developed and maintained by their functions. The multifunctional nature of the IPTs ensures early consideration of all issues relevant to cost, schedule, and performance of the product throughout its life cycle. The IPTs should be formed early in the proposal phase of a program and should retain their focus throughout the life cycle of the product. This early involvement of all functional disciplines that are vested in the development and support of a product is the defining difference between serial and concurrent approaches to managing a program.

Colocation is a key enabler to the IPD process. Through the colocation of core members of the IPT, integration team, program manager, and appropriate business support resources, the free exchange and timely flow of information among program team members is spontaneous. Brain storming sessions are performed on an as needed basis.

Although this early involvement of all appropriate functional disciplines increases initial program costs when compared to the serial approach, product changes downstream are either avoided or greatly reduced, resulting in both cost and schedule savings.

Project/program management

The work of an enterprise generally involves either operations or projects. They are similar in that they are performed by people, constrained by limited resources, and then planned, executed, and controlled. Operations and projects differ in that operations are ongoing and repetitive, whereas projects are temporary and unique. The project management body of knowledge is documented in the Project Management Institute's *Guide to the Project Management Body of Knowledge*. They define a *project* as "a temporary endeavor undertaken to create a unique product or service. Temporary means that every project has a definite beginning and definite end. Unique means that the product or service is different in some distinguishing way from all other similar products or services."

The Project Management Institute defines *project management* as . . . "the application of knowledge, skills, tools and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project. Meeting stakeholder needs and expectations invariably involves balancing competing demands among:

- Scope, time, cost and quality
- Stakeholders with differing needs and expectations
- Identified requirements (needs) and unidentified requirements (expectations)."

Project management involves planning the project, executing the plan, monitoring the execution, and wrapping up the project when complete. Good project managers

would die for their projects; great project managers inspire a team that would die for their leader.

Process management

Michael Hammer's book *Re-Engineering the Corporation* launched business process reengineering in the early 1990s. The fact that you do not hear the term as frequently today will lead some to believe it was another management fad. In fact, it is quite the opposite. The e-business boom we are seeing today is simply a massive reengineering project. When we introduce the integrated enterprise architecture later in the chapter, you will see that the impact e-business is having on the movement of data is not possible without fundamental process change. An enterprise runs on a series of processes. Process reengineering involves examining in detail how the organization performs the tasks that create value. Using process thinking, we stop thinking of the enterprise as a collection of functions and begin to see it as a collection of integrated tasks that make up processes designed to create and deliver value to the customer.

These processes run across the organization moving information or physical materials from function to function (or department to department). In process reengineering, we examine these flows, document them, measure them, cut steps, add new steps, and ask the fundamental question, "Should this process exist at all?" Michael Hammer's landmark *Harvard Business Review* article in July 1990 was entitled "Reengineering Work: Don't Automate, Obliterate."

Organizational change/political management

Not so many years ago managers had time to worry about the next wave of change that they potentially would have to ride. As a manager in the new millennium, that wave of change has become perpetual white water. In managing organizational change, we utilize organizational behavior techniques to understand and systematically overcome resistance to change. Engineers in management positions often give short shrift to this "wooly side" of management. They would prefer to deal with laws of physics or physical properties of materials. The body of knowledge is as diverse as Maslow's hierarchy of needs, psychology techniques, sociopolitical management, and military strategy. On its own, this discipline is merely mental gymnastics. An improvement initiative that ignores the people aspects will certainly fall from the balance beam. The book *The Change Masters* written in 1985 by Rosabeth Moss Kanter was one of the first texts to address this body of knowledge. Its central theme focused on achieving an American corporate renaissance by stimulating more innovation, enterprise, and initiative from the people.

Product data management

Product data management (PDM) is a class of software designed to provide easy access to the mountains of data that engineers create. PDM systems provide a

central repository for the design data so that authorized people can access the current design documentation with the confidence that they are using the appropriate version. PDM systems help the organization to define relationships between data elements. Any authorized person can easily locate a given component and then access all related information such as the CAD drawing, the stress analysis, the test results, and the modifications to the component that are in work, approved, or in production. Advanced PDM systems also provide the functionality to help manage the product development process. They can enforce a standard routing, known as a *workflow*, and can help project managers monitor activities through the workflow, thereby offering rudimentary project management functionality.

Systems engineering

Systems engineering is the practice of coordinating and executing development activities for designing and building systems – large or small, simple or complex. Systems engineering work begins with the needs of stakeholders, users, and operators, and transforms these needs into a responsive, operational system design and architecture. The deliverable must conform to the demands of the marketplace as well as to the initial set of functional and nonfunctional requirements.

The International Council on Systems Engineering (INCOSE) defines *systems engineering* as "an interdisciplinary approach and means to enable the realization of successful systems." More succinctly put, systems engineering is an organized approach to problem solving by an experienced engineer with a broad, systemwide overview toward solving the problem, weighing options, and evaluating risks and constraints.

Systems engineering is responsible for integrating all the technical backgrounds, subject matter experts, and specialist groups in a development effort. It starts with defining customer needs and required functionality early in the life cycle and managing requirements and proceeds into design synthesis and system verification and validation.

A major element of system engineering is risk management. Project management specialists will argue that risk management is just a chapter of the program management body of knowledge. Indeed, program directors are responsible for assessing the risks their projects face, assessing the potential impact, and taking the steps necessary to mitigate those risks. Risk, however, can have as large an impact on cost and schedule as it has on the original product requirements. We have all heard of projects that take twice as long to complete and cost twice as much as the baseline plan. On complex programs, managing risk is a major process. From a holistic approach, risk management involves identifying the appropriate senior people and gaining their commitment to assist in managing the technical and business risks on the program. Effective risk management involves controlling elements of timing, managing the political environment in the organization, and being sensitive to the needs of the team, the partners, the customer, and executive management.

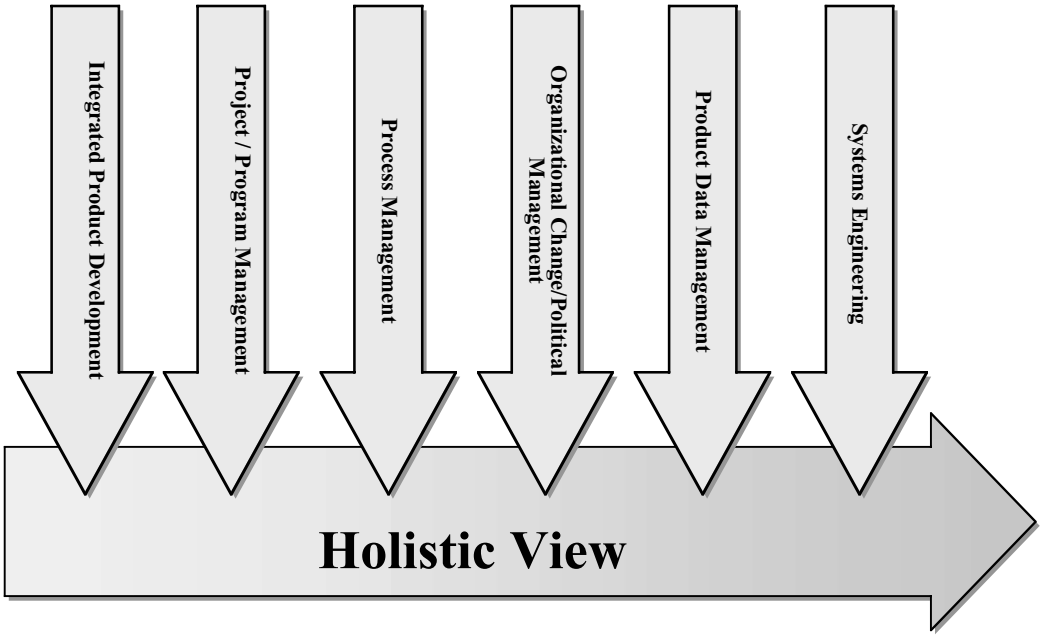

Figure 1-2: The holistic view of the bodies of knowledge

1.2 THE HOLISTIC APPROACH

In the holistic approach shown in Figure 1-2, we take the best that these discrete bodies of knowledge have to offer. We rigorously practice what they preach, but we take a step back to consider the impact our actions in one area will have on another. We will redefine the engineering process, but we will do it in a way that makes project management simpler and more effective as well as one that allows for the implementation of product data management, and so on. Throughout the book, we will identify key points where you should stop driving down one path and examine how to integrate concepts from the other bodies of knowledge to create an entire route map.

1.3 THE MOTIVATION FOR TAKING THE HOLISTIC APPROACH

Programs or projects, regardless of their scope, size, or complexity, must be acquired and executed in a similar manner by performing a basic set of activities. A methodology is the organization of these activities into a standard framework, one that is used to guide the planning, execution, and management of programs. This methodology allows us to manage programs with repeatable results by approaching them with scientific methods and to make sure that these methods are aligned with the human aspirations and political climate.

IPD objectives

Companies that engineer products stake their future on their ability to continue to play a significant role in the development of new products. As such, we must address a basic issue faced by all engineering organizations, namely to reduce cost and overall product development cycle time and improve quality. Some typical goals follow:

- Meet program cost targets
- Reduce total program costs
- Meet program milestones
- Reduce time to market
- Reduce engineering change following design freeze

As a management tool, this book is intended to help the management team answer the following questions:

- What work needs to be completed?
- What deliverables will be produced during the process?
- What skills are necessary to complete the work?
- How long will the work take?
- How much will it cost?
- How does each piece of work relate to other pieces of work?
- When are program reviews appropriate?
- What resistance must we overcome to achieve our goals?
- How do we organize for deployment an enterprise-wide architecture?

We aim to provide a standard framework for executing engineering projects, thereby allowing your company to concentrate its efforts on applying skills (e.g., stress analysis, mechanical design, and process design) so as not to be defocused recreating the approach for each program.

1.4 BENEFITS OF THE IPD APPROACH

The main benefit of the IPD approach is that it provides an effective mechanism for planning and managing an engineering program. This benefit can be broken down into five more specific benefits:

- To help ensure high-quality product and process definition
- To improve project management and business process definitions
- To capitalize on experience gained from other projects
- To establish consistency across projects and divisions
- To provide a framework for training

1.4.1 Ensuring high-quality product and process definition

A consistent approach helps to ensure high-quality product definition through efforts involving both people and technology. The following discussion introduces these concepts.

Effective communication

High-quality product definition requires effective communication processes among project team members and between the team partners and the customer. One of the greatest benefits of a well-documented approach is that all involved in the development process speak the same language. The team members and the customer agree on what work is involved in each phase of the project. The process promotes effective communication by building regular reviews into the project. These reviews enable all key players to monitor the program's progress and to identify and correct flaws early in the development process.

Complete documentation

Complete project and system documentation is another key to ensure quality product definition. Documentation is produced throughout the course of the project. The documentation is cumulative in that deliverables resulting from one task are typically used as input for subsequent tasks. At the project's end, these deliverables become the final design documentation.

1.4.2 Improving project management

In this book, we will outline techniques for high-level and detailed project planning as well as provide additional information on risk assessment, estimating, and project execution and control.

Project structuring and planning

The starting point for effective planning is the business process framework. It provides a way to break down the design activities to help identify deliverables (called a work breakdown structure or WBS), plan major segments of work, and determine the program review points necessary for a program. At a detailed level, the process flows provide a foundation for work-planning templates and for the project WBS. These templates contain lists of tasks and work steps that represent the work typically involved in the development of an engineered product.

In addition, we will develop a template specifically for defining the project management tasks associated with a project such as the steps for planning the project, setting up the program review process, establishing program-specific standards, initiating the project, and monitoring and controlling it. By separating these project management tasks from the development tasks, we focus the project manager/engineer on the activities necessary to successfully manage a project.