Project and Process Management

Chapter 1: Introduction: Why Projects, What are Their Implications

CHAPTER OUTLINE

Definition of a Project
The Project Management Knowledge Areas and Processes
Project Management Context/Culture
Uniqueness of Information, Technology, and Business Projects
A Systems Approach to Project Management
Systems Thinking and Project Management
Summary and Conclusions
Definition
Exercises
References
Supplement 1.1: System Integration

LEARNING OBJECTIVES

After reading this chapter, you will be able to:

1. Define what a project is and what projects consist of.
2. Understand the role of processes in project management.
3. Identify what is unique to information, technology and business projects.
4. Analyze how systems concepts relate to projects and processes.
5. Discuss why projects and processes occupy center stage in the corporate world.
6. Explain why systems thinking has become so widespread in today's organizations.
7. Understand what system integration is and how it relates to projects.

Box 1.1: Projects and People: Exxon's Merge with Mobil

Exxon's 75 billion takeover of Mobil created the world's largest corporation and the world's largest SAP systems integration project. SAP is a software solution that accommodates all of the corporations' accounting, finance, marketing, production, and exploration initiatives. This collection of software systems has come to be known as enterprise resource planning systems or ERP systems. ERP systems are the heart and soul of any firms' software infrastructure. In order for the two firms to merge, their ERP systems also had to be merged. The merging of the two firms' ERP systems created a system that had to support a combined global operation with annual revenue of more than $200 billion and 115,000 employees. Because of the global nature of competition, the Federal Trade Commission allowed this merger.

This merge and the resultant merging of the two firms' information systems caused more integration to take place. The integration enabled the two firms to eliminate inefficiencies and redundancies. For one, only one administrative structure is required to run the company, whereas two were required before. The merger of the two oil giants yielded cost savings in the billions annually. The merge was accomplished by a vast collection of projects. One of which involved the joining of the two SAP systems. Each project was carefully planned and orchestrated to be completed by a certain date to accommodate other projects and thus to finalize the merge of the two companies.

Nothing is more commonplace than change in the world of business today. Organizations change with a rapidity that is mind-boggling. And so it is with project management. What was considered good practice a few years ago is not so today. Like all disciplines, project management continues to evolve toward ever better practices and processes. A contemporary coverage of what constitutes "best practice" within the discipline of project management is one of the aspirations of this book. Because project management is a core competence for most firms, each firm must stay current with the practice of project management. As stated in the preface, one purpose of this book is to provide a contemporary perspective to this evolving discipline.

In this chapter, we provide an overview of project management. Increasingly, corporate executives are organizing the work around projects because doing so enables them to respond more quickly and efficiently to market pressures. The use of projects brings about integration. While integration shortens the time to complete a task and reduces cost, it also increases complexity because it ties so many different persons and goals together. This kind of situation gives rise to the need for tools to cope with the complexity, which we also discuss in this chapter. Systems thinking tools are discussed later in the chapter and in the Supplement to Chapter 2. These tools can assist managers and professionals in understanding the dynamic and detail complexity of the problems they are confronting.

These are the themes of this introductory chapter—simple project concepts, the attendant integration and complexity, and tools for coping with the complexity deriving from integration. By **integration** we mean the bringing together of various parts to achieve a whole. By **complexity** we mean a more intricate, involved, or complicated situation or scenario. In exploring these themes in this introductory chapter, we lay important ground-work for the chapters that follow.

As an example of the integration and consequent complexity that projects create, consider what takes place when projects are used in place of less structured work. When management decides to use a project format, a team must be created. The creation of a team causes integration to take place, often across traditional functional boundaries. Instead of working in relative isolation and independence, team members now work together. This integration expedites the timeliness and improves the quality of the work while reducing costs. But the integration also brings with it added complexity. Team members now have to communicate their work to the other team members. They must take time to share their beliefs, views, and mental models of the problem(s). The project manager should build consensus among the group and ensure that everyone is working toward the same goal. Clearly, there is added complexity. But, as we shall see, the bringing together of persons with varied talents and skills creates a result that far outweighs the risks associated with the added complexity.

DEFINITION OF A PROJECT

Projects are carried out by teams of professionals, directed by a project manager and intended by their stakeholders to create specific deliverables or accomplish unique goals. This definition of projects is similar to that of operations (processes that transform inputs like labor and materials into outputs such as goods and services). A project is actually a type of operation. As you are already familiar with operations, it is important to distinguish projects from operations. Projects have duration and are temporary as shown in Figure 1.1 below. Every project has a starting point and a stopping point. The project ends when its deliverable is created, when its goals are achieved. Operations that are not projects, by contrast, will continue indefinitely and are not bound by time, but by market demand for their deliverables. Operations are used to produce automobiles and appliances, whereas projects are used to build one-time deliverables like aircraft carriers, bridges, buildings and information systems (software applications, operating systems, hardware/software systems, etc.).

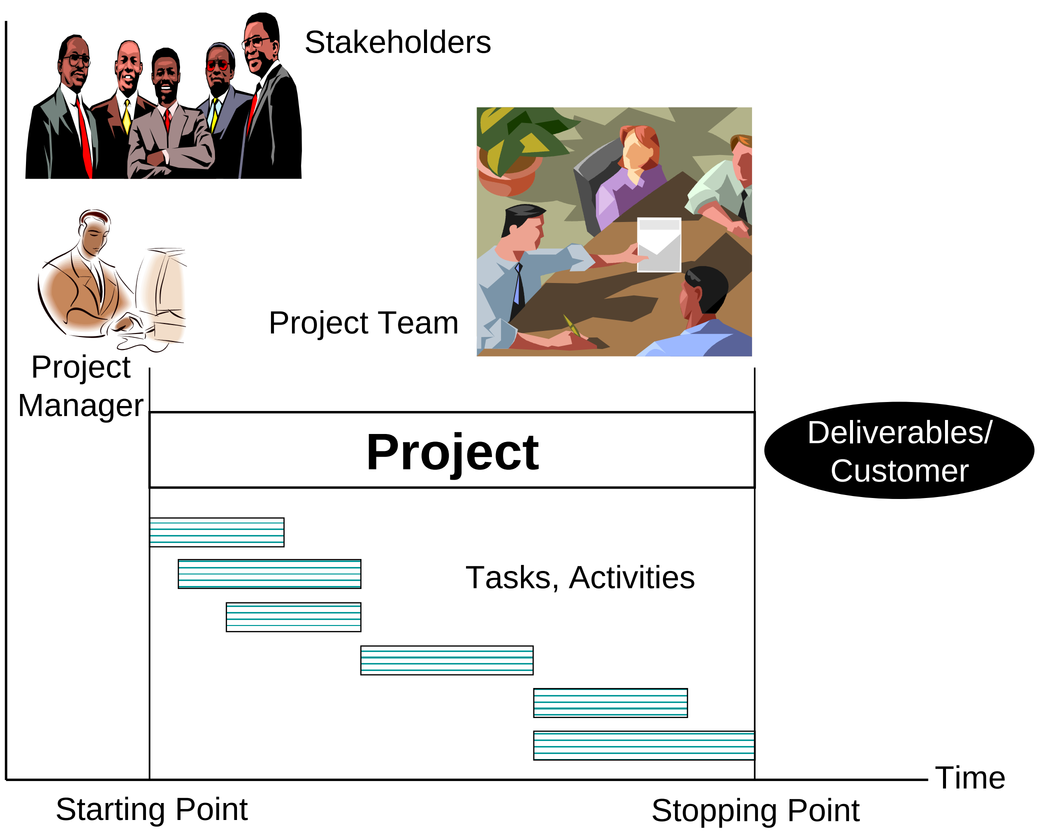

Figure 1.1: Components of A Project

Deliverables are systems, products, or services. Project deliverables are unique in certain respects and cannot be mass produced. For example, two different firms may both want a knowledge management system, but because of the way these firms acquire, retain and use knowledge, the knowledge management systems these firms will ultimately implement and install may be entirely different and unique. In this book we are interested in a specific type of product or deliverable—an information system, product or service. But the result or deliverable of a project can be as simple as a document or a presentation. For example, a project might simply entail a team assessing a customer's accounting system. After conducting interviews, the team might compile their findings into a report. The report becomes the deliverable.

Projects are organizational structures through which management and/or a customer addresses a particular problem. A team with the expertise to solve a problem focuses on it. Studies have shown that the most effective project teams consist of five to seven people, working on a single project until it is completed.

Projects are teams of people working toward a common goal with a common vision. Whatever the problem that a company is focusing on, upper management must select the right people to tackle the job. Team members may come from several functional areas—for example, from finance, human resources, and management information systems. Generally, the team has a project manager, who has the responsibility to keep the team moving forward and communicating progress to all stakeholders, among a myriad of other responsibilities.

Box 1.2: Projects and People: Student Term Paper Projects

Consider what is necessary to produce a term paper (often called a "term project"). You must first decide on a topic that interests you and the professor. Then you must research the topic, perhaps by searching on the Internet, and by going to the library. From the relevant materials, you compile a bibliography on 3x5 cards or on your computer. Then you must digest all of these materials. Having a topic in mind, you outline your paper and begin to organize your thoughts into sections and paragraphs. You then write. If your project runs on-schedule, you rest the night before it's due; otherwise, you stay up all night attempting to pull the project together on time. After the writing is done, you must proofread your paper for grammatical errors and search for content omissions. Finally, you deliver the paper to the professor.

What you have in your term paper is a logical progression of activities. **Activities** are tasks or steps that take time to complete; they have a starting time and a stopping time. Collections of activities or tasks are another way in which we can view and understand projects. Logically, some activities may precede others; conversely some activities may logically follow others. For example, you must compile a bibliography before you can outline your paper and you must outline your paper before you can begin to write it. Certainly, it must be written before it can be proofread, and so forth. The feeling of completion does not occur until you deliver it to the professor, on or before its due date. This last action is a milestone. A **milestone** is an instant in time at which a major event takes place, such as the completion of a deliverable and its transferal to the "customer." Milestones occur at the end of activities.

Thus the following activities for completing a term paper were identified and their progression is strictly sequential in this case.

TOPIC	DAYS DEVOTED TO IT
Select topic	2
Research the topic	5
Compile a bibliography and notes	4
Outline the paper	1
Organize your thoughts into sections	1
Write the sections	5
Proofread the paper	1
Deliver paper to professor	1

The total time required to complete the paper would be 20 days and each of the above tasks would be performed in sequence, one after the other by you, until they were all done.

As discussed in Box 1.2 and depicted in Figure 1.1, every project is made up of tasks or steps or activities[1]. There is usually a precedence order to the activities. You can't frame a house until the foundation and footings are in place; likewise, work on a foundation and footings cannot commence until a set of blueprint plans are created. For software projects, coding of a software system cannot be started until the requirements are well understood and there has been a well-designed response to those requirements. Thus, a precedence relationship exists among the tasks, what was described earlier[2] as a *logical progression of activities*. In addition, the tasks or activities are broken down into subtasks or sub-activities. The project manager may, in turn, further break the subtasks down into sub-subtasks.

At the same time a project may be broken up into a collection of subprojects. A project to install fiber optic Internet infrastructure throughout a campus might be broken up into subprojects, one for each major building and a subproject for connecting all of the buildings. All of these subprojects could then proceed independently and in parallel.

Projects always result in at least one deliverable or achieve at least one goal. In doing so, projects use human resources. Projects consume budgets and time and frequently materials. Budget and schedule are tracked against a plan. Specifically, project managers are concerned about the actual consumption of budget and time, taken in relation to the planned consumption of the same.

Typically, project personnel must be responsive to customers. The customer is usually the initiator of the project and the agency that pays for it. In a larger context, projects have stakeholders to whom the project personnel are accountable. In addition to the customer, stakeholders might include the upper-level management (to whom the project manager reports), and perhaps line management because line management provides the project personnel.

Project personnel use a process, often referred to as a methodology, to achieve the completion and goals of the project. For the past ten years there has been substantial and profitable focus on processes. The result has been significant improvement in processes relative to such measures as cost, quality, and cycle time.

Why Projects and Processes Are Important

Today, companies are organized around projects and processes. They are doing so because this approach makes professional people more accountable. With this form of organization, employees experience focus, vision, and purpose. There is a commitment to creating a project deliverable by a specific date that did not exist before a project structure was in place. There is a cost account to which the tasks that make up the project must be charged and there are specific deliverables and due dates expected of the project professional. When the project is complete, each project player is evaluated and eventually moves on to another project.

Over the last fifteen years, the realization began to develop that products are produced and services are delivered through processes. Processes, as much as products or services, constitute a firm's competitive advantage. Following the advice of such business gurus as Hammer, Champy, Hunt, Davenport, Taylor and others, many firms have developed a process focus. Previously, these firms may have concentrated on organizational structures, on resources or on the marketplace. By redesigning processes, firms have seen huge increases in productivity and tremendous improvement in the traditional dimensions of competition (cost, quality, time-to-market). But it has been recent developments in information technology that has enabled these vastly improved process designs. And, all of these redesigned processes were accomplished through projects.

[1] Unless explicitly stated otherwise, we shall use these words interchangeably.
[2] The student term project scenario involved a logical progression of activities.

At the same time, many firms began to develop a project perspective. Doing so meant establishing a deadline and budget for the work to be done. It meant completing one piece of work before starting the next. It meant working toward the project goal with some intensity. Projects force discipline upon the structure of work that makes it more focused. Projects are becoming the preferred way to accomplish almost everything that a firm undertakes. Process re-engineering initiatives are accomplished within the structure of projects. Projects are even used to re-organize firms around projects. Traditional organizational structures are not adequate to the task because of the increased complexity of work in general, because of competition, because timeliness and speed are critical and because customers “are king,” as we shall see.

We exist in the era of time and technology, in which time is of the essence and technology is its conservator. Our socioeconomic culture accepts innovations and technology with “open arms.” Therefore, getting to the market place first with the latest innovation and technology creates an advantage in terms of marketability of a product or service. Chrysler created the minivan market with its introduction of the Dodge Caravan in 1984. It is still the leader in sales of minivans. The American Airlines Sabre Reservations System was the first successful information system of its kind. With it, American was able to destroy its leading competitor, Braniff. Sabre is still the leading airline reservations system in the world. Results must come faster, decisions must be made quicker and deliverables must get delivered sooner, because, in the private sector, profit is at stake.

How to get work done quicker is a concern that receives special attention in this book. One way is to use teams and projects. Teams allow for work to be done in a concurrent fashion. This is best illustrated by Figure 1.2 that follows. Clearly, work that is accomplished concurrently is taking place in parallel, as illustrated below. Without teams and projects, work may be accomplished in a sequential fashion, as shown in Figure 1.3.

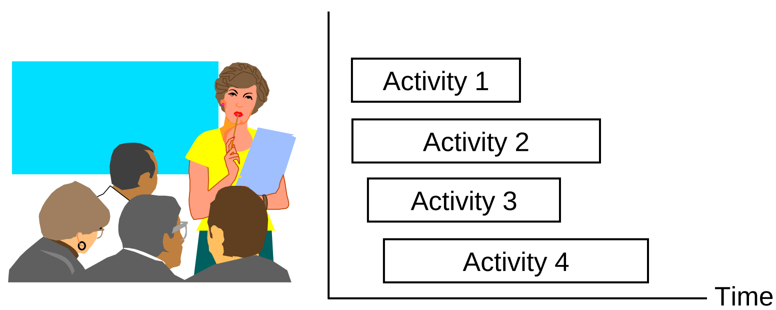

Figure 1.2: Concurrent Teamwork

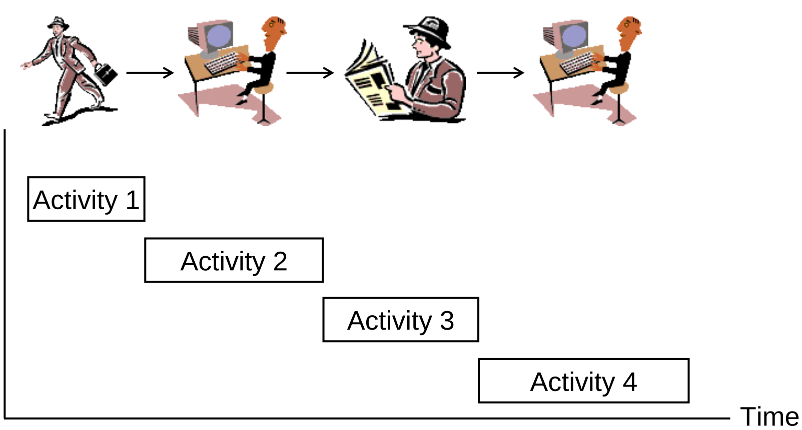

Figure 1.3: Sequential Work

Project management is integrative. It puts people of varied talents, capabilities and departments together in teams. Upper management gives the team a mission that energizes it and gives it direction. Team members can work on various aspects of the project in parallel. This enables the work to be completed *concurrently* as opposed to *sequentially*. For example, suppose a newly proposed software system required the approval of three people—a person in marketing, a person in manufacturing, and a person in accounting. If these people make up a team, they can get together and simultaneously review the system's requirements. Without the team structure, the proposed requirements might move serially—first to the marketing person, who might propose some changes. The requirements would then travel to the manufacturing person, who might also make some changes. If so, the revised requirements would have to go back to the marketing person. Eventually, accounting would evaluate the requirements, and this person in turn might make changes that would have to move back to both manufacturing and marketing. Companies just don't have time for this. By building a team, the company stands to complete the task faster, at lower cost, even with better quality.

Why Bad Things Happen to Good Projects

As the Standish Group CHAOS Report indicates, American companies spent $81 billion on failed IT projects and another $59 billion for IT projects that were not completed on time or within budget. Between 1995 and 1998, close to 70 percent of all IT software development projects were not completed on time or within budget[3]. The report suggested that bridge-building is a project type that gets completed on-time and within budget. According to the report, the reason bridge-building projects get completed on time and within budget is because bridge-building requirements, once determined, remain static and frozen until well-after the bridge is completed. Such is not the case for IT projects, however. IT projects are more difficult to execute primarily because their requirements do not remain static or frozen. Requirements are constantly changing, especially for software applications that support business processes. Customer requirements can change before the deliverable can be completed. When this happens, the project may be terminated before ever being finished.

Moreover, IT project requirements are inadequate when they are hastily defined without consensus on the part of the users. Inadequate or changing requirements are cited as the number one cause of project failure by project researchers in the Standish Group and elsewhere. When the project requirements are inadequate, the project doesn't get off the ground properly. During the execution phase of a project, the project "*ramps-up*" to full steam. Too often the project is ramped up without the project team having a clear vision of why the project was started and what exactly it is to accomplish. It doesn't have well-defined deliverables or a well-developed plan. There are no specific milestones.

What are other causes of project failure? Decades ago, projects were completed without consideration for the people who would use the resultant deliverables. This usually resulted in a software product that was either disliked or unacceptable to the users. The software application would not do what the users needed for it to do. The problem here was lack of user involvement in the definition and design phases of the project. Lack of user involvement is the second most cited reason, according to the Standish Report, for project failure. Without user involvement, the completed deliverable is almost certain not to satisfy the users and will need to be reworked. Today, it is commonplace for users and developers to work together as a team on a project. Users are empowered to define the non-technical requirements in terms of what the product does, and how rapidly it does it. The IS staff of developers decide how. **User involvement** produces many benefits. First, it builds commitment and ownership on the part of the users. This increases the likelihood they will use the deliverable once the project is complete. Second, users

[3] The Standish Group, "1998 CHAOS Report," 1998. Cabanis, Jeanette, "Standish Research Indicates IT Project Success," *PM Network*, September 1998, p.7.

can participate in some of the less technical aspects of the project, such as helping to prototype the user interface and creating user documentation.

Projects also fail because of a lack of adequate resources when they are needed. Consider the following scenario. At the beginning of a project, the project manager negotiates with upper-level management for the needed human resources. The project manager anticipated and planned that key persons would be available down the road for the design and construction phases of the project. But when the project reached that point, one of those individuals had left the company. Another had been assigned to a higher priority project, and the third was relegated to “putting out fires” in connection with a project that should have already been completed. It must make do with less-qualified personnel. The effect on the project is to cause it to be completed behind schedule, with greater cost and/or with less functionality.

Still another reason for project failure is scope creep. Scope has to do with requirements. **Scope creep** occurs when the requirements are somehow enlarged beyond their original definition and usually happens when requirements are not well defined. As the development team gets further and further into the project, they *discover*[4] that there is much more work than what had been originally planned or anticipated. Perhaps the technology called for in the requirements document can’t meet the performance specifications in terms of speed and reliability. Users that are online may expect sub-second response times[5] to any query they might pose to the system, for example. Depending on capacity and budgetary constraints, that may not be possible.

Another reason for scope creep stems from an inability by some developers to stay focused on just the requirements agreed to by both the users and developers. There is a tendency for developers to push the requirement boundaries out further, to enlarge the functionality of the deliverable. A developer says, “wouldn’t it be neat, if … the program automatically catalogued these transactions, instead of having the user do it manually.” When this happens, a developer may be getting side-tracked into some functionality that is not part of the original requirements, but represents, he believes, an extra piece of valuable functionality. But the functionality is not documented, and cannot be supported or tested. The problem with undocumented functionality is that it can result in schedule overruns as well as cost overruns to the project. Depending on the type of contract in place, the developer may be giving away functionality that should be charged to the client. Again, the problem is one of scope creep arising from discovery.

THE PROJECT MANAGEMENT KNOWLEDGE AREAS AND PROCESSES

As is the case for most disciplines, a professional organization springs up to foster, manage, and maintain professional excellence with the discipline. Such is the case for project management. The name of that institute is the Project Management Institute or just PMI. In 1996, PMI published its first body of knowledge called “*A Guide to the Project Management Body of Knowledge (PMBOK Guide)*.” The *PMBOK Guide* is now universally accepted as the standard for project management information, methodologies, and practices. To ensure a successful in managing projects, project managers regularly use this *PMBOK guide* as a reference for recognized tools, techniques, knowledge, and processes. The PMI maintains a body of knowledge for the discipline that it supports and provides training and certification relative to its

[4] In all of information systems project management, there will always be an element of “discovery” when relatively or absolutely new projects are undertaken. This is one risky aspect of projects. All too often the development team is unaware of exactly what will be entailed in the delivery of the product. As the team gets further and further along with the project, the team often discovers problems that must be resolved, but which were unanticipated and unaccounted for in the original planning and requirements determination for the software product.

[5] By “sub-second response time,” we mean the time to respond to any query or data input once the user presses ENTER is less than a second of real time.

body of knowledge. The two certifications offered by the PMI are Project Management Professional (PMP) and Certified Associate in Project Management (CAPM). Candidates must study and possess knowledge, skills, and competencies described in the body of knowledge.

Project Management Knowledge Areas

According to the Project Management Institute's Body of Knowledge, projects involve ten knowledge areas as depicted in Figure 1.4. These knowledge areas describe the key skill-sets or competencies that project personnel must develop. There are four core knowledge areas. These are shown on the left. The five remaining knowledge areas, displayed on the right, are considered to be facilitating ones. The four core knowledge areas include scope, time, cost, and quality management, while the five facilitating knowledge areas are human resource, communications, risk, procurement, and stakeholder. The knowledge area shown at the top of Figure 1.4 is known as project integration management. It is a ninth knowledge area providing for integration across the previously mentioned eight knowledge areas. Brief descriptions of each are provided below:

1. Project **scope management** entails conceptualizing and defining all the work required to successfully complete the project.
2. Project **time management** includes developing an acceptable project schedule, and completing the project on time.
3. Project **cost management** means determining a budget for the project and tracking the project's progress relative to that budget.
4. Project **quality management** ensures that the project meets its predetermined quality requirements.
5. Project **human resource management** refers to choosing the best human resources and making the most efficient use of them.
6. Project **communications management** involves establishing the communications discipline and technology[6].
7. Project **risk management** means the assessment and mitigation of risk.
8. Project **procurement management** entails acquiring the goods and services that are needed for a project.
9. Project **integration management** concerns with the integration of the other eight knowledge areas.
10. Project **stakeholder management** involves proactive management of stakeholders.

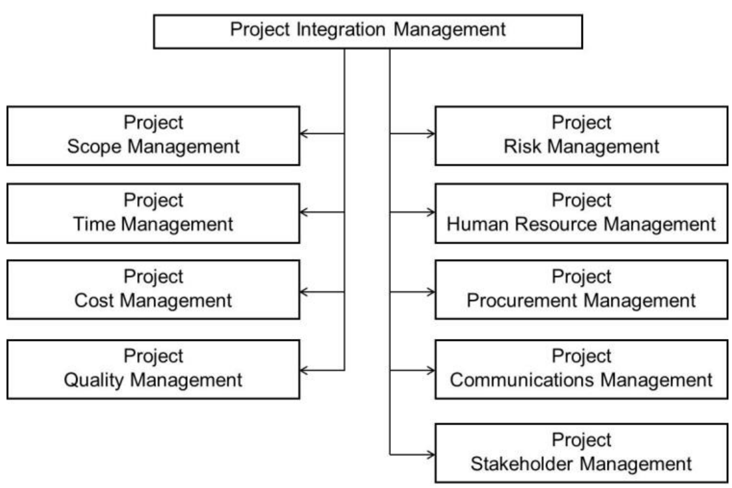

Figure 1.4: Project Management Knowledge Areas[7]

[6] Agreeing to send a status report once a week to all stakeholders by way of email establishes a discipline of "once a week" and a technology, "email."

Project Management Processes

As earlier mentioned, projects involve ten knowledge areas. Each knowledge area consists of process interactions, process inputs, outputs, and tools and techniques aiding managing a wide range of projects. Since the first publication in 1996, the *PMBOK Guide* has undergone various changes and revisions the most recent of which is the fifth edition, 2013. The fifth edition reflects the efforts to document more clarity and reduce ambiguity and redundancy in several aspects of project management practices. This revision represents the PMI's intent to remain proactive in a process of continuous development and improvement. Perhaps the most significant changes between the third and fourth editions are the addition, consolidation, removal, renaming of several processes. Table 1.1 compares the similarities and differences in the processes between the third, fourth and fifth editions of the *PMBOK Guide*.

Table 1.1: *PMBOK Guide*'s the Third, Fourth and Fifth Editions Processes Comparison

PMBOK 5th Edition (2013)	PMBOK 4th Edition (2008)	PMBOK 3rd Edition (2004)
Project Integration Management	**Project Integration Management**	**Project Integration Management**
- Develop Project Charter	- Develop Project Charter	- Develop Project Charter
		- Develop Preliminary Project Scope Statement
- Develop Project Management Plan	- Develop Project Management Plan	- Develop Project Management Plan
- Direct and Manage Project Work	- Direct and Manage Project Execution	- Direct and Manage Project Execution
- Monitor and Control Project Work	- Monitor and Control Project Work	- Monitor and Control Project Work
- Perform Integrated Change Control	- Perform Integrated Change Control	- Integrated Change Control
- Close Project or Phase	- Close Project or Phase	- Close Project
Project Scope Management	**Project Scope Management**	**Project Scope Management**
- Plan Scope Management		- Scope Planning
- Collect Requirements	- Collect Requirements	
- Define Scope	- Define Scope	- Scope Definition
- Create WBS	- Create WBS	- Create WBS
- Validate Scope	- Verify Scope	- Scope Verification
- Control Scope	- Control Scope	- Scope Control
Project Time Management	**Project Time Management**	**Project Time Management**
- Plan Schedule Management		
- Define Activities	- Define Activities	- Activity Definition
- Sequence Activities	- Sequence Activities	- Activity Sequencing
- Estimate Activity Resources	- Estimate Activity Resources	- Activity Resource Estimating
- Estimate Activity Durations	- Estimate Activity Durations	- Activity Duration Estimating
- Develop Schedule	- Develop Schedule	- Schedule Development
- Control Schedule	- Control Schedule	- Schedule Control
Project Cost Management	**Project Cost Management**	**Project Cost Management**
- Plan Cost Management		
- Estimate Costs	- Estimate Costs	- Cost Estimating
- Determine Budget	- Determine Budget	- Cost Budgeting
- Control Costs	- Control Costs	- Cost Control
Project Quality Management	**Project Quality Management**	**Project Quality Management**
- Plan Quality Management	- Plan Quality	- Quality Planning
- Perform Quality Assurance	- Perform Quality Assurance	- Perform Quality Assurance
- Control Quality	- Perform Quality Control	- Perform Quality Control

[7] Project Management Institute (PMI) Standards Committee, *A Guide to the Project Management Body of Knowledge (PMBOK)*, Fifth Edition, 2013.

Table 1.1: *PMBOK Guide*'s the Third, Fourth and Fifth Editions Processes Comparison (Cont.)

Project Human Resource Management	**Project Human Resource Management**	**Project Human Resource Management**
- Plan Human Resource Management	- Develop Human Resource Plan	- Human Resource Planning
- Acquire Project Team	- Acquire Project Team	- Acquire Project Team
- Develop Project Team	- Develop Project Team	- Develop Project Team
- Manage Project Team	- Manage Project Team	- Manage Project Team
Project Communications Management	**Project Communications Management**	**Project Communications Management**
	- Identify Stakeholders	
- Plan Communications Management	- Plan Communications	- Communications Planning
	- Distribute Information	- Information Distribution
- Manage Communications	- Manage Stakeholder Expectations	- Performance Reporting
- Control Communications	- Report Performance	- Manage Stakeholders
Project Risk Management	**Project Risk Management**	**Project Risk Management**
- Plan Risk Management	- Plan Risk Management	- Risk Management Planning
- Identify Risks	- Identify Risks	- Risk Identification
- Perform Qualitative Risk Analysis	- Perform Qualitative Risk Analysis	- Qualitative Risk Analysis
- Perform Quantitative Risk Analysis	- Perform Quantitative Risk Analysis	- Quantitative Risk Analysis
- Plan Risk Responses	- Plan Risk Responses	- Risk Response Planning
- Control Risks	- Monitor and Control Risks	- Risk Monitoring and Control
Project Procurement Management	**Project Procurement Management**	**Project Procurement Management**
- Plan Procurement Management	- Plan Procurements	- Plan Purchases and Acquisitions
		- Plan Contracting
- Conduct Procurements	- Conduct Procurements	- Request Seller Responses
		- Select Sellers
- Control Procurements	- Administer Procurements	- Contract Administration
- Close Procurements	- Close Procurements	- Contract Closure
Project Stakeholder Management		
- Identify Stakeholders		
- Plan Stakeholder Management		
- Manage Stakeholder Engagement		
- Control Stakeholder Engagement		

According to the current edition of Project Management Institute's Body of Knowledge, there are 47 processes comprising the ten knowledge management areas. Following is the brief overview of each process.

Project Integration Management

- Develop project charter—developing a formal document to authorize a project or phase.
- Develop project management plan—documenting the steps necessary to define, integrate, and coordinate all subsidiary plans.
- Direct and manage project work—performing the work according to the project management plan to meet the project's objectives.
- Monitor and control project work—tracking, reviewing, and regulating the project's status to achieve the planned performance.
- Perform integrated change control—reviewing, approving, managing change activities.
- Close project or phase—ensuring a formally complete project.

Project Scope Management

- Plan scope management—creating a scope management plan that documents how the project scope will be defined, validated, and controlled.
- Collect requirements—defining the customer's needs to achieve the project objectives.
- Define scope—identifying a detailed description of the project deliverables.
- Create WBS—decomposing the project work into smaller, more manageable components.

- Validate scope—reviewing the project deliverables to gain formal acceptance from the customer.
- Control scope—monitoring and updating the status of the project deliverables and managing changes to the scope baseline.

Project Time Management

- Plan schedule management—establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule./
- Define activities—analyzing the specific tasks to be performed to produce the project deliverables.
- Sequence activities—identifying logical relationships among the project tasks.
- Estimate activity resources—estimating needed resources, such as people, materials, equipment, to complete individual activities.
- Estimate activity durations—approximating the time required to perform each task.
- Develop schedule—developing activity sequences, durations, resource requirements and constraints to create the project schedule.
- Control schedule—monitoring and updating the progress of the project and managing changes to the schedule baseline.

Project Cost Management

- Plan cost management—establishing the policies, procedures, and documentation for planning, managing, expending, and controlling the project costs.
- Estimate costs—approximating the budget required to perform the project work.
- Determine budget—aggregating the estimate costs of individual tasks to create the project cost baseline.
- Control costs—monitoring and updating the status of the project and managing changes to the cost baseline.

Project Quality Management

- Plan quality management—analyzing quality requirements and/or standards for conducting the project and the project deliverables.
- Perform quality assurance—auditing the quality requirements and the results from quality control measurements to assure appropriate quality standards are executed.
- Control quality—assessing and recording the results of executing the quality activities and recommending required changes.

Project Human Resource Management

- Plan human resource management—determining and documenting project roles and responsibilities, and necessary skills for completing the project, and developing a staffing management plan.
- Acquire project team—ensuring needed human resource availability to perform the project work.
- Develop project team—improving individual competencies, team interaction, working environment to optimize project performance.
- Manage project team—observing team member performance, providing feedback, resolving conflicts, and managing changes to enhance project performance.

Project Communications Management

- Plan communications management—identifying the project stakeholder information needs and determining a communication approach.
- Manage communications—coordinating with project stakeholders to meet their needs and addressing concerns and issues that occur.
- Control communications—collecting and delivering the project performance reports, such as status reports, progress measurements, forecasting reports, to project stakeholders.

Project Risk Management

- Plan risk management—determining how to implement risk management activities for the project.
- Identify risks—defining which risks may affect the project.
- Perform qualitative risk analysis—prioritizing identified risks and assessing their relative probability of occurrence and effect.
- Perform quantitative risk analysis—numerically analyzing the impact of prioritized risks on overall project objectives.
- Plan risk response—developing strategies to deal with opportunities and threats to project objectives.
- Control risks—executing risk response plans, monitoring for identified, new, changing, and outdated risks, and evaluating risk process effectiveness throughout the entire project.

Project Procurement Management
- Plan procurement management—determining project purchasing decisions, identifying the approach, and finding potential sellers.
- Conduct procurements—requesting seller responses, evaluating and selecting a seller, and establishing a contract.
- Control procurements—managing procurement relationships, ensuring procurement obligations, and making necessary changes and corrections.
- Close procurements—verifying all work and deliverables are complete and acceptable.

Project Stakeholder Management
- Identify Stakeholders—identifying the people, groups, or organizations that could impact or be impacted by a decision, activity, or outcome of the project.
- Plan stakeholder management—developing appropriate management strategies to effectively engage stakeholders throughout the project life cycle.
- Manage stakeholder engagement—communicating and working with stakeholders to meet their needs/expectations, address issues as they occur, and foster appropriate stakeholder engagement in project activities throughout the project life cycle.
- Control stakeholder engagement—monitoring overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders.

PROJECT MANAGEMENT CONTEXT/CULTURE

Different firms provide different environments into which their projects get completed. Some firms support a project management office or PMO. The **project management office** is an organizational unit that centralizes and coordinates the management of projects. A project management office may provide a number of project-related services for the firm including training in project management, a career path for project personnel, the maintenance of a set of best practices for project management, boilerplate for project documents, etc. The project management office may dictate how projects, yet to be completed will be organized. Projects may be organized into programs or portfolios or both.

Sometimes collections of projects are organized together in groups, often referred as programs. Evidently, **programs** are collections of projects. The U.S. Federal Government uses this concept. For example, NASA's Discovery Program contains many projects. NASA engineers and scientists in the Discovery Program are responsible for exploration of our solar system. This includes a number of current projects, including a project to study the diversity of comet nuclei, a project to collect particles ejected by the Sun, a project to conduct a scientific investigation of the planet Mercury, the Mars pathfinder project which placed the Sojourner Rover on the surface of the planet Mars, and a project called Stardust which will collect and return a sample from a comet to Earth. NASA has many other programs, such as the International Space Station, the Galileo Program, the Space Shuttle Program, the Manned Mar Exploration Program and so forth. The construction of each module that comprises the International Space Station could be thought of as a project. The U.S. Department of Defense is also organized into programs and within those programs, projects are funded.

Projects may also be organized into **portfolios**. The purpose of a portfolio of projects is to determine the sequencing of projects in time and to determine from a value-added perspective which projects should be pursued next. Companies are always looking for the greatest potential gain for the least amount of expenditure. An optimization model of a companies' portfolio of projects can be formulated and solved. Such a solution tells the firm which projects to pursue, which to remain on hold, given the finite resources accessible to the firm.

UNIQUENESS OF INFORMATION, TECHNOLOGY AND BUSINESS PROJECTS

Projects dealing with technology, software, hardware, and systems are ubiquitous, yet often these are the hardest to manage. Information technology (IT) projects are especially difficult in part because they entail newness that is not present in other types of projects. Buildings, roads, and bridges have all been constructed many times. But when an IT project is undertaken, there are frequently unexpected paths that have never been traveled, and must be traversed to complete the project. The level of risk inherent in any IT project is correlated to the project manager's and team members' level of familiarity with the project. The more familiar these people are with the type of project, the lower is the risk, and vice versa.

IT projects tend to be bottlenecks in any initiative concerning corporate restructuring or change. In the mid 1990's, Texas Instruments merged two of its divisions. The company spent six months working out all of the merger logistics, but they spent 18 months reconciling all of the software differences. Frequently, business and industrial processes are re-engineered, and the software applications that support those processes must then be revised as well. The revision of the software to accommodate the re-engineered process always delays completion of the project. Typically, a non-IT person might complain, "Why can't those IT guys get their act together and finish their part of the re-engineered process in a timely fashion like the rest of us!" How to complete software projects faster to accommodate the rapidity of change is a major problem for firms today.

Within information systems, where software is being developed, one tendency of the IT project team is to spend more time on analysis to reduce **total life cycle cost** (the accumulation of all costs of developing and using the software). Most IT professionals realize that when management spends one dollar on development, it is planning to spend anywhere from three to five dollars down the road maintaining the new software. Software engineers perceive the solution to reduction of life cycle costs as one of spending more time and money on definition and analysis of the software product to ensure that the product meets its requirements. The rationale is as follows: "If we can do a better job getting the requirements right, we will spend less on maintaining the product down the road and total life cycle costs will be lower."

Improved requirements definition usually means spending more time on analysis. All too often, management doesn't have the luxury of spending a lot of time on analysis and getting the requirements absolutely right. Customers and competition are driving the rapidity of change upward. Goldman, et al., write, "Rapid, relentless and uncertain change is the most unsettling marketplace reality that companies and people must cope with today. New products, even whole markets, appear, mutate, and disappear within shorter and shorter periods of time." Moreover, the requirements for new software are changing so rapidly that once the project team gets them right, they will have changed before the software product can be designed, constructed, tested, and installed. Today, project managers must find ways of delivering the software product faster and at lower cost, yet with the required functionality. One way to do this is to use systems concepts. Systems concepts enable us to understand the dynamics of teams and thus what enables/motivates them to get quality work done more quickly.

Yet another way in which IT projects differ from construction projects is that visibility is significantly curtailed. If you're building a home and need for it to be completed by, say June 1st, you can check on its progress on February 1st, March 1st and so forth simply by driving by the construction site and visiting with the builder. Based on what you see completed, you can gauge whether or not the home will be completed by June 1st or not. In software construction, you may see little or nothing until the entire product is complete. There is significantly less visibility. If you ask, team members will tell you what you want to hear, namely that the project is on schedule, until it becomes evident to all concerned that a team member will not complete his assignment on time. This usually happens at a milestone or other occasion in which the team member has to hand-off a deliverable. By then it is too late. One way to address this problem is to have team members show the progress of their work on a regular basis, like every Friday afternoon.

A SYSTEMS APPROACH TO PROJECT MANAGEMENT

Organizational behavior and dynamics in project management can be described in terms of systems thinking. Because project management is an outgrowth of systems management, we will digress here and discuss the underlying principles of systems theory.

Systems theory attempts to integrate and unify scientific information across many fields of knowledge. Project management encompasses many disciplines. Specifically, project management includes operations management, operations research, psychology, sociology, and organization theory and behavior. In systems theory, problems are solved by examining the total picture as a "system." Projects are accomplished by processes which are a type of system. Processes, like systems, possess inputs, outputs, and use tools and techniques. Projects involve measures of performance which involve information feedback loops to assess performance in relation to plan or to a pre-established standard. These are just a few reasons to consider systems in a course on project management.

Projects do not take place in a vacuum. The products produced by projects have an impact that is much broader than the project itself. The project resources come from outside the project. Many of the stakeholders who judge the performance of the project reside outside the project. The project sponsor, upper management, and the client are stakeholders who do not actively participate in the daily activities of the project, but nevertheless do have an interest in the project and can have a significant impact upon it. Systems are used to study the interaction that takes place between the entity (the project in this case) and the environment it is embedded in. In order to understand the project within the context of the larger organization that is affected by the project and that affects the project, we need a systems approach.

SYSTEMS THINKING AND PROJECT MANAGEMENT

Project management always takes place within the context of a larger "system." A **system** is a collection of interacting components with inputs and outputs that exist together for a particular purpose, goal, or objective. Projects themselves are a kind of system with specific inputs like budget, time, and scope, and specific outputs like creation of one or more deliverables within the constraints of the inputs.

Our understanding of systems is reflected in the models of those systems we carry in our heads. As it is physically impossible to embed a system into our brain, we carry a model of it around instead. We call this a **mental model**. According to Senge, mental models "are ingrained assumptions, generalizations, or even pictures or images that influence how we understand the world and how we take action." Senge says "the discipline of working with mental models starts with turning the mirror inward, learning to unearth our internal pictures of the world to bring them to the surface and hold them rigorously to scrutiny."

Models are powerful cognitive aids that affect our thinking about problems and, ultimately, the decisions we make regarding those problems. The structural, causal, physical, computer, and simulation models[8] that we create ultimately affect our mental model of the problem at hand. That mental model is the basis for the decisions or actions we pursue. For example, a student observes closely her performance pattern in her classes to determine how much effort she will be required to expend to achieve the grades she wants. In her mind she builds a model of the desired end result and the actual condition. For example, suppose she is targeting a B in the course, but currently her grade is a low C. Her mental model tells her she must redouble her efforts to reach her goal.

Another example is two spouses examine their budget in relation to their aging automobile and decide whether to replace the auto or wait another year. In their minds they assess how much excess budget they have and whether this use of it constitutes the highest and best usage taken in relation to their values. In all of these instances there are deeply ingrained assumptions about life. In the case of the student, the deeply ingrained assumption is the grade of at least a B in her course. In the case of the two spouses, the question relates to their collective driving expectations, taken in relation to other opportunities to spend or save the excess budget. In each case a mental model is formulated as a basis for making decisions.

Our mental concepts of a situation represent the model we use as a basis for our conscious response to the situations life brings our way. Carefully formulated analytical models can influence our mental models and improve the quality of our decision making. The question, then, is not whether to use models; we always use them to make decisions or take actions, even if they are only mental models. It is rather how thorough, complete, authentic, and accurate are the models we use.

In the physical sciences, scientists use simulation models as the basis for developing strategies to improve the behavior of a given physical system. Using a computer model of the gravitational attraction acting on a spacecraft, scientists can determine an optimal direction, thrust, and time duration of a *burn* that will take the spacecraft from launch site to earth orbit. Such a burn is a kind of policy or strategy for getting from one point to another. Evidently, a policy can be used to *drive* the system from one state to another more desirable state. The technology for finding such policies has been available for decades. It boasts a number of remarkable and dramatic successes in the aerospace sciences, the most memorable of which was leaving footsteps on the moon.

As is true of the physical sciences, successful applications of models in the behavioral sciences are myriad. Again, what is required is a model of the system concerned. Unfortunately, however, the behavioral sciences lacked the historical presence of a Sir Isaac Newton to set forth the laws of motion governing all behavior. For this reason, computer models of behavioral processes were nonexistent prior to 1960. The absence of behavioral models before 1960 can be explained by the facts that (a) behavioral processes may be more complex than physical systems, and (b) there was no requirement for a thorough understanding of such systems prior to that time period. That situation has changed today as humans find themselves confronted with a host of societal enigmas—energy, food, and resource shortages, deterioration of the environment, inflation, recession, bureaucratization, loss of satisfaction in work, poverty, deforestation, alienation of the youth, disregard for law and order—the list could go on and on. Models can help us make better decisions concerning systems, processes, and projects. In subsequent chapters, we will address questions such as “What form do these models take?” and “How are they fabricated, validated, and used?”

[8] Simulation models endeavor to characterize the behavior of a system or process over time. Such behavior is determined by the inherent structure of the system and the parameter values used in it.

Models and Modeling

Numerous definitions of models are particularized to a specific class of systems. The following definition is more general than most: "A **model** is a qualitative or quantitative representation of a process or endeavor that shows the effects of those factors which are significant for the purpose being considered.[9]"

The reference to *purpose* in this definition is significant. All models contain information about the system; however, they contain less information than is contained within the system itself. The purpose relates to the quantity, type, and organization of the original system's essence into a model. The amount of detail that should be included, for example, relates to purpose. The fact that the model contains less information than is contained within the real system is an advantage for the person building the model of the system. Because the model contains less detail than is contained within the system, the model simplifies the situation by eliminating superfluous detail. For decision makers, all aspects of the real situation not relevant to the purpose of the model should be ignored. This helps all of us to see the whole of the system and not just the parts. We do not want to be accused of not seeing the forest for the trees. As Senge pointed out, no more poignant example of this exists than the U.S.—U.S.S.R. arms race that lasted from 1950 to 1990. The U.S. saw the buildup in U.S.S.R. arms as a threat to Americans and increased spending on U.S. arms, resulting in more U.S. arms. Soviet leaders, on the other hand, saw the same threat; namely, they saw U.S. arms as a threat to Soviets and therefore increased spending on U.S.S.R. arms, resulting in more U.S.S.R. arms. Neither side saw the cycle of escalation brewing here, in spite of the abundance of systems analysts working the arms race problem for both sides. These analysts were immersed in the details of analyzing the other sides weapons complexes and nuclear arsenals and in running complex computer simulations of attack/counterattack war scenarios. They were so involved in the details that they did not fully comprehend the dynamics. This is what superfluous detail can do to good quality decision making.

For complex systems, however, all elements are relevant to the stated purpose. If you were asked to study the arms race to find a way to bring an equitable end to it, chances are you would get involved in counting intercontinental ballistic missiles, nuclear warheads, nuclear submarines, battleships, aircraft carriers, etc., on each side, to ensure equity. The model builder is consequently faced with the difficult problem of defining the relative relevancy of different elements of the real situation. This is one reason why model-building is still largely an art. Model-building will become a science only after the techniques for deciding what information is relevant (and what is not) are well-defined and standardized.

Why is all of this discussion of systems and models in a book about project management? Before any project can be undertaken, the stakeholders and the selected project manager must create a variety of system models. First, a model of the deliverable must be developed; this model assumes the form of a requirements document. Second, a model of the overall process by which that deliverable will ultimately be developed must be created. Such a model might be implemented in a project management software package like Microsoft Project. The creation of all such models involves the use of systems concepts. In the next section, we discuss another reason why systems concepts are so important in the world of project management.

The issue of relevance is closely akin to the more contemporary concept of "value-added." In a sense, to say that an activity doesn't add value is to say that the activity is not relevant. Therefore, the concept of "purpose" as a criterion for deciding which activities to include

[9] Austin, Larry and James Burns, *Management Science: An Aid for Managerial Decision Making*, New York: Macmillan, 1985, p. 8.

in a process model and which to exclude is pertinent. In the chapter on methodology for project management (Chapter 4), the use of these concepts in establishing a process model or methodology for completing a project of a particular type will be discussed.

Models of Time and Cost

The most common form of a model of time is shown below in Figure 1.5. The activities are on the left, and the time sequencing of the activities is on the right. The "calendar" on the right shows what activities will be performed when. The model is a schedule, a plan for completion of the project. More will be said about such models in the Chapters on planning (Chapters 7 and 8).

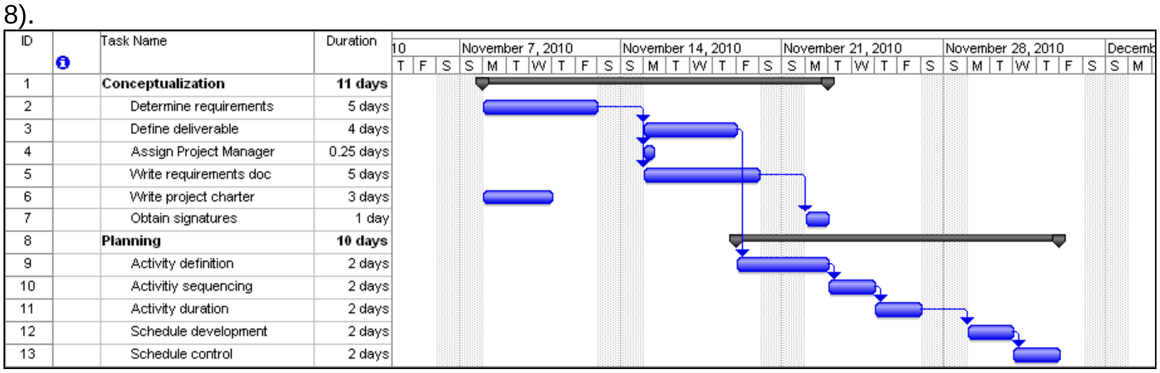

Figure 1.5: Microsoft Project's Model of How the Project will Progress Over Time

In this model, activities (tasks) are listed on the left and a chart known as a **Gantt chart** is exhibited on the right. Using a timeline, Gantt charts show when those activities will be performed. Some activities are to be completed before the ones following them can start. This is indicated by a link with an arrow attached. The horizontal bars in the chart on the right show starting dates, stopping dates, and durations for each of the activities exhibited there. For example, the task "determine requirements" has a start date of November 8, 2010 and a stop date of November 12, 2010. It has duration of five days.

Exhibited below is a model of cost showing how costs will accumulate over time. In this model, expenditures are running at $5,000 a month for months 1 and 2. After two months, accumulated expenditures are at $10,000. After twelve months cumulative expenditures are running at $48,000. This is a model of monthly and accumulated costs.

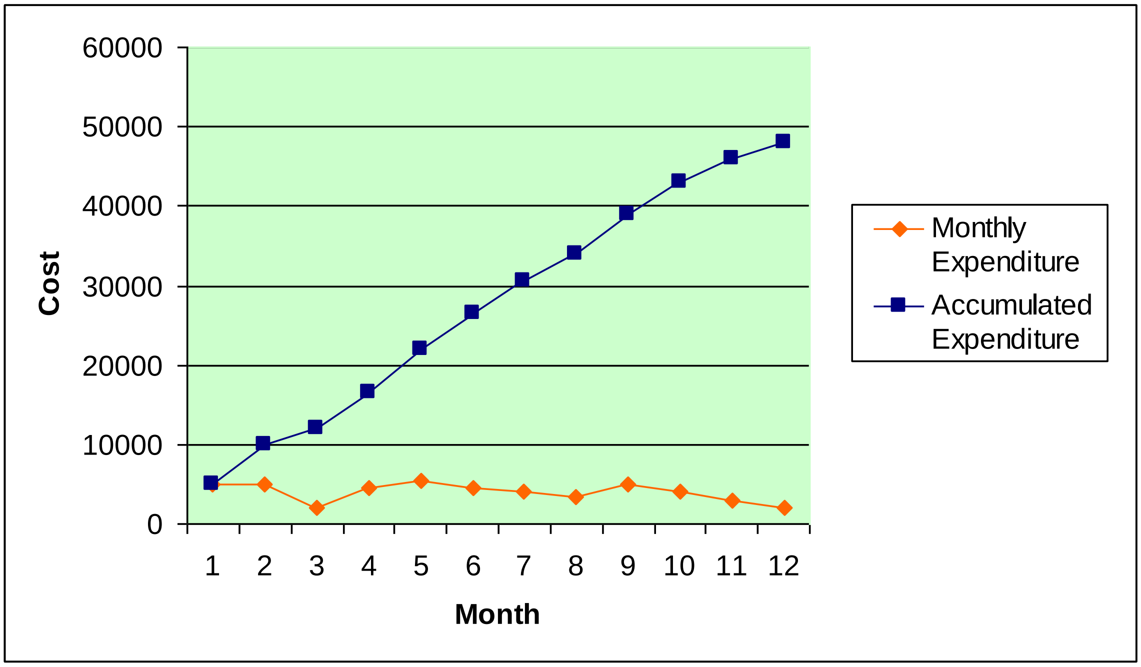

Figure 1.6: A Model of Accumulated Cost Expenditure Over Time

Exhibited below is a model of precedence relationships among activities that make up a project. Activities (tasks) that appear on the left must precede those that appear to the right. The exact nature of the precedence is indicated by lines connecting the boxes. This diagram shows precedence only; it does not display boxes as bars on a calendar as does the previous chart exhibited in Figure 1.5. The model of precedence relationships shown in Figure 1.7 is called a network diagram. As its name suggests, a **network diagram** is a picture of what activities must precede what other activities. Boxes exhibited in red are on the critical path. The **critical path** is the longest path through the network and the path that determines the duration of the project. If a task on the critical path is late, it will make the entire project late.

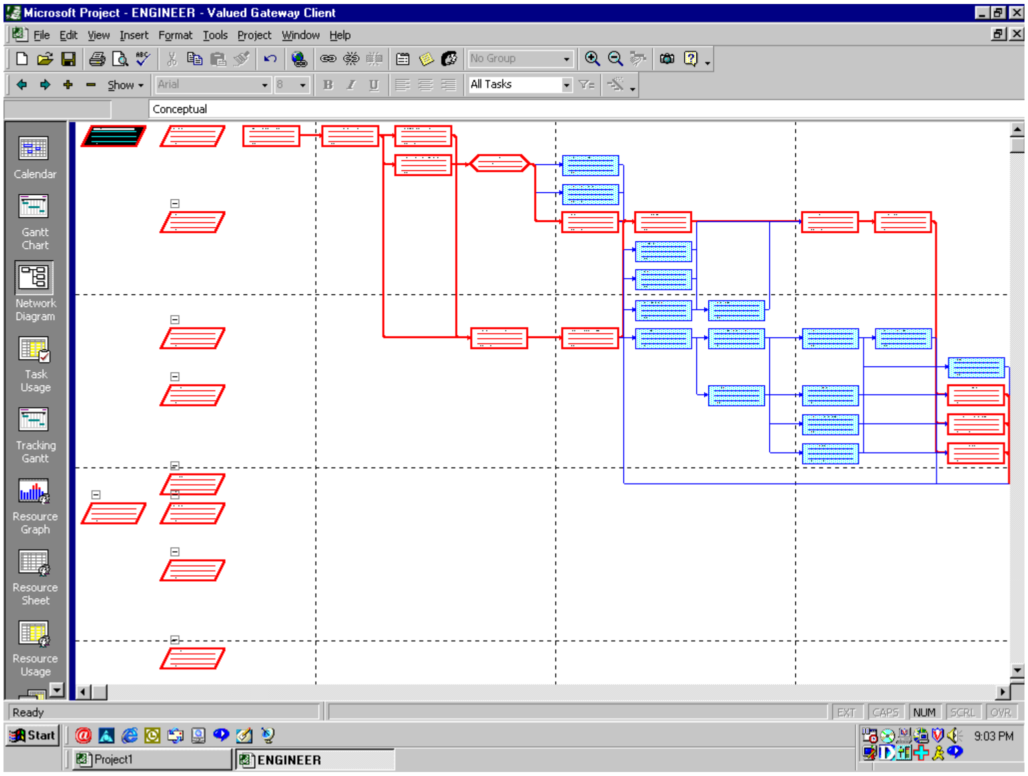

Figure 1.7: Microsoft Project's Network Diagram: A Model of Precedence Relationships Among Activities

Models like this appear throughout this book. They enable us to know what to do next, to assess level of effort, to monitor progress according to plan, and to take corrective action.

As further examples of the need to treat projects as systems, consider that a change in one part affects the project in every part. For example, if resources are removed from one part of the project and placed elsewhere within the project, the affect is felt everywhere. Suddenly, as depicted by the models presented above, some tasks now take longer while others take less time. Start and stop dates of all subsequent tasks are affected. Expenditure will also be changed; there may be less expenditure early on in the project and more later.

As a further example, if the requirements for the deliverable of the project change, then the entire project is affected. Frequently, this will lead to a later completion date and an increase in total expenditure, but it could also lead to outright cancellation. If one person begins to talk negatively about the project manager, then eventually everyone is impacted by the diminishing remarks. If one person slacks off and doesn't do the assigned job, then the rest of the project team must make up the shortfall of undone work. Because of the complex nature of the interactions, we need to treat the project and its attendant processes as a system so we can model that system with the intent of better understanding and managing it.

Today's Modern Business Enterprise

Modern business enterprises use information technology to integrate (the Supplement to this chapter contains extensive discussion on system integration), monitor, and control all of its functions. Walls between marketing and engineering, engineering and manufacturing, and manufacturing and sales will be effectively removed and these departments will be integrated by the use of information technology, cross-functional work teams, and project management. Projects and processes will reign supreme and be seen as core competencies.

With over one billion desktop computers now available worldwide, the PC has become the window into the enterprise. Distributed computing architectures have made better use of the processing power that exists on desktops while making enterprise data more accessible. The networking of these machines has facilitated workgroup computing and collaborative processing, which are virtual ways of enabling groups or teams of individuals to work in a more powerful, cooperative fashion. For most large organizations, mainframe computers will stay in place for some time, to support very large databases involving many terabytes of data and to support high-volume, real-time transaction processing systems. However, distributed computing, Internet-supported systems are the computing paradigms of choice for decision support systems, mail systems, and low-volume, real-time transaction-processing systems in most division and departmental computing environments.

Workflow computing is contributing greatly to the integration of the enterprise and enabling firms to deliver products and services faster, with better quality and at lower cost. Workflow computing is integrative in the sense that it brings work places and people together, and gives them a central point of control over the process. There is much work remaining to be done in this area. Digital communications will be increasingly important in the enterprise of the future, as companies transition from traditional analog communications to the digital variety. Digital communications will enable the integration of PC, work stations, telephones, copiers, fax machines, and many other computing devices, regardless of location. It will be possible to integrate data, text, voice, video, and images in real-time.

Hair-thin strands of fused sand will make all of this possible through a technology known as fiber-optics. Traditional communications devices such as telephones and fax machines are “endangered species” as these technologies are being integrated with PC's into single devices. Consider the portability realm for a moment. For the short term, portable computers with wireless digital communications capability, cellular telephones and personal digital assistants will co-exist. Then all of these devices will be integrated into a single appliance.

Systems and Integration Concepts

According to Forrester, understanding a concept is easiest to acquire in those areas where knowledge has been structured and organized. Consider the tremendous changes that have occurred during the last century in the science curriculum as compared to the state of the liberal arts curriculum. A liberal arts education has been essentially the same over the last century, while the science curriculum covers at the high school level what was, just a generation ago, at the cutting edge of scientific knowledge. Forrester attributes this accelerated pace to the scientific concentration on exposing the systematic structural relationships that underlie the observations of physical behavior. In other words, writers in the sciences have structured scientific knowledge in comprehensible packets that begin with a set of primitives. This being the case, let us digress a moment to define and describe the primordial concepts—the primitives on which everything else is based. These primitives define the perspective by which we shall endeavor to describe and characterize the business world.

Systems are Comprised of Systems

Every system is itself comprised of other systems. Thus every system has subsystems embedded within it, and every system is part of a larger (super) system. This subsystem concept gives rise to the construction of pre-fabricated components that can be rapidly assembled into a complete system. This principle enables systems to be decomposed because systems can be perceived as assemblies of subsystems. Decomposition is an often-used technique in project management for determining how much work will be necessary to complete a project. We call the subsystem concept the system principle of decomposition.

Systems Possess Hierarchies

As the organizational chart of a firm usually suggests, there are those whose responsibility is to coordinate the functions of others, usually subordinates. Hierarchies are commonplace in projects. Project managers supervise project leaders who supervise project professionals. At the same time, project managers report to the project sponsor, the project customer, and upper management. The processes used to complete projects possess, by virtue of the precedence relationships among the tasks, a kind of hierarchy in which tasks are performed. Haines alludes to hierarchy as one of the most common characteristics found in all systems.

Taylor suggested that our software structures must mimic our organizational, business and enterprise structures, including the hierarchies. In this way, there is only one model to manage—the organizational model and its underlying mirror image in software, not two. Thus software developers may create hierarchies of software components that represent the hierarchies exhibited amongst the components in the real world. All software development projects involve systems that can be decomposed into a hierarchy of subsystem components. Such decomposition is necessary in order to adequately plan a schedule and budget for a project. For example, a database system may contain a user interface, a business logic component and a data management component. The user interface component may contain a variety of screens with menus and toolbars. The specific construct that we use to do this decomposition is called a **work breakdown structure (WBS)**. As one last example of the embedded, hierarchical nature of systems, consider the following:

The universe contains the galaxy, which contains the solar system that contains the planet Earth, which contains the country you live in (such as the U.S.), that contains you. Conversely, subatomic particles are contained within the atom that is contained within a molecule, that is contained within a cell that is contained within a body part or organ, that is contained within you. Here are two distinct hierarchies leading to the individual (you) as a system. In the first case, you are the smallest and least significant of the subsystems and embedded in all of the systems that contain you. In the second case, you are the largest and most significant of all the described subsystems and all of the described subsystems are contained within you. An example of the above is shown in Figure 1.8 below.

Figure 1.8: Systems are Embedded Within Larger Systems Which are Embedded in still Larger Systems

Similarly, it is true that projects are composed of projects and that many small projects can be integrated together to create a large project.

Systems Have Boundaries

Every system has a boundary that separates the content within the system from the content outside the boundary. Firms make decisions about what should be included within the system and what is outside of the system based on 1) what can be influenced by a manager of the system and 2) what can be observed by a manager of the system. If a particular component can neither be influenced nor observed by a particular manager, then the manager cannot control it, and the manager cannot observe it. Thus, that component is considered to be outside of the manager's system. The boundary that circumscribes a particular system is very much determined by the manager's perspective of that system. Thus, the boundary and contents are defined with a specific manager, owner, or administrator in mind. His or her perspective determines the boundary as well as the content of the system. The concept of “boundary” becomes very important when we consider such definitional issues as project scope, content, and related matters in Chapter 3. Even the universe system is finite.

Systems Possess Inputs and Outputs

Consider the human system once again. We take in food, air and water and transform these inputs into an output called work. Thus, systems convert inputs into outputs through what is known as a transformation process. The outputs are closely monitored and the inputs and process are adjusted to ensure that the desired outputs are achieved. For projects, the inputs are time, money, resources and scope (or requirements). The outputs are the deliverable, the actual finish date, and the actual completion cost. Sometimes in IT projects, the outputs are only observed on certain dates, as opposed to continual observance of the outputs. As owner of a new home I am having constructed, I can go to the job site and watch its progress every day. As the person in charge of a software project, I may only be able to observe its progress on certain dates at which milestones are completed and presented to me. The milestone dates are the only dates at which I can really observe the progress on the software. This is a visibility issue and it creates problems from time to time; we will address this issue elsewhere in this tome.

As we look at processes, again we find inputs and outputs. We shouldn’t be surprised; after all, processes are simply a type of system, as discussed in Box 1.3.

Box 1-3: Processes in Practice: Processes as Systems

Processes are special types of systems whose purposes are to create a product or produce a deliverable. As such, processes are embedded within processes. An example of a process as a system might be a change management process embedded within an execution and control process which is part of the larger lifecycle process. Processes consist of hierarchies. This will become apparent in such Figures as 3.2, 4.1, and 5.1. Processes have boundaries. Since processes are exclusive in terms of what they contain, naturally they have boundaries. Processes have inputs and outputs. In fact, processes transform inputs into outputs, as exhibited by the following.

We can transfer everything we know about systems to processes, because processes are simply a special type of system. Because processes are so important, we will, from time to time, include process boxes like the one used here in forthcoming chapters.

SUMMARY AND CONCLUSIONS

Projects are temporary endeavors that are accomplished by teams of professional people who are directed by a project manager. Projects always have a specific goal or goals. That goal usually takes the form of a deliverable. Projects have a definite starting date and usually a defined ending time as well. Projects consist of steps or activities. The activity sequence is the logical progression of activities. The collection and sequence of activities used is referred to as the process or methodology for completion of the project. The processes used within projects consume inputs—time, money, etc., apply the tools and techniques, while transform them into outputs.

As is the case for industry standard, the Project Management Institute (PMI) published *A Guide to the Project Management Body of Knowledge (PMBOK Guide)* as a reference for accepted tools, techniques, knowledge, processes and practices. According to *PMBOK Guide*, projects involve ten knowledge management areas: four core knowledge areas, five facilitating knowledge areas, and an integration knowledge area. Each knowledge area consists of various processes and activities to be performed by the project team.

The nature of global competition, the competitive pressures of time, cost and quality have forced companies to organize around projects and processes. By focusing on processes, firms can find ways to bring a product to market faster, cheaper and with better quality. Companies are recognizing that project management is a core competence and that a project-oriented culture is desirable. Indeed, some firms are even establishing a project management department to facilitate the development and growth of project professionals that will eventually become project managers.

Information technology projects, compared to almost any other type of project, are more difficult to complete on time and within budget because IT projects entail greater risks and uncertainties. Prior to 1995, 31 percent of IT projects were canceled for several reasons. Chief among these was the fact that requirements tend not to be as well-defined or as static as in, for example, construction projects. In other cases, user error or inadequate top management supervision resulted in numerous failures. Some projects don't get off the ground properly. Others fail because of lack of adequate resources. Still, others fail because they take too long and requirements for the deliverable change during the course of the project. Often, these projects are scrapped. Still, other IT projects fail because of scope creep. IT projects tend to be bottlenecks when they are undertaken in conjunction with other restructuring projects. In such situations, IT projects take longer than the other projects in a business climate where the fastest firm is also the most profitable.

More so than ever in the history of mankind, the planet is becoming more and more integrated and connected. This trend is expected to continue unabated well into the 21st Century. The Internet and its Information Superhighway replacement does this. The tearing down of political and trade barriers does this. The removal of organizational walls, "stovepipes" and "silos" does this. And the use of information technology projects does this, as does the deployment of the deliverables of IT projects. The philosophical question then becomes one of "when will firms have 'arrived' at the ultimate (or at least a higher) integrated state and will they be happy with it once they get there?"

System integration has become important because it is a means by which firms achieve strategic advantage over their competitors. The rules of engagement in the 21st Century prescribe the competitive environment in which firms find themselves. Those rules mandate the removal of trade barriers and such removal creates a marketplace in which there are global competitors of substantial means. To survive, a firm must be "world class." Nevertheless, with every passing year there are fewer competitors as some firms are acquired while others fail. It is system integration vis-à-vis information technology that enables firms to deliver better-quality products to the marketplace faster and at lower cost. Projects are the means by which system integration is achieved. In fact, projects themselves yield a kind of integration of human resources that would otherwise be nonexistent across departments and functions of the firm.

Systems thinking provides the basics, the structure on which everything else is built. That structure enables us to learn faster and retain what we have learned longer. At the same time, systems thinking concepts provide a vehicle for understanding the complexity that is being created by the integration that is taking place. To paraphrase Senge, people and projects are often immersed in structures that they do not understand. Consequently, they do not know how to cope with the problems that confront them. Systems are comprised of systems, they have hierarchies and boundaries, and they possess inputs and outputs. We use models to delineate all of these characteristics of systems. And because processes are a type of system, processes, the mechanisms by which projects are brought to completion, have all of these same system characteristics, as well.

Because systems concepts permeate modern project management, it is important that project managers are aware of these cyclical mechanisms of causality and try to break these cycles when necessary. Systems-thinking helps project teams to find leverage points where substantial change to the system can be effected with minimal effort. Systems cannot be defined or described without also discussing models. In fact, model building is what systems-thinking project people do. They build and use many models to enable them to better understand the dynamics of the processes and projects they are dealing with. Among the ubiquitous models are project plans of how, ideally, the project will proceed over time. Projects are completed by the use of processes.

DEFINITIONS

Activity—a task or step within a project that takes time to complete, has a starting time and a stopping time

Architecture—the overall structure and design of a system

Boundary—the artificial or actual separation between what is and what is not a part of the system of interest

Causality—the causal connections between the various components that make up a system

Complexity—said of some systems when the number of components and interactions between them is large

Core Competency—the competencies that most affect a company's bottom line

Creativity—the ability to bring new ideas, concepts, innovations to the attention of others

Critical Path—is the longest path through the network and the path that determines the duration of the project

Deliverable—the end product produced by a project and delivered to a customer

Enterprise—the collection of firms that taken together create an end product from scratch

Feedback—information about outputs are fed back to a decision point which adjusts inputs to make the outputs conform to desired outputs

Gantt Chart—using a horizontal time line; this chart shows when activities will start and end

Hierarchy—an ordering or ranking of tasks, components, systems

Inputs—the information and materials needed by processes to create the required outputs

Learning Organizations—organizations that pilot innovations, and if successful, adopt them for use by the organization as a whole

Mental Models—the mental constructs people use as a basis for making decisions

Model—a representation of a real-world system that contains only the essential elements relative to the purpose of the modeling exercise

Network Diagram—a picture of what activities must precede what other activities

Open/Closed System—an open system is one that can be influenced or changed by its environment; a closed system is just the opposite

Outputs—the deliverables of any process or project

Program—a collection of related projects each of which contributes to an overall larger purpose

Portfolio—a collection of projects yet to be undertaken that are being contemplated

Project—a collection of tasks which taken together accomplish a goal

Project Management Office—an organizational unit that centralizes and coordinates the management of projects

Scope Creep—when project scope tends to get enlarged beyond its definition in the requirements document as the project proceeds

Shared Vision—the vision held in common by a team of people working toward a shared goal

Simulation—a specific type of model in which the dynamics of the process are characterized over time

System—a collection of components, parts which taken together achieve a purpose or accomplish a goal

Systems Thinking—a way to view and frame what we observe in the world

Total Life Cycle Cost—all costs associated with developing and using the software over its lifetime, so development and maintenance costs

User Involvement—when users are involved in the determination of requirements, analysis, design, construction and testing of a technology product

Work Breakdown Structure—a graph or structure that delineates the total scope of work involved in accomplishing a goal or creating a deliverable

EXERCISES

1. Describe what is meant by the catch 22 in software developments.
2. Describe what is meant by a logical progression of activities.
3. Explain why bad things happen to good projects.
4. Who has ultimate responsibility for the success or failure of a project? Why?
5. The new tools being applied to problems and decisions assume the form of models. What is a model?
6. How has client server architecture facilitated integration?
7. Name and briefly describe at least three basic concepts of systems.
8. What do project managers, team leaders, and team members use models for?
9. According to Forrester, when is understanding of a discipline easiest?
10. Describe the system principle of decomposition.
11. According to Lester Thurow, what three things must America do more of?
12. What is fundamentally different about simulation models as compared to verbal models?
13. Describe how systems theory is used to solve problems.
14. What does systems thinking create a need for?
15. Describe what is meant by the art or process of modeling?
16. Will the process of modeling ever be reduced to an exact mechanizable science? Why or why not?
17. Describe why ignoring all aspects of a problem not relevant to the purpose of the model is an advantage?
18. What are the steps to the process of modeling?
19. Why are systems important in a book on project management?
20. Provide some examples of integration (social, organizational, or technological) that you are aware of?
21. List ten technologies that support systems integration.
22. Name and describe some visual models used by project managers and personnel?

PROBLEMS

1. Develop a hierarchical organization chart for a typical university system. Begin with the chancellor or president and proceed downward to a provost, dean, department chairs, and faculty. This is a model of the reporting authority for the university system.
2. Provide some examples, as suggested in this chapter, of integration, technological, political, organizational, structural, or otherwise. Can you think of any counter examples?
3. What do you think is driving the “whole world” toward more and more integration? What values, gestalts, paradigms has the world bought into that are pushing it in this direction?
4. Having hypothesized that complexity leads to chaos and catastrophe, what solutions need to be implemented now to cope with the complexity being created by systems integration?

5. Project management was described in this chapter as integrative. Describe how project management creates integration within and across organizations. Since integration has been characterized as having a dark side to it, can you think of any negative effects created by extensive use of project management?

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SUPPLEMENT 1.1: SYSTEM INTEGRATION

In today's world, the phenomenon of integration is paramount and pervasive. Just as physical and psychological walls are coming down worldwide, so are corporate walls between firms and among departments within a firm. Everywhere people are finding ways to work together to achieve win/win goals. The Berlin Wall crumbled and the two Germanys were integrated. The Iron Curtain is gone and the former Soviet Union seeks help from (integration with) the West as it endeavors to privatize its economy. Trade "walls" and barriers are disappearing as agreements like the North American Free Trade Agreement (NAFTA) and the General Agreement on Trade and Tariffs (GATT) are enacted. The end result is **integration**—people working together to achieve mutual or disparate goals. As the article at the beginning of the chapter suggested, mergers like the one that took place between Exxon and Mobil entail projects. These projects produce deliverables that result in integration.

Integration of systems and processes is ubiquitous. How to create coordination, collaboration, cooperation, communication, and consolidation are subjects of intense interest around the world. Nothing less is at stake than the material standard of living that we all enjoy. People expect companies to be the champions of our collective material standard of living. And companies deliver by creating jobs and paying salaries to the jobholders, by paying dividends on shares of their stock to the shareholders, and by generating products and services at competitive prices. Everywhere, companies create wealth—the means by which people can look after their material needs.

With increasing global competition, it is becoming ever more difficult for companies to hang onto market share and generate reasonable profits. Some firms are still trying to compete in the twenty-first century with nineteenth century strategies and processes. As we shall see, these no longer work. The trick for firms is to add more market value to the deliverable than they spend to create the perceived increase in value. And to add value in a sustained manner, firms must find strategies for shortening time-to-market while increasing quality and reducing costs.

Futurists like Alvin Toffler and Lester Thurow have important insights for us in this context. Thurow asserts unequivocally that America must do three things: first, it must be more focused on making things; second, it must be more competitive in markets where other firms are producing the same products under the same pressures, and third, it must do more of both one and two. The basis of all wealth creation is to produce a product or service that is of value to others and sell it to them. The product may be real and tangible, or it may be an information product. Toffler states that new systems for wealth creation are emerging, based not on muscle, but on mind. According to Toffler, the essence of these systems is information. Further, a product or service is always part of these systems. Regardless of whether the products and services are tangible or virtual, the market value added must exceed the cost.

Toffler maintains that knowledge (he uses this term loosely to mean information, data, images, rules, etc.) is creating the demassification of society. **Demassification** is a Toffler-coined term that means the breakup of the traditional industrial approach to production, namely, mass production. Toffler says we are seeing the demassification of production, as manufacturing firms can custom manufacture *in lots of one*. We have witnessed the demassification of marketing as segmented marketing is giving rise to particle marketing (marketing to just a few individuals) made possible by information. Even the media has been demassified as a result of fragmentation produced by cable, and later by the information super highway and interactive TV. Again, the greatly increased choices at the consumer's disposal have contributed to the demassification. Millions of websites and hundreds of TV channels enable marketers to reach very small markets. All of these factors create a need for integration.

Organizations participate in something called a supply chain in which they take an incoming item, add value to it, and pass it on to another organization. Supply chain integration and management are of paramount interest to firms, and information systems and technologies are making this integration happen. **Supply chains** support the flow of goods and materials from the original supplier through multiple production and logistic operations to the ultimate consumer. Through the use of information technology, customer orders/sales can be quickly transmitted back up the chain so that suppliers can respond instantaneously. With information technology these supply chains will exhibit reduced cycle times, inventory, and costs.

While proponents of systems integration aim to link together different systems, they also seek to bring together different technologies that will influence the scope and performance of information technology as we know it today. Systems integration advocates want to join all possible communication media and computing systems, simplify usage of systems by presenting similar interfaces, and increase human productivity. The integration of various forms of media and communications with the PC is a trend that has been underway for several years. The Internet has been integrated with the PC. In short, those who favor systems integration endeavor to make a computing system ever more automated, functional and efficient, thereby making life for human beings easier and more productive.

System integration is motivated by a collection of C words. The C words embody and present some of the most important issues in the private sector today—*customers*, *competition*, and *change*, or so suggests Michael Hammer. But as we shall see, integration also addresses the issues of *competencies*, *constraints*, *complexity*, *costs*, and *creativity*. Customers have become king in the quality-intensive production orientation of the twenty-first century. Competition carries with it the threat of survival and extinction, while change is becoming increasingly fast-paced. Competencies have to do with those capabilities in which the firm is particularly strong.

Constraints are the impediments that prevent a company from making more money, both now and in the future. Constraints occur because all firms are capacitated in terms of resources; they have only so much production capacity, so much marketing budget, and so forth. Add to that the complexity resulting from governments' involvement in private enterprise and from the dispersion of the enterprise across continents and you still have another C word that integration must address—complexity. Moreover, firms have become increasingly cost conscious. Under pressure from institutional shareholders (pension and mutual funds, mostly) companies have downsized (cut their payrolls) to reduce costs and be more profitable[10].

If companies are to survive, they must learn how to foster and commercialize creativity more quickly. Too often American firms and American research institutions were responsible for new developments in technology, but were too slow in getting their innovations to the marketplace. The end result was that foreign competition outpaced Americans in getting the new technology to market, even though American ingenuity and capital investment made the innovative technology possible.

Why Systems Integration Is So Important

Systems integration leads to significant improvements in productivity, in cost reduction, in improved quality, and in decreased time-to-market. One way to achieve system integration is through the use of project management as we have seen. However, it is also noteworthy that the deliverables of information technology projects usually result in some form of integration. Over the fifty years that computing technology has evolved in the United States, major changes in concepts, architectures, and interfaces have taken place. In the following figure, we delineate a causal loop diagram. A **causal loop diagram** is a construct that shows the causal interactions

[10] There are too many C words in this and previous paragraphs. However, it seems rather incredible how "C" words capture so much of what is critical in project management. Let's list them: costs, constraints, core competencies, creativity, complexity, customers, competition, change, customization, and companies. Moreover, system integration and project management are about coordination, collaboration, cooperation, communication, and consolidation.

between a variety of interacting parties. In this diagram we endeavor to exhibit the causal interactions between a firm and its competitors.

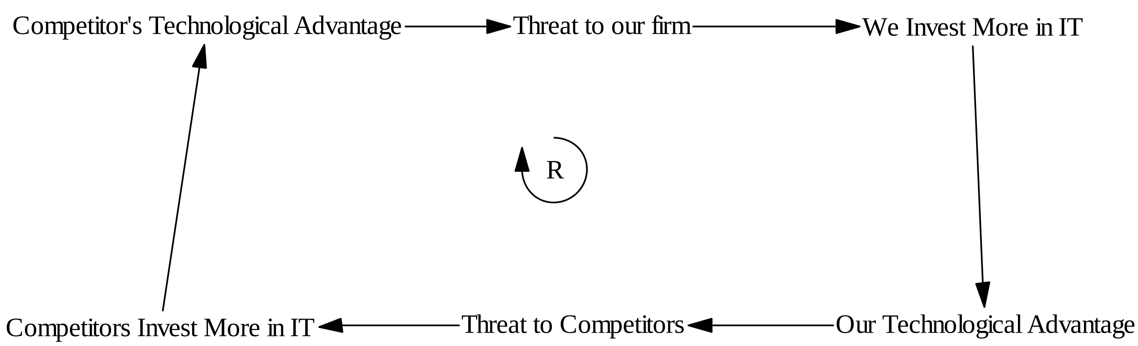

Figure 1.9: Technological Interactions Between a Firm and its Competitors

The arrows indicate causation. Thus, the technological advantage of competitors is viewed as a threat to our firm. This causes the firm to invest more in information technology (IT). That investment leads to a technology advantage for the firm that is viewed as a threat by the firm's competitors, which leads the firms' competitors to invest more in their IT infrastructure, and so forth. A cycle of escalation is created in which technological investment by the firm leads the firms' competitors to invest in IT. Consequently, companies will continue to implement more and more information technology to create non-sustainable competitive advantage. Clearly, the advantage is non-sustainable because competitors can always invest in the same technology that the firm has invested in to achieve parity with the firm.

In spite of non-sustainability, most of today's organizations experience with information technology has met expectations, and the proliferation of information technology products and vendors continues unabated. This proliferation has produced a need for even more IT products to support connectivity and interoperability. The search for new applications and sources of competitive advantage increases in a global economy, where technological advantage cannot be taken for granted any more, and where firms must rely on telecommunications and information technology to manage and coordinate their operations and to stay abreast of international competitors. By the sheer weight of its experience in computing technology and an inherent ability for thinking flexibly and managing complexity, the United States has held its own against international competition. But the United States cannot take its superior position in the international marketplace for granted with Japan and the European countries becoming more organized and coordinated at a national level as they pursue the upper hand in the information technology market. If the United States does not continue its IT investments, it may lose the significant position of strength that it holds in information technology. The same vicious cycle of technological competition depicted in Figure 1.9 exists for countries as well.

Clearly, companies, competitors, indeed even countries must continue to invest more and more into IT. What are the implications of such investments long term? The following causal loop diagram addresses that question. Investments in IT lead to more IT projects and products, which leads to more integration. The integration leads to more complexity, a subject about which more will be said in Chapter 2.

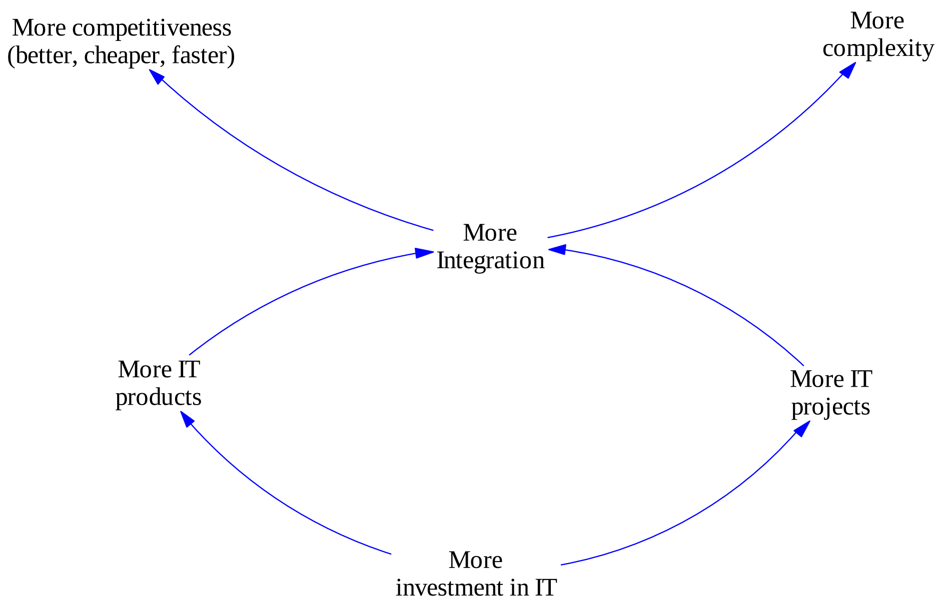

Figure 1.10: The Effects of More and More IT Investment

Integration is also important because it is ubiquitous. Components (hardware and software) are being integrated into corporate computing infrastructures known as networks. Communications companies are being integrated with cable companies. Television is being integrated with digital communication, resulting in interactive TV, and vice versa. Data, voice, and video are all being integrated via digitization and the growth of multimedia. Information systems personnel are being integrated into the various functional departments—accounting, finance, marketing and sales, manufacturing, engineering—which are themselves becoming more integrated. Companies become more integrated through mergers and acquisitions. Supplier/customer value chains are becoming more integrated through electronic data interchange. Computer hardware suppliers become more horizontally integrated as they acquire the more profitable aspects of the business, namely, the software and service components. The service aspect of the computer business also has system integration as its primary thrust.

What Personnel Are Involved

To make integration of business and technology a reality, there needs to be truly integrated planning and thinking across all levels of the enterprise. Information technology personnel must be included on the management teams that are created and must become an integral part of determining vision, goals, directions, plans, processes, and projects for the firm. Also, organizations must 1) look outside themselves to the suppliers and customers they work with and 2) integrate these into their infrastructures and architectures. A new breed of professional is required who understands how to cope with the complexities of enterprise integration in a project management context. This book is directed toward this end.

Why Systems Integration Is Needed Within and Across Enterprises

Systems integration, as the name implies, is an integration of diverse systems to perform in a coordinated manner. It is the creation of a system of systems. Proponents of systems integration envisage a common architecture[11] that will encompass an entire enterprise[12]. Such an enterprise may be multinational and will offer a diversified array of products and services that are produced by an equally diversified array of processes. The systems integration architecture will include all corporate resources and will focus on the products as well as the processes used to produce them. Client/server architectures introduced in the 1990's helped foster data integration that was unavailable in the days of mainframes but very much needed. A new era of enterprise integration arose out of that data integration, upon which a new software industry focused on enterprise software was built.

Methodologies for bringing together all the technologies and devices required to assemble an ideal computing system that will serve as the corporate neural/cerebral infrastructure are badly needed. Meeting this need entails understanding what technology is available in the marketplace, what components are interoperable, and how these components can be tuned to maximize performance for the price. Enterprise software is vended by such firms as Oracle, IBM, SAP, Microsoft, Siebel and many others.

The possibility of being able to intermix hundreds of technological components, each with a different vendor, is rapidly becoming a reality and standards are creating this reality. These standards are created by standards-making organizations like the American National Standards Institute and the Institute of Electrical and Electronics Engineers. In other instances, these standards are created by the vendors themselves. Microsoft has created a number of widely used standards. In the long-run, users should be able to choose from thousands of different products, each capable of being plugged into the same information pipe, and play away. The name of this game is "plug and play" and it involves reuse of existing commercially-available products. The benefits of reusing commercially available hardware and software are decreased cycle times, lower costs and better quality, when compared to the other alternative which is to recreate the product from scratch. Projects are used to make this a reality.

As systems integrators become more sophisticated, simulation models will play a more important role. Thirty years ago, the Boeing Company was systems integrator and prime contractor for the AWACS airplane. The AWACS is a Boeing 707 with a large radome strapped to its back. Inside is a dozen or so workstations, each with its own set of displays. The airplane is capable of tracking all battle movements in the air and on the ground. At the time, the company was making decisions about which radar vendor to select. The ultimate question was how that component would match up with the rest of the system. The company had a simulation model of the AWACS airplane built, and ordered the prospective radar vendors to build simulation models of their radar components. These models were eventually received and integrated with the rest of the AWACS simulation. Performance tests were then conducted and based on those performance tests, the company ultimately selected a radar vendor. This is system integration at its finest.

In an era in which time is the most important consideration, the construction of software products through the integration of commercially available components has become commonplace. Hence integration (of reusable components) is necessary to accommodate the time pressure to have software applications developed rapidly.

[11] An architecture is a "picture" or description of how systems ought to be.
[12] An enterprise is the entire collection of firms along a supply chain that starts with raw materials and ultimately delivers a finished product or service to the consumer.

DEFINITIONS

Causal Loop Diagram—is a construct that shows the causal interactions between a variety of interacting parties

Demassification—the breakup of the traditional approach to mass production so products can be uniquely customized to customers

Integration—a bringing together of people, processes, information

Supply Chains—the flow of goods and materials from the original supplier through multiple production and logistic operations to the ultimate consumer

EXERCISES

1. Identify and define up to eight "C" words that motivate system integration.
2. Discuss why there is a "dark side" to systems integration.
3. Why is system integration needed within and across enterprises?
4. It has been said that "no one individual or group is driving the integration train—that no one is in charge and there is no 911 number to call if the train wrecks." Explain.

PROBLEMS

1. Consider the following system: a university is to be studied to forecast future budgetary requirements for facilities, faculty, and staff. It is known that the university "owns" about 10% of the state's college-bound students. Currently, the state's college bound population is 100 thousand but is growing at the rate of 10% a year. At the same time, it is known that 90% of freshmen become sophomores, 90% of sophomores become juniors, 90% of juniors become seniors. Only 15% of seniors go on to graduate school. One faculty member is needed for every 20 students and 100 sq. ft. of facility space is needed per student. One staff person is needed for every 30 students. Currently there are 3 million sq. ft. of facility space, 1,200 faculty, and 1,000 staff persons. Take this system through each of the model building steps suggested in this chapter. Is there enough faculty currently? Why or why not?