# 1 An Introduction to Project Management

## Learning Objectives

On completion of this chapter, the reader should be able to do the following:

- LO 1.1 State why there is a growing need for people with strong project management skills.
- LO 1.2 State the four dimensions that define a project.
- LO 1.3 Define the phases of a project life cycle.
- LO 1.4 Explain measures of project success or failure through costs, schedule, organizational structure, and technical goals.
- LO 1.5 Differentiate types of risk that can affect project outcomes.
- LO 1.6 Discuss the various trade-offs that project managers must consider.
- LO 1.7 State the differences between program management and project management.
- LO 1.8 State the role Agile project management plays in project management today.



## 1.1 Introduction

LO 1.1 State why there is a growing need for people with strong project management skills.

The need to correctly select and effectively manage complex projects has become increasingly important as the number, size, and significance of projects have steadily increased (e.g., researchers at Oxford Economics estimate that global spending on capital projects will increase to more than $9 trillion in 2025[1]). Many of these projects are related to developing and implementing new products and services—complex strategic projects that have a direct impact on an organization's long-term survival. As a result, leaders in both the public and private sectors are increasingly focused on ways to increase the likelihood of positive project outcomes. A primary goal of this book is to present the concepts and methodologies that are most useful for managing complex projects and help readers understand when, why, and how these methodologies can and should be used to maximize the likelihood of project success.

### 1.1.1 Risk Management

The importance of managing risks in complex projects is a theme we emphasize throughout this book. We define **risk** as any event or factor that may increase the likelihood that a project will fail to achieve its goals. These events can be classified as exogenous or endogenous. Since the focus of this book is at the project level, we classify any detrimental event that is outside the direct control of the project managers or project team as an **exogenous factor**. For example, exogenous events include adverse weather, general economic conditions, workers who are unavailable due to an unexpected illness, or a strike by workers for higher wages. Note that the last example (a strike for higher wages) is usually within an organization's control but outside of a specific project manager's control since wage rates and contracts are typically negotiated at a corporate (and not project) level. However, we note that most risks associated with exogenous factors can be managed at the project level; for example, a project manager can provide flu shots for employees to reduce the risk of ill—and absent—workers.

**Endogenous factors** are those factors that are within the control of the project manager (e.g., employees hired or fired, parking and transit options provided). As we discuss throughout this text, both exogenous and endogenous factors must be identified at the beginning of every project and carefully managed throughout the project's duration.

**Risk** Any event or factor that increases the likelihood a project will fail to achieve its goals.

**Exogenous factor** Any event falling outside the direct control of the project manager or project team.

**Endogenous factors** Factors that fall within the control of the project manager and project team.

## 1.1.2 Increasing Project Complexity

Factors that have contributed to an increase in project complexity and associated risks include globalization, project decentralization, shortening project life cycles, changes in information technology (IT), and increased customer focus. Furthermore, many projects today include environmental and social goals that may be difficult to define and even more difficult to implement. As we note in Chapter 3, these goals frequently conflict; for example, a project goal to increase corporate sustainability may result in reducing its profitability, or a project to decrease carbon emissions may increase project duration (and possible costs). The optimal trade-offs among these goals are difficult decisions facing organizational leaders today; these issues are discussed in Chapter 6.

Global projects make coordination and communication among project stakeholders more difficult as work is conducted across multiple countries, time zones, cultures, and languages. In addition, projects are likely to be decentralized where a parent or client organization outsources part (or all) of a project's work to independent subcontractors. The success or failure of these decentralized projects is determined by many factors, including the choice of subcontractors, how work is allocated among these subcontractors, and the nature of the contractual relationships between the client organization and subcontractors. The development of the Boeing 787 Dreamliner illustrates many of the problems with decentralized projects that resulted in more than $5.1 billion in penalty costs (see "PM in Action: The Boeing 787 Dreamliner").[2] Other factors that increase complexity and risk as well as ways to mitigate these risks are described throughout this book.

## 1.1.3 Change Management

In addition to increasing the likelihood of project success, the project management (PM) concepts discussed in this book offer other advantages. For example, PM is increasingly synonymous with change management as organizations use projects to introduce changes in processes, organizational structure, and resource utilization. To illustrate, consider a company that wants to introduce robotics into their manufacturing processes. By combining this process change with a new product development (NPD) project, the robotic introduction becomes less threatening and more acceptable to workers as they observe the success of both the development project and the process change.

## 1.1.4 Shrinking Project Life Cycles

Rapidly shrinking product life cycles have also increased the need for effective PM. Research indicates the communications industry has been subject to the 4-3-3 rule: 4 months to

## PM IN ACTION

### THE BOEING 787 DREAMLINER

Over a period of several years, Boeing Commercial Airplane developed a new airliner that was officially named the 787 Dreamliner in 2003. The plane is largely made of composite materials to reduce its weight and increase its fuel efficiency. In addition to the new materials, Boeing officials adopted a new production process that was based on an outsourcing strategy; it is estimated that approximately three quarters of the plane's components are produced by outside suppliers who then ship these components to the Boeing plant in Everett, Washington, for final assembly. For the first time, Boeing outsourced the wing and wing-box design and production (to Mitsubishi Heavy Industries in Japan); many experts consider these parts to be the most technologically advanced components of any airliner.

The first 787 Dreamliner was scheduled for delivery to the launch customer, All Nippon Airways, in May 2008. Actual delivery of the initial plane (following FAA [Federal Aviation Administration] and EASA [European Aviation Safety Agency] certifications) occurred in September 2011. In 2009, *Aviation Daily* estimated that the delays in the Dreamliner development project cost Boeing more than $5.1 billion in penalties and lost sales.

The 787 Dreamliner development project provided several important (and expensive) PM lessons. First, the initial plan adopted by Boeing officials failed to incorporate information from previous development projects and ignored many of the risks associated with their outsourcing strategy and implementing new technologies. Second, the 787 development project illustrated the perils of poor communication; for example, one supplier (Advanced Integration Technology) faced serious production problems beginning in 2006, but Boeing did not become aware of these problems for over a year. Third, Boeing used "delayed payment contracts" (also called "risk sharing contracts") specifying that subcontractors were only paid when the first plane was delivered. These contracts imposed subtle incentives on subcontractors to delay their production schedules; Boeing has since abandoned these contracts.

The delays and problems with managing this complex project have clearly hurt Boeing's reputation (as well as their profits), which may affect their ability to compete with their main competitor, Airbus, in future development projects.

*Source.* Fingleton, E. (2013, January 21). What went wrong at Boeing: My two cents. *Forbes.* https://www.forbes.com/sites/eamonnfingleton/2013/01/21/what-went-wrong-at-boeing-my-two-cents/#911574830fc4; Peterson, K. (2011, January). Special report: A wing and a prayer: Outsourcing at Boeing. *Reuters* https://ca.reuters.com/article/businessNews/idCATRE70J2UX20110120?sp=true



develop a new product, 3 months to make money from it, and 3 months to get it off the shelf.[3] Consultants at McKinsey & Co. estimated that a typical firm's gross profit potential for a new product is reduced by approximately 12% if the product is introduced 3 months late, and 25% if 5 months late.[4] The case for NPD very succinctly states that "time to market means life or death, and anything that can tip the scale in your favor is precious."[5] The importance of dealing with short product life cycles is more important today as technology continues to evolve at an increasing rate.

### 1.1.5 Newer Methodologies

In this book, we focus on complex projects that include many tasks likely to fail and require rework or redesign. These projects include NPD projects, IT projects, and research and development (R&D) projects. The uncertainty associated with these projects increases the importance of careful planning and managing project risks. In addition, we show why some of the methodologies (e.g., critical path method [CPM]) that were originally developed more than 60 years ago for construction projects may not be appropriate for complex R&D and IT projects. Today, newer methodologies such as Agile PM are being increasingly used although many of these methodologies are not well-defined or understood. This book tries to bridge the gap between traditional PM approaches (e.g., the Waterfall model) and newer methodologies (e.g., Agile and Scrum). In doing so, we hope to give the reader a better understanding of both traditional and Agile approaches and improve project outcomes associated with both approaches.

Given the costs associated with project failures and the gains associated with project successes, an increasing number of organizations are recognizing the importance of correctly understanding and implementing PM concepts. As a result, PM has become an essential part of technology management, a critical element of electronic commerce, and an important part of the global economy. Given the size and scope of current projects, it is not surprising that PM has become a major focus of for-profit and nonprofit organizations throughout the world.

### 1.1.6 Implications and Costs of a Lack of Project Management

Given this increasing focus on PM, it is disturbing to see how many projects fail to achieve their goals. In 2002, Flyvbjerg et al. conducted an empirical study of publicly funded projects undertaken over the previous 70 years in various parts of the world.[6] Their conclusions were clear. For 258 transportation infrastructure projects (with a combined value of approximately $90 billion), costs were underestimated in 9 out of 10 of these projects and actual costs were, on the average, 28% greater than the estimated cost (for a randomly selected project, there was an 86% chance of a cost overrun). Their findings apply to other types of projects as well, including power plants, dams, water distribution, oil and gas extraction, IT systems, aerospace systems, and weapons systems. Their data indicate that "other types of projects are at least as, if not more, prone to cost underestimation as transportation infrastructure projects."[7] Furthermore, no region in the world is immune to these cost overruns; Flyvbjerg et al. noted that the development of the Concorde supersonic airplane cost 12 times its original forecast amount while the final cost of the Sydney Opera House was 1,450% greater than the original forecasted amount. The private sector is not immune to these project failures as well (see PM in Action: The Boeing 787 Dreamliner).

The modern Olympic Games offer additional examples of troubled public megaprojects. The estimated costs versus the final costs of the Olympic Games from 1996 through 2018 are given in Exhibit 1.1.[8] Not only have these costs increased significantly (each event at the Winter Olympic Games in Sochi, Russia, averaged $520 million per event compared with an average cost per event of $130 million at the 2008 Olympic Games held in Beijing), but the difference between the estimated and final costs has also increased simultaneously. These cost increases and overruns have resulted in fewer cities bidding on Olympic Games, and the residents of many cities that have hosted the games left with massive debts that require years to pay off.[9] In addition, even the reported final costs are likely to underestimate the true total costs as the reported costs rarely include infrastructure investments in roads, bridges, and so on. The failure to effectively manage these projects means that fewer cities are willing to host the Olympic Games, threatening the long-term existence of the Olympic Games.

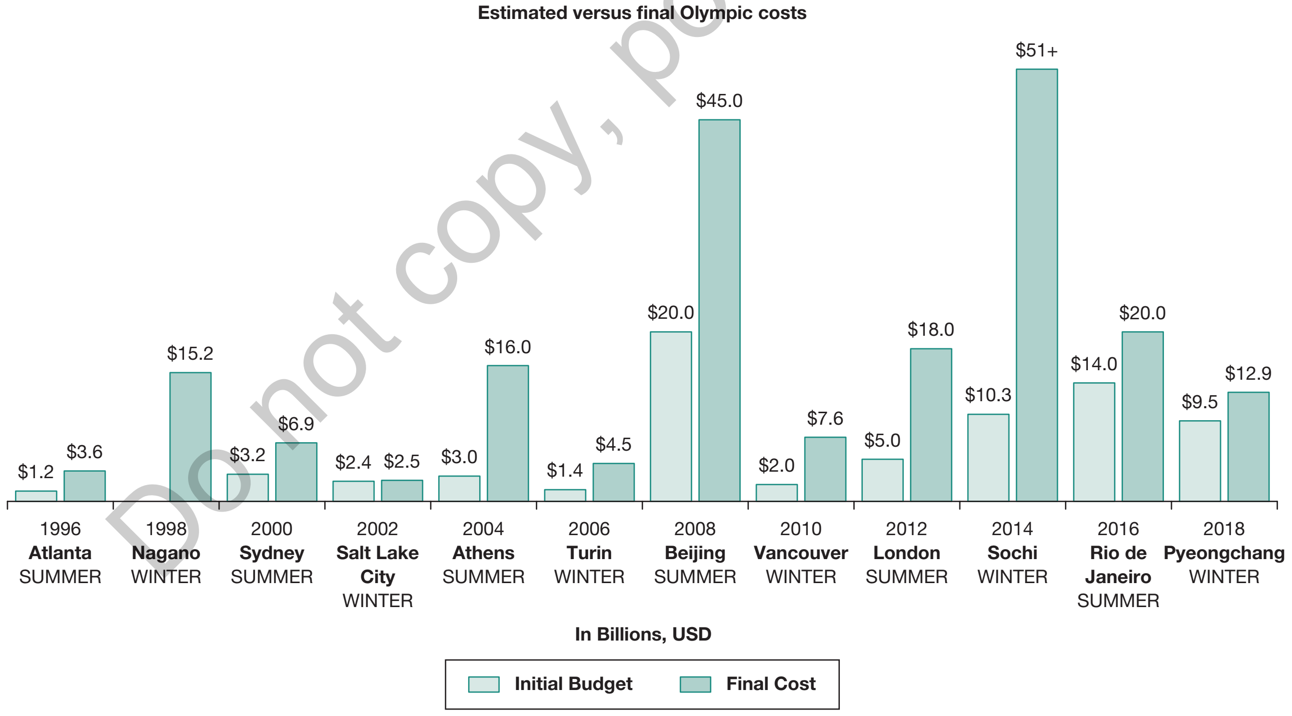
Most strategic projects today include an IT component or subproject. IT projects have a unique set of issues that make them especially difficult to plan, design, manage, and control. One notable IT project failure was the attempt by the state of Oregon to develop an online

**PHOTO 1.1**
The Sydney Opera House is a world famous performing arts center located in Sydney, Australia. In 1957, it was originally expected to cost $7 million and take 6 years to complete; when it officially opened in 1973 (10 years late), the final cost was $102 million—a 1,450% cost overrun. The Sydney Opera House is considered to be one of the best examples of a poorly managed public project.

©iStockphoto.com/simonbradfield.



**Exhibit 1.1** **Estimated Versus Actual Costs of Olympic Games**




*Source.* *AP*, Robert A. Baade and Victor A. Matheson, Douglas Booth and Colin Tatz, *New York Times*, *Xinhua*, Andrew Zimbalist; Pyeongchang—https://www.forbes.com/sites/christinasettimi/2018/02/08/by-the-numbers-the-2018-pyeongchang-winter-olympics/#2b57cd997fb4

*Note.* Figures are all estimates based on academic and news wire sources.

health care exchange known as *Cover Oregon*, which was authorized by the Patient Protection and Affordable Care Act (PPACA) signed into law in 2010. Oregon's attempt began in March 2011; after spending between $248 million and $310 million without developing a working website, the Oregon legislature officially terminated this project in March 2015 without signing up a single person (see "PM in Action: Cover Oregon").

## PM IN ACTION

### COVER OREGON

One notable IT project failure was the attempt by the state of Oregon to develop an online health care exchange, *Cover Oregon*, the name given to the health insurance marketplace for the state of Oregon that was authorized by the PPACA that was signed into law in 2010. Individual states were authorized to create their own insurance online marketplaces as a result of the PPACA and that was signed into law by President Obama in 2010. *Cover Oregon* was intended to enable Oregonians and small businesses to purchase health insurance at federally subsidized rates.

The project to develop a state exchange started in 2011 with the passage of Oregon Senate Bill 99; in October 2011, the exchange was officially named *Cover Oregon*. Multiple problems plagued this project. In April 2014, the board of directors voted to close the state-run exchange and adopt the Federal HealthCare .gov exchange beginning in 2015. The FBI (Federal Bureau of Investigation) began investigating the failed development in March 2014.

In March 2015, the state of Oregon officially abolished *Cover Oregon*. Estimated losses range from $248 million to more than $310 million. Much of the funding was provided by the federal government but a sizable percentage of the funds were provided by the state of Oregon.

The prime contractor Oracle sued the state of Oregon in 2014; in return, Oregon sued Oracle for $5.5 billion and accused Oracle of fraud, false claims, breach of contract, and civil racketeering. In 2018, the state of Oregon and Oracle reached a settlement that resulted in Oracle paying Oregon approximately $100 million in cash and various products and services. Oregon citizens who wish to sign up for health care under the Affordable Care Act (ACA) use the federal health care exchange.

*Source.* Lane, D. (2014, January 10). "We look like fools"; A history of *Cover Oregon's* failure. KATU.com.



A study by Hendricks and Singhal underscored the need to manage NPD projects effectively; the authors studied publicly traded firms that were forced to publicly announce delays in the introduction of new strategic products.[10] In their study, the authors compared the market performance of 101 firms that experienced product delays with similar firms that did not experience product delays. Hendricks and Singhal found that firms with delay announcements lost an average of 5.25% of their market value, usually within five business days of the announcement. Furthermore, this negative impact on market value persisted for some time. Given that product introduction announcements directly influence consumers' expectations (and buying behaviors), it is not surprising to find that the market punishes companies that cannot meet their own preannounced product development schedule. Setting a realistic due date for any project is a fundamental issue in PM (and in this book), whether it is the announced introduction of a major new strategic product or letting a customer know when her car repair job will be completed. Not meeting a promised due date imposes short-term and long-term costs on all stakeholders.

A recent episode of the *Freakonomics* podcast titled "Here's Why All Your Projects Are Always Late—and What to Do About It" tried to explain why projects are usually late. The moderator focused on several factors, including the planning fallacy initially defined by Kahneman and Tversky.[11] The planning fallacy states that people who are planning a new project fail to accurately account for many factors—even when they have extensive experience with similar projects—and thereby underestimate the costs and duration of proposed projects. The planning fallacy is related to the "optimism bias" that occurs when people discount multiple risks because each has a small likelihood of occurring. Other factors that lead to underestimating the effort needed to successfully complete a proposed project include the following:

- *Availability heuristic:* using a biased set of tasks to estimate effort
- *Anchoring heuristic:* tendency of humans to remain close to their initial estimates
- *Selective perception:* the tendency to ignore evidence that disputes planners' hypotheses

In this book, we discuss ways to counter these biases and present more accurate methods for planning, understanding, and executing complex projects. Since projects (and the real world) are inherently random or stochastic, many of the methodologies we discuss throughout this book are based on the application of statistical analyses. We define and explain many of these methodologies using small examples based on Excel spreadsheets to make these methodologies as comprehensible as possible. Nevertheless, it is important for readers to understand how the concepts illustrated by these examples can be applied to real-world projects and their corresponding implications for all project stakeholders.

## 1.2 What Defines a Project?

LO 1.2 State the four dimensions that define a project.

All types of organizations undertake projects, including public and private organizations as well as profit and nonprofit organizations (and individuals). Examples of projects include the following:

- Great Pyramid built by King Cheops (Egypt)
- Finding a job after college graduation
- End-of-the-month closing of accounting records
- Installing and debugging a new computer system
- Planning and launching a new product
- Running a campaign for political office
- Repairing an automobile
- Trying to get tickets to a World Cup soccer match

**Project** A finite set of tasks or activities that must be completed to meet a set of goals and objectives.

A **project** is generally viewed as a finite set of tasks or activities* that must be completed to meet the project's goals. Typically, we assume the tasks or activities that constitute a project are defined such that

*We use the terms *task* and *activity* interchangeably in this book.

- each task defines a finite amount of work that should be performed by a single worker or group of workers,
- there are precedence constraints that specify the order in which tasks can be performed (e.g., you must build the foundation of a house before the walls), and
- tasks can be started or stopped independently of each other subject to precedence and resource constraints (e.g., workers may be assigned to multiple tasks but can only work on one task at a time).

In addition, we usually assume that once tasks are started, they cannot be stopped or interrupted and must be continued until completed; we refer to these tasks as "nonpreemptive." If a task can be stopped and restarted at some point without incurring additional costs, we usually assume the task should be divided into two or more subtasks that cannot be preempted.

To illustrate the issues relating to task definition, consider the activity "Write the documentation for a new IT program." Let's say we expect the documentation will have five chapters. Should the task of writing the documentation be subdivided into five subtasks (e.g., each chapter defining a subtask), more than five subtasks (e.g., each page defining a subtask), or left as a single task?

To answer this question, many factors need to be considered. For example, if one person is assigned to write the documentation, the five chapters will be written sequentially; if several people are assigned, then the chapters could be completed simultaneously. If we have more workers and subtasks, we increase the task coordination costs, but we are better able to assess the task progress (Chapter 11) as well as complete the documentation in a shorter time.

Our definition of a project as a finite set of tasks has several implications. First, it means that a project has a well-defined life span between the time when the first task is started and the last task is completed (although, in reality, it is sometimes difficult to tell when a project is fully completed). Second, the set of tasks defining a project are designed to meet all the goals associated with the project (e.g., time, cost). Project goals are typically determined by a collaboration of all concerned stakeholders (especially the customers).

Every project has four dimensions. These four dimensions define each project and should be clearly understood before the project begins.

1. *Time:* How long will the project take? Project duration is frequently referred to as project **makespan**. Related to this dimension, there may be a due date with penalties and/or bonuses associated with meeting or exceeding this due date.

**Makespan** The duration of a project.

2. *Cost and cash flows:* How much will the project cost and what will it earn when successfully completed? Typically, projects have their own budgets that constrain the amount and/or rate that resources can be used during the life of the project. Cash flows also determine the discounted value of the project when the time value of money is considered.
3. *Scope or design:* What are the characteristics of the completed project? In an IT project, what functions will be included? Related to the scope of the project is the concept of deliverables; that is, what are the precise items or services that will be delivered to the customer?
4. *Quality:* How will quality be measured and what quality standards will be used and how will they be enforced? Quality is typically the most difficult dimension to measure and generally the first dimension to be compromised when projects are running late. In this text, we use the term *quality* to refer to the level of workmanship or defects in the product or service under development.

These dimensions are not independent; for example, many costs are time dependent and increase with the project makespan. As a project runs late and nears a due date, errors are likely to increase and quality decreases. Changes in scope (i.e., scope "creep") usually increase both time and cost although scope creep may result in a product that better meets the needs of the customer or client.

Some authors define projects in terms of three dimensions: time, cost, and scope/quality, where quality refers to the number of features in a product (i.e., a lower quality product has fewer features than a higher quality product). In this case, quality and scope are interchangeable concepts and defined by a single metric. In this book, we assume the number of features in a product defines the scope of the product while the quality of the product is defined by the number of errors, defects, and workmanship.

Many projects are managed and completed by project teams. Project teams may be fixed for the project duration or changed throughout the life of a project (as different levels of expertise are needed). Issues relating to project teams are discussed in Chapter 9.

Given that projects are temporary endeavors, resources are usually not acquired for specific projects but are drawn from other parts of the organization or outsourced to independent subcontractors (sometimes in the form of independent contractors or consultants). Nevertheless, projects should fit into the overall portfolio of experience and knowledge available in an organization and support the overall mission of the organization. More information on this topic is provided in Chapters 2 and 3.

Projects differ from other forms of work by their uniqueness and finite durations. Unlike programs, a project manager wants to complete her "job" as soon as possible; in a program, managers want to continue producing a product or service as long as there is a viable market. In a repetitive operations environment, data are generated that allow managers to continuously improve the quality and efficiency of the process. In contrast, projects have many unique elements that cannot be improved without delaying the completion of the project. This uniqueness, in turn, increases project risk and makes it difficult to manage.

### 1.2.1 A Taxonomy of Project Types

Throughout this book, we discuss generic projects. All projects, however, are obviously not the same; a project to develop a complex new software product is quite different from, say, a road construction project. In the former case, the project design and scope may be difficult to clearly define, the external environment is rapidly changing, and the IT staff developing the software is usually involved with many other activities and projects. In contrast, most construction projects proceed in isolation from other projects; while there are many uncertain factors, of course, we typically consider a road construction project less risky (in terms of ultimately meeting its goals) than most software development projects.

A number of researchers have studied project types and argued that different project types require different organizational structures as well as strategies and management styles.[12,13,14] For example, a highly centralized and hierarchical organization with limited communication may be very effective with road construction projects but would probably not fare well when developing a technologically complex new product in a highly uncertain environment. Frequently, projects require an organizational structure that differs from the organizational structure of their sponsoring organization. Shenhar defined projects as "temporary organizations within organizations that may exhibit variations in structure when compared to their mother organization."[15] However, every project must contribute to both the strategy and vision of the sponsoring organization as well as positively contribute to its long-term market value.

Based on studies of new product (or process or service) development projects, Shenhar suggested a **taxonomy** (classification) for complex projects based on two dimensions: complexity and uncertainty.[16] One dimension in this taxonomy indicates the relative degree of technological uncertainty/risk in a project, ranging from low-tech projects that use well-established and stable technologies (e.g., construction projects) to super high-tech projects that require the development of new technologies during the course of the project (e.g., the Apollo moon landing project). Along this continuum, Shenhar defined medium-tech projects that extend a stable technology (e.g., product upgrades) and high-tech projects that require the development of a new technology. The second dimension defined by Shenhar is project complexity or system scope. According to Shenhar, a project with limited complexity is "a subsystem performing a well-defined function within a larger system, or it can be an independent stand-alone product that performs a single function of a limited scale."[17] Shenhar refers to these types of projects as **assembly projects**. At the other end of the complexity spectrum are **array projects**, geographically dispersed projects that require the integration of many sophisticated subsystems. Between

**Taxonomy** A system of classification.

**Assembly project** A type of project using existing technology that is usually colocated.

**Array project** A type of project with high complexity; requires the integration of multiple subsystems that are generally not colocated.

the high and low complexity are **systems projects**; these types of projects require the development of numerous subsystems that, in turn, will define a functioning product (or process or service). An example of Shenhar's taxonomy is represented in Exhibit 1.2.

Throughout this book, it is useful to keep Shenhar's taxonomy in mind. Not surprisingly, Shenhar found that a project's location in his taxonomy has significant implications for organizational design, communication and control systems, resource planning and scheduling, extent of testing, and the need for prototype building. As project scope and complexity increase, for example, projects require more formal planning and control systems; organizations associated with these types of projects tend to be larger, more formal, and more bureaucratic.

**Systems project** A type of project with moderate degrees of complexity, consisting of numerous subsystems to define the function of the end product.

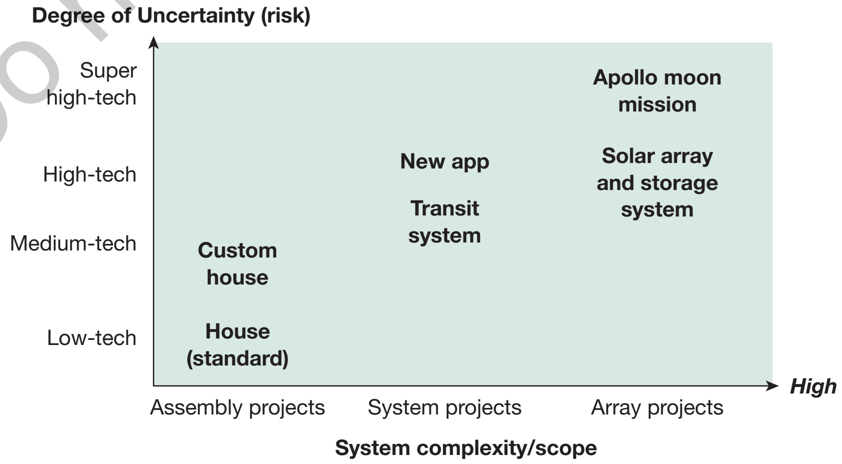
An alternative taxonomy for development project types was suggested by Wheelwright and Clark, who classified projects based on two dimensions: (1) the degree of product change and (2) the degree of process change.[18] Using this two-dimensional classification scheme, the authors identified various project types that require different resource levels and management styles. For example, in the area of low product and process change, they identified derivative projects as projects that make relatively minor enhancements to existing products. According to Wheelwright and Clark, derivative projects produce incremental change in the product and/or the process (e.g., a change in packaging, a new feature, or improved quality). Platform projects make significant changes in the product and/or process but avoid the major changes that occur with breakthrough projects. The former projects result in significant product and/or process improvements based on developed and proven technologies (examples include the Apple iMac computer and some new car models); breakthrough projects represent radically new products and/or processes (examples include the NASA [National Aeronautics and Space Administration] space shuttle and the development of the Apple iPhone). Breakthrough projects typically result in the development of new markets and generally have a high degree of risk and complexity.

### 1.2.2 Project Governance

**Project governance** refers to the organizational structure and culture that oversees project portfolios and makes certain that ongoing and future projects support the organization's mission and strategy. This system determines how projects and risks are defined and managed, how resources are allocated among competing projects, when projects are started, terminated, expedited, and so on. Today, this includes defining projects that are socially responsible and meet ethical and environmental goals. An important part of project governance also involves setting priorities among projects that compete for the same resources. This is further discussed in Chapters 2 and 12.

**Project governance** The organizational structure and culture that oversees project portfolios and ensures that ongoing and future projects support the organization's mission and strategy.

**Exhibit 1.2 Shenhar's Taxonomy of Project Types**



The governance system manages relationships among all stakeholders, including subcontractors and customers, within an organization's political environment. Identifying relevant stakeholders (both internal and external) can be challenging; too many stakeholders increase the complexity and cost of a project, while too few stakeholders increase the risk of defining high-level requirements incorrectly. These concepts are further discussed in Chapters 2 and 3.

## 1.3 The Project Life Cycle

LO 1.3 Define the phases of a project life cycle.

In Exhibit 1.3, we define the four phases of a project's life cycle:

1. Initiation and selection
2. Planning, budgeting, and scheduling
3. Execution and control
4. Project termination and postproject audits

In the first phase (initiation and selection), managers define (and refine) the project and its scope and consider the impact of the project on the mission and strategic direction of the organization. Assuming the project is selected for further development, managers then proceed with more detailed planning in the second phase. In this phase, they define the specific tasks that will constitute the project and estimate the resources (workers, materials, etc.) that will be needed to successfully complete the project. As part of the planning phase, managers decide which tasks will be subcontracted and define requests for bids (RFBs) or requests for proposals (RFPs) for these tasks. The planning phase is critical; it is this phase that defines the **6P Rule** of PM:

**6P Rule** Aids in defining the planning stage of project management: *P*rior *P*lanning *P*recludes *P*oor *P*roject *P*erformance.

*P*rior *P*lanning *P*recludes *P*oor *P*roject *P*erformance.

Generally, work on a project is most intense during the third phase; as indicated in Exhibit 1.3, the resources assigned to the project peak during this phase. Finally, the project is implemented and handed off to the users in the fourth phase (e.g., this is the stage when a new building is occupied by the users or a new component is inserted into an assembly process).

This view of a project's life cycle is further discussed in Chapter 3. The relationship among the planning, scheduling, and control functions is indicated in Exhibit 1.4, where a baseline

**Exhibit 1.3 Project Life Cycle**

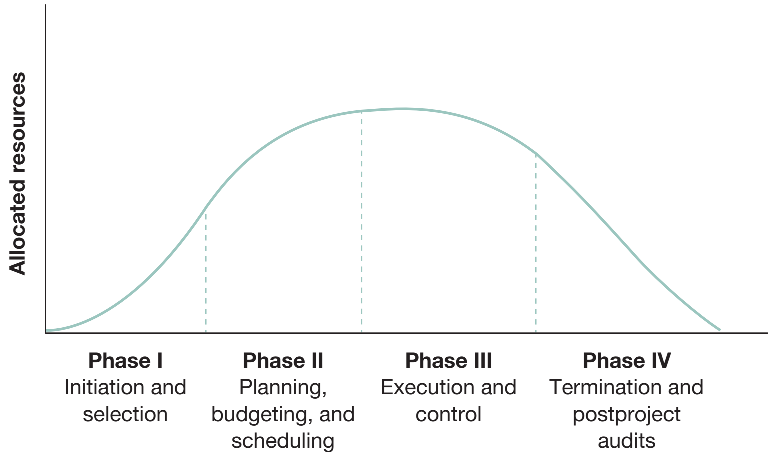
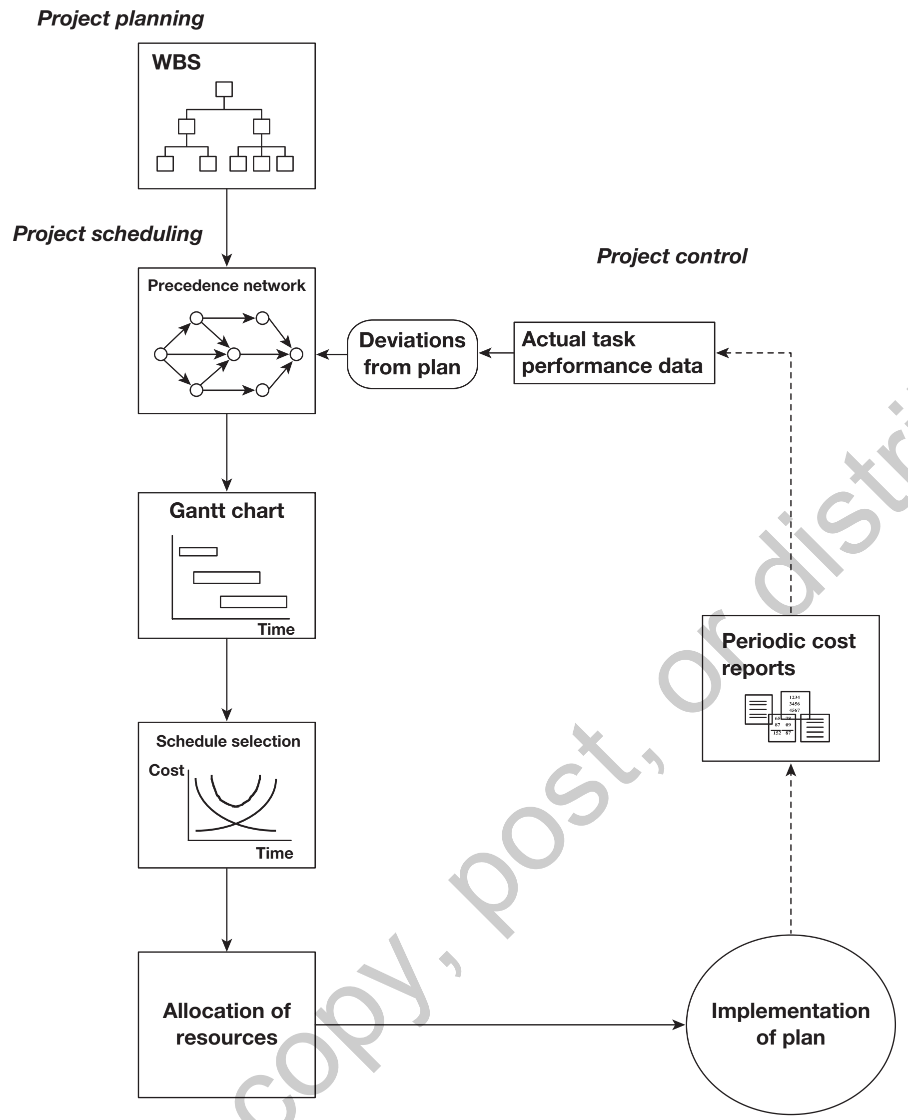


**Exhibit 1.4** **Relationship Between Project Planning, Scheduling, and Control**




*Note.* WBS = work breakdown structure.



schedule and budget developed in the project planning phase serves as a benchmark for future performance. The project team can then monitor the deviations from this benchmark plan as the project is implemented. The problem of controlling a project becomes one of determining if these variances are the result of random fluctuations or represent a structural problem that must be addressed by the project team. When the latter occurs, the project team must take appropriate actions to bring the performance of the project back on track.

## 1.4 Measures of Project Success and Failure

LO 1.4 Explain measures of project success or failure through costs, schedule, organizational structure, and technical goals.

Most projects have clearly defined cost and schedule goals and are frequently judged by whether the project was completed within its budgeted amount and due date. However, many projects have multiple goals in addition to the budget and schedule goals. For example, did the completed project meet its stated requirements and specifications? Did the project add to the organization's learning that would give future projects a greater chance to succeed? And perhaps most important, did the completed project satisfy the customer(s)? Based on an extensive review of complex projects and their outcomes, we have identified five factors that are critical for project success:

1. Clearly defined goals (including complete high level requirements)
2. Top management support
3. Good communication
4. Effective feedback and control mechanisms
5. Responsiveness to—and involvement of—clients and customers

Having these factors does not guarantee project success, of course, but it is quite clear that *not* having these factors significantly decreases the likelihood of project success.

Many projects, especially the NPD projects, are judged by the success or failure of the final product in the marketplace. Did the product that was developed succeed in increasing long-term market share, revenues, profits, and so on? In this text, we focus on the *management of the project*; that is, the design, development, and implementation of a product or service—NOT the ultimate success or failure of the product in the marketplace (although they may be related). For example, consider the movie *Titanic*, which was released in 1997 after several years of development and filming. When the movie was finally released, it was significantly delayed behind its original schedule (a 50% schedule overrun) and $90 million over its original budget of $110 million (an 82% cost overrun). However, the movie clearly succeeded in the marketplace, winning numerous awards (including the best picture award in 1997) as well as becoming the first movie in history to gross more than $1 billion in revenues. Was this project a success or a failure?

What is interesting about the *Titanic* example is that the movie was almost canceled due to cost and schedule overruns; the movie was only completed due to the perseverance of the producer who was able to secure additional funding to complete the project. The *Titanic* example also illustrates the important distinction between *project management success* (or failure) and *product success* (or failure).

As another example, consider the NASA Mars Climate Orbiter Project, which attempted to place a satellite in Mars orbit to study the climate and weather on Mars. The space probe was lost (at a cost of $125 million) when it came too close to the Martian atmosphere and disintegrated. An investigation subsequently blamed the failure on PM; one project team working on the project used the metric system (i.e., meters and kilograms) while a second team used the U.S. measurement system (feet and pounds). This lack of communication, coordination, and quality control resulted in the failure of the mission and loss of an expensive spacecraft. NASA, however, learned valuable lessons from this failure and took a number of actions to reduce the risks on future space missions. This example illustrates two important points: (1) There are few projects that are complete failures (but may provide very expensive lessons learned) and (2) one can have successful PM but a failed product or service (or vice versa).

Even when cost and schedule are the primary goals of a project, these goals may be difficult or even unrealistic to achieve, especially when set by senior managers who are not directly involved in a project's planning process. According to Frable, "meeting outrageously short schedules seems to have become a badge of honor among certain owners and project managers."[19] A study of 1,471 IT projects found an average cost overrun of 27% but reported that one of six projects, on the average, had a cost overrun of 200% and a schedule overrun of 70%.[20] These projects with huge cost and schedule overruns, sometimes known as black swans, have doomed many companies (e.g., Kmart) as well as their senior leadership.

In a study examining project performance and organizational issues, Might and Fischer identified six measures of project success:[21]

1. *Overall:* What is the overall perception of project success?
2. *Cost:* Is the final cost over or under the initial budget?

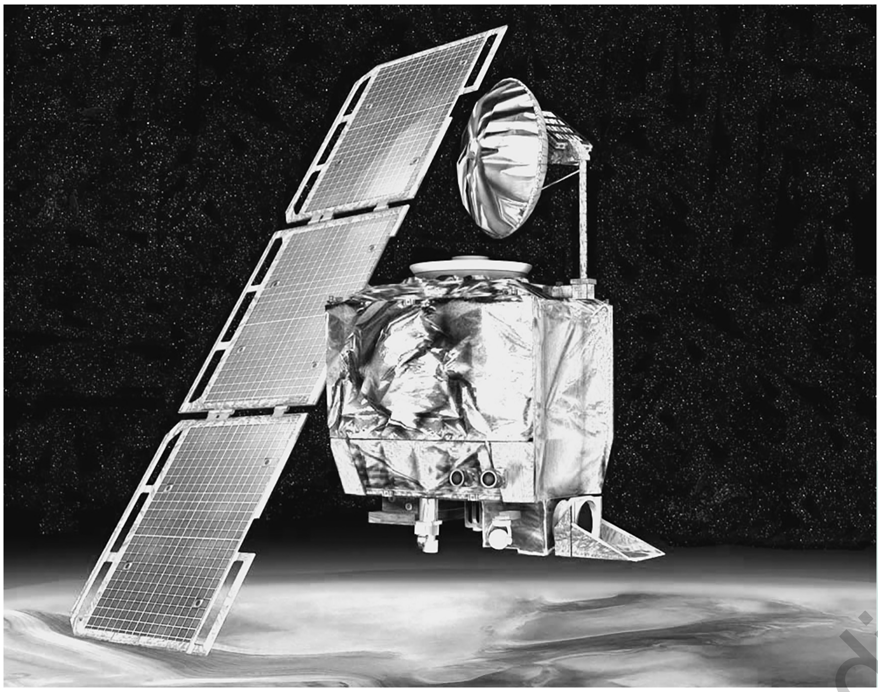


PHOTO 1.2
Two review panels found that emphasis on cutting costs and need to complete missions quickly ultimately led to failure of the Mars Climate Orbiter mission.

Courtesy NASA/JPL-Caltech.

3. *Schedule:* Is the final completion time over or under the initial schedule?
4. *Technical Goal 1:* What is the overall perception of the technical performance of the project compared with the initial specifications?
5. *Technical Goal 2:* What is the overall perception of the technical performance of the project compared with other projects in the organization?
6. *Technical Goal 3:* What is the overall perception of the technical performance of the project compared with the problems encountered during the project?

This study also considered the possible correlation between these measures; for example, Is a project that meets its initial technical specifications more likely to be viewed as successful with respect to the second and third technical goals? In their survey of 103 development projects, the researchers reported a positive correlation (0.68) between the cost and schedule goals, implying that projects that are delayed are more likely to have cost overruns. However, some of the other correlations indicate that managers often face a trade-off between technical goals on one hand and cost and schedule goals on the other.

A great deal has been written about the critical factors necessary to make a project successful. An early study by Hughes provides insight into some of the causes of project failure.[22] According to Hughes, there are three main factors:

1. Lack of understanding of PM tools and an overreliance on PM software
2. Communication problems
3. Failure to adequately adjust for changes that occur during the course of a project

Hughes emphasizes that many managers lose sight of a project by focusing on PM software instead of the project. Hughes's observation, which has also been noted by others (including the authors), emphasizes the need for managers to have a fundamental understanding of the concepts that are critical for the successful management of any project. Hughes's observation forms one of the themes of this book.

Hughes also observes that many project managers fail to reward those actions by project employees that contribute to meeting a project's most important goals. While it may be difficult to determine the relative benefit of individual actions, Hughes notes that such rewards can pay significant dividends. The practice of setting incentives within projects is discussed in Chapter 9.

Communication is one of the most important elements of managing project risks. Effective communication must exist at all levels; managers must effectively communicate the project goals to other stakeholders and avoid focusing on unimportant project details. In this respect, the development of IT is making communication issues easier to resolve; the Internet and cellphones are helping to facilitate communication among project managers and teams, clients, and contractors.[23,24] Communication and coordination issues are further discussed in Chapter 9.

Finally, Hughes points out that managers frequently fail to adjust for changes that occur during the life of a project. To successfully manage a project, a manager must explicitly incorporate all changes into updated plans, budgets, and schedules and communicate these changes to all stakeholders associated with the project. Effective monitoring and controlling of ongoing projects is discussed in Chapter 11.

### 1.4.1 Organizational Structure and Project Success

A number of researchers considered the relationship between the structure of an organization and the impact on project outcome, especially for more complex and risky R&D projects.[25,26,27] As defined by Might and Fischer, different organizational structure types can be viewed along a continuum that ranges from a functional organization (where functional managers have total authority and project managers merely serve to coordinate, communicate, and persuade) to project organizations (which is organized by projects and has no functional departments).[28] This continuum of organizational structures is indicated in Exhibit 1.5.

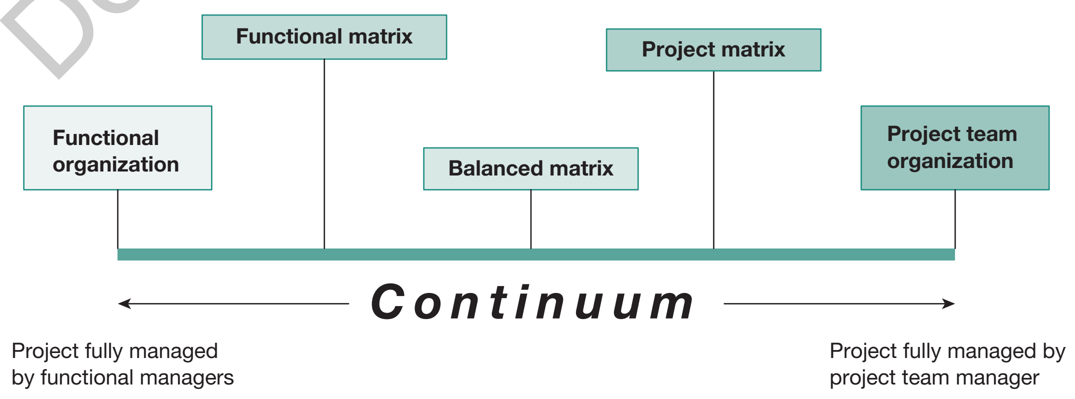
Larson and Gobeli defined five types of organizational structures that exist along the continuum in Exhibit 1.5.[29] Between the functional organization and the project team organization lie the functional matrix, balanced matrix, and project matrix organizations, which are defined as follows:

*Functional matrix:* Project manager does not have direct authority over resource assignments; functional managers direct the design and work within their own departments.

*Balanced matrix:* Functional and project managers share equal authority over design and resource allocation decisions.

*Project matrix:* Project managers have direct authority over resource allocation and design issues; functional managers provide advice and consultation.

**Exhibit 1.5 Organizational Structure Related to Project Management**



The issue of organizational type is a complex one with difficult trade-offs. On one hand, functional departments are the most effective way to keep technical workers in touch with their respective knowledge base.[30] As technology continues to evolve, it is critical that technical workers remain knowledgeable about new developments in their respective fields and maintain their disciplinary support. On the other hand, intraproject coordination is facilitated by the organizational structures on the right side of the Exhibit 1.5 continuum that improve intraproject communication and reduce the barriers between disciplines.

The trade-off between organizational types often reflects the balance between the technical excellence and project performance. Functional managers typically want to optimize product performance and design while project managers focus more on the cost and schedule dimensions of a project. This difference can result in conflicts and problems that range from products that suffer from quality defects (to meet the cost and schedule goals) to promised products (the so-called vaporware in the packaged software industry) that cannot be delivered (as a result of project managers who don't adequately understand technology).

Other studies compared project performance and organizational structure. Katz and Allen studied 86 R&D project teams in nine large U.S. organizations that included government laboratories, nonprofit firms, as well as for-profit companies in the electronics, food processing, and aerospace industries.[31] Individuals in these organizations were given questionnaires that asked about the relative influence of functional versus project managers in the areas of (a) technical design, (b) salary increases and promotions, (c) the work assignment process, and (d) the overall conduct of the organization. Project performance was measured by interviewing between four and five managers who were above the project level and asking them how they viewed the performance of the project team.

Katz and Allen reported that project performance was not influenced by those who had control over the technical aspects of the project. That is, whether a project manager, functional manager, or both had control over the technical aspects of the project did not appear to affect the performance of the project. Control over salaries and promotions, however, did have a significant impact on project performance. In this case, project performance was directly related to the influence of project managers; when functional managers had most control over salaries and promotions, project performance was significantly lower. In addition, the control of work assignments did not appear to be related to project performance; however, project performance was higher when project managers had greater influence in the organization than functional managers.

Might and Fischer surveyed managers of 103 development projects in 30 different organizations using the six measures of project success defined earlier.[32] Using data gathered from questionnaires, they compared the responses to the types of organizational structures indicated in Exhibit 1.5. (A matrix organization was defined as an organization where the project manager had project authority but the functional managers held administrative authority.) Might and Fischer's results support previous findings that there is a significant (albeit small) relationship between organizational design and project outcomes. Specifically, they reported a significant and positive correlation between some type of matrix organization and the overall measure of project success as well as cost performance. Interestingly, they found that the use of matrix organizations was not related to schedule or technical performance. In fact, they reported that technical success did not appear to be related to organizational structure in any way.

A similar study was performed by Larson and Gobeli using data from questionnaires sent to 855 randomly selected Project Management Institute members.[33] The respondents included project managers or directors of PM programs, top managers, functional managers, and specialists working on projects in a cross section of industries (e.g., pharmaceuticals, aerospace, computer and data processing) that represented all five organizational structures in Exhibit 1.5. Each respondent was asked to evaluate their project as "unsuccessful," "marginal," or "successful" with respect to four criteria: (1) cost control, (2) schedule, (3) technical performance, and (4) overall results. Based on the submitted questionnaires, they reported that organizational structure, while statistically significant, explained between 5% and 7% of the total variance in project performance measures.

While these studies have significant limitations (e.g., the use of self-reported questionnaire data, analysis based on ongoing projects), there are several conclusions that we can draw from these studies. First, organizational structure does appear to have a significant—but small—impact on project performance. Second, it appears that a balanced matrix or project matrix organizational design is most effective since they provide project managers greater levels of authority and responsibility than available in a functional or functional matrix organization. The increased authority allows project managers to better control the dimensions of a project as well as signaling the importance of the project from top management. With respect to NPD projects, traditional functional organizations had the lowest level of success in controlling costs, meeting schedule deadlines, achieving technical performance, and attaining overall results.

### 1.4.2 Success and Failure of Information Technology Projects

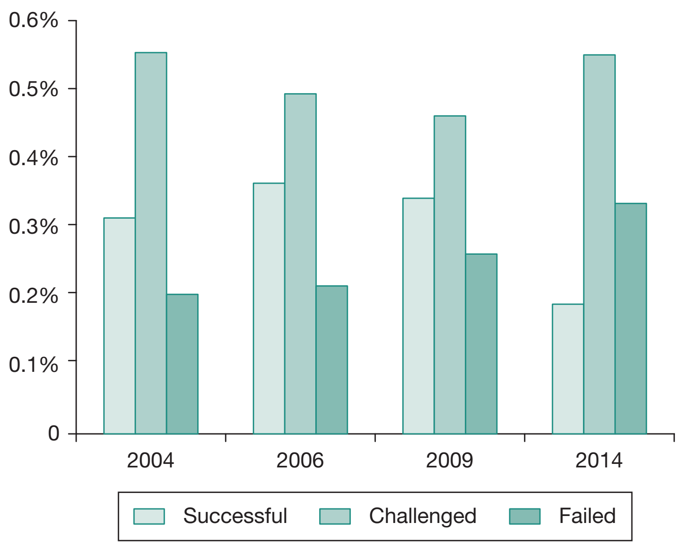
Most strategic projects today include an IT component or subproject. IT projects have a unique set of issues that make them especially difficult to plan, design, manage, and control. Perhaps the most extensive study of IT projects was conducted by the Standish Group and reported in their Chaos reports.[34] Based on a study of 8,380 IT projects in 2014, the Standish Group reported that 31.1% of IT projects were canceled before they were completed or implemented. Furthermore, the percentage of projects that were successful as per the Standish Group's criteria (i.e., the project was completed on time, within budget, and included all intended functions) was only 16.2%, while the percentage of challenged projects (i.e., project completed but failed to meet its schedule, budget, or design goals) was 52.7%. A greater concern is indicated by the graph in Exhibit 1.6, which shows the percentage of failed, challenged, and successful IT projects reported by the Standish Group between 2004 and 2014. The graph in Exhibit 1.6 indicates that IT PM showed a significant improvement between 2004 and 2009 but markedly slipped in 2014. Of course, many factors other than inappropriately applied PM methodologies could explain this finding (including the Standish Group's proprietary methodology); nevertheless, it would be foolish to ignore these results.

Many IT projects fail due to a lack of a clear statement of purpose or vision. When such a statement does exist, it may not be communicated to all project stakeholders. A second, and related, characteristic of IT project failures is the absence of realistic goals. Not surprisingly, this often results when senior managers fail to adequately include project managers and team members in all phases of the planning process. This is further discussed in Chapter 3.

Finally, the failure of many IT projects can be traced to exogenous factors. Technology continues to change at a rapid pace as Gordon Moore's 1965[35] predictions continue to hold: Every 18 months, processor speeds and memory capacity appear to double for the same cost. The



**Exhibit 1.6** **Outcome Statistics of 8,380 Randomly Selected IT Projects**




*Source.* Standish Group Report (2014).

implication is clear. For an IT project that spans more than a year, the technology is most likely obsolete by the time the project is completed—assuming that the project is completed at all.

### 1.4.3 When to "Pull the Plug"

Related to the issue of project success is the issue of knowing when to "pull the plug" on an ongoing project. Prematurely terminating a project means there must exist an effective control and monitoring system as well as metrics that indicate when the project has reached a point where it can no longer be efficiently salvaged. Clearly, this is a difficult and challenging decision in most organizations where managers and workers are committed to successfully completing a project.

Staw and Ross discuss this issue in more detail, pointing out that it often benefits an organization to design a project in modular form.[36] In this way, the organization may be able to realize some gain from a project that is prematurely terminated. Staw and Ross cite the Deep Tunnel project in Chicago as an example of such a project. In that case, the project to upgrade the city's sewer system was designed to provide benefit to the city only when completed in its entirety. When the project was delayed due to cost overruns, Chicago had nothing to show for its efforts and considerable expense. The concept of defining and implementing projects in modular form is discussed further in Chapter 2, which discusses the initiation, design, and timing of new projects.

Sometimes a project must be prematurely terminated due to changing market forces. It is understandable that most managers are reluctant to pull the plug on a project as individual careers and reputations become tied to specific projects. The fallacy of sunk costs frequently plays a role as well. How can we terminate a project where we have already invested millions of dollars?. The result is that we typically continue projects well beyond the point of "no return" (or "negative" return) and incur a significant loss.

To avoid this problem, managers must carefully monitor and control projects. In the planning phase, it is critical to define delivery milestones that define a significant phase of a project; these milestones typically identify key reviews that may result in the premature project termination. This is discussed in more detail in both Chapter 3 ("Project Planning") and Chapter 11 ("Assessing Project Progress").

## 1.5 Managing Project Risks

LO 1.5 Differentiate types of risk that can affect project outcomes.

Throughout this text, we emphasize the importance of managing the risks associated with complex projects. Risks are characterized by two elements: (1) the probability of some unexpected event and (2) the magnitude of the effect on project outcome of that event. There are numerous sources of uncertainty in all projects, including random variations in component performance, inaccurate or incomplete data, and an inability to accurately forecast due to a lack of data, experience, and so on. The probability of most events is influenced by both exogenous and endogenous factors; for example, bad weather (an exogenous factor) or bad management (an endogenous factor) can equally delay the completion of a project. In either case, the costs to the organization may be the same (delay costs, loss of customer goodwill, etc.); unlike bad weather, however, bad management can be avoided. Common exogenous sources of risk include the following:

- Changes in technology
- Unexpected losses due to deterioration, theft, fire, and so on
- Market fluctuations in prices and supplies
- Changes in legal and regulatory environments
- Natural hazards such as weather, earthquakes, and so on

Endogenous risks include random variations in resource or component performance, inaccurate or incomplete data, personnel issues, impacts of other projects (including cash flows), and inaccurate and incomplete forecasts resulting from lack of data, experience, or foresight.

Uncertain events do not always result in increased costs; many uncertain events can increase expected cash flows (e.g., inflation rates that are lower than expected). These events frequently lead to new opportunities for organizations to expand their product line, improve their services, and improve their knowledge base. However, we focus on events and factors in this book that increase the likelihood of project failure and refer to events that reduce the probability of failure as opportunities.

With respect to R&D projects, researchers identify five sources of uncertainty or variability commonly associated with these types of projects:

1. Schedule variability (task work content and durations are characterized by elevated uncertainty)
2. Budget variability (unforeseen costs and large cost overruns occur with greater frequency)
3. Performance variability (the product under development may not achieve its targeted specifications)
4. Market requirement variability (product specifications required by the market may change)
5. Market payoff variability (the market payoff may change due to competition, environmental changes, etc.)[37]

A risk management plan that identifies possible risk factors and includes strategies for managing project risks is an integral part of any project plan. As part of a risk management plan, managers should estimate the likelihood of each possible adverse event and the distribution of its related cost. This is discussed further in Chapter 3.

In Chapter 10, we discuss the topic of outsourcing part or all of a project; in this case, the parts of a project that are outsourced and the contracts negotiated with subcontractors allocate risks among project stakeholders. Project risk is also managed by the degree of diversification in an organization's project portfolio; this topic is discussed in Chapter 2 ("Project Initiation and Selection").

### 1.5.1 Risk Classes Defined

We can characterize risk factors into a number of categories based on their underlying cause; these categories can be helpful for identifying risks and designing risk mitigation plans. Generally, risks fall into one or more of the following categories:

- Requirements
- Schedule
- Cost (budget)
- Resource
- Technology
- Competition
- Political/regulatory
- Legal
- Organizational

### 1.5.1.1 Requirements Risk

Every project has a set of requirements that it must satisfy. One of the key roles the client/sponsor organization fills on a project is specifying and/or validating the project's requirements. For example, the requirements on a construction project might specify maximum occupancy, airflow requirements, and seismic accommodations. Requirements on IT projects, on the other hand, will include data specifications, validation rules, and reporting needs.

What are the risks associated with requirements?

- Incorrect requirements
- Missing requirements
- Incomplete specification
- Overspecification
- Scope creep

To illustrate problems with incomplete requirement specifications, the 1995 Chaos Report discussed a $165 million information system project that failed and cited incomplete requirements as a major cause of the failure.[38] The report also indicated that 12.3% of respondents identified incomplete requirements as a cause of their challenged projects.* An even larger percentage (13.1%) of respondents cited incomplete requirements as causing their failed projects.

### 1.5.1.2 Schedule Risk

Since task durations are random variables, the duration (or makespan) of a project is likewise a random variable. Thus, there is some likelihood that any project will be completed after its due date; we would refer to the probability of exceeding the due date as a schedule risk.

In general, schedule risk includes those issues, events, and conditions that are uniquely related to the schedule:

- Task identification errors
  - Missing tasks
  - Improperly identified/described tasks
- Estimation errors
- Incorrect precedence relationships

### 1.5.1.3 Cost (Budget) Risk

Cost risks include those issues, events, and conditions that may affect a project's having sufficient funds on a timely basis. The following represent the most common types of budget risks:

- Cost estimation errors
- Cash availability
- Defunding (full or partial)

For example, a project manager may correctly estimate the work content of a task (e.g., the number of hours required by an average resource to complete a task), but the hourly cost of these resources may increase unexpectedly.

### 1.5.1.4 Resource Risk

The risks associated with a project's resources include the following:

- Having the correct resources available when required
- Having sufficient resource units available when required

* Challenged projects are described as completed and operational but overbudget, over the time estimate, and offering fewer features and functions than originally specified.

- Unexpected loss of key resources (e.g., illness, retirement)
- Delays due to temporal, geographical, or cultural differences
- Project team cohesion

### 1.5.1.5 Technology Risk

Risks associated with technology are not limited to technology projects. For example, a construction project relying on a superfast curing concrete to meet its due date faces a technology risk given the possible cracking associated with the use of fast drying concrete. Other technology associated risks include the following:

- Early adoption of new technologies
- Applying existing technologies to new application
- First time integrating existing technologies (each of the technologies is individually proven, but the set of technologies as a whole is unproven)
- Issues of
  - Reliability
  - Consistency
  - Obsolescence

While using a technology that is early in its life cycle can carry significant risk, choosing a technology nearing the end of its life cycle can be equally risky. The latter technologies may become unsupported, or new improved technologies may offer superior capabilities, cost structures, and so on.

### 1.5.1.6 Competitive Risk

Competition may be a factor that affects your ability to deliver a successful NPD project. For example, consider the case when a rumor emerges that a competitor may enter the market before your project is completed. In this case, you might decide to increase the number of resources allocated to your project to reduce the project makespan, change the project requirements, or subcontract out part of your development project. In these cases, competitive risk can exert a significant impact on the management and outcome of your project.

### 1.5.1.7 Political/Regulatory Risk

Political risk may arise from internal and external, personal and institutional sources. Political risks may be difficult to identify, and even more difficult to quantify. Yet many projects may fail because the project manager either didn't recognize or failed to properly manage political risks that might include

- internal opposition to a project's goals or approach and/or
- external opposition from majority politics or special interest groups

How does regulatory risk differ from political risk? Whereas political risk may be endogenous or exogenous and is largely related to *opposition*, regulatory risk is largely exogenous and established through laws, ordinances, and regulations. Frequently, regulatory risk is related to potential *changes* to laws or regulations that may affect a project.

### 1.5.1.8 Legal Risk

Projects may face a variety of legal risks. Most project managers lack the expertise to manage the legal risks, but they should be aware of the *kinds* of risks their project is likely to face and engage the resources with the necessary expertise. You should look for potential legal risks in a variety of areas, including (but not limited to) the following:

- Contracts
  - Clients
  - Subcontractors
  - Suppliers
- Legal filings
- Patents and copyrights
- Proprietary information
  - Nondisclosure agreements
  - Noncompete agreements

#### 1.5.1.9 Organizational Risk

Projects exist within larger organizations. When these organizations change, the project environment may change to an extent that threatens or changes a project's plan. For example, consider the case when an organization is acquired by another organization through a purchase or merger; the new (combined) organization may find an ongoing project redundant or irrelevant, in which case the project might be redesigned, postponed, or terminated.

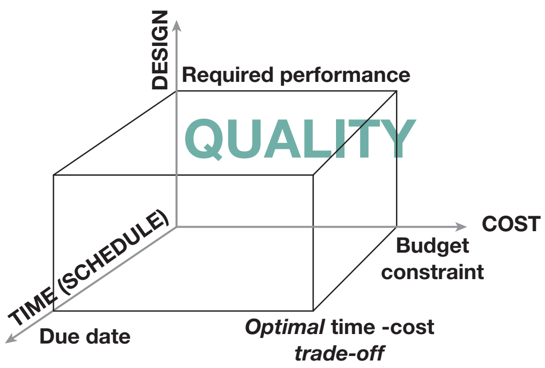
## 1.6 Project Management Trade-Offs

LO 1.6 Discuss the various trade-offs that project managers must consider.

Managing complex projects requires trade-offs among multiple goals; managers must decide the relative importance of these goals to maximize the long-term value of the completed project. For example, in many NPD projects, introducing a new product or service in a timely manner may be the most important goal, while minimizing costs may be a lesser consideration. In other projects, when costs are a greater concern, managers may have to revise the design and specifications of the project to complete the project within a given budget. Managers must also consider trade-offs among the portfolio of ongoing and future projects as well as a rapidly changing technological environment.

Trade-offs among the four previously defined project dimensions can be visualized by viewing a project as a cube where each axis represents a major project dimension: *cost*, *time*, and *scope/design* (the fourth dimension—*quality*—is indicated in the background but is no less important). The relationship among these dimensions is presented in Exhibit 1.7.

**Exhibit 1.7** **Trade-Offs Among the Four Project Dimensions**



In the project planning stage (discussed in Chapter 3), managers frequently assume that one or more goals are fixed (e.g., scope/design) and optimize the remaining goals (e.g., the time–cost trade-off). This occurs in many bidding situations when the design is considered fixed and an RFB or an RFQ (request for quote) is issued by a client. The bidder, given a fixed design, can only compete on the basis of time and cost (quality is rarely considered explicitly in these trade-offs). However, an increasing number of organizations are recognizing the need to make trade-offs among all four dimensions simultaneously. To accomplish this, they use multifunctional project teams (e.g., design-build teams) involving both subcontractors and customers in the design process as well as in the cost and schedule determination. Japanese companies, as well as some U.S. companies, have used this approach with considerable success.

In Chapter 6, we discuss the trade-off between time (schedule) and cost that assumes the scope/design and quality targets are held constant. Experienced project managers know they can realistically achieve one (or perhaps two) of their target goals in most situations. Since quality is difficult to measure, it is frequently overlooked and compromised in many projects. When scope/design is held constant, it is understandable why cost and schedule targets are often not met.

## 1.7 Program Versus Project Management

LO 1.7 State the differences between program management and project management.

Projects differ from other forms of work by their uniqueness and finite durations. On the other hand, programs represent ongoing operations that continue indefinitely and are larger in scope and duration than most projects. As such, program managers usually "own" projects and are instrumental in initiating and selecting new projects (more about this in Chapter 2). Program managers often oversee resource allocation among various projects and may change these allocations in response to changing external and internal conditions. This view has led to the creation of program management offices (PMOs) in many organizations that consist of experienced managers who oversee resource allocation and process standards among ongoing projects. PMOs are discussed in more detail in Chapter 12.

It should be noted, however, that PM concepts can be (and often are) applied to repetitive and ongoing operations. For example, consider an automobile assembly line. In one sense, this line can be viewed as a continuous assembly process or transfer line (if automated). However, in another sense, this line can be viewed as a series of sequential projects (since the number of possible options available from most automobile manufacturers today make almost every car unique). Using the latter analogy, PM concepts can be applied to each automobile as it is assembled. We discuss other issues relating to multiple projects in Chapter 12.

## 1.8 Agile Project Management: A Modern Development

LO 1.8 State the role Agile project management plays in project management today.

Recently, Agile PM has been widely discussed and increasingly utilized. Agile PM breaks a project into subprojects called iterations or sprints that are implemented sequentially. Each iteration starts where the previous iteration left off and moves forward based on the status and progress of the previous iteration. Project goals, scope, schedule, and costs may be revised at the beginning of each iteration. Iterations typically range from 1 to 3 or 4 weeks.

Agile PM is useful in projects when the scope is unclear and priorities are changing (common in many IT software projects). Agile PM reduces requirements risk in these cases as the design/scope of a project can be revised between iterations and clients as clients and customers indicate their changing priorities. On the other hand, Agile PM increases the schedule and cost risks. If a project has a defined due date (with penalties), Agile PM may not be an appropriate methodology.

Since each iteration in an Agile application defines a subproject, the concepts of traditional PM (sometimes referred to as Waterfall models) remain applicable. The choice between Agile PM and traditional PM methodologies is not binary; many organizations are increasingly using a combination of Agile and Waterfall methods with considerable success. Using Agile at the start of a project increases the customers' input into the definition of goals, deliverables, and critical success factors when these have not been initially well-defined. As goals become better defined, more traditional methods can be used to maximize the likelihood of meeting due dates and budgets. We discuss Agile PM in more detail in the Chapter 3 Supplement.

## 1.9 A Brief History of Project Management

PM has been around since the beginning of history. In fact, some theologians might say the first project manager built the heavens and earth in 6 days (with one additional day as a buffer for unexpected contingencies). Many projects—such as the Egyptian pyramids of El Giza (2590 BCE) and the Colossus of Rhodes (292 BCE to 654 CE)—illustrate many of the massive construction projects that were completed centuries ago.

Two other projects, however, have had the greatest impact on the development and practice of PM methodologies. In the latter 1950s, engineers for the DuPont Corporation were concerned about the maintenance downtime at their Louisville, Kentucky, plant that had become a bottleneck in their neoprene production process. To avoid building an additional plant, DuPont executives hired the Catalytic Construction Company to study the Louisville plant and suggest ways to reduce the maintenance downtime. The study, which indicated that a significant reduction in the number of maintenance hours at the Louisville plant was possible, was based on a new methodology that became known as the CPM. CPM is explained and discussed in Chapter 5 ("Scheduling a Deterministic Project"). As a result of this study, the engineers predicted that production at the Louisville plant could be increased to a level such that the plant would no longer be a bottleneck and a second plant would not be needed.

At approximately the same time, the consulting firm of Booze, Allen, and Hamilton was developing a new PM system for the Polaris Fleet Ballistic Missile program in the U.S. Navy's Special Projects Office. The Polaris missile, the first intercontinental ballistic missile that could be launched from a submerged submarine, represented the largest (and one of the riskiest) R&D efforts undertaken to date. Given the uncertainty involved with the project, the managers wanted a methodology that would not only incorporate uncertainty into their planning but also allow them to estimate probabilities for important milestones (e.g., If the propulsion system proceeds as planned, what is the probability that we can test launch a missile by a given date?). The methodology that was developed to assist with the management of this project became known as PERT (program evaluation and review technique) and explicitly introduced uncertainty into the project scheduling and allocation process. The basic concepts of PERT, as well as its shortcomings, are discussed in Chapter 7 ("Scheduling Stochastic Projects").

The DuPont study and the benefits from CPM and PERT were reported in *Business Week*[39] and *Fortune*[40] articles. In 1963, Levy et al. published an influential primer on CPM in the *Harvard Business Review*.[41] Following the publication of these articles, both CPM and PERT became widely adopted by both public and private organizations and evolved into PM systems that were adopted by many organizations (some willingly and some not).

While the terms *CPM* and *PERT* are sometimes used interchangeably, this book uses these acronyms as they were originally defined. Specifically, CPM refers to the case when task durations and other parameters are deterministic and known with complete certainty, while the PERT model assumes that task durations are random variables that can be described by some appropriate probability distribution. Most commercial PM software programs today (e.g., Microsoft Project) are based on the CPM model (even though many of these programs use the term *PERT* in their documentation and/or title).

Since the original development of CPM and PERT, many extensions have been suggested and implemented. In 1997, Goldratt published the book *Critical Chain* that described the critical chain methodology.[42] The critical chain methodology is based on the concept that precedence networks must include resource and technological precedence constraints as well as many other important concepts relating to risk pooling and buffers. In the critical chain methodology, Goldratt states that a project manager's primary concern should be to meet the announced project deadline even if this results in cost and/or schedule overruns.

As previously noted, Agile PM and related methodologies (e.g., Scrum) have become increasingly popular and widely implemented. Agile PM was originally developed for IT projects when the scope and design were not clearly defined at the start of the project. An early paper describing Agile PM appeared in 1986 by Takeuchi and Nunaka.[43] The ideas of Takeuchi and Nunaka were extended into Scrum and related approaches by Beedle and others.[44] Extensions and further development of Agile PM and related techniques are continuing today.

## 1.10 Overview of the Text

This text is organized following the life cycle of a project indicated in Exhibit 1.3. In Chapter 2, we discuss how projects are initially defined and proposals evaluated; we also discuss the timing of new projects (e.g., Should we adopt an NPD project but postpone its start for a year?) and the use of options thinking in project selection. In Chapter 3, we discuss one of the main themes of this book; that is, how to plan a project and the elements that constitute a project plan. In the supplement to Chapter 3, we discuss Agile PM, which is a popular approach based on dividing a project into smaller subprojects (or sprints) and compare Agile PM with a more traditional PM methodology. In Chapter 4, we discuss project costs and the process of defining a project's tasks using a work breakdown structure (WBS).

In Chapter 5, we discuss the well-known tools used to schedule project activities: precedence networks, Gantt charts, and the CPM. In Chapter 6, we show that the trade-off between schedule and cost has several fundamental properties that are critical for understanding certain elements of managing risk. This topic is extended in Chapter 7, which discusses project planning and scheduling when task durations and costs are random variables. In Chapter 8, we discuss numerous issues relating to resource management, including the "critical chain" philosophy and approach. In Chapter 9, we extend our discussions concerning resources and focus on project teams—specifically, how they are (or should be) defined, whether harmonious or contentious teams perform better, and consider the optimal size of a team. In Chapter 10, we focus on decentralized projects where a parent or client organization plans, directs, and funds a project, but much of the work is performed by independent subcontractors who pursue their individual goals. Relating to decentralized projects, we discuss various types of contracts between client organizations and subcontractors and show how various types of contracts allocate risk and expected profits among the various stakeholders.

In Chapter 11, we move to the execution phase of a project and discuss methodologies used to monitor and assess ongoing projects. We discuss a widely used monitoring and control system: earned value analysis (EVA), which is also known as earned value management (EVM). We discuss the limitations of EVA and present some alternative approaches that avoid some of EVA's limitations. In the final chapter (Chapter 12), we focus on multiple projects and related topics, including project termination and postproject audits.

At the beginning of each chapter, we indicate the learning objectives associated with that chapter. We suggest that each reader review these learning objectives before and after working through each chapter.

### 1.10.1 Important Concepts to Remember

This book develops a theory of managing complex projects and emphasizes the need to manage risks and associated trade-offs among the four dimensions indicated in Exhibit 1.7. Based on the authors' combined experience of more than 60 years working with complex projects, it is our firm belief that a better understanding of these trade-offs leads to improved project outcomes.

To provide a better understanding of PM methodologies and risk management, we use spreadsheet models throughout the book. Spreadsheet models provide insights into many PM problems that are not part of most commercial PM software packages (e.g., Microsoft Project). For example, project managers can use the optimization feature of many spreadsheet models to optimize trade-offs or they can use the random number generator built into most spreadsheet software to construct Monte Carlo simulation models to analyze project risk. These spreadsheet models provide a better understanding of the problems facing most project managers as well as how to manage these problems.

Finally, PM, like management in general, is quintessentially an experiential activity. However, we hope that this book will sensitize students to the problems and trade-offs that they must confront while managing complex projects. In this way, managers will gain a better understanding of the factors that result in various project outcomes (both good and bad) and will be better able to manage projects and their associated risks.



## SUMMARY

**LO 1.1 State why there is a growing need for people with strong project management skills.**

Projects are growing in complexity and size. As a result it has become more important than ever to have strong PM skills. These include the needs for risk management, change management, management of short project life cycles, and mastery and implementation of new PM methodologies. The lack of product management skills can lead to product failures from loss of schedule, budget, and consumer expectations.

**LO 1.2 State the four dimensions that define a project.**

A project is broadly defined as a finite set of tasks or activities that must be completed to meet specified goals. Four dimensions make up every project: (1) time, (2) cost and cash flows, (3) scope or design, and (4) quality. A project differs from a program primarily based on duration and scope. A project is usually temporary and may not be tied directly to the sponsoring organization's structure. A program, however, is generally continuous, larger in scope, and may be made up of many projects. Projects are broadly classified based on complexity and uncertainty. This is assessed on a continuum.

**LO 1.3 Define the phases of a project life cycle.**

There are four phases to a project's life cycle: (1) initiation and selection; (2) planning, budgeting, and scheduling; (3) execution and control; and (4) project termination and postproject audits.

**LO 1.4 Explain measures of project success or failure through costs, schedule, organizational structure, and technical goals.**

A project's success or failure is measured by project goals. These are most often defined by cost and schedule. However, other goals contribute to success and failure such as technical requirements, learning, organizational structure, and customer satisfaction.

**LO 1.5 Differentiate types of risk that can affect project outcomes.**

Risk is any event or factor that may cause a project to fail to achieve its goals or incur additional costs with some probability. Risk factors are characterized by two elements: (1) the probability of some unexpected event and (2) the magnitude on project outcome of that event. Categories of risk include requirements, schedule, cost or budget, resource, technology, competition, political/regulatory issues, legal requirements, and organizational risk.

**LO 1.6 Discuss the various trade-offs that project managers must consider.**

Project managers must make decisions regarding the project dimensions and often must make trade-offs among project goals. Often the manager must determine which goals are fixed and which can be optimized.

**LO 1.7 State the differences between program management and project management.**

Projects are unique and finite in scope whereas programs represent ongoing operations that tend to be repetitive.

**LO 1.8 State the role Agile project management plays in project management today.**

Agile PM is a newer PM methodology that breaks projects down into subprojects called iterations that are worked on sequentially. Each iteration begins where the previous one leaves off. It is a useful methodology for projects that lack clarity of scope and priorities. A disadvantage of Agile PM relates to the potential for increases in cost and schedule.

## KEY TERMS

6P Rule 10
Array project 8
Assembly project 8
Endogenous factors 1
Exogenous factor 1
Makespan 7
Project 6
Project governance 9
Risk 1
Systems project 9
Taxonomy 8

## STUDY QUESTIONS

**Problem 1.1.** Identify a project where you have been part of the project team. How would you benefit from an application of PM techniques in this project? Consider how you would define the specific tasks and their respective durations in this "project." What were the goals of the project? What constraints were imposed on the project managers?

**Problem 1.2.** Consider projects that you have worked on. Were these projects successful or not? If so, why? If not, why not? Is there anything that you learned from these projects that you would apply to future projects?

**Problem 1.3.** Suppose your organization has defined a strategic project that is viewed as essential for the continuing success of your organization. How would you convey the importance of this project to the organization's employees and project members? Would you use any incentives to motivate folks to work hard on this project? If so, how would you define such incentives?

**Problem 1.4.** You have been assigned as project manager for a strategic project in your organization. How would you decide whether or not to subcontract parts of this project to independent subcontractors? How would you decide which parts of the project to subcontract? How would you select subcontractors?

**Problem 1.5.** Think about a new product that was supposed to be available on a given date (e.g., a new IT product) that you planned to purchase. The company has just announced that this product would not be available when promised. What would you do? How would this affect your view of the company that is producing the product?

**Problem 1.6.** Consider a small project that you plan to complete with another person who is geographically separate—examples include analyzing a case study or writing a document. How would you plan such a project? How would you decide to divide the project between you and the other person? How would you coordinate the project during execution? How often would you communicate?

**Problem 1.7.** Consider a small construction project such as building a dog house. You plan to complete this project by yourself. How would you plan such a project? How would you determine what raw materials you need to purchase before beginning the project?

## NOTES

1. Abadie, R. (2014). Capital project and infrastructure spending: Outlook to 2025. *Oxford Economics*. https://www.pwc.com/gx/en/capital-projects-infrastructure/publications/cpi-outlook/assets/cpi-outlook-to-2025.pdf
2. Anselmo, J. (2009, October 30). Boeing 787 late delivery penalties reach $5.1 billion. *Aviation Daily*. https://aviationweek.com/boeing-787-late-delivery-penalties-reach-51-billion
3. Yang, S. (2000, May 15). CSOC's shorten design cycles. *Copyright Electronics News*, p. 22.
4. Vesey, J. (1992). The new competitors: They think in terms of "Speed to Market." *Production and Inventory Management Journal, 33*(1), 71–77.
5. Yang (2000).
6. Flyvbjerg, B., Holm, M., & Buhl, S. (2002). Underestimating costs in public works projects: Error or lie. *Journal of the American Planning Association, 68*(3), 279–295. https://doi.org/10.1080/01944360208976273
7. Flyvbjerg et al. (2002). (p. 286)

8. McBride, J. (2018). *The economics of hosting the Olympic Games*. Council on Foreign Relations. https://www.cfr.org/backgrounder/economics-hosting-olympic-games

9. McBride (2018).

10. Hendricks, K., & Singhal, V. (1997). Delays in new product introductions and the market value of the firm: The consequences of being late to the market. *Management Science, 43*(4). https://doi.org/10.1287/mnsc.43.4.422

11. Kahneman, D. P., & Tversky, A. (1979). Intuitive prediction: Biases and corrective procedures. *TIMS Studies in Management Science, 12*, 313–327.

12. Yap, C. M., & Souder, W. E. (1994). Factors influencing new product success and failure in small entrepreneurial high-technology electronics firms. *Journal of Product Innovation Management, 11*, 418–432. https://doi.org/10.1111/1540-5885.1150418

13. Brown, S. L., & Eisenhardt, K. M. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly, 42*, 1–34. https://doi.org/10.2307/2393807

14. Eisenhardt, K. M., & Tabrizi, B. N. (1995). Accelerating adaptive processes: Product innovation in the global computer industry. *Administrative Science Quarterly, 40*, 84–110. https://doi.org/10.2307/2393701

15. Shenhar, A. (2001, March). One size does not fit all projects: Exploring classical contingency domains. *Management Science, 47*(3), 394–414. https://doi.org/10.1287/mnsc.47.3.394.9772 (p. 395).

16. Shenhar (2001).

17. Shenhar (2001).

18. Wheelwright, S. C., & Clark, K. B. (1992, March–April). Creating project plans to focus. *Harvard Business Review, 70*(2), 70–82.

19. Frable, F. (1999, April 12). Delayed openings are a fact of life in the foodservice, hospitality industry. *Nation's Restaurant News*, p. 18.

20. Flyvbjerg, B., & Budzier, A. (2011, September). Why your IT project may be riskier than you think. *Harvard Business Review, 89*(9), 23–25. https://doi.org/10.2139/ssrn.2229735

21. Might, R. J., & Fischer, W. A. (1985, May). The role of structural factors in determining project management success. *IEEE Transactions on Engineering Management, EM-32*(2). https://doi.org/10.1109/TEM.1985.6447584

22. Hughes, M.W. (1986, April). Why projects fail: The effects of ignoring the obvious. *Industrial Engineering, 18*(4), 14–18.

23. Schmidt, E. (2000, March). Regional construction industry is going through a communications revolution. *New York Construction, 48*(8), 59.

24. Bagli, C. (2000, December 13). Digitally speaking, builders remain on the ground floor. *New York Times*, p. 4.

25. Allen, T. J. (1986, November). Organizational structure, information technology, and R&D productivity. *IEEE Transactions on Engineering Management, 33*(4). https://doi.org/10.1109/TEM.1986.6447681

26. Katz, R., & Allen, T. (1985). Project performance and the locus of influence in the R&D matrix. *Academy of Management Journal, 28*(1), 67–87. https://doi.org/10.2307/256062

27. Larson, E., & Gobeli, D. (1989, May). Significance of project management structure on development success. *IEEE Transactions on Engineering Management, 36*(2). https://doi.org/10.1109/17.18828

28. Might and Fischer (1985).

29. Larson and Gobeli (1989).

30. Allen (1986).

31. Katz and Allen (1985).

32. Might and Fischer (1985).

33. Larson and Gobeli (1989).

34. The Standish Group Report (Chaos). (2014). https://www.projectsmart.co.uk/white-papers/chaos-report.pdf

35. Moore, G. (1998, January). Cramming more components onto integrated circuits. *Proceedings of the IEEE, 86*(1), 82–85. https://doi.org/10.1109/JPROC.1998.658762

36. Staw, B., & Ross, J. (1987, March–April). Knowing when to pull the plug. *Harvard Business Review, 65*(2), 68–74.

37. Huchzermeier, A., & Loch, C. H. (2001, January). Project management under risk: Using the real options approach to evaluate flexibility in R&D. *Management Science, 47*(1), 85–101. https://doi.org/10.1287/mnsc.47.1.85.10661

38. The Standish Group Report (Chaos). (2014).

39. Better plans come from study of anatomy of an engineering job. (1959, March 21). *Business Week,* pp. 60–66.

40. Boehm, G. A. W. (1962, April). Helping the executive to make up his mind. *Fortune, 65*, 128–132.

41. Levy, F., Thompson, G. L., & Wiest, J. D. (1963, September–October). The ABC's of the critical path method. *Harvard Business Review,* 98–108.

42. Goldratt, E. M. (1997). *Critical chain*. North River Press.

43. Takeuchi, H., & Nonaka, I. (1986, January–February). The new new product development game. *Harvard Business Review, 64,* 137–146.

44. Beedle, M., Devos, M., Sharon, Y., Schwaber, K., & Sutherland, J. (1999). Scrum: A pattern language for hyperproductive software development. In N. Harrison (Ed.), *Pattern languages of program design* (Vol. 4, pp. 637–651). Addison-Wesley.