PROJECT MANAGEMENT FOR ENGINEERING, BUSINESS AND TECHNOLOGY

JOHN M. NICHOLAS AND HERMAN STEYN

SIXTH EDITION

"An excellent book which provides comprehensive coverage of project management theory and practice with insights from technology-based case studies, practical examples and exercises. An essential core text for project management students in engineering and technology disciplines."

—**Jane Britton,** *University College London, UK*

"As a Professor who has taught Project Engineering for the last 14 years, I have also performed large scale Project Engineering throughout my first career (over 20 years) in Aerospace, Defense and Information Technology. When deciding on a textbook for my graduate Project Engineering class, I looked long and hard. I wasn't finding what I was looking for and was going to write my own, until I found *Project Management for Engineering, Business and Technology*. This is the textbook I would have written. It is robust, complete and easy to follow. The graphics, charts and figures are all very descriptive and real. . . . I highly recommend this textbook for anyone teaching Engineering, Business or Technology Project Management/Engineering. I also recommend it as a 'keeper' for students who will be guiding projects in the future."

—**Mark Calabrese,** *University of Central Florida, USA*

"This book has long been a comprehensive but accessible publication that provides valuable insights into the strategic and day-to-day management of projects both large and small. There are numerous publications in this field but Nicholas and Steyn have found the balance between the needs of experienced practitioners looking for ways to improve project outcomes, and the needs of students who are new to the project management field. The concepts are clearly and logically laid out, and the language is appropriate for a wide range of audiences. It continues to be a benchmark in a crowded field of publications offering both practical and strategic insights into the art and craft of project management."

—**Barrie Todhunter,** *University of Southern Queensland, Australia*

"I have absolutely no hesitation in recommending this book as a standard resource for teaching students in a university set up and/or for working executives in a project environment. The book is also a good resource as a study material for certification courses."

—**Krishna Moorthy,** *Ex-Dean, Larsen & Toubro Institute of Project Management, India*

"*Project Management for Engineering, Business and Technology* is one of the most comprehensive textbooks in the field. Nicholas and Steyn explain the matter in a readable and easy-to-understand way, illustrated with interesting examples. The authors combine the 'hard matter' of project management with relevant behavioural aspects. Overall, a useful work for anyone new to the field or as reference for the more advanced project manager."

—**Martijn Leijten,** *Delft University of Technology, The Netherlands*

"A very comprehensive text. An excellent mix of materials to enable students to learn techniques and engage in discussion of scenarios."

—**Richard Kamm,** *University of Bath, UK*

Project Management for Engineering, Business and Technology

Project Management for Engineering, Business and Technology is a highly regarded textbook that addresses project management across all industries. First covering the essential background, from origins and philosophy to methodology, the bulk of the book is dedicated to concepts and techniques for practical application. Coverage includes project initiation and proposals, scope and task definition, scheduling, budgeting, risk analysis, control, project selection and portfolio management, program management, project organization, and all-important "people" aspects—project leadership, team building, conflict resolution, and stress management.

The systems development cycle is used as a framework to discuss project management in a variety of situations, making this the go-to book for managing virtually any kind of project, program, or task force. The authors focus on the ultimate purpose of project management—to unify and integrate the interests, resources, and work efforts of many stakeholders, as well as the planning, scheduling, and budgeting needed to accomplish overall project goals.

This sixth edition features:

- updates throughout to cover the latest developments in project management methodologies;
- a new chapter on project procurement management and contracts;
- an expansion of case study coverage throughout, including those on the topic of sustainability and climate change, as well as cases and examples from across the globe, including India, Africa, Asia, and Australia; and
- extensive instructor support materials, including an instructor's manual, PowerPoint slides, answers to chapter review questions, and a test bank of questions.

Taking a technical yet accessible approach, this book is an ideal resource and reference for all advanced undergraduate and graduate students in project management courses, as well as for practicing project managers across all industry sectors.

John M. Nicholas is Professor of Operations and Project Management at Loyola University Chicago, USA. He is an active teacher, writer, and researcher in the areas of project management and lean production and has led or participated in projects with organizations such as Lockheed Martin Corporation, Bank of America, and Argonne National Laboratory.

Herman Steyn is Professor of Project Management in the Graduate School of Technology Management, University of Pretoria, South Africa. He has also managed a variety of large- and small-scale engineering projects and is the author of widely cited papers on project management.

Project Management for Engineering, Business and Technology

SIXTH EDITION

John M. Nicholas
Loyola University Chicago

Herman Steyn
University of Pretoria

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To Sharry, Julia, Joshua, and Abigail
J.M.N.

To Karen and Janine
H.S.

Brief Contents

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Preface

When people see or use something impressive—a bridge arching high over a canyon, a space probe touching down on a distant planet, an animated game so realistic you think you're there, or a nifty phone/camera/computer the size of your hand—they sometimes wonder, "How did they do that?" By *they*, of course, they are referring to the creators, designers, and builders, the people who created—thought up and made—those things. Seldom do they wonder about the *leaders* and *managers*, the people who organized and lead the efforts that brought those astounding things from concept to reality and without whom most neat ideas would never have been achieved. This book is about them—the managers of projects, the mostly unsung heroes of engineering, business, and technology who stand outside the public eye but ultimately are responsible for practically everything that requires collective human effort.

The projects is but one of many people involved in the creation of society's products, systems, and artifacts, yet it is he or she who gets the others involved and organizes and directs their efforts so everything comes out right. Occasionally, the manager and the creator happen to be the same: Burt Rutan, Woody Allen, and Gutzon Borglum are examples; their life work—in aerospace, motion pictures, and monumental sculptures, respectively—represent not only creative or technological genius but leadership and managerial talent as well.

In the last several decades, businesses have expanded from domestic, nationalistic enterprises and markets into multinational, global enterprises and markets. As a result, from a business perspective, there is more of everything to contend with—more ideas, competitors, resources, constraints, and, certainly, more people doing and wanting things. Technology is advancing and products and processes are evolving at a more rapid pace; as a result, the life cycles of most things in society are getting shorter. This "more of everything" has had a direct impact on the conduct of projects—including projects to develop products, systems, or processes that compete in local, domestic, and international markets; projects to create and implement new ways of meeting demand for energy, recreation, housing, communication, transportation, and food; and projects to answer basic questions in science and resolve grave problems such as disease, pollution, climate change, and the aftermath of natural disasters. All of this project activity has spurred a growing interest in improved ways to plan, organize, and guide projects to better meet the needs of customers, markets, and society within the bounds of limited time and resources.

Associated with this interest is the growing need to educate and train project managers. In the past—and still today—project managers were chosen for some demonstrated exceptional capability, although not necessarily managerial. If you were a good engineer, systems analyst, researcher, architect, or accountant, eventually you would become a project manager. Somewhere along the way, presumably, you would pick up the "other" necessary skills. The flaw in this reasoning is that project management encompasses a broad range of skills—managerial, leadership, interpersonal—that are much different from and independent of skills associated with technical competency. And there is no reason to presume that the project environment alone will provide the opportunity for someone to "pick up" these other necessary skills.

As a text and handbook, this book is about the "right" way to manage projects. It is intended for advanced undergraduate and graduate university students and practicing managers in engineering, business, and technology. It is a book about principles *and* practice, meaning that the topics in it are practical and meant to be applied. It covers the big picture of project management—origins, applications, and philosophy, as well as the nitty-gritty, how-to steps. It describes the usual project management topics of schedules, budgets, and controls but also the human side of project management, including leadership and conflict.

Why a book on project management in engineering *and* business *and* technology? In our experience, technology specialists such as engineers, programmers, architects, chemists, and so on involved in "engineering/technology projects" often have little or no management or leadership training. This book, which includes many engineering and technology examples, provides somewhat broad exposure to business concepts and management specifics to help these specialists get started as managers and leaders.

What about those people involved in product-development, marketing, process-improvement, and related projects commonly thought of as "business projects"? Just as technology specialists seldom receive formal management training, students and practitioners of business rarely get formal exposure to practices common in technology projects. For them, this book describes not only how "business" projects are conducted but also the necessary steps in the conception and execution of engineering, system development, construction, and other "technology" projects. Of course, every technology project is *also* a business project: it is conducted in a business context and involves business issues such as customer satisfaction, resource utilization, deadlines, costs, and profits.

Virtually all projects—engineering, technology, and business—originate and are conducted in a similar way, in this book conceptualized using a methodology called the systems development cycle (SDC). The SDC serves as a general framework for discussing the principles and practices of project management and illustrating commonalities and differences among a wide variety of projects.

This book is an outgrowth of the authors' combined several decades of experience teaching project management at Loyola University Chicago and University of Pretoria to business and engineering students, preceded by several years' experience in business and technology projects, including for aircraft design and flight tests, large-scale process facility construction, and software application development and process improvement. This practical experience gave us an appreciation not only for the business-management side of project management but also for the human-interpersonal side as well. We have seen the benefits of good communication, trust, and teamwork, as well as the costs of poor leadership, emotional stress, and group conflict. In our experience, the most successful projects are those where leadership, trust, communication, and teamwork flourished, regardless of the formal planning and control methods and systems in place. This book largely reflects these personal experiences. Of course, comprehensive coverage of project management required that we look much beyond our own experience and draw upon the published works of many others and the wisdom and suggestions of colleagues and reviewers.

In this sixth edition, we have revised and added material to incorporate new topics of interest, current examples, and the growing body of literature in project management. Among significant changes are a new chapter on project procurement management (Chapter 12) and completely reorganized chapters on project execution and closeout (Chapter 5) and project monitoring and control (Chapter 13). The Introduction includes updated tables that relate sections of the book to the project management knowledge areas and methodologies of PMI, PMBOK, IPMA, APM, and PRINCE2. Also newly included are examples recognizing the role of project management in addressing sustainability and climate change (Chapters 3, 11, and 19). Books tend to grow in size with each new edition; to combat that, all chapters have been rewritten to make everything more readable and concise. Despite the inclusion of new material, we've held the page count to roughly the same as it was in the previous edition.

Our goal in writing this book is to provide students and practicing managers the most practical, current, and interesting text possible. We appreciate hearing your comments and suggestions. Please send them to us at jnichol@luc.edu and herman.steyn@up.ac.za.

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John M. Nicholas
Herman Steyn

About the authors

JOHN M. NICHOLAS is Professor of Operations Management and Project Management in the Quinlan School of Business at Loyola University Chicago. He is an active teacher, writer, and researcher in project management and production management and conducts executive seminars and consuls on project management and process improvement. John is the author of numerous academic and technical publications and five books, including *Lean Production for Competitive Advantage* (2018) and *The Portal to Lean Production* (2006). He has held the positions of team lead and engineer on military and commercial aircraft development projects at Lockheed-Martin Corporation, team lead and business analyst on operations projects at Bank America, and researcher on energy-environmental research projects at Argonne National Laboratory. He has a BS in aeronautical and astronautical engineering and an MBA in operations research from the University of Illinois, Urbana-Champaign, and a PhD in industrial engineering and applied behavioral science from Northwestern University.

HERMAN STEYN is Professor of Project Management in the Graduate School of Technology Management, University of Pretoria, South Africa. He has been involved in projects in industry since 1975; has managed a variety of large and small engineering projects (system, product, and process development) in the minerals, defense, and nuclear industries; and has also managed programs and project portfolios. In 1996, he was appointed in his current position at the University of Pretoria, where he initiated a masters' program in project management. Besides supervising project management research and teaching graduate project management courses, Herman has conducted more than 200 seminars and workshops on project management. He has a bachelor's degree and graduate diploma in metallurgical engineering, an MBA, and a PhD in engineering management.

Introduction

I.1 In the beginning. . .

Sometime during the third millennium BC, workers on the Great Pyramid of Khufu set the last stone in place. They must have felt jubilant, for this event represented a milestone of sorts in one of humanity's grandest undertakings. Although much of the ancient Egyptians' technology is still a mystery, the enormity and quality of the finished product remains a marvel. Despite the lack of sophisticated machinery, they were able to raise and fit some 2,300,000 stone blocks, weighing 2 to 70 tons apiece, into a structure the height of a modern 40-story building. Each facing stone was set against the next with an accuracy of 0.04 inch (1 mm), and the base, which covers 13 acres (52,600 m^2), deviates less than 1 inch (25 mm) from level (Figure I.1).[1]

Equally staggering was the number of workers involved. To quarry the stones and transport them down the Nile, 20,000–30,000 laborers were levied. In addition, skilled masons and attendants were employed in preparing and laying the blocks and erecting or dismantling the construction ramps. Public works were essential to keep the working population employed and fed, and it is estimated that no less than 150,000 women and children also had to be housed and fed.[2] But just as mind-boggling was the managerial ability exercised by the Egyptians throughout the estimated 20-year duration of the pyramid construction. Francis Barber, a nineteenth-century pyramid scholar, concluded that:

> It must have taken the organizational capacity of a genius to plan all the work, to lay it out, to provide for emergencies and accidents, to see that the men in the quarries, on the boats and sleds, and in the mason's and smithies shops were all continuously and usefully employed, that the means of transportation was ample . . . that the water supply was ample . . . and that the sick reliefs were on hand.[3]

Some have suggested the pyramid was built by slaves, but research indicates that such a massive undertaking could only have been accomplished by a highly skilled, motivated, and well-fed workforce, eager to participate in such an historic and honorable endeavor.

Building the Great Pyramid is what we today would call a large-scale project. It stands among numerous projects from early recorded history that required massive human works, complex and thorough planning, and managerial competency. For the Great Pyramid's construction, we know that the pharaoh Khufu chose his vizier, Hemiunu, to manage and lead the project.

Figure I.1
The Great Pyramid of Khufu, center back, an early (circa 2500 BC) large-scale project.
Source: Photo courtesy of iStock.

Also worthy of note are the managerial and leadership accomplishments of Moses. The Biblical account of the exodus of the Hebrews from the bondage of the Egyptians gives some perspective on the preparation, organization, and execution of this tremendous undertaking. Supposedly Moses did a magnificent job of personnel selection, training, organization, and delegation of authority.[4] The famed ruler Solomon also was the "manager" of great projects. He transformed the battered ruins of many ancient cities and crude shantytowns into powerful fortifications. With his wealth and the help of Phoenician artisans, Solomon built the Temple in Jerusalem. Seven years went into the construction of the Temple, after which Solomon took 13 years more to build a palace for himself. He employed a workforce of 30,000 Israelites to fell trees and import timber from the forests of Lebanon.[5] That was almost 3,000 years ago.

With later civilizations, notably the Greeks and Romans, projects requiring extensive planning and organizing escalated. To facilitate their military campaigns and commercial interests, the Romans constructed networks of highways and roads throughout Europe, Asia Minor, Palestine, and northern Africa so that all roads would "lead to Rome." The civilizations of Renaissance Europe and the Middle and Far East undertook river engineering, construction of aqueducts, canals, dams, locks, and port and harbor facilities. With the spread of modern religions, construction of temples, monasteries, mosques, and massive urban cathedrals was added to the list of projects.

With the advent of industrialization and electricity, projects for the construction of railroads, electrical and hydro-electrical power facilities and infrastructures, subways, and factories became commonplace. In recent times, development of large systems for communications, defense, transportation, research, and information technology have spurred different, more complex kinds of project activity.

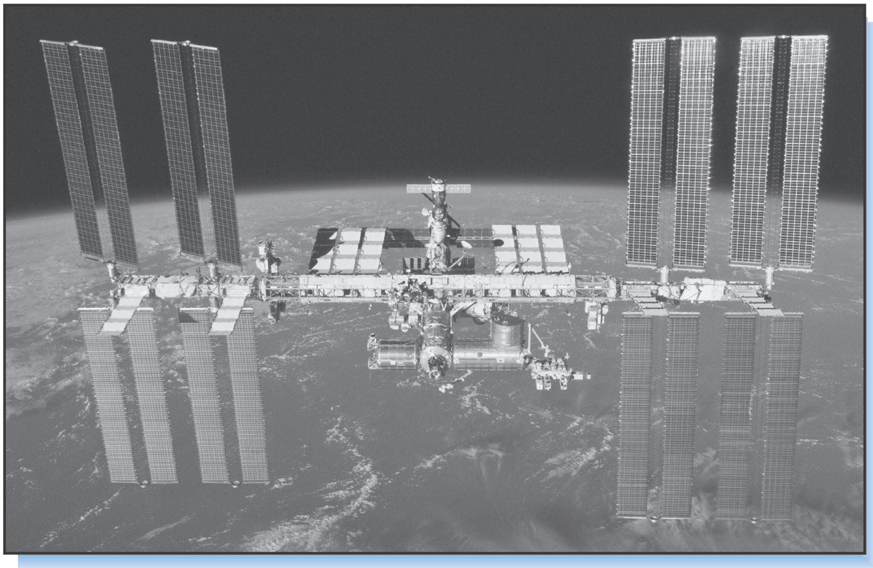

Figure I.2
The International Space Station, a modern large-scale project.
Source: Photo courtesy of NASA.

As long as people do things, there will be projects. Many projects of the future will be similar to those in the past. Others will be different either in terms of increased scale of effort or more advanced technology. Representative of the latter are two recent projects, the English Channel tunnel (Chunnel) and the International Space Station. The Chunnel required tremendous resources and took a decade to complete. The International Space Station (Figure I.2) required development of new technologies and the efforts of the US, Russian, European, Canadian, and Japanese space agencies.

I.2 What is a project?

From these examples, it is clear that humankind has been involved in project activities for a long time. But why are these considered "projects" while other human activities, such as planting and harvesting a crop, stocking a warehouse, issuing payroll checks, or manufacturing a product, are not?

What is a project? This is a question we will cover in much detail later. As an introduction, though, listed subsequently are some characteristics that warrant classifying an activity as a project.[6]

1. A project has a defined *goal—a purpose* with *well-defined end-items, deliverables*, or *results* to achieve specific *benefits*.
2. It is *unique*; it requires doing something differently than was done previously. It is a one-time activity, never to be exactly repeated again.
3. It is a *temporary* organization formed to accomplish the project goal in a limited time frame.
4. It utilizes people and other resources *from different organizations and functions*.
5. Given that each project is unique, it carries *unfamiliarity* and risk.

The examples described earlier are for familiar kinds of projects such as construction (pyramids) and technology development (space station). In general, the list of activities that qualify as projects is long and includes many that are commonplace. Weddings, remodeling a home, and moving to another house are projects; so are company audits, major litigations, corporate relocations, and motion picture productions; and so are efforts to develop new products and implement new systems. Military campaigns also qualify as projects; they are temporary, unique efforts directed toward a specific goal. The Normandy Invasion in World War II on June 6, 1944 is an example:

> The technical ingenuity and organizational skill that made the landings possible was staggering. The invasion armada included nearly 5,000 ships of all descriptions protected by another 900 warships. The plan called for landing 150,000 troops and 1500 tanks on the Normandy coast *in the first 48 hours*.[7]

Most artistic endeavors are projects, too. Composing a song or symphony, writing a novel, or making a sculpture are one-person projects. Some artistic projects also require the skills of engineers and builders, for example, Mount Rushmore, the Statue of Liberty, and the Eiffel Tower.

Many efforts at saving human life and recovering from man-made or natural disasters become projects. Examples are the massive cleanup following the Soviet nuclear accident at Chernobyl; rescue and recovery operations following disastrous earthquakes in Chile, Haiti, China, Pakistan, Mexico, Turkey, Italy, and elsewhere; the Indian Ocean tsunami of 2004; the Ebola outbreak in western Africa in 2014; and the COVID-2019 pandemic. Ongoing efforts to stem climate change and mitigate its global effects will of necessity spur innumerable projects.

Figure I.3 shows diverse project endeavors and examples of well-known projects and where the projects fall with respect to complexity and uncertainty. Complexity is measured by the magnitude of the effort—the number of groups and organizations involved and the diversity of skills or expertise needed to accomplish the work. Time and resource commitments tend to increase with complexity.

Uncertainty is measured roughly by the difficulty in predicting the final outcome in terms of the dimensions of *time*, *cost*, and *technical performance*. In most projects, there is some uncertainty in one or two dimensions (e.g. weddings); in complex projects, there is uncertainty in all three (e.g. the space station).

Generally, the more often something is done, the less uncertainty there is in doing it. This is simply because people learn by doing and so improve their efforts—the "learning curve" concept. Projects that are very similar to previous ones and about which there is abundant knowledge have lower uncertainty. These are found in the lower portion of Figure I.3 (e.g. weddings, highways, dams, system implementation). Projects with high uncertainty are in the upper portion of the figure.

When the uncertainty of a project drops to nearly zero, and when the project effort is repeated a large number of times, then the work is usually no longer considered a project. For example, building a skyscraper is definitely a project, but mass construction of prefabricated homes more closely resembles a scheduled, repetitive operation than a project. The first flight to the South Pole by Admiral Byrd was a project, but modern daily supply flights to bases there are not. Early human missions to Mars will be projects, but future chartered tourist trips to hotels and excursions on Mars will not be. They will just be run-of-the-mill scheduled operations.

The cost curve in Figure I.3 indicates that a project's expense tends to increase roughly in proportion to its complexity and uncertainty. Cost, represented in terms of time or economic value, is at the level of tens or hundreds of labor hours for projects with low complexity and uncertainty but increases to millions and billions of hours for projects with the greatest complexity and uncertainty.

In all cases, projects are conducted by organizations that, after the project is completed, go on to do something else (construction companies) or are disbanded (Admiral Byrd's crew, the Mars exploration team). In contrast, repetitive, high-certainty activities (prefabricated housing, supply flights, and tourist trips to Antarctica or Mars) are performed by permanent organizations that do the same thing repeatedly, with few changes in operations other than scheduling. Because projects are not repetitive, they must be managed differently.

Figure I.3
A typology of projects.

I.3 All projects are not the same[8]

Besides Figure I.3, another way to illustrate the diversity in projects is with the so-called NTCP model or Diamond model, which classifies projects and their end results or products into four dimensions, each with three or four possible levels. The dimensions and levels are:

- *Novelty*: Represents how new the project end-item or product is to customers and potential users and how well defined its initial product requirements are. It has three levels:
    - *Derivative*—the project end-item or product is an extension or improvement of an existing product or system, for example, new features to an existing car model
    - *Platform*—the end-item or product is a new generation of an existing product line in a well-established market, for example, a new car model
    - *Breakthrough*—the end-item or product is new to the world, for example, the first mobile telephone, the first commercially available flying car.
- *Technology*: Represents the project's technological uncertainty and whether it is new or mature. It addresses the question of how much new technology is required to create, build, manufacture, and enable the use of the product and how much technical competency is needed by the project manager and the team. It has four levels:
    - *Low-tech*—involves only well-established technologies
    - *Medium-tech*—uses mainly existing technologies but also limited use of some new technology or new features, for example, automotive and appliances industries
    - *High-tech*—uses technologies that are mostly new to the firm but already exist and are available at project initiation; typical of many defense and computer projects; is synonymous with "high-risk"
    - *Super-high-tech*—relies on new technologies that do not exist at project initiation. The project goal is well defined, but the solution is not; is synonymous with "very high-risk," for example, landing humans on Mars.
- *Complexity*: Represents the complexity of the product and the project organization; has three levels:
    - *Assembly*—the project involves combining a collection of elements, components, and modules into a single unit or entity that performs a single function, for example, developing a new coffee machine or creating a department to manage a single function (such as payroll)
    - *System*—involves a complex collection of interactive elements and subsystems that jointly perform multiple functions to meet specific operational needs, for example, creating a new car, new computer, or entirely new business;
    - *Array*—the project involves a large variety of dispersed systems (a system of systems, or "super system") that function together to achieve a common purpose, for example, national communications network, mass transit infrastructure, regional power generation and distribution network, an entire corporation.
- *Pace*: Refers to time available for the project—the urgency or criticality of meeting project's completion targets; has four levels:
    - *Regular*—no urgency; time is not critical to immediate success
    - *Fast/competitive*—complete project in adequate time to address market opportunities, create a strategic positioning, or form a new business unit, for example, launching a new drug, introducing a new product line
    - *Time-critical*—complete project by a specific deadline; missing the deadline means project failure, for example, Y2K projects, construction of facilities for the Olympic Games, launch of space probe to a comet
    - *Blitz*—a crisis project; the criterion for success is solving a problem as fast as possible, for example, rescue the survivors of a tsunami or develop a vaccine in a pandemic.

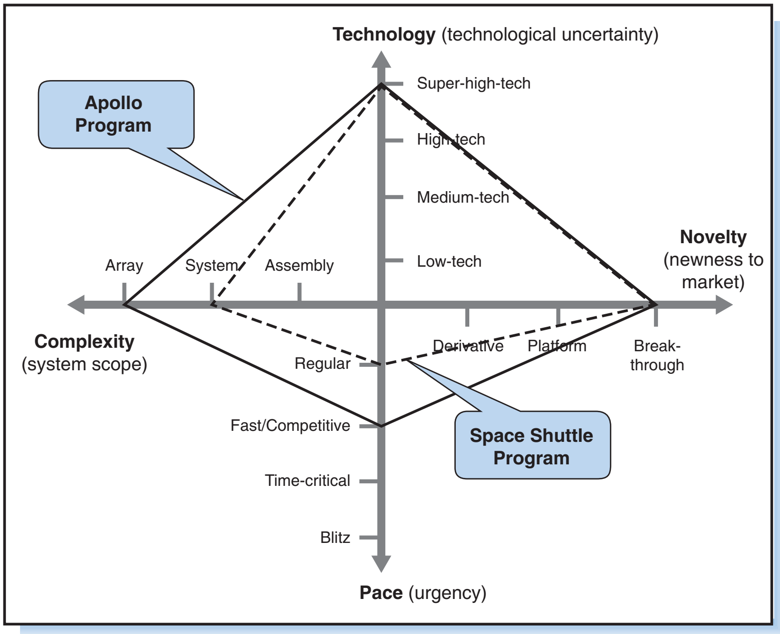

Figure I.4
Shenhar and Dvir's NTCP diamond model contrasting the Apollo and space shuttle programs.
Source: Shenhar A. and Dvir D. *Reinventing Project Management: The Diamond Approach to Successful Growth and Innovation*. Cambridge, MA: Harvard Business School Press; 2007.

All projects can be characterized according to the four dimensions. In Figure I.4, each of the dimensions is represented by a quadrant on the graph. The diamond-shaped profiles show the four dimensions for two examples, the Apollo lunar program and the space shuttle program.

I.4 Project management: the need

Although mankind has been involved in projects since the beginning of recorded history, obviously the nature of projects and the environment have changed. Many modern projects involve technical complexity and challenges in terms of assembling and directing large temporary organizations while subject to constrained resources, limited time schedules, and environmental uncertainty. An example is the NASA Pathfinder Mission to land and operate a rover vehicle on the surface of Mars. Such a project was unparalleled not only in terms of technical difficulty and organizational complexity but also for the requirements imposed on it. In ancient times, requirements were more flexible. When Renaissance builders ran out of funds during construction of a cathedral, they stopped the work until more funds could be raised (one reason cathedrals took decades or centuries to complete). When a king ran out of money while building a fortress or palace, he could just levy more taxes. In cases where additional money or workers could not be found or the project delayed, then the scale of effort or quality of workmanship was reduced.

More common, however, project requirements are not flexible. Khufu's Great Pyramid had to be completed before the pharaoh died to serve as his tomb and portal to the afterlife, and tens of thousands of skilled artisans and laborers were recruited so as to meet that deadline (pun intended). The Mars Pathfinder project was challenged with developing and landing a vehicle on Mars in less than 3 years' time and on a $150 million budget—less than half the time and 1/20th the cost of the last probe NASA had landed on Mars. The project involved advanced research and explored new areas of science and engineering. Technical performance requirements could not be compromised.

Beyond large-scale engineering efforts, constraints and uncertainty are common in everyday business and technology projects where organizations strive to develop and implement new products, processes, and systems and to adapt to changing requirements in a changing world. Consider Dalian Company's development of "Product J," a product development project that exemplifies companies everywhere in the struggle to remain competitive. Product J is a promising but radically new idea. To move the idea from a concept to a real product will require the involvement of engineers and technicians from several Dalian divisions and suppliers. Product J will require meeting tough technical challenges, launching the product ahead of the competition, and doing it for an affordable cost.

Another example is Shah Alam Hospital's installation of a new employee benefits plan. The project would involve developing new policies, training staff workers, familiarizing 10,000 employees with the plan, and installing new software and a database and require participation from personnel in human resources, financial services, and information systems, plus experts from two consulting firms. It typifies "change" projects everywhere—projects initiated in response to changing needs and with the goal of transforming the organization's way of doing things.

Finally, consider that virtually every company has or will have a website. Behind each site are multiple projects to develop or enhance the website and to integrate electronic business technology into the company's mainstream marketing and supply-chain operations. Such projects are also examples of organizations' need to change, in this case to keep pace with advances in information technology and business processes.

Activities such as these defy traditional management approaches for planning, organization, and control. They are representative of activities that require the use of project management to meet technological or market-related performance goals in spite of limited time and resources.

I.5 Project goal: time, cost, and performance

The goal of every project can be conceptualized in terms of hitting a target that floats in three-dimensional space—the dimensions of *cost*, *time*, and *performance* (Figure 1.5). Cost is the specified or budgeted cost for the project. Time is the scheduled period over which the work is to be done. Performance is what the project end-item, deliverables, or final result must do; it includes whatever the project customer, user, and other stakeholders consider necessary or important. The target represents a goal to deliver a certain something to somebody by a certain date and for a certain cost. The purpose of project management is to hit the project target goal.[9]

But technological complexity, changing markets, and an uncontrollable environment make hitting the target difficult. Time, cost, and technical performance are interrelated, and exclusive emphasis on any one will likely undermine the others. In trying to meet schedules and performance requirements, costs increase; conversely, in trying to contain costs, work performance erodes and schedules slip. In earlier times, one or two aspects of the goal could be allowed to slide so that the "most fixed" could be met. Many projects, such as the Pathfinder, Dalian Company, and Shah Alam Hospital examples, do not have this luxury. Project management offers a way to maintain focus on all three dimensions and to control the tradeoffs among them.

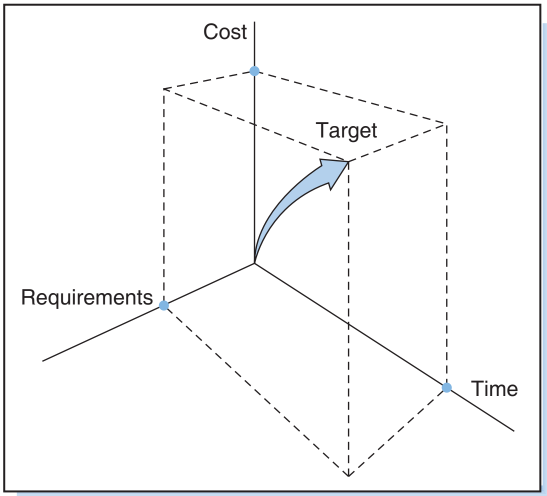

Figure I.5
Three-dimensional project goal.
Source: Adapted from Rosenau M. *Successful Project Management*. Belmont, CA: Lifetime Learning Publications; 1981, p. 16.

I.6 Project management: the person, the team, the methodology

Three features distinguish project management from traditional forms of management: the person, the team, and the methodology.

The most prominent feature of project management is the role of the project manager—the individual who has overall responsibility to *plan, direct*, and *integrate* the efforts of everyone associated with the project to achieve the project goal. In the role of project manager, one person is held accountable for the project and is dedicated to achieving its goals. The project manager coordinates the efforts of every functional area and organization in the project and oversees the planning and control of costs, schedules, and work tasks. As we will discuss, numerous other parties (stakeholders) are also involved in and crucial to project management; nonetheless, the role of project manager is a key feature distinguishing project- from non-project management.

Doing a project is a team effort, and project management means bringing individuals and groups together to form the team and directing them toward the common goal. The team will often consist of people and groups from different functional areas and organizations. Depending on the project, the size and composition of the team may fluctuate; usually the team disbands after the project is completed.

The project manager and project team typically perform work in phases according to a "project management methodology." This methodology provides for *integrative planning and control* of projects, which, says Archibald, refers to the pulling together of all important elements of information related to (1) the products or results of the project, (2) the time, and (3) the cost, in funds, manpower, or other key resources . . . for all (or as many as practical) phases of the project. [It] requires continual revision of future plans, comparison of actual results with plans, and projection of total time and cost at *completion* through interrelated evaluation of all elements of information.[10]

As a project proceeds from one phase to the next, the project manager relies on the methodology to (1) identify the project tasks, (2) identify the required resources and costs, (3) establish priorities, (4)