

Based on the Bestselling Seminar by the American Management Association

IMPROVING YOUR PROJECT MANAGEMENT SKILLS

SECOND EDITION



LARRY RICHMAN, PMP

Improving Your Project Management Skills



Second Edition

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Improving Your Project Management Skills

Second Edition

LARRY RICHMAN

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This book is based on the seminar "Improving Your Project Management Skills: The Basics for Success," revised for the American Management Association by Gary Cbin and Helen Gordon.

Library of Congress Cataloging-in-Publication Data

Richman, Larry L. (Larry Leon), 1955–
Improving your project management skills / Larry Richman.—2nd ed.
p. cm.
Includes bibliographical references and index.
ISBN-13: 978-0-8144-1728-7 (alk. paper)
ISBN-10: 0-8144-1728-0 (alk. paper)
1. Project management. I. Title.
HD69.P75R526 2011
658.4'04—dc22

2011003247

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Printing number

10 9 8 7 6 5 4 3 2 1

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Introduction to the Second Edition

PROJECT MANAGEMENT KNOWLEDGE and skills can help you complete projects on schedule, within budget, and in full accordance with project specifications. At the same time, they help achieve the other goals of the organization, such as productivity, quality, and cost-effectiveness. By definition, every project is unique—a specific set of tasks aligned to meet stated requirements. But a skilled project manager consistently applies universal processes and skills to bring consistency and results to one project after another. Learning project management skills can help you implement these proven strategies for clarifying project objectives, avoiding serious errors of omission, and eliminating costly mistakes.

This book guides you step-by-step through all the processes in the life of a project, beginning with defining project scope and requirements. It explains how to create a work breakdown structure and diagram the activities into a logical sequence using simple network diagrams. It then describes

techniques for estimating work on these activities, including trade-offs in time, cost, and resource allocation. You then learn how to compile your schedules, budgets, and resource plans into a comprehensive project plan.

Chapters will teach you how to monitor and control project activities using your project plan as a baseline. In addition to hard project management skills, you will learn the people skills needed to lead and direct project teams to get the job done. The book also includes chapters on identifying and managing risk and how to properly close the project and document lessons learned.

This book is based on the best-selling American Management seminar “Improving Your Project Management Skills,” attended by thousands of project professionals every year. This second edition has been updated for consistency with *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*—Fourth Edition, published by the Project Management Institute. It reflects the latest professional standards in project management and provides current project management practices and examples.

Your organization demands and deserves superior project execution and consistent results. These powerful project tools, based on a world-class learning program and proven, universal project management tenets, will help you streamline processes, reduce costs, and improve productivity in your project environment.

PART 1

Project Management Foundations

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The Core Concepts

PROJECTS ARE AN ESSENTIAL PART of human history. Some projects arise in myth, some in wartime, some from faith, and others from science and commerce. Some projects are monumental, and others are more modest. Ancient Egypt created the Great Pyramids, the Sphinx, the Library, and the Lighthouse of Alexandria. China's Great Wall, which still stands today, took over 1,000 years to build. Peru's Incan culture left us the lingering splendor of Machu Picchu. In our own time, we have placed men on the moon and returned them safely. We have developed drugs that target specific diseases. We have responded to environmental incidents, managed failures at nuclear sites, and responded to natural disasters. We have linked individuals and organizations through the miracle of the Internet. We have fulfilled the promise of integrated business systems that embrace enterprise resource planning, inventory management, production and control, human resources, and financial systems. This history of accomplishment will not end.

Some projects are ambitious and far-reaching in their social, economic, and political impacts. Others are less grand and more self-contained. Some require advances in basic science, and others deploy proven technology or best practices. Some projects challenge deeply held beliefs, and others uphold traditional values. And some projects fail.

The goal is always to achieve some beneficial change. Every project is an endeavor. Every project is an investment. Every project will end. Some will end when the goal is achieved, and others when the time or cost is disproportionate to the value. Some projects will be cancelled. In all cases, the project manager serves as the focal point of responsibility for the project's time, cost, and scope.

Project Management Vocabulary

Success requires that the project manager serve as the focal point of effective, timely, and accurate communication. To do this well, the project manager must master a new vocabulary and must use it consistently to communicate successfully. The definitions introduced in this chapter are the project manager's methods of art—words and terms used in the context of planning, scheduling, and controlling projects.

A *project* is “a temporary endeavor undertaken to create a unique product, service, or result.”* Projects are *temporary* because they have a definite beginning and a definite end. They are *unique* because the product, service, or result is different in some distinguishing way from similar products, services, or results. The construction of a headquarters building for ABC Industries is an example of a project. The unique

*A *Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fourth Edition*, Project Management Institute, 2008, p. 5.

work is defined by the building plans and has a specific beginning and end.

Project management is “the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements” (Ibid., p. 6).

In mature organizations, multiple projects may be grouped and managed together in a *program* to obtain benefits and control not available from managing them individually (see Ibid., p. 9). Multiple programs may be grouped and prioritized into *portfolios* aligned around larger strategic organizational objectives. *Portfolio management* is the “centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work, to achieve specific strategic business objectives” (Ibid., p. 9).

Why Project Management?

Project management stems from the need to plan and coordinate large, complex, multifunctional efforts. History provides us with many project examples. Noah’s project was straightforward—build an ark. The material requirements indicated that the ark should be built with gopher wood and to prescribed dimensions. Ulysses built the Trojan horse. Medieval cathedrals were designed and built over the course of centuries. However, not one of these projects deployed a consistent, coherent methodology of management techniques aimed at schedule development, cost control, resource acquisition and deployment, and risk management.

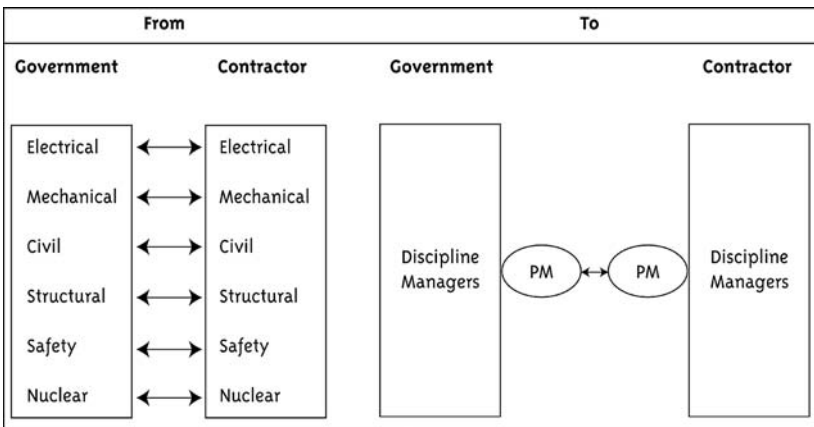
Project management, as we have come to know it, was the solution to a practical problem. Governmental communications in the latter part of the twentieth century, unfortunately, often involved technical staff speaking only with their techni-

cal counterparts in defense-contractor organizations. Each discipline conferred with its own colleagues. Changes in one aspect of a system—say, payload weight—were not always communicated to other interested and affected parties, such as avionics or engine design. Too often, the results were cost and schedule overruns, as well as systems that failed to meet expectations.

The concept of the project manager emerged as a focal point of integration for time, cost, and product quality (see Figure 1-1). This need for a central point of integration was also apparent in many other types of projects. Architectural, engineering, and construction projects were a logical place to use project management techniques. Information systems design and development efforts also were likely candidates to benefit from project management. For projects addressing basic or pure research, principal investigators were no longer only the best scientists, but were also expected to manage the undertaking to one degree or another.

If project management is indeed a solution, then we have

Figure 1-1 Evolution of Project Management.



to recognize how it reacts and adapts to workplace and marketplace needs such as the following:

- ▶ Higher-quality products
- ▶ More customized products
- ▶ Shorter time-to-market
- ▶ Global competition
- ▶ Easier information access
- ▶ Technology growth
- ▶ Global organizations seeking uniform practices

Classic Functions of Project Management

Management is routinely understood to be accomplishing work through the expenditure of resources. More rigorously, management is the science of employing resources efficiently in the accomplishment of a goal. The classic functions of management are planning, directing, organizing, staffing, controlling, and coordinating.

Planning

Planning is a process. It begins with an understanding of the current situation (the “as-is” state) and the desired future (the “to-be” state). The gap between these two states causes the project manager to identify and evaluate alternative approaches, recommend a preferred course of action, and then synthesize that course of action into a viable plan. Planning raises and answers the questions shown in Figure 1-2.

Directing

Directing communicates the goals, purposes, procedures, and means to those who will do the work. Directing is the process of communicating the plan, whether orally or in writing.

Figure 1-2 Planning Questions.

QUESTIONS	DOCUMENTATION
What is to be done?	Scope Definition document
Why should we do it?	Business Case or rationale
How should we do it?	Strategy and Work Breakdown Structure
In what sequence?	Network Diagram
Where should work be done?	Organizational Breakdown Structure
When should work be done?	Schedule Plan
Who should do the work?	Resource Utilization Plan
How much should it cost?	Cost Plan or Budget Plan
How do we judge progress?	Milestone Plan or Earned Value Plan

Organizing

Organizing brings together the nonhuman resources needed to achieve the project's objectives. To organize is to manage the procurement life cycle. It begins with the need to define requirements for materials, equipment, space, and supplies. It also identifies sources of supply, ordering, reception, storage, distribution, security, and disposal activities.

Staffing

Staffing brings together the human resources. From a managerial perspective, human resources are first seen as the number and mix of individuals in terms of skills, competency levels, physical and logical location, and costs per unit of time.

Controlling

Controlling is the process of measuring progress toward an objective, evaluating what remains to be done, and taking the necessary corrective action to achieve the objectives. In project management terms, it involves determining variances from the approved plan, then taking action to correct those variances.

Coordinating

Coordinating is the act of synchronizing activities to ensure they are carried out in relation to their importance and with a minimum of conflict. When two or more entities compete for the same resource—time, space, money, or people—there is a need for coordination. The primary mechanism of coordination is prioritization.

Processes in the Life of a Project

The Project Management Institute, an organization dedicated to advocating the project management profession, has produced a valuable document called *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*. This publication provides a broad view of what project management professionals should know and what they do in performing their work. This guide identifies and describes the body of knowledge that is generally accepted, provides common project management terminology and standards, and acts as a basic reference for anyone interested in the profession of project management.

The *PMBOK® Guide* groups project management processes into five categories:

1. *Initiating*: Defining and authorizing the project
2. *Planning*: Establishing the project scope, refining the objectives, and defining the course of action to attain the objectives
3. *Executing*: Integrating people and other resources to carry out the work defined in the project plan
4. *Monitoring and Controlling*: Tracking, reviewing, and regulating the progress and performance of the project plan,

identifying where changes to the plan are required, and taking corrective action

5. *Closing*: Finalizing all activities across all the process groups to formally close the project

Each of these groups has a number of interrelated processes that must be carried out for the success of a project.

Knowledge Areas

The *PMBOK® Guide* also identifies nine areas that describe the knowledge and practice of project management:

1. *Integration Management*. Identifying, defining, combining, unifying, and coordinating the various processes and project management activities within the project management process groups. It includes developing the project charter and plan, directing and managing the project execution, monitoring and controlling project work, controlling change, and closing the project.
2. *Scope Management*. Ensuring that the project includes all the work required, and only the work required, to complete the project successfully. It includes collecting requirements, defining scope, creating a work breakdown structure, verifying scope, and controlling scope.
3. *Time Management*. Managing timely completion of the project. It consists of defining activities, sequencing activities, estimating activity resources, estimating activity durations, developing schedules, and controlling schedules.
4. *Cost Management*. Estimating, budgeting, and controlling costs to complete the project within the approved budget.

It includes estimating costs, determining budgets, and controlling costs.

5. *Quality Management*. Determining quality policies, objectives, and responsibilities so that the project will satisfy the needs for which it was undertaken. It consists of planning quality, performing quality assurance, and performing quality control.
6. *Human Resources Management*. Organizing, managing, and leading the project team. It includes developing human resources plans and acquiring, developing, and managing project teams.
7. *Communications Management*. Ensuring timely and appropriate project information, including its generation, collection, distribution, storage, retrieval, and ultimate disposition. It consists of identifying stakeholders, planning communications, distributing information, managing stakeholder expectations, and reporting performance.
8. *Risk Management*. Conducting risk management planning, identification, analysis, response planning, and monitoring and control on a project. It includes planning risk management, identifying risks, performing qualitative risk analysis, performing quantitative risk analysis, planning risk responses, and monitoring and controlling risks.
9. *Procurement Management*. Purchasing or acquiring products, services, or results needed from outside the project team. It consists of planning procurements, conducting procurements, administering procurements, and closing procurements.

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PART 2

Initiating

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Defining and Authorizing the Project

THE PROJECT MANAGER IS RESPONSIBLE for achieving project results. Therefore, he must be sure he understands and can adequately convey the project's overall goal and specific objectives. The project manager is the steward of the project scope, so even if he or she inherits a project where the project has been predefined and there is little flexibility, the first obligation of the project manager is to validate the project goals, objectives, and scope.

The aim of this chapter is to help you understand how to define the goals, objectives, and scope of your project and secure agreement from key stakeholders. At the highest level, the goals and objectives of the project are defined in clear, simple, nontechnical language. Later in the process, the scope of work is developed and refined in more detail. It is impor-

tant to document the intended outcomes of your project in terms of the current condition and what it will be when the project is completed. During the initiation phase, you should establish critical success factors and critical success measures.

The Role of Stakeholders in the Authorization Process

Stakeholders are individuals and organizations who are affected by or have an interest in the project. They include those who benefit from the project, those who contribute to the project, and those who are impacted by the project. It is important to identify all project stakeholders as soon as possible. Recognize that any of the stakeholders may exert positive or negative influence over the project and its results. Key stakeholders common to many projects include sponsors, customers, users, project managers, project team members, and subject matter experts.

The Business Case for Undertaking the Project

It is important for the project manager to understand the business reasons for the project being undertaken. This is articulated as the *business case*. Be sure to consider all reasons, not just the financial justifications, for pursuing the project. The following need to be fully understood by the project manager:

- ▶ *Problem or Opportunity*. State the problem that the project is intended to resolve or the opportunity to be taken advantage of.
- ▶ *Solution and Vision*. Describe what the situation will look like after the project is completed.

- ▶ *Expected Benefits.* Enumerate the benefits to be derived from the project.
- ▶ *Estimated Costs.* Give a high-level estimate of the personnel and expense costs of the project, based on the available information at this stage of the project. Understand that this estimate will be revised as the project is better defined.

Projects should be seen as investments and should produce beneficial results, which may be defined in a variety of ways. One way is to justify a project on the grounds that it ensures an organization's *survival*. Here, the project is mandatory rather than discretionary. It must be done either to comply with government or industry standards, or to sustain operational readiness—for example, repair a leaking roof or an essential manufacturing tool.

Other projects might contribute to improved *profitability*. Projects in this group may provide improved cost controls, margin management, business-process reengineering, system upgrades, streamlined workflows, and strengthened customer satisfaction through product and service improvements. Projects in this area could also include product launches or advertising campaigns, trade show exhibits, packaging changes, office relocations, and organization restructuring.

Finally, there are some projects that try to secure the long-term *growth* of the organization. These strategic projects may seek to extend plant capacity, deploy new or emerging technologies, or bring new products and services to the market.

Regardless of the underlying reason, every project takes on the appearance of an investment—the need to produce significant benefits within the constraints of time, cost, and scope. Strategic projects, by definition, try to leverage investments so that short-term dollars yield longer-term revenue

and profit dollars. The key is that every project must be aligned with something bigger than itself. Each project should be linked to some enterprise goal, objective, or strategy. Ask yourself the extent to which a particular project is aligned along these parameters:

- ▶ Business goals and objectives
- ▶ Business strategies and timetables
- ▶ Corporate culture, core values, and beliefs
- ▶ Organizational structure
- ▶ Operating policies, practices, and procedures
- ▶ Business systems
- ▶ Professional and ethical standards

A helpful tool for determining the business case is to conduct a SWOT analysis—a review of the internal and external environment to determine the Strengths, Weaknesses, Opportunities, and Threats. This is a classic tool used in strategic planning and capital budgeting. At the project level, it may provide a rationale or justification for the project, or it may uncover important information that is helpful in matching the organization's resources and capabilities to the competitive environment in which it operates. Strengths and weaknesses are environmental factors internal to the organization; opportunities and threats address external or market issues.

The Goal Breakdown Structure

The goal breakdown structure is a logical and hierarchical structure that demonstrates, at increasing levels of detail, the results that a project should achieve. The specific names shown in this hierarchy are representative, not mandatory.

Use terms that apply to your enterprise or organization. The following is one scheme you could use in a goal breakdown structure:

Level zero defines the project's *goal*—a clear, nontechnical description of the desired result or outcome of the work. Some organizations define the highest level of a project or program as the project's *mission* or *vision*. What is important is that everyone agrees on the outcomes sought.

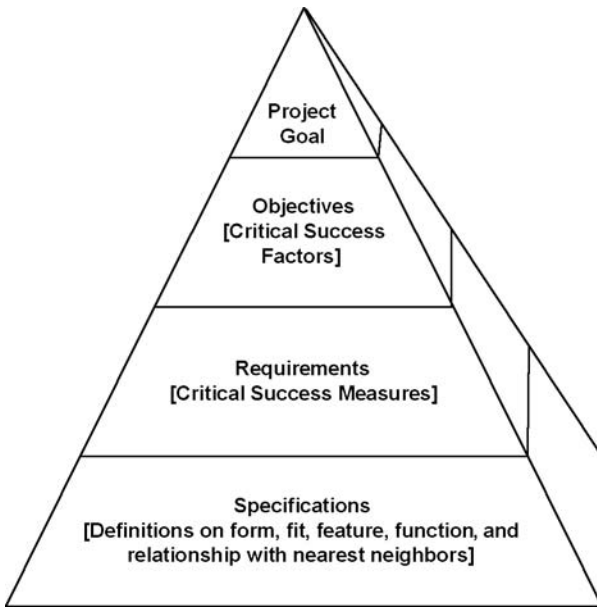
Level one defines project *objectives*—generally no more than five to ten essential attributes or characteristics of the project's goal statement. Taken together, these objectives document the project's *critical success factors*—statements of qualitative criteria describing what will make the project successful. For example, the statement “Minimize time to completion” is a critical success factor.

Level two defines the *requirements* or the *critical success measures* of the final product, service, or result. These are statements of quantitative criteria, each of which provides a measure of one or more of the project's critical success factors. For example, the corresponding critical success measure to the aforementioned critical success factor would be the statement “Complete by January 6, 2015.”

Level three establishes the *specifications* for intermediate and final deliverables of the project. Specifications can be thought of as detailed descriptions of how something will work and its relationship(s) to its nearest neighbors.

The generic concept of goal breakdown structure levels is shown graphically in Figure 2-1. Figure 2-2 shows the levels in the familiar Noah's Ark project.

Figure 2-1 The Goal Breakdown Structure (GBS).



Let us now look at more recent project examples to illustrate this idea. Figure 2-3 is a starting point for developing a goal breakdown structure with three illustrative projects: one in marketing, one for information technology, and a third for an imaginary medical device.

Figure 2-2 Goal Breakdown Structure Levels in the Noah’s Ark Project.

GBS Level	Name	Example and Illustration
0	Goal	Build an Ark
1	Critical Success Factors	<ol style="list-style-type: none"> 1. Maximize species survivability. 2. Maximize durability. 3. Complete on time.
2	Critical Success Measures	<ol style="list-style-type: none"> 1.1 Provide life-supporting quarters for 2x2 (or 7 x 7) based on type of species. 1.2 Demonstrate ability to float upright for a minimum of 6 months. 1.3 Complete by scheduled start of rain date.
3	Specifications	<ol style="list-style-type: none"> 1.1.1 Dimensions shall be 300 x 50 x 30 cubits. 1.1.2 The ark shall be constructed of gopher wood. 1.1.3 Interior and exterior sealants shall be pitch.

Figure 2-3 Detailed Goal Breakdown Structure.

GBS Levels	General Business Project	Information Systems & Technology Project	Scientific, Engineering, & Technical Project
Illustrative Goal Statements	Double market share of left-handed doodads by the end of 2010	Install the newest release of the Operating System used in our configuration	Improve the sensitivity of a diagnostic test to detect PM pedo-oralgia (project manager's foot-in-mouth disease)
Illustrative Objectives (Critical Success Factors)	<ol style="list-style-type: none"> 1. Market size 2. Market share 3. Retention rate(s) 4. Satisfaction rates 5. Product quality 	<ol style="list-style-type: none"> 1. Timing 2. Continuity of operation 3. Compatibility 4. Security 5. Transparency 	<ol style="list-style-type: none"> 1. Accuracy 2. Speed 3. Cost 4. Reimbursable 5. Office-based
Example Requirements (Critical Success Measures)	<ol style="list-style-type: none"> 1.1 From 25K/yr to 40K/yr 1.2 Capture 7.5% of new market 1.3 Achieve reorder rate of 75% 1.4 Achieve customer satisfaction rating of "best-in-breed" using J.D. Power and/or Consumer Reports as benchmark(s) 1.5 Conform to applicable standards for left-handed doodads 	<ol style="list-style-type: none"> 1.1 Installed by 12-31-10 1.2 Downtime = 0 throughout install and cutover 1.3 New product must be compatible with current configuration's hardware, software, and net ware 1.4 No unauthorized CRUD, i.e., create, read, update, destroy information holdings 1.5 New release shall require no incremental training of technical, operational, or user staff 	<ol style="list-style-type: none"> 1.1 Less than 0.1% false positives or negatives 1.2 Less than 15 minutes from receiving sample until result is displayed and confirmed 1.3 Cost to manufacture shall not exceed \$15.50/test kit; target for gross margin is 45% 1.4 Employee health plans (and Medicare) will cover this test/service 1.5 Test can effectively, efficiently, and safely be performed in physicians' offices
Specification	TBD	TBD	TBD

Consider the following as you develop goal breakdown structures:

Senior management “owns” the goal statement. If it fails to endorse or support a fundamental statement of project purpose, your issues as project manager will be overwhelmingly political rather than technical, organizational rather than operational, and personal (and personnel) rather than scientific.

Functional managers, users, and clients “own” critical success factors and their essential metrics. Deriving and documenting these items is likely to take more time and effort than you imagined.

Subject matter experts “own” the specifications in the execution and implementation stages of the project. Expect robust debate and dramatic conflict when the worlds of experts collide!

Project Charter

The project charter is the document that formally authorizes a project and defines the initial requirements that satisfy the stakeholders' needs and expectations. It explains the business needs the project addresses, states the high-level project requirements, and defines the approvals and authority granted to the project manager by the client or senior management.

PART 3

Planning

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Collecting Requirements and Defining Scope

COLLECTING REQUIREMENTS AND DEFINING your project's scope are critical to planning a successful project. The *PMBOK® Guide* offers two related definitions for scope. *Project scope* includes “the work that needs to be accomplished to deliver a product, service, or result with the specified features and functions.” Because projects often create products, you may also have to define the scope of a product. *Product scope* includes “the features and functions that characterize a product, service, or result.”*

Clearly defining a project's scope is not merely good theory and common sense. Project schedules and budgets overrun when the scope is unclear and when the scope is not

*A *Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fourth Edition*, Project Management Institute, 2008, p. 103.

aligned with enterprise goals, core values, structure, strategy, staff, and systems. Studies show that projects that spend more time in planning and design have fewer overruns.

The Five Processes of Project Scope Management

The processes for collecting requirements and defining scope may be simple or complex, trivial or traumatic. In all cases, it is best done by the project team, with the sustained participation of all interested and affected parties. Figure 3-1 suggests a high-level approach to scope definition.

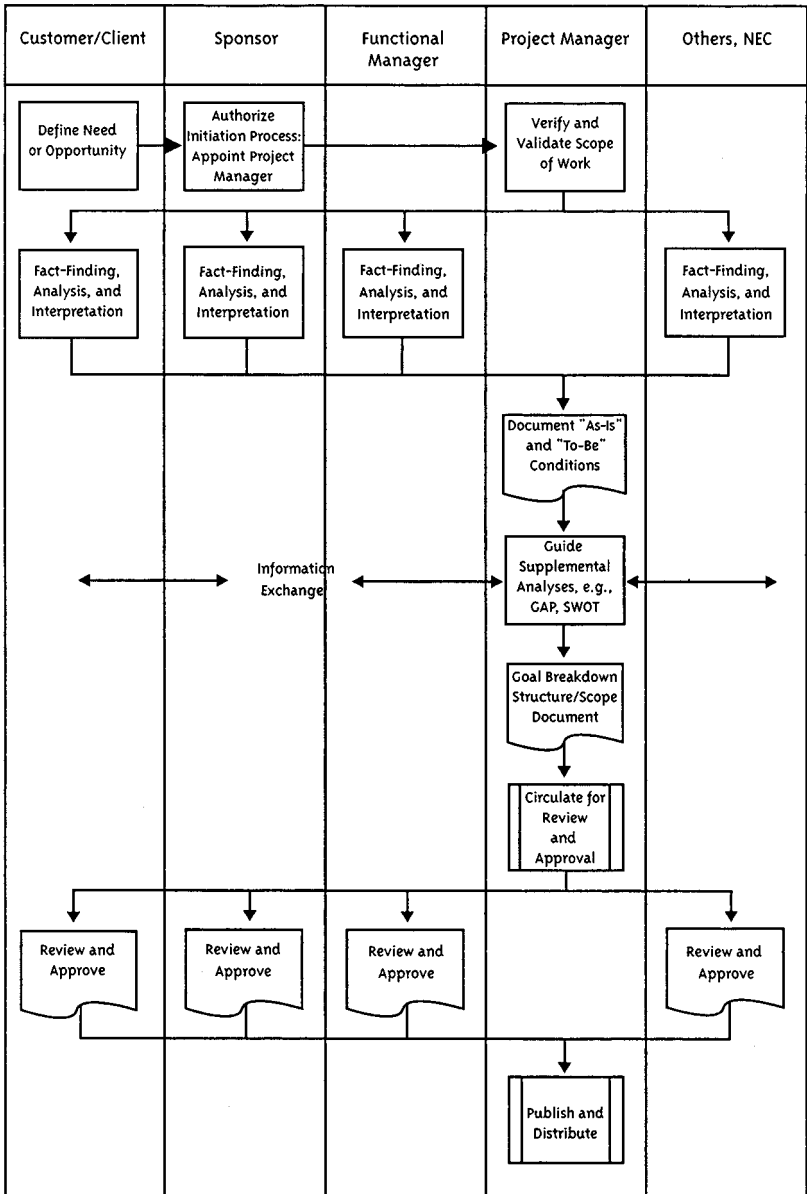
Project scope management includes five processes, the first two of which will be discussed in this chapter, and the last three will be discussed in Chapter 4:

1. *Collecting requirements* includes the processes for identifying and documenting features and functions of the end result of the project (the product, service, or result).
2. *Creating a scope statement* formally documents what the project will and will not produce.
3. *Creating a work breakdown structure (WBS)* creates a hierarchical breakdown of activities and end products, which organizes and defines all the work to be completed in a project.
4. *Verifying scope* achieves formal acceptance of the project scope.
5. *Controlling scope* creates a change control system to manage the project scope.

Collecting Requirements

This step includes the processes for identifying and documenting the features and functions of the end result of the project

Figure 3-1 Scope Definition Process.



(the product, service, or result). There are several methods you can use to collect project requirements. The methods described in this section are not exhaustive and should be tailored for each project and its unique context.

Interviews

Interviews are the most traditional means of collecting requirements. Interviews may be informal or formal and are tailored to each type of stakeholder. Interviewing techniques are discussed in Chapter 12, “Leading and Directing Project Teams.”

Focus Groups

Conducting a focus group is a form of research in which the members of a group are asked about their knowledge of or attitude toward a product or service. Questions are asked in an interactive group setting where participants are free to talk with other group members.

Expert Judgment

Expert judgment is a technique that relies on the experience of others. It involves consulting with experts who, based on their history of working on similar projects, know and understand the project and its application. Although it is often used, expert judgment may be biased.

Gap Analysis

Gap analysis is routinely used for business-process reengineering, quality improvement, industry certification, cost reduction, and efficiency-improvement projects. This approach is

also helpful in collecting requirements because it highlights the difference between the current state and the desired state. The following is an example of a gap analysis on the project of hosting a dinner party:

Step one: Determine the desired status. The desired outcome is that the necessary food, condiments, and supplies are available in sufficient quantity, quality, and time for the event. Special attention should be paid to dietary needs based on religion, tradition, or health needs of your guests.

Step two: Determine the current status. The current situation is found by taking inventory of pantries, refrigerators, and freezers.

Step three: Determine the difference between the two. In essence, subtract the as-is list from the to-be list.

Step four: Develop a strategy to fill the gap. The difference is your shopping list.

Walk-Throughs

The project team can conduct a walk-through or site inspection of the client's processes in order to understand the business process and to document data flow, materials, supplies, and correspondence. This is helpful when the project involves replacing a process, usually through automation, and for process improvement. A walk-through is particularly helpful when it can be combined with operations data, such as that of dealing with complaints, response times, and rejects.

Creativity Tools

There are many creativity tools that can assist in collecting requirements. Brainstorming is a technique used for problems

that resist traditional forms of analysis. The goal of a brainstorming session is to stimulate the generation of ideas and then check them for potential use. The key characteristic of a brainstorming session is that there are no wrong answers. An affinity diagram can then be used to refine the results of the brainstorm by organizing the ideas into related groups.

Mind mapping is a tool for processing information in both serial and associative forms. One begins with a central idea and then asks teammates to identify and list whatever comes to mind, periodically regrouping the ideas under headings that seem natural and appropriate.

Other Tools

There are many other tools and methodologies that can help you collect requirements. These include flowcharts, process reviews, data reviews (such as financial, operational, and managerial audits), models, simulations, competitive intelligence, focus groups, and literature searches.

SMART Requirements

One important aspect of establishing client and stakeholder expectations takes into account the difference between well-defined requirements and poorly defined ones. Although several models exist, one of them asks if the project requirements meet the SMART test, that is, whether they are Specific, Measurable, Agreed upon, Realistic, and Time/Cost limited. The SMART model is designed to minimize misinterpretation or vague assumptions. Figure 3-2 lists the characteristics of SMART objectives and provides a brief description of their implementation.

Figure 3-2 SMART Objectives.

Characteristic	What It Does	Why It Works
<i><u>S</u>pecific</i>	Makes objectives so clear and well-defined that anyone with a basic knowledge of the project area can understand them. Objectives must precisely define what the project will and will not do.	Forces you to search for precision. Removes ambiguity and forces hidden agenda items into view. It clarifies erroneous assumptions.
<i><u>M</u>easurable</i>	Forces objectives to be defined in measurable terms. If they cannot be measured, they are too ambiguous and need to be defined more clearly. It establishes project metrics for success early.	Defines the quality measure against which the objective can be evaluated—it either meets the standard or it does not. Allows you to measure and report on the progress.
<i><u>A</u>greed upon</i>	Ensures that all stakeholders agree on the project objectives before the project begins. There must be agreement that the end result will solve the problem or respond to the opportunity defined.	Establishes expectations and reduces politics.
<i><u>R</u>ealistic</i>	Ensures that sufficient resources, knowledge, and skills are available to complete the objective.	Helps prevent cost and schedule overruns. Helps ensure project scope will be achieved.
<i><u>T</u>ime/Cost limited</i>	Ensures that sufficient time/cost is available to achieve the objective. Defines how much time and budget is available and if there is any flexibility.	Establishes client and stakeholder expectations.

Fuzzy Requirements

Frequently, the project manager will be faced with the situation that a client cannot or does not fully understand what he or she wants. A similar issue exists when a client and internal stakeholders are in conflict regarding the project requirements. These situations create what are known as *fuzzy* requirements—those that are not specific, measurable, agreed upon, realistic, or time/cost limited.

Frequently, clients and project managers create fuzzy requirements because of misunderstandings. Clients may not understand the technology, or project teams may not understand the clients' needs. The following represent several helpful techniques:

- ▶ Define terms or use different terms to reach understanding and agreement.

- ▶ Concentrate on outcomes or desired results, not on process variables.
- ▶ Build prototypes.
- ▶ Use acronyms sparingly.
- ▶ Avoid needless technical jargon.
- ▶ Reflect on and revisit what you have heard.
- ▶ Use physical demonstrations or experiments.
- ▶ Document your agreements early and often.
- ▶ Use idea-generating techniques like brainstorming and mind mapping.

Creating a Scope Statement

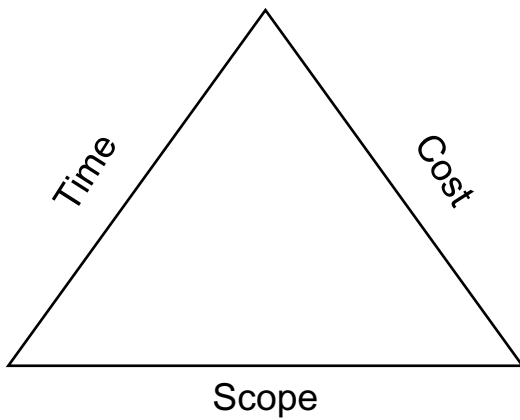
The scope statement formally documents what the project will and will not produce. It defines your project, including objectives, specifications, exclusions, constraints, risks, and assumptions.

Objectives: Time, Cost, Scope

Projects are defined and managed within the triple constraints (or expectations) of time, cost, and scope. These objectives are commonly referred to as the *project triangle*, which is depicted in Figure 3-3.

The time constraint is defined in the project's schedule. The ceiling on cost expenditures is the project budget. The budget itself is a scorekeeping tool that measures the anticipated rate and timing of expenditures for the labor costs, equipment, material, travel, and other items needed to meet project objectives. And, finally, the project scope includes the predefined technical and performance targets. The challenge of the project manager is to keep all sides of the project triangle balanced. If the triangle is not balanced, the project will

Figure 3-3 The Project Triangle.



fail along one of the three sides. For example, if you start with a “balanced” triangle and then receive a request for additional features from your customer (an increase in scope), you must make an adjustment in the time and/or cost. Otherwise, you simply won’t be able to accomplish the increased amount of work in the time and within the budget previously defined. This concept also highlights the importance of clearly and completely defining project requirements during project planning.

In prioritizing the project objectives, it is critical to recognize what drives the project. Some projects are driven by schedule. This means that a completion date is fixed and the other sides of the project triangle (cost and scope) can to some degree be negotiated. In other projects, the most important drivers are budget or scope. The following are reasons to understand what drives the project:

- ▶ Project drivers influence all dimensions of project planning.
- ▶ Project drivers help guide your selection of corrective actions.

- ▶ Project drivers assist you in controlling proposed changes to project scope, schedule, or cost.
- ▶ Project drivers help create appropriate management reserves and contingencies.

The scope document should address the trade-offs among time, cost, and scope. Conventional wisdom says: “You may want it good, fast, and cheap. Pick two!” Underlying this aphorism is an intuitive grasp of simple points:

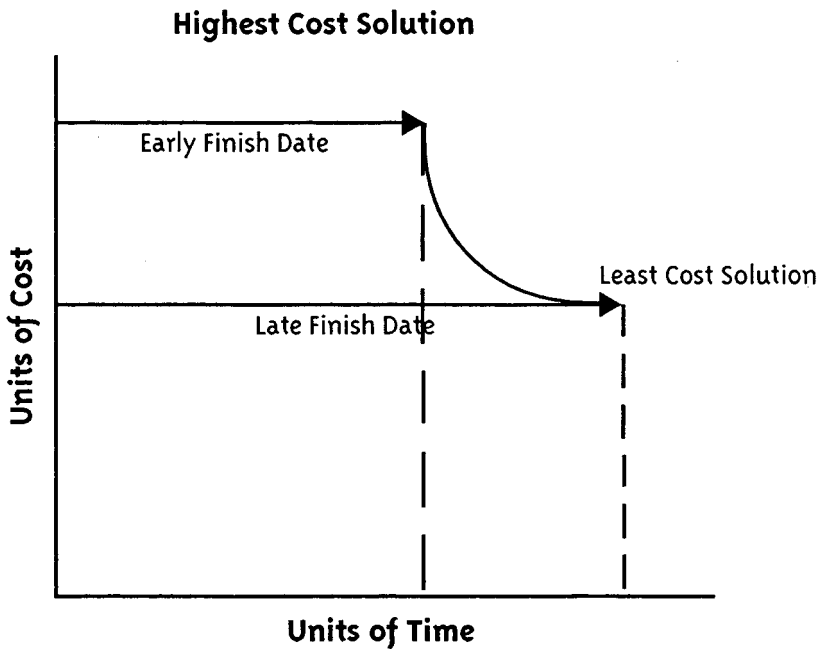
- ▶ If the technical requirements of a project are fixed, then compressing the project schedule will probably increase project costs.
- ▶ The more the schedule is compressed, the greater the rate of increase in cost per unit of time.
- ▶ If you add requirements to the scope, then either time or cost (or both!) will increase.
- ▶ If the project budget is fixed (as by legislative appropriation or a fixed-price contract), then negotiation arises on the other two sides of the project triangle (time and scope).

Visualizing these relationships is straightforward and shown in Figure 3-4. The graph shows the range of cost-versus-time solutions for a given project scope. For any project, there are three critical data points:

1. The earliest finish date of the last activity
2. The latest allowable finish date of the last activity
3. The least cost to accomplish all the work required

By extension, we can find a point that describes the *late finish* and *last dollar*. This point is the sponsor’s expectation that she or he will receive the final product or service on or

Figure 3-4 Visualizing a Time/Cost Trade-Off.



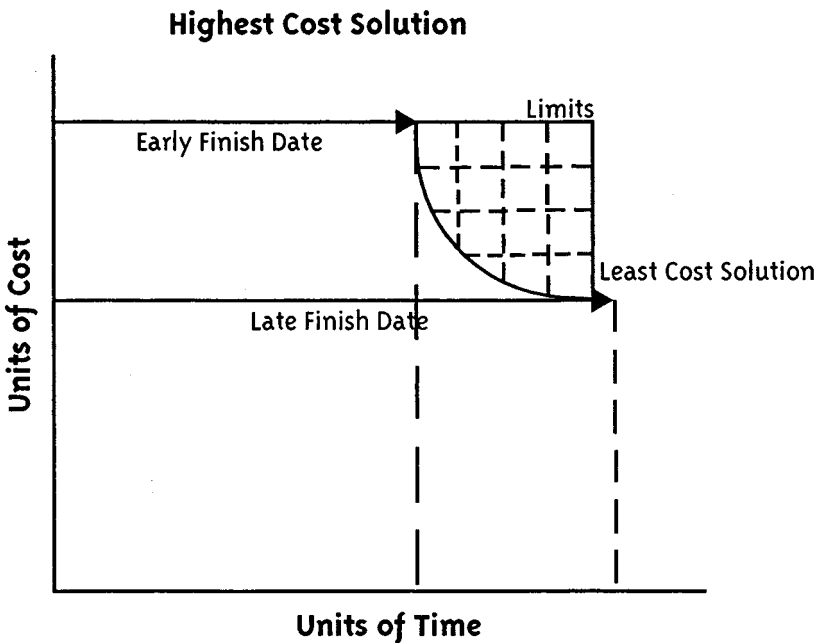
before a given date and at a cost not to exceed some predefined amount. The area between any point on the time/cost trade-off line and the outer limits of the project is a management reserve or contingency for the project manager. Now the drawing looks like that shown in Figure 3-5.

The project manager can now present the options to senior management and other stakeholders. Problems will arise only when the project budget is less than the cheapest solution or the needed delivery date is sooner than the fastest solution.

Specifications

Specifications, by definition, are unique for each project. Nevertheless, they must also conform to applicable laws, stan-

Figure 3-5 Project Limits and Contingency.



dards, codes, and conventions, which may derive from sources such as the following:

- ▶ *Government agencies* may be international, national, state, or local agencies involved in regulating specific industries, the environment, health, safety, or transportation. Some agencies regulate standards, licensing, or zoning.
- ▶ *Industry-specific professional or trade associations* may develop codes, conventions, or standard practices. These associations and practices include the International Organization for Standardization (ISO); the American National Standards Institute (ANSI); Underwriters Laboratories, Inc. (UL listing); Generally Accepted Accounting Principles (GAAP); Generally Accepted Auditing Standards (GAAS); the

Software Engineering Institute (SEI); and the Project Management Institute (PMI).

- ▶ *Your own organization* may have standards for data names and uses, numbering schemes for engineering drawings, or a visual identity program to guide the use of the company logo.
- ▶ *Your customers, clients, or end users* may impose their standards on your work. For example, “The contractor shall prepare and submit all engineering drawings as [name of product] files.” The standards that apply to your project should be developed early in the development of specifications. They should be articulated by subject matter experts, embedded in the scope document, and used later on to judge the quality of intermediate and final deliverables.

Exclusions

An adequate scope document defines not only what the project includes; it also establishes project exclusions. This delineation, although seldom perfect, forces stakeholders to confer openly and candidly in the early stages of a project. The project manager guides this dialogue. Its product is a scope definition with clear boundaries, diminished uncertainty, and minimal likelihood that the project manager will hear (at the end of the assignment), “I know it’s what I said, but it’s not what I want.”

Scope exclusions define items that may be closely related to the project’s goal but are not to be included in this phase, stage, or release. Exclusions may extend to piece parts, specific features and functions, materials, and performance measures. The important issue is that these exclusions be identified early, debated openly, and resolved with finality.

Constraints

Constraints are items that limit the project manager's degree of freedom when planning, scheduling, and controlling project work. Often, these constraints are administrative, financial, or procedural in nature. The following are examples of constraints:

- ▶ There is a hiring freeze for specific positions.
- ▶ The project has a capital equipment ceiling of \$500,000.
- ▶ The team must use an executive's brother-in-law as the architect.
- ▶ A vice president must approve all travel.

Risks

Risks are uncertain events that may affect the project for better or worse. These events may be categorized in various ways, but their central theme is that one cannot predict with certainty the source, timing, impact, or significance of specific risks. Therefore, at the start of a project, it makes sense to undertake a high-level risk assessment by identifying the sources and types of uncertainty.

The initial assessment of risks to the project involves three steps:

1. Identify the risks likely to impede project progress and success.
2. Rank each risk in terms of the likelihood of occurrence and the impact on the project if the risk occurs. Figure 3-6 illustrates a simple and convenient way to present the results of this initial, high-level risk analysis.
3. Develop an initial list of responses for the risk that have unacceptable outcomes.

Figure 3-6 Risk Probability and Impact.

		IMPACT		
		Low	Moderate	High
PROBABILITY	High			
	Moderate			
	Low			

Assumptions

Assumptions are made to fill in gaps of credible knowledge, to simplify complex realities, and to get others to react. One way to categorize assumptions is to group them under one of four headings:

1. *Technical and scientific assumptions* routinely deal with hardware, software, or related configuration issues. We can postulate change or stability. In designing an experiment, we might assume that ten tests will be required or that a certain number of patients must be enrolled to achieve some level of confidence in results.
2. *Organizational and administrative assumptions* typically deal with roles and responsibilities, issues of outsourcing versus internal development, or make-or-buy decisions. By extension, they may address applicable standards for documentation or the tenure of project staff at the end of the project.

3. *Resource and asset availability assumptions* address issues regarding whether adequate numbers of people, materials, supplies, space, and equipment are available to meet project requirements. This set of assumptions requires the project manager to revisit some of the organizational assumptions just noted.
4. *Macro-level assumptions* are those that are so profound or pervasive that project managers cannot negotiate them in any meaningful way. We could include here issues of currency fluctuations, exchange rates, public policy, population migrations, and related demographic trends.

Example Scope Document

This chapter concludes with an example that consolidates the key themes and serves as a working model of a high-level scope document (and the thinking process that underlies its development). The example used here is simple and specific. It is not intended to show all possible scenarios, but it does provide a concrete example of how to develop a scope document. It captures the way a project manager thinks.

The case example begins when you receive the following e-mail from your supervisor, the business-unit manager of the bridge-building company where you are an experienced project manager:

To: D. Smith
From: S. Darby
Re: New Bridge Project

I have another bridge project for you. Our biggest client, Glenfracas Distilleries, wants to move its product over land into a new market at the rate of 100,000 liters per week using its own ten-ton trucks. The River Why stands in the way. The company is already prepared to spend mid-seven figures, and

our signed contract is for a cost-plus-percentage fee. The client's major competitor plans to have product in the same market within three months. Take this ball and run with it. We can discuss your understanding of the project scope when I call you from Cancun tomorrow.

Although you may rather be in Cancun to discuss this project with the boss in person, it is time to ask some questions:

- ▶ *What is the client's goal?* Move product by road. So what? The River Why stands in the way.
- ▶ *What is the boss's goal?* Make money. Keep our biggest client happy. So what? At least he has signed a contract, but mid-seven might not be enough money unless we keep the costs down.
- ▶ *How does the client describe the finished product?* He doesn't . . . at least not yet. So what? Maybe I can make some assumptions: If a ten-ton truck carries ten tons, and one ton of product is approximately nine hundred liters, that means that the bridge has to be available for only eleven loaded trucks each week. So what? Maybe this bridge has to be only one lane wide, and maybe it has to support only one loaded truck at a time. So what? If I can assume that a loaded ten-ton truck is three meters wide, the roadway on the bridge has to be only a little bit wider than that. If I can assume that a loaded ten-ton truck weighs seventeen tons, the bridge has to support only that weight. Anything else? I'm going to assume that they have no specific location for this bridge. So what? Site acquisition will be a major—and risky—part of this project.
- ▶ *How does the boss describe the finished product?* He doesn't . . . at least not yet. So what? It looks like the bridge design is going to be a part of the project.

- ▶ *What is the current state of the client?* The boss hasn't mentioned anything new, so I can assume that Glenfracas is still doing well and still satisfied with our previous work for it. So what? If all goes well, there should not be any surprises from the client. It has always turned the approvals around quickly and has always taken our word for the engineering. So what? That will really help on the risk analysis.
- ▶ *What is the current state of our company?* We have a good track record, and none of our union contracts are up for renewal. Our plate was full until earlier this year, but we are at about 80 percent capacity right now. So what? I should have no problem finding the project team and project resources that I need.
- ▶ *What is my current state?* In another two weeks, my role in the Glenwidge Tay River bridge project will be over, I just finished my annual vacation last month, and my evening classes for my postgraduate work do not start for another four months. Except for seeing our oldest off to the university next month, this project comes at a pretty good time.
- ▶ *Is quality an issue?* We have to meet government code, but if this is a private bridge there could be some leeway. Other than that, it will have to go all the way across the river and support the expected traffic. So what? There seems to be some opportunity for scope creep, but little room for surprises. And, in the end, this is not a constraint.
- ▶ *Is time an issue?* The boss hasn't set any deadlines, but the client's competitor seems to be moving into the same territory in the next few months. So what? I won't tie my project's success to someone else's actions, but it may be necessary to constrain this project to three months. That's another assumption to be checked.

- ▶ *Is cost an issue?* The boss hasn't set any cost limits, but knowing the parsimonious culture of this part of the world, I fully expect to have to minimize the frills. So what? That should help keep this project simple and quick.

So, in preparation for the discussion with the boss tomorrow, what have we got?

The *project goal* is to build a "Bridge on the River Why."

My *assumptions* that I will have to validate with the boss and the client are:

- ▶ Time is of the essence.
- ▶ A loaded ten-ton truck is three meters wide.
- ▶ A loaded ten-ton truck weighs seventeen tons.

The project's *critical success factors* are:

- ▶ Complete the bridge on time.
- ▶ Make it support a loaded ten-ton truck.

The project's *critical success measures* are:

- ▶ Complete the bridge within ninety calendar days.
- ▶ Make it support seventeen tons.

The obvious *project risks* are:

- ▶ Insufficient time
- ▶ Regulatory denial
- ▶ Regulatory delay
- ▶ Environmental issues

- ▶ Geotechnical issues
- ▶ Site acquisition issues
- ▶ Vendor performance failures
- ▶ Resource availability

That ought to be enough until he calls tomorrow. I feel that I have a pretty good handle on what is in scope and what is not.

Creating a Work Breakdown Structure

THE *WORK BREAKDOWN STRUCTURE (WBS)* describes the work needed to create the project deliverables that will meet the previously determined requirements. The WBS defines and organizes the total scope of a project in a hierarchical breakdown of activities and end products. It is an essential tool for effective project planning, scheduling, and controlling. If defining the project's goal is the heart of project management, then the WBS is the skeleton, musculature, connective tissue, and central nervous system. The WBS provides both structure (for stability) and articulation (for movement) to the project plan.

Creating the WBS is simple, but not always easy. The underlying concept is clear. A WBS describes, in outline form, the work needed to meet project objectives. The outline is logical and hierarchical, but not necessarily sequential. At its

highest level, the WBS conveys an approach, a strategy, a methodology, a template, or a best practice routinely used in your type of project. At its lowest level of detail are unique *work packages*, or activities that must be performed.

The WBS is ordinarily displayed in a top-down manner. In actual development, a WBS may have some pieces developed top-down or bottom-up. In either case, as the WBS becomes increasingly detailed, work packages appear. These work packages will then be used to sequence the work into network diagrams, schedule work, assign resources and costs, and establish the definitions of appropriate quality for each deliverable that emerges from the project work.

Later on, in the execution and control processes, the WBS becomes a tool for monitoring, reporting, communicating, motivating, and establishing accountability. If the WBS is incomplete, then the project manager has little hope of success. Specifically, if there is work that must be done but it is not in the WBS, the project will likely be late, be over budget, exceed its resource usage, or be of diminished quality. The anticipated benefits will not be delivered, and the end result will be an upset sponsor or client.

The Work Breakdown Structure Is an Outline

Work breakdown structures are traditionally created in outline form. The highest level of description embraces and includes all subordinate levels. The outline itself is logical and hierarchical, but not necessarily sequential. Here is a simple example of a WBS for a term paper:

1. Title
 - 1.1. Section
 - 1.1.1. Paragraph
 - 1.1.1.1. Sentence

Writing the report does not have to be done in section sequence. Nonetheless, each section has the same logical and hierarchical structure. The WBS is a template or guideline and works independently of whatever report is being produced.

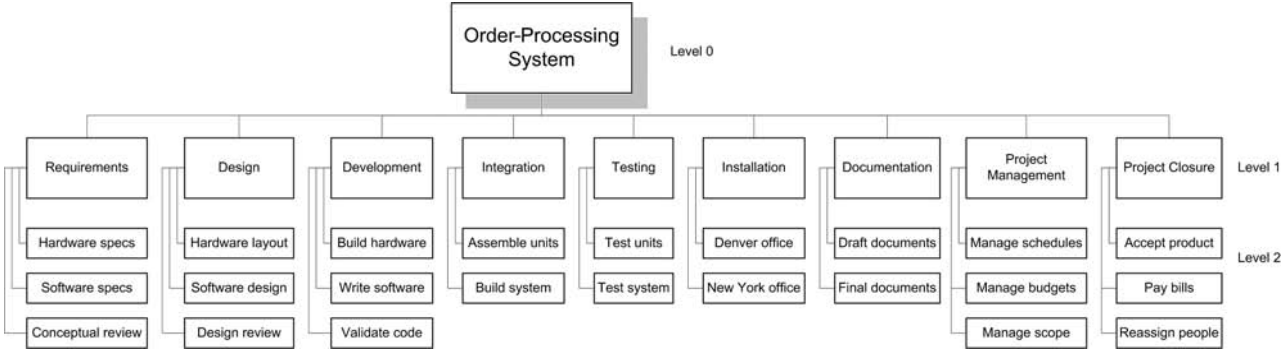
Work breakdown structures may be displayed either as lists or as graphical decomposition diagrams (which typically resemble organization charts), such as the one shown in Figure 4-1. Each level in the WBS is oriented toward groups of deliverables. Each level is complete only when all of its subordinate work items are completed.

Considerations in Creating Work Breakdown Structures

In preparing a work breakdown structure, keep the following in mind:

- ▶ Use any category that makes sense for your project. This might include components of the product, functions, organizational units, geographical areas, cost accounts, time phases, or activities.
- ▶ Do not be constrained by sequence. The diagram does not need to represent a logical or time sequence of events.
- ▶ The diagram does not have to be symmetrical. The number of levels might vary from one branch to the next. Break each branch down to the number of levels necessary to adequately define the project.
- ▶ Each box is a summary of the boxes in the levels below it.
- ▶ The final box in each branch must end in a product or deliverable. These must be measurable and definable in terms of an end result.

Figure 4-1 Work Breakdown Structure of an Order-Processing System.



- ▶ The number of levels of detail that should be included in the WBS may differ for each project, depending on the size, complexity, and risk of the project.
- ▶ The boxes in the lowest level are called *work packages*. They represent the lowest level of detail you want to estimate, schedule, monitor, and control. They should represent eight to eighty hours of work. Each work package can be divided into specific activities. For each work package, describe the completion condition. Ask yourself what must be delivered to consider the activity finished.
- ▶ The entire project team should be involved in developing the work breakdown structure.
- ▶ The sum total of boxes must represent the complete project. You can leave nothing out. When all these deliverables are completed, will the project be done?
- ▶ When completed, you should review the work breakdown with the client and customers. This is to ensure that it is complete and that it addresses their specific concerns.

The Work Breakdown Structure is a Validation Tool

At its higher levels—usually levels one and two—the WBS describes and validates your project’s approach or methodology. At these levels, the WBS is often broken into phases or stages. These are often viewed as pieces of work delineated by milestones, deliverables, or management decisions that authorize future work. In other words, the WBS summarizes all subdivided elements in your work plan.

The WBS is an example of a *functional decomposition* diagram. It is milestone (or deliverable or product) driven until its lowest level of *work packages* is reached. Thus, a top-down

development approach yields progressively better-defined work products. A bottom-up approach is used to develop estimates. In other words, planning is done from a global level down to work packages. Estimating is done using work packages as units of analysis that are then aggregated to form project totals.

At lower levels, where subactivities and work packages emerge, the WBS serves several purposes:

- ▶ The *work package* (or lowest level of decomposition) is used to later define the logical sequence in which the activities could be performed in a *network diagram*. (Note: This is explained in detail in Chapter 5.)
- ▶ Members of the planning team use each work package as a basis for estimating. Each discrete piece of work will have estimates for duration, assets, resources, and costs.
- ▶ Work packages can be used to capture technical and performance objectives. Each work package must produce some kind of deliverable or product that will be accepted by the next sequential activity. Therefore, when you create a customized WBS for your project, you automatically create an index of deliverables—a master list of documentation items that flow from each piece of work. Each deliverable, in turn, has quality standards associated with it.
- ▶ The WBS can also be used to assign accountability and develop a responsibility assignment matrix for each work package and work product. This is a spreadsheet where work packages are in rows and organizational units are the columns. The resulting cells can then be used to describe the relationship between work and performing organizational units. Figure 4-2 shows a simplified example. Include in the matrix who is responsible, who is accountable, who should consult or review, and who should be informed.

Figure 4-2 Responsibility Assignment Matrix.

	Engineering Department	Purchasing Department	Receiving Department	Accounts Payable
1. Define Requirement	Primary; notifies Purchasing of potential need			
2. Prepare RFP (technical)	Primary	Reviews Engineering documentation		
3. Prepare RFP Bid Package	Reviews Purchasing documentation	Primary; focuses on T&Cs, noncollusive bidding		
4. Evaluate Bids (technical)	Conducts technical evaluation			
5. Evaluate Bids (cost and contract)		Conducts business and contractual evaluation		
6. Select Vendor (after negotiation)	Supports evaluation process	Issues PO to successful vendor; notifies Engineering and A/P		Creates A/P "dummy" record
7. Monitor Progress	Evaluates Work in Process	Processes invoices		
8. Accept Final Product	Evaluates quality of product	Processes invoices	Receives end item; notifies Engineering	
9. Authorize Payment	Validates deliverable	Authorizes final payment		Issues final payment

- ▶ The WBS is a foundation for project risk analysis. As the planning team develops the detailed WBS, members can isolate those packages where uncertainty abounds. This will, in turn, affect estimating the work because team members must factor in the probability of occurrence and the likely impact of each occurrence.
- ▶ Not only is the WBS the foundation for detailed planning, it is also the centerpiece of controlling work in process, management reporting, change control (or configuration management), and closure. Simply put, the structure you use to

plan the work in the WBS becomes the basis for tracking work performed, variance analysis, and corrective action.

Work Breakdown Structures Are Flexible

The WBS is a flexible and adaptive tool. There is no single scheme that can be applied to all projects. In fact, even within a specific industry or for a repetitive application, the WBS may need to be customized to meet the particular needs of a project. The WBS may be tailored to account for geography, culture, language, social convention, or the names of particular components. A WBS may be shown in graphical format or in a numbered list.

It is helpful to look at WBS examples from various industries or businesses so that you can adapt them to your particular requirements or organization. Included here are several examples, each at a fairly high level, to indicate both the commonality of approach and the distinctiveness of specific project types.

The example in Figure 4-3 comes from projects involving construction projects, plant expansions, or design-bid-build projects. In this example, the highest level of the WBS drawing represents project phases. This six-phase project may be adequate for senior management, but it lacks any real appreciation of specific work that needs to be accomplished.

Figure 4-4 shows the expansion of phase two to illustrate

Figure 4-3 Sample WBS for an Engineering Project (Strategic Level Only).

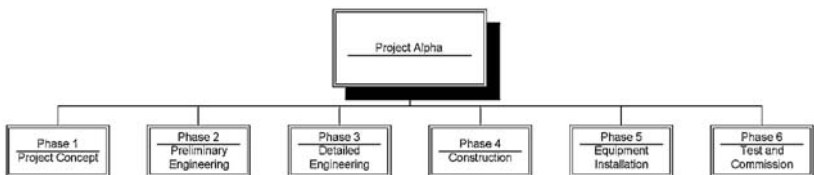
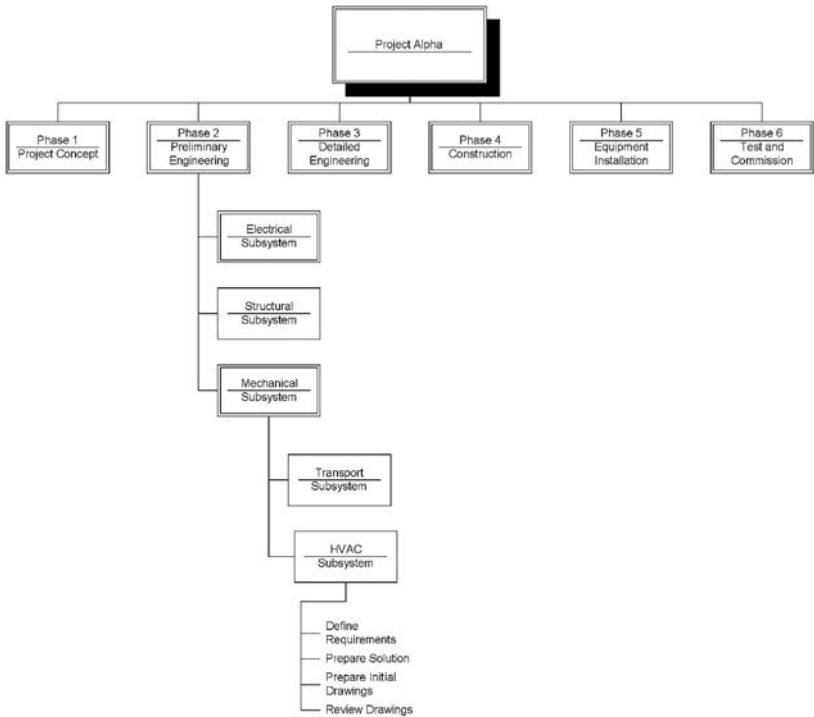


Figure 4-4 Sample WBS for an Engineering Project (to Four Levels of Detail).



how that phase could be shown in four levels of detail. This plan is obviously incomplete. Where, for example, would you insert nuclear engineering or instrumentation and control subsystems in this example? Your project team would use this template to validate the project’s technical objectives. It would expand the WBS to ensure that all technical objectives and requirements were properly addressed in this early version of the WBS.

In some technical projects, the WBS may be developed in terms of piece parts or components. Each component then has work packages for design, building a prototype, testing, revising and refining, and building a production model.

When projects are to be done at multiple locations, the first level of decomposition could be geographic. A country manager or site manager then becomes responsible for all the work packages performed under his or her direction.

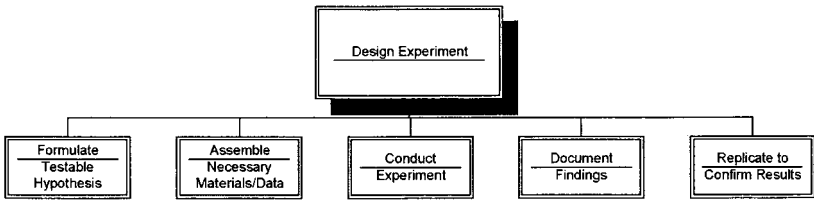
Figure 4-5 illustrates a project that will develop and deploy an assembling machine. It assumes that proof of concept and proof of principal have been demonstrated. This figure shows a WBS in a list format rather than a graphical format.

The two preceding WBS examples presume a well-developed and familiar methodology. If, however, your project involves significant unknowns or is a research and development project, then your WBS model may resemble Figure 4-6.

Figure 4-5 Sample WBS for Product Design.

WBS No.	Description of the Work	Key Deliverable
1.	Phase 1—Product Design	Design document
1.1	Produce initial sketches and drawings	
1.2	Review and revise documentation	
1.3	Produce detailed line drawings	
2.	Phase 2—Build Prototype	Working prototype
2.1	Verify design documentation	
2.2	Assemble necessary materials	
2.3	Build working prototype	
2.4	Test prototype; create punchlist; repair defects	
3.	Phase 3—Build Production Model	Production model
3.1	Create bill of materials	
3.2	Purchase necessary items	
3.3	Build to print	
3.4	Conduct progressive testing	
3.4.1	Systems integration testing	
3.4.2	Systems acceptance testing	
4.	Phase 4—Deploy the Production Model	Installed system
4.1	Prepare facility	
4.2	Train operators	
4.2.1	Cold commissioning	
4.2.2	Hot commissioning	
4.3	Perform postinstallation validation test(s)	

Figure 4-6 Design Experiment.



If we expand the first part of this example, then the WBS might look like Figure 4-7 (in list format) or Figure 4-8 (as a graphical decomposition diagram).

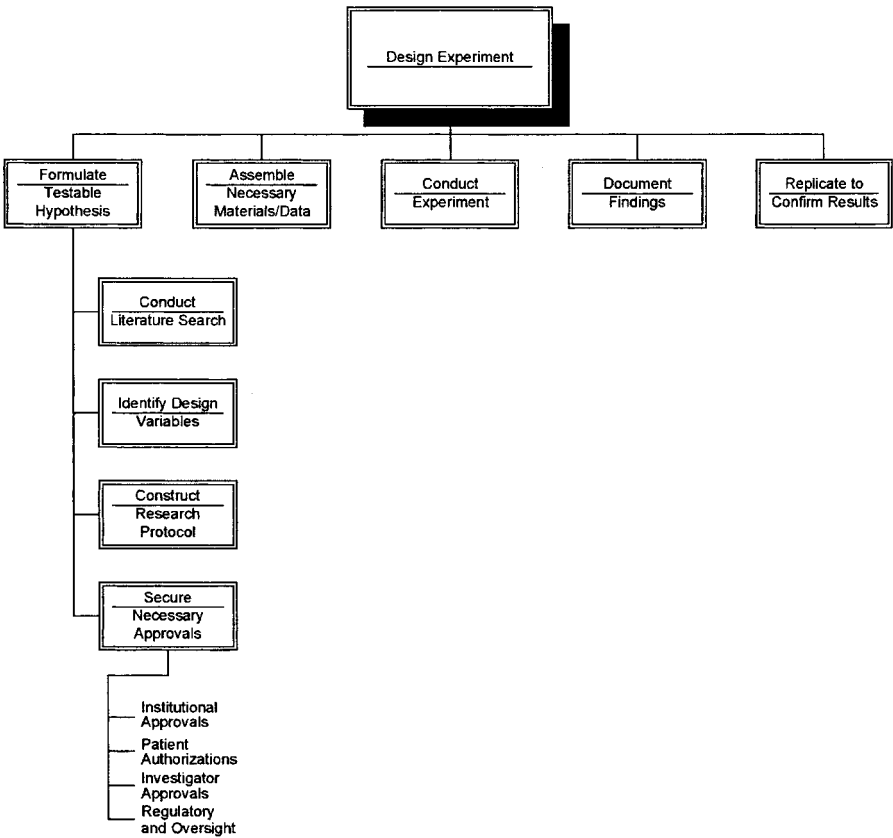
Techniques in Creating Work Breakdown Structures

The following are tools that may help your team create a WBS that addresses unique requirements of a project. These tools help project teams address scope ambiguities, overlaps and

Figure 4-7 WBS in List Format.

1. Formulate Testable Hypothesis and Research Design
 - 1.1. Conduct Literature Search
 - 1.2. Identify Design Variables
 - 1.2.1. Experimental Group
 - 1.2.2. Control Group
 - 1.3. Construct Research Protocol
 - 1.4. Secure Necessary Approvals
 - 1.4.1. Institutional Approvals
 - 1.4.2. Patients
 - 1.4.3. Participating Clinicians
 - 1.4.4. Oversight and Regulatory Bodies

Figure 4-8 WBS in Graphical Format.



duplication, unrealistic expectations of one or more stakeholders, conflicting objectives, and differential priorities associated with requirements.

- ▶ *Preexisting templates or checklists.* These may include industry-specific or government-furnished checklists, best practices, guidelines, specifications, or standards. Industry-specific templates may be found on the Internet.
- ▶ *Brainstorming (or another idea-generating tool).* Use these when a problem resists traditional analysis.

- ▶ *Mind mapping and affinity diagrams.* These are powerful tools that reflect the mind's ability to use associative, rather than purely serial, reasoning.
- ▶ *Index cards or sticky notes.* Use these to organize ideas, goals, roles, and responsibilities.

Verifying Scope

Verifying scope is where the project manager achieves formal acceptance of the scope by the customer or sponsor. Sometimes it is difficult to know when you have planned enough and when it is time to move on with the project. There are two countertendencies in defining project scope. One impulse is to insist on near-total definition and documentation before moving from planning to project execution. Some projects never escape from this planning limbo, even though market forces may make the project increasingly irrelevant. At the other extreme, the tendency is to “hit the ground running,” feeling there is no time to plan. This school of thought fails to understand the role of planning. The purpose of planning is not to produce a perfect plan; it is to guide thoughtful implementation and execution in order to achieve the desired outcome.

Controlling Scope

Controlling scope is the process of monitoring the status of the project scope and managing changes to the scope baseline. It ensures that all requested changes and recommended corrective or preventive actions are processed through the established change control system. Uncontrolled changes are often referred to as *project scope creep*. Change is inevitable,

and not all changes are bad. But all changes should be controlled through a system whereby they may be evaluated and approved or rejected. Approved changes can then be implemented in an orderly way, with full understanding of their effect on the schedule and budget.

Defining and Sequencing Activities

IN CHAPTER 4, YOU LEARNED to create a work breakdown structure. This chapter explains how to take the work packages from the WBS and build a logic network diagram that faithfully captures the relationships among the work packages discovered in the WBS.

Defining Activities

Begin with a solid understanding of the work breakdown structure. The lowest level of detail in the work breakdown structure is the work package or activity. Activities are small pieces of work that have clear accountability (can be assigned to a person or team) and consume time, resources, and money. If constructed correctly, the lowest level of the work breakdown structure contains all the activities needed to com-

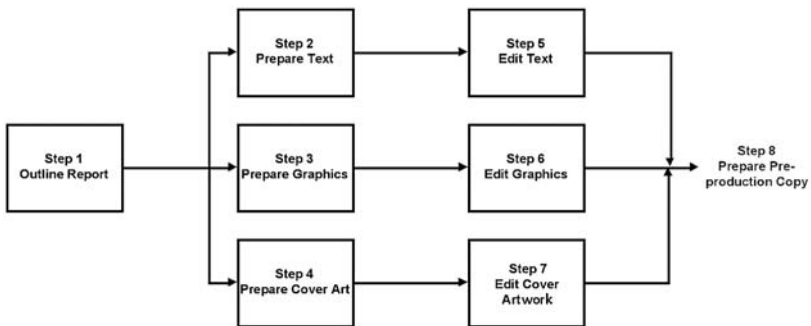
plete all project work. If, during the course of sequencing and scheduling the activities, you determine that additional activities need to be defined, be sure to add them into the WBS.

Sequencing Activities Using Network Diagrams

A network diagram is a graphical display of the sequence in which activities will be performed. The basis of a network diagram is the project's work breakdown structure. Clearly, not all activities can be performed at the same time. The technique used to determine the logical sequence of work identifies and documents the dependency relationships between activities or work packages. To construct a network diagram, you need to answer the following question for each activity in the WBS: "What other activities must be completed before I can start this activity?"

In a network diagram, the nodes (usually squares) represent the activities in the project, and the arrows imply the milestones or deliverables from each activity. Figure 5-1 illustrates part of a project that produces a report for management. Project managers typically create a network diagram

Figure 5-1 Sample Network Diagram.



using the precedence diagramming method (PDM), also illustrated in Figure 5-1. This is alternatively, sometimes referred to as *activity-on-node* because it shows the activities in a node—box—with arrows showing dependencies between activities and, therefore, the sequence in which they will be performed.

Project managers may also use a method called conditional diagramming method in specialized situations, such as research and development projects, where some activities might be performed more than once, only partially, or not at all. This method would be helpful in an investigational drug study where you would not know up front the number of trial test periods needed to gather sufficient data to complete the study.

Ideally, network diagrams are constructed twice in the planning process. The first time a network diagram is built assumes the availability of all essential people, tools, equipment, supplies, and money. The resulting diagram illustrates the most natural and efficient sequence of work that accomplishes the project's objectives.

After this sequence appears, the project planning team then estimates the time needed for each activity in the network as well as the resources needed. This creates a *demand function*, or a requirement for each resource by activity and time period. The demand function is then contrasted with supply or capacity for each resource. All too often, what results is a situation in which demand exceeds supply or requirements exceed capacity. The planning process then has several options. The most frequent solution—a form of resource leveling—adjusts the schedule so that it accommodates resource availability. A second option is to change the dependency relationships in the network diagram. This may lead to activity

overlaps, activity splitting, or other less-than-optimal scheduling solutions.

One final point is that the act of examining network logic and dependency relationships can validate the project's work breakdown structure. Conversely, when your planning team begins to define predecessors for particular activities, you may discover that activities or work packages need to be added to the work breakdown structure or that current activities need to be modified to make the logic work.

Identifying Dependencies Between Activities

To identify which work activities may be completed at the same time and which must be completed in sequence, you need to determine the relationships or dependencies among the activities. There are four basic types of dependencies:

1. *Mandatory (Hard) Dependencies.* These are activities that *must* happen before another activity can start, usually because it is physically impossible to do otherwise. For example, in a construction project, the foundation must be completed before the walls can be framed. In a training project, you must develop the training before you can deliver it.
2. *Resource Constraints.* Each piece of equipment, each person, each facility, and every dollar is subject to availability as to time, place, quantity, and quality.
3. *Administrative or Operational Dependencies.* Sometimes work products must be approved before subsequent work

begins. Frequently, such dependencies bring related requirements for exceptions, exemptions, appeals, permits, procedures, and regulations.

4. *Dependencies of Convention*. Sometimes the order of work is merely traditional, doctrinal, or simply a matter of preference.

Defining Activity Relationships

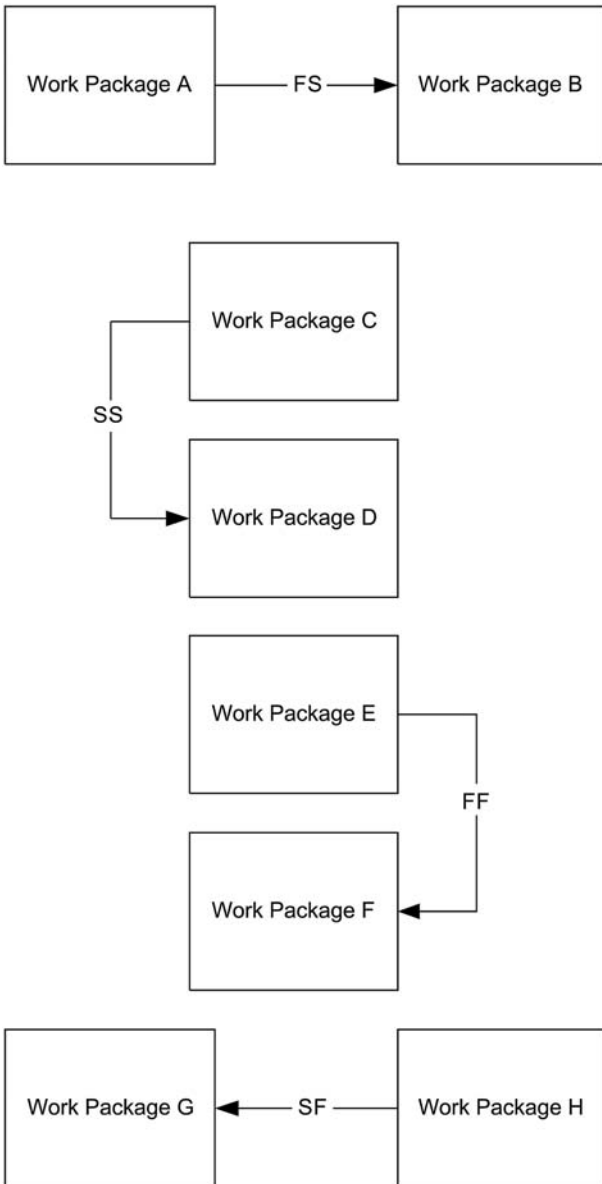
All activities in the network diagram must be linked using one of the following four logical relationships:

1. *Finish-to-Start (FS)*. Activity A must finish before activity B can begin.
2. *Start-to-Start (SS)*. Activity A must begin before activity B can begin.
3. *Finish-to-Finish (FF)*. Activity A must finish before activity B can finish.
4. *Start-to-Finish (SF)*. Activity A must begin before activity B can finish.

Of these four relationships, finish-to-start (FS) is the most common and start-to-finish (SF) is the least common. All four are illustrated in Figure 5-2.

After determining the ideal sequence of activities, project managers may find that the project schedule doesn't meet the needs of the customer. One way to accelerate (compress) the schedule is to overlap activities that, ideally, should wait for a finish-to-start relationship. This creates a *lead* relationship. For example, in a finish-to-start dependency with a ten-day lead, the successor activity can start ten days before the prede-

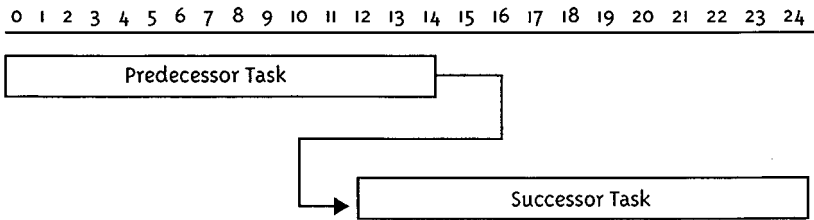
Figure 5-2 Sample Network Diagram.



cessor is finished. Figure 5-3 shows a lead relationship (with generic units of time).

Conversely, a *lag* relationship defers the start of a successor activity. For example, in a finish-to-start relationship with a ten-day lag, a successor activity cannot start until ten days

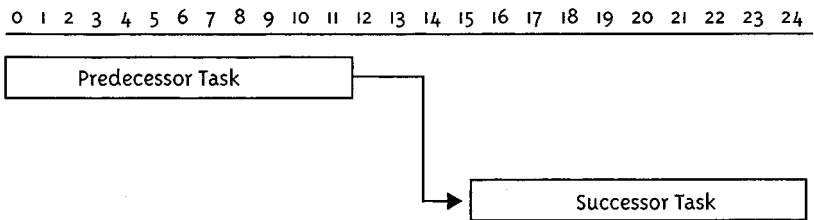
Figure 5-3 Lead Relationship.



after the predecessor is complete. Lag can be helpful to schedule a waiting time needed (for example, the curing time needed after pouring concrete). Figure 5-4 illustrates a lag relationship (with generic units of time).

Depending on project conditions, it may become necessary for activities to be further defined using indirect constraints such as the following:

Figure 5-4 Lag Relationship.



Must start on . . . (Activity must start on a given date.)

Must start before . . . (Activity must start before a given date.)

Must start after . . . (Activity must start after a given date.)

Must finish on . . . (Activity must finish on a given date.)

Must finish before . . . (Activity must finish before a given date.)

Must finish after . . . (Activity must finish after a given date.)

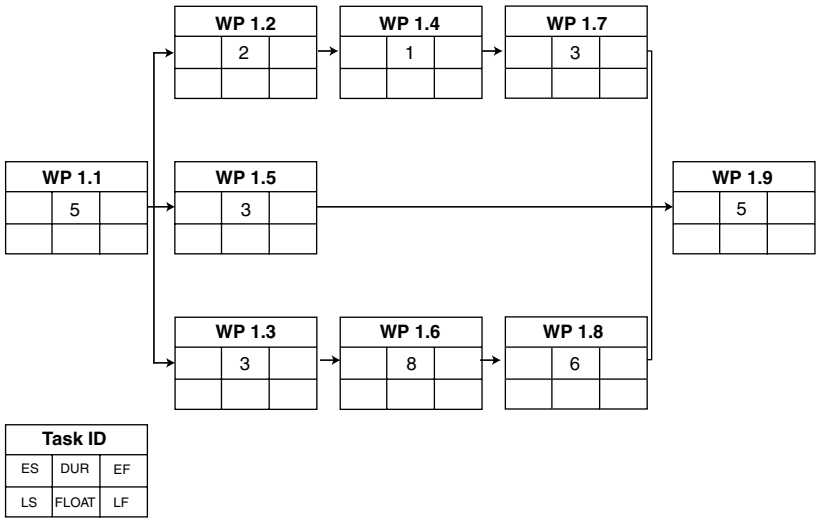
Sample Network Diagram

Let us put all this good information to use in a practical example. Imagine a project with nine work packages. The relevant information for each work package is found in Figure 5-5. Using this information, you could draw the network diagram shown in Figure 5-6.

Figure 5-5 Data Entry Requirements for a Network Diagram.

WBS No.	Description	Duration	Predecessors
1	Project Summary		
1.1	Work Package A	5 days	—
1.2	Work Package B	2 days	1.1 FS
1.3	Work Package C	3 days	1.1 FS
1.4	Work Package D	1 day	1.2 FS
1.5	Work Package E	3 days	1.1 FS
1.6	Work Package F	8 days	1.3 FS
1.7	Work Package G	3 days	1.4 FS
1.8	Work Package H	6 days	1.6 FS
1.9	Work Package I	5 days	1.5 FS; 1.7 FS; 1.8 FS

Figure 5-6 Network Diagram Solution.



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Estimating Activities

AT THIS POINT, YOU HAVE COMPLETED several key parts of project planning. You defined and bounded project scope, developed a project work breakdown structure, and built a network diagram that described the preferred sequence in which activities (work packages) would be performed. This chapter will teach you how to estimate the time, cost, labor resources, material costs, travel expenses, equipment rental, and other costs to accomplish each activity included in the work breakdown structure.

Estimates are predictions and have varying degrees of confidence. Predictions rest on assumptions and have associated probabilities of coming true. All estimates have some confidence and risk associated with them. Estimates are predictions for three plan parameters:

- ▶ **Time:** How long it will take to accomplish the work in terms of hours, days, weeks, or months

- ▶ *Resources*: How many units of labor, equipment, or supplies are likely to be used
- ▶ *Cost*: How much each work package will cost and how much the entire project will cost

The resources required for each work package are estimated and applied to the schedule. This is called *resource allocation* or *resource distribution*. If imbalances exist—usually because demand exceeds supply or because requirements exceed capacity—then the process selectively repeats itself. This iteration is called *resource smoothing*. The net effect is that, in a resource-limited environment, we arrive at a reasoned solution that allocates the right people with the right skills to the right activities at the right time.

The project budget is the WBS expressed in financial terms. In an ideal world, we create a plan-driven budget, not a budget-driven plan. As the planning process goes on, management has several opportunities to fine-tune or to calibrate the relationships among time, cost, and scope. Clearly, the key to this recalibration is the accuracy and usefulness of the estimates for each work package.

Using the Work Breakdown Structure

The work breakdown structure is the foundation for estimating. The WBS is typically constructed from the top down. Functional decomposition progressively gets to smaller and smaller pieces of work until, at last, we get to work packages or activities that are small in size; unique in terms of organizational responsibility; and consumers of time, resources, and cost. These work packages are the basis for estimating.

Work package estimates of time and cost are then rolled up or summarized to create project master plans for schedule,

resource usage, and costs. These work packages are then used to monitor and control work, to detect variances from the approved plan, to initiate corrective actions, and to serve as a basis for lessons learned during the project closure process.

It is important to note that a poorly developed or erroneous WBS will create problems when estimating time and cost. For example, any task that is missing from the WBS will not be estimated and not included in the project's schedule and budget. In which case, you will almost be guaranteed to go over schedule or over budget, or both!

Steps in Estimating Activities

To properly estimate each activity (work package), use the following three steps:

1. For each activity, develop a statement of work that succinctly defines the work to be accomplished in the activity. Then ask team members to complete an estimate for each, supported by the following:
 - ▶ Technical specifications of the end products, such as performance, quality, reliability, survivability, operability, and maintainability.
 - ▶ Compliance with standards (governmental, institutional, international, and organizational).
 - ▶ Project assumptions, constraints, and exclusions (a description of what is not included in this work package).
2. Ask the functional groups to document how the estimate is made, including assumptions and factors that might affect the validity of the estimate. For example, did the cost pro-

jections make allowances for the suppliers' annual price increases?

3. Review the estimates for all the activities in the project and clear up discrepancies.

Estimating Methods

The four basic methods for estimating activities are analogous, parametric, bottom-up, and simulation.

Analogous (Historical) Approach

This approach uses the actual costs and durations of previous, similar projects as the basis for estimating the current project. Because known historical information is the best source for creating estimates, organizations should build a project database with information on the actual time, cost, and labor used to complete activities. You can then compare the current project against the database. If the new project is easier to do than the standard, revise the estimate downward. If the new project is more complex than the standard, revise the estimate upward.

The analogous approach is also called a *top-down* estimate, because it relies on information from the top row of activities of the work breakdown structure. It can be used to estimate projects with a limited amount of detailed information. Such an analogous approach is generally less costly than other approaches.

Parametric Modeling

Parametric modeling uses mathematical parameters and industry standards to predict project costs. An example is residential home construction that is often estimated using a

specified dollar amount per square foot of floor space. Complex examples can be found in the software development industry, where models use various factors to predict the complexity of the software.

Bottom-Up Estimate

This approach estimates the cost and duration of the individual work packages from the bottom row of activities of the work breakdown structure, then totals the amounts up each row until reaching an estimate for the total project. This approach can produce a more accurate estimate, but at a higher cost to create the estimate.

Simulation

In this approach, a computer calculates multiple costs or durations with different sets of assumptions. The most common is the Monte Carlo method, in which a range of probable results is defined for each activity and used to calculate a range of probable results for the total project. Simulation can provide a more accurate estimate and is principally used on large or complex projects.

Guidelines for Estimating

Estimates should be realistic and achievable. The following are guidelines and considerations for developing good, solid estimates.

Ownership of the Estimate

Generally, the most accurate estimates come from those who are answerable and held accountable for performing the work

on the project. If a separate group of estimators is used to create the estimates, the project workers should at least review and validate the estimates for which they will thereafter be held accountable. The reason for this rule is twofold:

1. Subject matter experts (or practitioners) know more about specific work packages than the project manager does. If the project manager is skeptical about the initial estimates received, she should respect the expertise of others.
2. An estimate dictated to a functional group or department from higher up generates little or no loyalty to the estimate by those who perform the work. A project manager who dictates an estimate (for example, “You’ll have to get this done by the fifteenth of next month and your budget is \$6,500”) sets everyone up to fail.

When the functional or resource manager cannot predict which employee will be assigned to the work package, then she should assume average performance and productivity of the work group.

Level of Detail

The smaller the unit of work being estimated, the more accurate the estimate is likely to be.

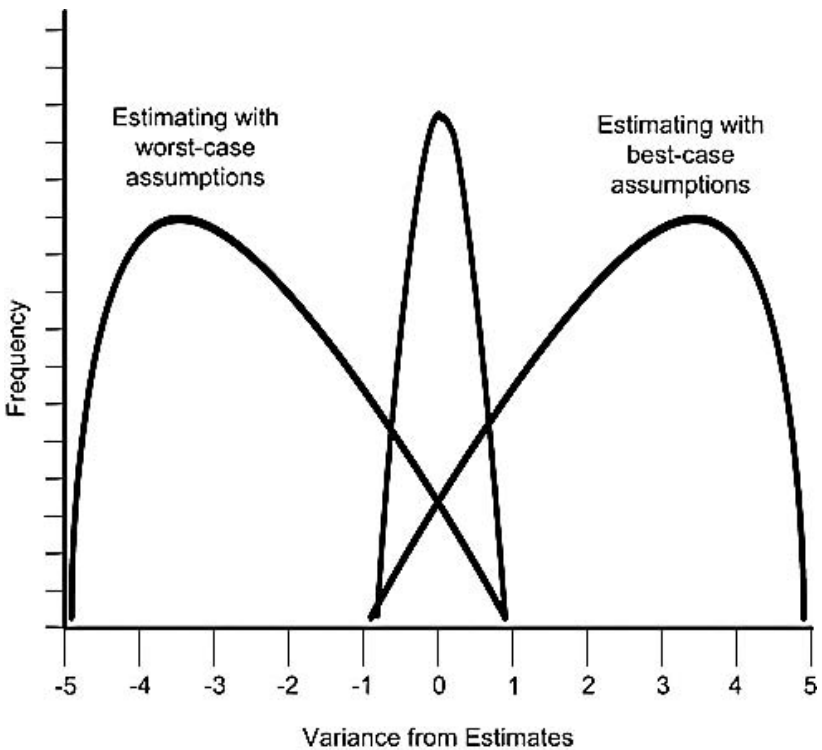
Distribution of Estimates

In any scenario, the best estimate has the same likelihood of being over as being under the actual time or cost (normal distribution). Using only the worst-case (pessimistic) estimate generates arbitrarily high estimates. And using the optimistic

estimate generates scenarios that are desirable but probably not realistic. The easiest way to grasp this rule is shown graphically in Figure 6-1. This figure has three curves, or distribution patterns, that show estimates against actual results achieved. The three curves reflect three kinds of estimators.

The *worst-case estimator* is represented by the curve on the left of the graph. On a regular basis, this estimator presents estimates for work packages and then routinely beats the estimates. Initially, this seems to be a positive outcome, but it has several genuine flaws:

Figure 6-1 The Distribution of Estimates.



- ▶ Estimates routinely commit the organization's resources that could have been used elsewhere.
- ▶ The organization may incur unforeseen costs for inventory storage, product obsolescence, or decay and malfunction.
- ▶ If the estimates are needed to attract new business, none will materialize because the prospective customers see too high a price or bear too great a share of the risk.

Estimators in this field need coaching to help them learn to take prudent risks when asked to estimate.

The *overly optimistic estimator* is represented by the curve on the right of the graph. Looking at life through rose-colored glasses, she estimates work packages on assumptions of a best-case scenario. Regrettably, this type of estimator makes promises that do not materialize because risks were neither identified nor quantified. The net result is the distribution pattern where activities are completed later than they should be, use more resources than were planned, and cost more than the approved budget. The net effect is that the anticipated benefit streams, regardless of how they are calculated, do not materialize, and the customer is disappointed in the project's return on investment.

The *ideal estimator* is represented by the middle curve, which shows little variance (0, plus or minus 1) and has no left or right skew. In short, what was estimated is what routinely occurred with only minimal variances both over and under the estimates.

The distribution-of-estimates guideline suggests that we (1) do not politicize estimates in an attempt to make supervisors, customers, or clients happy; (2) tell the truth; (3) negotiate requirements first and budgets second; and (4) provide estimates that are neither too lean nor too heavy.

Human Productivity

People cannot be expected to perform their activities with uniform production over a business day. When considering an eight-hour workday, be sure to consider the following:

- ▶ Lost productivity when shifting from working on one project or task to another
- ▶ Variations in productivity across workers due to skill levels and individual capabilities
- ▶ Lower productivity during certain hours of the day and during extended shifts
- ▶ Missed productivity from vacations, sick leave, holidays, meetings, and training

Time/Cost/Resource Trade-Off

There is a trade-off among time, cost, and resource hours needed for a work package. The relationship is illustrated in Figure 6-2. Assume an activity could be done by one practitioner working without interruption over the course of a week. The cost per hour for this expert is \$75. The estimate for this work package becomes:

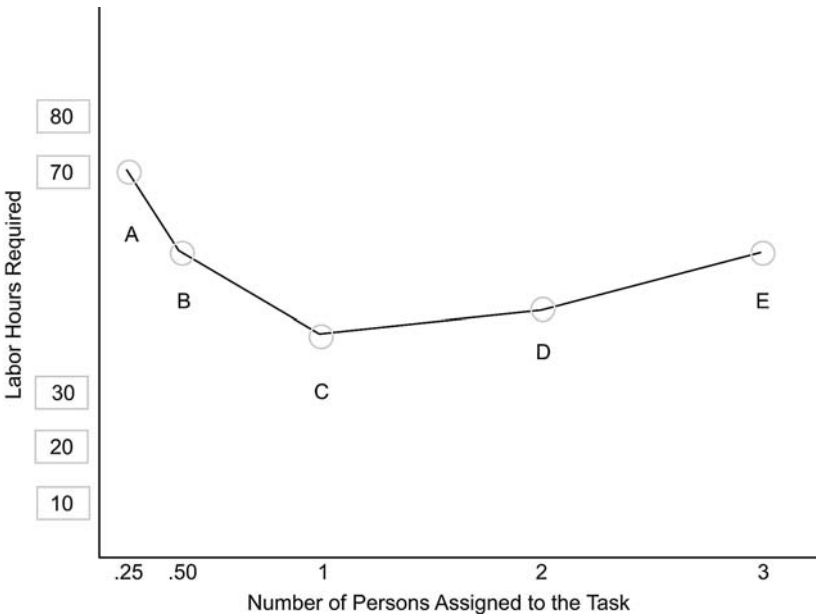
Time = 5 days

Labor hours = 40 hours

Labor cost = \$3,000

This is reflected as point *C* in the figure. If we must add another expert to the activity, then we discover at point *D* in the drawing that total time may be compressed, but labor hours and costs increase because the additional communication and complexity may reduce the team's efficiency in com-

Figure 6-2 Time/Cost/Resource Trade-Off Curve.



pleting the task. Point *E* carries this example further to show what is likely to happen when management assigns three staff members to perform an activity that could most efficiently be done by a single worker without interruption. Points *A* and *B* indicate what happens when staff members are assigned to multiple activities simultaneously—they become increasingly less productive with each newly assigned activity. The empirical results of the trade-off are shown in Figure 6-3.

Considering Risk in Estimating: Using Three-Point Estimates

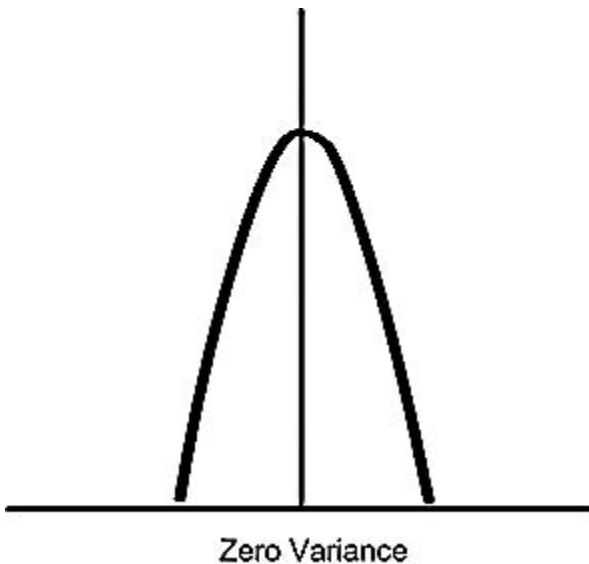
The time, cost, and resource estimates for a work package should reflect the degree of risk associated with that activity. If an activity is well understood, familiar to practitioners, rou-

Figure 6-3 Time/Cost/Resource Trade-Off Data Points.

Data Points	Staffing Pattern (Simplified)	Task Duration	Labor Hours Needed	Labor Cost (@ \$75/hour)
A	0.25 (2 hours/day)	35.00 days	70.00	5,250
B	0.50 (4 hours/day)	14.00 days	56.00	4,200
C	1.00 (8 hours/day)	5.00 days	40.00	3,000
D	2.00 (16 hours/day)	2.75 days	44.00	3,300
E	3.00 (24 hours/day)	2.33 days	56.00	4,200

tinely done, and frequently recalibrated to reflect best practices, then the estimate for the work package should consider a low-risk factor. The distribution pattern of a low-risk item (see Figure 6-4) is spiked at or near variance of zero, with neither left nor right skew. Activities with this low risk level are often found in estimating handbooks or guidelines for auto repairs and construction.

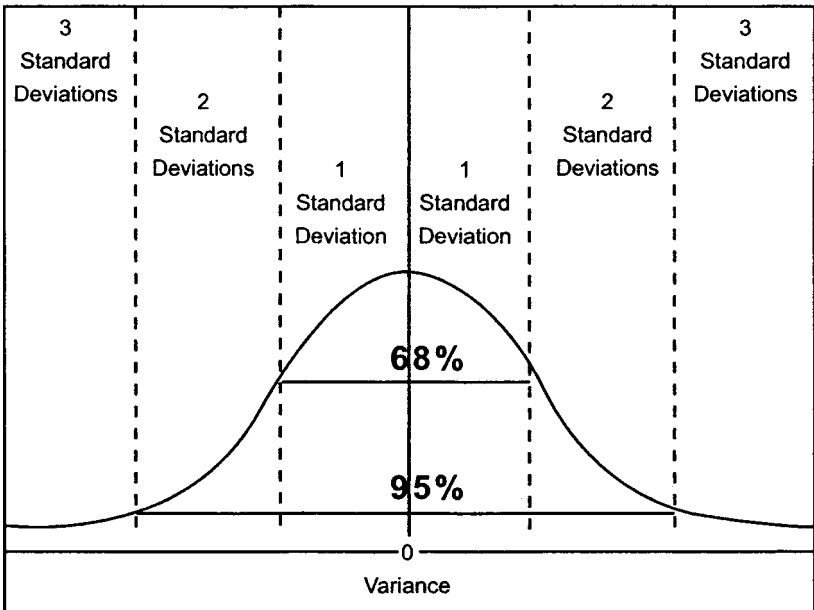
Figure 6-4 Distribution Pattern of a Low-Risk Item.



If the work package is somewhat well understood but still has important variables that could influence its outcome, then you should use a normal distribution as the underlying model for estimating. This distribution is illustrated in Figure 6-5, along with its indications for three standard deviations from the mean. This diagram shows that 95 times out of 100 the predicted outcome or estimate occurs within two standard deviations of the (arithmetic) mean. The most likely outcome takes up four estimating zones in the curve. Best-case and worst-case outcomes occur far less frequently—roughly once in every twenty instances.

This distribution gives rise to the program evaluation and review technique (PERT), which is a weighted-average estimating equation. This equation requires you to gather three estimates: a most likely estimate (given what you expect to

Figure 6-5 Normal Distribution Curve.



happen), an optimistic estimate (if everything goes very well), and a pessimistic estimate (if things go poorly). You then combine the three estimates to calculate the average expected duration or cost for the activity, using the following formula:

$$\text{estimated time} = [\text{optimistic} + (4 \times \text{most likely}) + \text{pessimistic}] / 6$$

This weighted estimate accounts for the uncertainty and variability inherent in project work and provides a risk-adjusted estimate. It works equally well for both time and cost estimates.

Precision of Estimates

In early planning, you might be asked to provide a preliminary or conceptual estimate, also called an *order-of-magnitude estimate*. This level of estimate is usually –25 percent to +75 percent. Thus, the range of the order-of-magnitude for a \$50,000 estimate would be \$37,500 to \$87,500. Later, at the project approval stage when more definition is available, you might be asked for a budget estimate, which usually ranges from –10 percent to +25 percent. During project planning, when well-defined specifications are available for individual activities, you might need to provide definitive estimates that can be used for bid proposals or contract negotiations. Definitive estimates usually use a bottom-up approach, and typically range from –5 percent to +10 percent.

The more specific the details, the better the estimate, and therefore the greater the chance of meeting the project objectives. However, the greater the detail, the greater the cost and time to get the estimate and the less time and budget will be left to accomplish the project.

To increase the accuracy and consistency of your estimates, you might want to:

- ▶ Use several independent techniques and sources.
- ▶ Compare and iterate estimates.

For example, you might ask two independent groups to use the same estimating method, or one group to use two different methods. Investigate the differences among the estimates and adjust the estimating approach to what is appropriate for your project. An analysis after the project is important to determine whether your approach was valid. This helps you learn from each project and produce a better estimate on the next.

Duration-Based vs. Resource-Based Estimates

When creating estimates, consider whether the activity is duration-based or resource-based.

A *duration-based activity* has a defined duration for completion, independent of the number of people assigned to work on it. Examples include laboratory experiments to grow specific tumors in mice, auto travel, or curing cement (once poured, it takes forty-eight hours to cure). Adding staff does not compress the schedule but may add considerably to labor costs.

A *resource-based activity* may be compressed in duration by adding staff. However, beyond a reasonable point, costs and risks may rise.

Building Contingency in Estimates

Increasingly, project managers are asked to create aggressive schedules with limited or untested resources. They are pres-

sured to prepare or accept estimates that are driven by political rather than technical considerations. It is best practice to build in some tolerance or *contingency* when establishing the budget and duration of a project or even, in some cases, individual activities. Building contingency into project schedules and budgets brings an element of reality into project management. This contingency provides leeway for unforeseen factors that inevitably will occur in any project.

The amount of contingency to build into the project schedule and budget depends on the degree of risk or uncertainty of the project, as well as the industry and culture of your organization.

- ▶ *Degree of Risk.* In a project with high risk or uncertainty, it is typical to include more contingency in the schedules and budgets.
- ▶ *Industry Standards.* Specific industries have commonly accepted levels of contingency. For example, engineering and construction companies may use these estimating guidelines:
 - ▶ Conceptual phase: + 50 percent
 - ▶ Preliminary engineering phase: + 25 percent
 - ▶ Detailed engineering phase: + 10 percent
 - ▶ Construction phase: + 5–7 percent
- ▶ *Culture of Your Organization.* For example, your organization may allow a tolerance level of “plus or minus 10 percent” in project budgets, meaning that you may overrun a budget by 10 percent without penalty. You would then need to judge whether this gives you enough tolerance in your project, or whether you need to build in additional contingency in the project budget.

Improving Estimates over Time

A good project management system improves the quality of estimates over time.

- ▶ Within a project, the confidence in your estimate should improve as your project progresses, because you have accomplished some tasks and have less work in front of you.
- ▶ Across projects, you should be able to create more accurate estimates with each succeeding project because of lessons learned on previous projects.

Scheduling Activities

THE CRITICAL PATH IS THE PATH through the network diagram (see Chapter 5) that takes the longest total time. It therefore determines the earliest possible time the project can be completed. The critical path is a network analysis technique used to determine the amount of scheduling flexibility (or total float) on each of the various network paths in the project schedule and to determine the overall project duration. Activities on the critical path are not inherently more important than other activities in the project, but they are more critical to the overall project schedule, because any delay in them will delay the completion of the entire project unless other adjustments are made. The critical path allows the project manager to understand which activities have schedule flexibility and which do not.

Scheduling Activity Dates

The critical path method calculates the following dates for each activity:

- ▶ *Early Start*: the earliest date the activity can begin
- ▶ *Late Start*: the latest date the activity can begin and still allow the project to be completed on time
- ▶ *Early Finish*: the earliest date the activity can end
- ▶ *Late Finish*: the latest date the activity can end and still allow the project to be completed on time

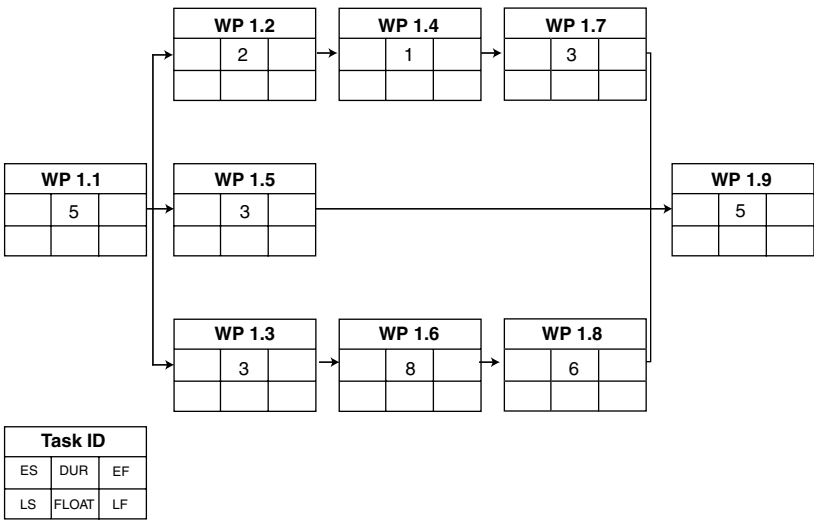
Project management software is commonly used for critical path calculations. Once you enter the activity durations and preceding activities, the program determines the critical path and the early start, early finish, late start, and late finish dates. This saves significant time creating the original schedule and subsequent reschedules. The following sections explain how these values are calculated manually in a two-step process with a forward pass and a backward pass.

Forward Pass

A forward pass calculates the *early start* and *early finish*, which are the earliest points in time an activity can start and finish, respectively. To compute these figures, start from the left side (the project start) of a network diagram and continue to ask yourself as you proceed incrementally to the right, “What is the earliest time I can start and finish an activity?” Using Figure 7-1, follow these four steps:

1. Start the project on the beginning of day zero. Therefore, the earliest time the first activity (WP 1.1) can start is day zero.
2. Add the duration of that activity to the early start to determine the earliest time the activity can finish (WP 1.1 has a duration of five days; therefore, the early finish is the beginning of day five).

Figure 7-1 Network Diagram Solution.



$$\text{Start} + \text{Duration} = \text{Finish}$$

3. The *early start* for WP 1.2, WP 1.3, and WP 1.5 is, therefore, the beginning of day five. Repeat the step 2 process for each of those work packages. Proceed from left to right.
4. Work package 1.9 must wait for WP 1.5, WP 1.7, and WP 1.8 to complete before it can start. The earliest time WP 1.9 can start is day twenty-two.

Backward Pass

Determining *late start* and *late finish* is done in exactly the opposite way as was done to determine early start and early finish. Instead of proceeding from left to right, we proceed from right to left. And instead of asking, “What is the earliest time we can start the activity?” we ask, “What is the latest time we can finish the activity without delaying the project?” Follow these five steps to conduct a backward pass:

1. Start at the end of the project. Because WP 1.9 must be complete to end the project, we ask, “What is the latest time we can finish WP 1.9 without delaying the project?” The answer is day twenty-seven—the end date of the project.
2. Because we’ve determined when the work package will end, we compute the late start by subtracting the duration. For WP 1.9: $27 - 5 = 22$.
3. Continuing from right to left, work packages 1.5, 1.7, and 1.8 must finish before WP 1.9 can start. Therefore, we ask, “What is the latest time we can finish these WPs without delaying WP 1.9?” The answer is day twenty-two. Therefore, the *late finish* for these work packages is day twenty-two.
4. Continue the same process moving right to left for work packages 1.4, 1.2, 1.6, and 1.3.
5. WP 1.1 must complete before WP 1.2, WP 1.3, and WP 1.5 can start. The latest time that WP 1.1 can finish, therefore, is the earliest late-start time of these three work packages. Therefore, WP 1.1 must complete by day five (see WP 1.3). The late start for WP 1.1 is then computed to be day zero.

Project Float

The term *float* (also known as *slack*) refers to the amount of time an activity can slip without affecting the project end date. Mathematically, it is the difference between the early finish and late finish. For activities on the critical path, the early and late start (and early and late finish) are the same, and therefore they have zero float. *Free float* is the amount of time an activity can be delayed without affecting any successor.

Accelerating Project Schedules

If the schedule you develop does not allow the project to complete when desired, you may have to take action to decrease the total project duration. Compressing (accelerating) the schedule is referred to as *crashing the schedule*. When attempting to crash a schedule, you should consider all the available options and choose those that provide the greatest compression for the lowest cost. Concentrate on the activities on the critical path. (Remember, shortening noncritical activities will not complete the project any sooner.) Focus first on activities that occur early in the project and also those with the longest durations.

Resources

One way to crash a schedule is to change the way resources are applied to the project. The following are some options to consider:

- ▶ Relieve employees of other responsibilities to allow them to devote more hours each day to the project.
- ▶ Reallocate resources from noncritical activities to provide the extra help you need. After you reassign the resources, check to see if the critical path has shifted to include other activities.
- ▶ Add resources to provide additional staff, overtime, additional equipment, vendor incentives to complete sooner, or the ability to outsource. Make wise choices because adding too many resources can cause problems in communication and interpersonal relations.
- ▶ Reserve overtime as a contingency. Rather than scheduling overtime in the original plan, keep it as a contingency for

unforeseen problems. Overtime is not as effective as regular work hours. Studies show that twelve hours of overtime by a knowledge worker increases actual output only by the equivalent of two hours of regular work. Overtime might be useful if a small increment (three to four days) will make a difference in the project, if the staff is able to see light at the end of the tunnel, and if extra money represents an incentive to them.

Activities

Another way to crash a schedule is to change the sequence of activities or reevaluate their estimates. The following are some options to consider:

- ▶ *Fast-track* the project by changing the sequence of activities in the network diagram to allow activities to be done in parallel (at the same time) rather than in sequence (one after another) or to allow some to overlap (for example, starting to write code on a software project before the entire design is complete). Fast-tracking usually increases risk.
- ▶ Reconsider the accuracy of the estimates for activities on the critical path. However, do not arbitrarily reduce the estimates to fit the time available.

Project Objectives

A third way to crash a schedule is to modify the project objectives. The following are some options to consider:

- ▶ Rethink the basic strategy to determine better ways to accomplish the same objectives.

- ▶ Renegotiate the project objectives. Reduce the scope, increase the budget, or increase the time.
- ▶ If the schedule still won't work, readdress the basic problem or opportunity to verify that it warrants the effort it will take to complete the project.

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Identifying Resources and Budgets

RESOURCE AND BUDGET PLANS are linked to project schedules. In practice, the schedule, budget, and resource plans are usually created simultaneously. The project team identifies for each activity the needed people, materials, equipment, supplies, travel, and other anticipated expenses. The project manager guides the planning team through the steps shown in Figure 8-1.

Identifying Resources

Let us look at the essential parts of a resource plan. The first thing we need to do is create an inventory of people and their skills. Figure 8-2 is an example with competencies shown on a scale of one to five (with five being the highest level of skill).

Fundamentally, resource plans show the need (or de-

Figure 8-1 Planning Steps for Resource Planning and Budgeting.

Who	Does What	Product
PM; PMO	Distribute preliminary schedule to SMEs and FMs	
WP Estimators	Estimate resource/asset requirements per work package	Demand function
SMEs; FMs	Compare demand to supply (requirements vs. capacity)	Analysis
FMs	Identify supply/demand imbalances	Document
FMs; SMEs	Develop alternative solutions	Options
FMs; SMEs	(Re)Allocate resources; redistribution; resource leveling	Revisions
PM; PMO	Modify schedule plan, as required	Revised schedule
PM; PMO	Price out the WBS (based on the revised schedule)	Project budget
PM; SM	Compare revised budget to approved targets	Analysis
PM; CPT	Perform necessary iterations	Iterations
PM; SM	Secure essential commitments and approvals	Approvals

mand) for a person, a skill set, or other asset by work package and desired time frame. First, resource demands are applied at the activity level and then summarized to the project level. Thereafter, these demands are added to nonproject requirements for a particular resource or person to create the total demand across certain time periods. These resource requirement data can be shown as spreadsheets, histograms, or cumulative curves.

Figure 8-2 Enterprise Skills Inventory.

Staff	R&D	EE	Arch	Hydro	Nuclear	Inst
Fig Newton	5.0	3.0	2.5	3.5		2.5
Upper Volta		3.5		2.0		
Watts Up	3.0	4.0				3.0
Ohm Igosh	3.0	4.0				3.0
Ampere Waist	2.5	3.5		1.5		1.5
Designer Jean	1.5	1.5	3.0	1.0		1.0
Muddy Waters			2.5	3.5		2.5
Newt Reno	2.5				4.0	3.5
Posit Ron					3.5	3.0
Viola Lynn Cello						4.5

The first requirement is to identify the resources by name or type. Figure 8-3 shows a resource pool available for our illustrative project. Resources are then assigned to specific work packages, as shown in Figure 8-4.

Finally, we can illustrate the distribution of people to work packages in particular time frames. At this point in the planning process, project management software (typically) alerts us that resource demand exceeds resource supply. This imbalance may be shown in a table (see Figure 8-5) or in a histogram. For resource managers, the cells of the table are critical because they describe the anticipated distribution of people to activities on specific days or weeks. For the project manager, the perimeter cells are critical because they define total demand across all activities, skills, asset types, and time frames. When project and resource managers consider the need or demand for labor hours (or any asset or resource), a convenient way to display this information is a histogram. The next three figures indicate how histograms could be used.

Figure 8-6 depicts the need for a systems analyst over a ten-week period (presumably the life of the project). Notice that the plan requires this person to work eighty hours a week in weeks four and five, but only twenty hours in week six.

Figure 8-7 is a more complex diagram illustrating the planned distribution of time of one person who is assigned to multiple activities, not all of which are projects.

Figure 8-8 indicates which persons are assigned to specific work packages.

Balancing Resources

Resource imbalance is a central issue for project and resource managers. A recurring problem is that demand is often greater than supply (or requirements exceed capacity) for people, supplies, and equipment. This imbalance may arise in particu-

Figure 8-3 Resource Table.

ID	Resource Name	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use
1	Fig Newton	F	R&D	100%	\$250.00/hr	\$0.00/hr	\$0.00
2	Upper Volta	U	EE	100%	\$150.00/hr	\$0.00/hr	\$0.00
3	Watts Up	W	EE	100%	\$150.00/hr	\$0.00/hr	\$0.00
4	Ohm Igosh	O	EE	100%	\$125.00/hr	\$0.00/hr	\$0.00
5	Ampere Waist	A	EE	100%	\$100.00/hr	\$0.00/hr	\$0.00
6	Designer Jean	D	Architect	100%	\$75.00/hr	\$0.00/hr	\$0.00
7	Muddy Waters	M	Hydro	100%	\$75.00/hr	\$0.00/hr	\$0.00
8	Newt Reno	N	Nuclear	100%	\$125.00/hr	\$0.00/hr	\$0.00
9	Posit Ron	P	Nuclear	100%	\$125.00/hr	\$0.00/hr	\$0.00
10	Viola Lynn Cello	V	Instrument	100%	\$150.00/hr	\$0.00/hr	\$0.00

Figure 8-4 Resources Assigned to Work Packages.

ID	Resource Name	Task Name	Duration	Predecessors
1		AMA Example: Feasibility Study Template	16 days	
2		Initial Problem Definition/Opportunity Analysis	2.5 days	
3	Fig Newton	Receive Charter from Initiation Process; Review	0.5 days	
4	Watts Up	Confirm Project Targets for Time, Cost, and Requirements	0.5 days	3
5	Upper Volta	Create Cross-Functional Team for This Phase of the Project	1 day	4
6	Fig Newton	Determine Current Status of Project and/or Problem	0.5 days	5
7		Collect Relevant Information	6 days	6
8		Identify Direct Sources of Evidence and Information	6 days	5
9	Muddy Waters	Schedule and Conduct Site Visit(s) and Inspections	3 days	5
10	Newt Reno	Schedule and Conduct Interviews	3 days	9
11	Fig Newton,Ohm Igosh	Schedule and Conduct Verification Tests	0.5 days	9
12	Posit Ron	Obtain Other Information TBD	1 day	9
13		Identify Indirect Sources of Evidence and Information	1.5 days	6
14	Viola Lynn Cello	Collect and Review Relevant Operational Documentation	1.5 days	6
15	Posit Ron	Collect and Review Organizational and Administrative Data	1 day	6
16		Collect and Review Legal and Contractual Data	0.5 days	6
17		Collect and Review Economic, Financial, and Performance Data	1.5 days	6
18		Collect and Review Other Relevant Information TBD	0.5 days	6
19		Confirm the Problem Definition or Opportunity Analysis	2 days	8,13
20		Document the "As-Is" Condition	1 day	10,11,12,14,15,16,17,18
21		Document the "To-Be" Condition	1 day	10,11,12,14,15,16,17,18
22		Document the "Gap Analysis"	0.5 days	20,21

Figure 8-5 Resources Assigned to Work Packages (by Day).

ID	Resource Name	Work	Details	Sep 2, '01					
				S	S	M	T	W	T
1	Fig Newton	12 hrs	Work			4h		4h	
	<i>Receive Charter</i>	4 hrs	Work			4h			
	<i>Determine Current</i>	4 hrs	Work					4h	
	<i>Schedule and Co</i>	4 hrs	Work						
2	Upper Volta	8 hrs	Work				8h		
	<i>Create Cross-fun</i>	8 hrs	Work				8h		
3	Watts Up	4 hrs	Work			4h			
	<i>Confirm Project T</i>	4 hrs	Work			4h			
4	Ohm Igosh	4 hrs	Work						
	<i>Schedule and Co</i>	4 hrs	Work						
5	Ampere Waist	0 hrs	Work						
6	Designer Jean	0 hrs	Work						
7	Muddy Waters	24 hrs	Work					4h	8h
	<i>Schedule and Co</i>	24 hrs	Work					4h	8h
8	Newt Reno	24 hrs	Work						
	<i>Schedule and Co</i>	24 hrs	Work						
9	Posit Ron	16 hrs	Work					4h	4h
	<i>Obtain Other Info</i>	8 hrs	Work						
	<i>Collect and Revie</i>	8 hrs	Work					4h	4h
10	Viola Lynn Cello	12 hrs	Work					4h	8h
	<i>Collect and Revie</i>	12 hrs	Work					4h	8h

Figure 8-6 Resource Histogram.

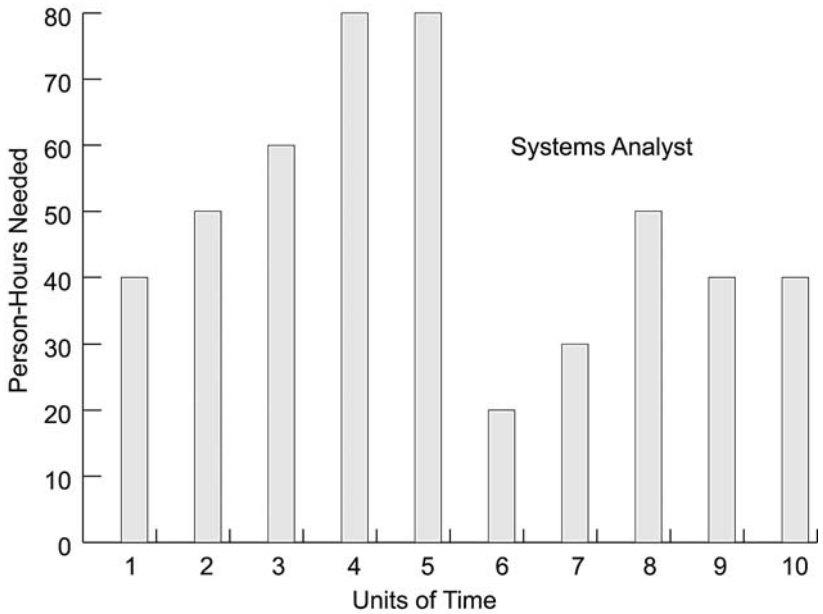


Figure 8-7 Distribution of a Single Resource Across Work Items.

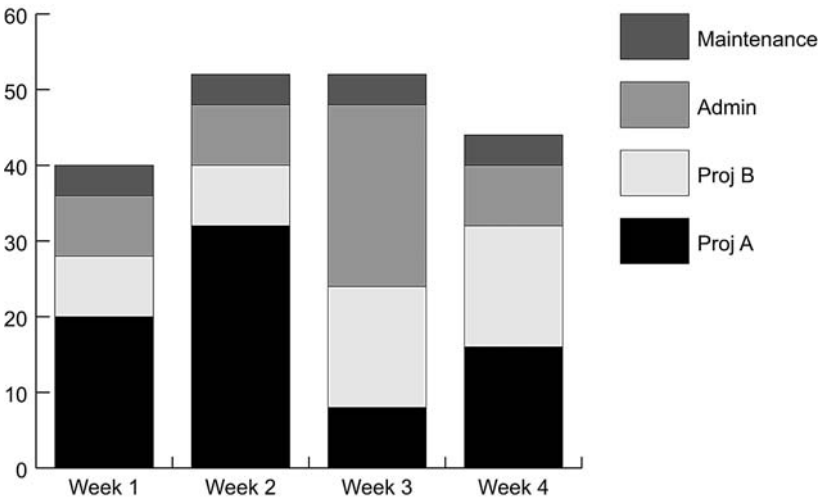
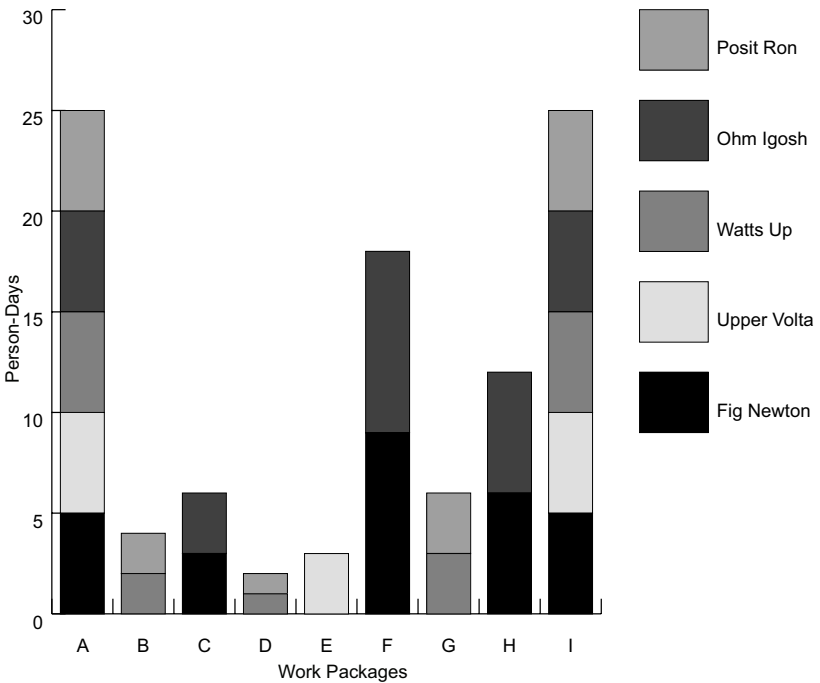


Figure 8-8 Distribution of Labor by Staff and Work Packages.



lar time frames or for particular work packages. This imbalance may be acute or chronic. All solutions require negotiating skills. The following are some actions that can be taken to alleviate the problem:

- ▶ Reduce the scope of the project.
- ▶ Extend the overall timeline by stretching out the work.
- ▶ Move activities (either in this project or in another project) with float to a time when people are available.
- ▶ Defer other nonproject work.
- ▶ Hire contractors or temporary help. Buy skills and deliverables. Assign nonproject personnel to the project.

- ▶ Adjust the time/cost/resource trade-off curve. Add people to compress time. Use your best people on high-risk activities. Assign fewer activities per person.
- ▶ Use overtime. Consider employees who are not compensated for overtime and instead grant them compensatory time for the overtime worked.
- ▶ Take measures to improve productivity. Use special, one time incentives. These could be financial rewards or other motivators.
- ▶ Review estimates to see if time or cost savings are possible.
- ▶ Redefine the work so that other available resources can perform it.
- ▶ Change the work order so that previously unavailable personnel are now available.

Creating a Project Budget

The total project budget is the sum of work package estimates plus financial contingencies. When costs will be incurred over time, you can apply these costs at the beginning of the activity (“front-end loaded”) or at the end of the activity (“back-end loaded”). Alternatively, you may have these costs prorated over the activity’s time.

Project budgets are typically shown in spreadsheets, as illustrated in Figure 8-9. Costs are allocated to each work package by type of cost and by period of time. The cost plan prices out the work breakdown structure, considering costs by type, by time, and by activity. Include both direct and indirect costs. The plan should also reflect commitments and obligations, cash flows, disbursements, and revenue streams.

The budget overlays the time and resource plans. The ultimate aim is a plan-driven budget, not a budget-driven plan.

Figure 8-9 Project Budget Spreadsheet.

Tasks	Month 1	Month 2	Month 3	Month 4	Month 5	Totals
WP-1						
Labor						
Labor OH						
Materials						
ODCs						
WP-2						
Labor						
Labor OH						
Materials						
ODCs						
Total						
CTD						

Compiling the Major Components of a Project Plan

IN CHAPTERS 1 THROUGH 8, you completed several steps related to project initiation and planning. You collected requirements, defined project scope, created a work breakdown structure, defined and sequenced activities, and estimated activities. You are now ready to compile all this information into an integrated project plan, communicate it to others, and secure necessary commitments and approvals. The final result of the planning process is a management decision on whether to proceed with the execution of the project.

This chapter outlines the major components of a typical project plan. Your management may require additional items. Some executives require a formal risk management

component; others look for detailed financial analyses. Some executives look for acceptance-test plans, and others look for explicit linkages between technology and organizational goals. Still others want written opinions from legal counsel, authorizations and permits from regulatory bodies or clients, and so on.

Before you submit your complete project plan, review it carefully with your planning team and get the necessary commitments from resource owners to provide the staff and other resources you will need in the specified number, skill level, mix, timing, and place.

The planning process ends when the integrated plan obtains the authorization to proceed to execute the project. Senior managers authorize performance of the work (along with approvals from customers, clients, and end users, as the case demands) and agree to provide the project manager and the team with the fiscal, physical, and intellectual resources needed for the project.

Project Charter

The project charter defines the purpose and rationale of the project. It describes, at a fairly high level, the results to be achieved, the products and services to be delivered, and the links between your goals and the broader goals of the enterprise. This document may also be called a business case.

Project Scope Statement

The project scope statement formally documents what the project will and will not produce. It defines your project, including objectives, specifications, exclusions, constraints, risks, and assumptions. It defines the parameters of time, cost, and scope.

Schedule Plan

The *project schedule* shows the anticipated duration for each activity (work package) and the start and end dates for each. The schedule plan also shows the roll-up of all work items to indicate total duration and the scheduled completion date for the project. The schedule plan must also reflect the logical dependencies among work packages so that the sequence of work can be understood and displayed.

The schedule plan shows all the activities (work packages) with estimates for time and sequence. You can build your schedule plan using these three elements:

1. Work package descriptions from the work breakdown structure (see Chapter 4)
2. Dependency relationships from the network diagram (see Chapter 5)
3. Duration estimates (see Chapter 6)

You can display your project's schedule in various ways. While the precedence network diagram is the most useful tool for determining the sequence of activities and setting the initial schedule, Gantt charts are often used to communicate information about activities. A Gantt chart is a bar chart that shows activities on a scaled timeline, with their durations shown as bars overlaid on the appropriate dates. Arrows on the Gantt chart show dependencies between the activities. Figure 9-1 shows a generic critical path bar chart. The information in this chart could also be presented as a table (see Figure 9-2). A more complex example of project schedule information, using the example introduced in Figure 8-4, appears in Figure 9-3.

Figure 9-1 Illustrative Critical Path Bar Chart.

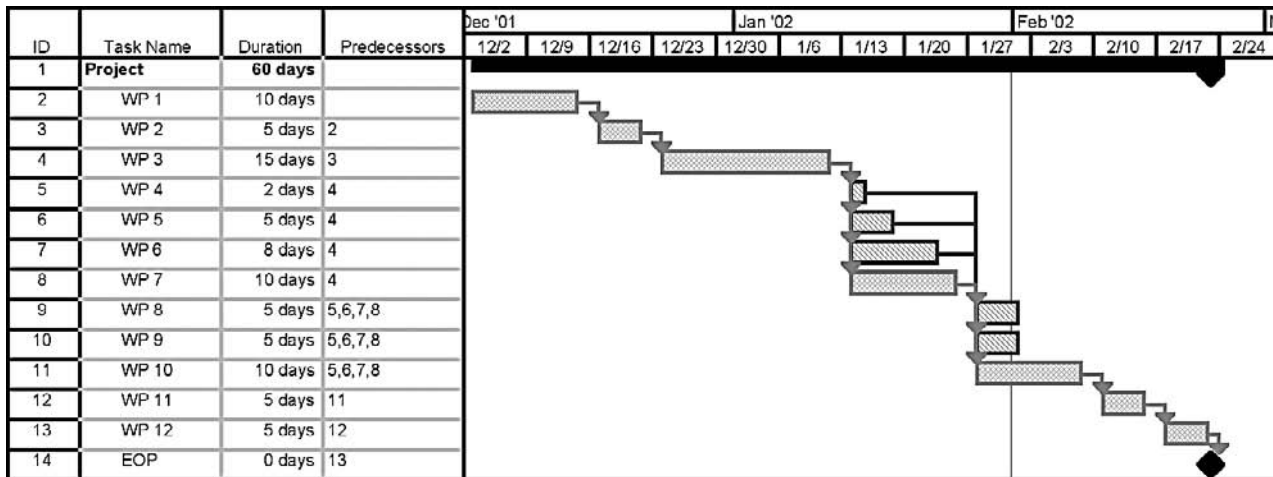


Figure 9-2 Project Schedule as a Table.

ID	Task Name	Duration	Predecessors	Early Start	Early Finish	Late Start	Late Finish	Total Slack
1	Project	60 days		Mon 12/3/01	Fri 2/22/02	Mon 12/3/01	Fri 2/22/02	0 days
2	WP 1	10 days		Mon 12/3/01	Fri 12/14/01	Mon 12/3/01	Fri 12/14/01	0 days
3	WP 2	5 days	2	Mon 12/17/01	Fri 12/21/01	Mon 12/17/01	Fri 12/21/01	0 days
4	WP 3	15 days	3	Mon 12/24/01	Fri 1/18/02	Mon 12/24/01	Fri 1/18/02	0 days
5	WP 4	2 days	4	Mon 1/21/02	Tue 1/22/02	Thu 1/31/02	Fri 2/1/02	8 days
6	WP 5	5 days	4	Mon 1/21/02	Fri 1/25/02	Mon 1/28/02	Fri 2/1/02	5 days
7	WP 6	8 days	4	Mon 1/21/02	Wed 1/30/02	Wed 1/23/02	Fri 2/1/02	2 days
8	WP 7	10 days	4	Mon 1/21/02	Fri 2/1/02	Mon 1/21/02	Fri 2/1/02	0 days
9	WP 8	5 days	5,6,7,8	Mon 2/4/02	Fri 2/8/02	Mon 2/18/02	Fri 2/22/02	10 days
10	WP 9	5 days	5,6,7,8	Mon 2/4/02	Fri 2/8/02	Mon 2/18/02	Fri 2/22/02	10 days
11	WP 10	10 days	5,6,7,8	Mon 2/4/02	Fri 2/15/02	Mon 2/4/02	Fri 2/15/02	0 days
12	WP 11	5 days	11	Mon 2/18/02	Fri 2/22/02	Mon 2/18/02	Fri 2/22/02	0 days
13	EOP	0 days	12	Fri 2/22/02	Fri 2/22/02	Fri 2/22/02	Fri 2/22/02	0 days

Figure 9-3 Project Work Breakdown Structure (with Durations and Dependencies).

ID	Task Name	Duration	Predecessors
1	AMA Example: Feasibility Study Template	16 days	
2	Initial Problem Definition/Opportunity Analysis	2.5 days	
3	Receive Charter from Initiation Process; Review	0.5 days	
4	Confirm Project Targets for Time, Cost and Requirements	0.5 days	3
5	Create Cross-Functional Team for this Phase of the Project	1 day	4
6	Determine Current Status of Project and/or Problem	0.5 days	5
7	Collect Relevant Information	6 days	6
8	Identify Direct Sources of Evidence and Information	6 days	5
9	Schedule and Conduct Site Visit(s) and Inspections	3 days	5
10	Schedule and Conduct Interviews	3 days	9
11	Schedule and Conduct Verification Tests	1 day	9
12	Obtain Other Information TBD	1 day	9
13	Identify Indirect Sources of Evidence and Information	1.5 days	6
14	Collect and Review Relevant Operational Documentation	1.5 days	6
15	Collect and Review Organizational and Administrative Data	1 day	6
16	Collect and Review Legal and Contractual Data	0.5 days	6
17	Collect and Review Economic, Financial and Performance Data	1.5 days	6
18	Collect and Review Other Relevant Information TBD	0.5 days	6
19	Confirm the Problem Definition or Opportunity Analysis	2 days	8,13
20	Document the "As Is" Condition	1 day	10,11,12,14,15,16,17,18
21	Document the "To Be" Condition	1 day	10,11,12,14,15,16,17,18
22	Document the "Gap Analysis"	0.5 days	20,21
23	Secure Agreement(s) as to the Problem Definition	0.5 days	22
24	Develop Alternative Solutions	1.5 days	23
25	Develop "Quick Fix" Operational Alternatives	0.5 days	22
26	Develop Mid-Term "Tactical" Alternatives	0.5 days	22
27	Develop Long-Term "Strategic" Alternatives	1 day	22
28	Rule Out Non-Viable Alternatives	0.5 days	25,26,27
29	Evaluate Viable Alternatives	2 days	28
30	Determine Technical Feasibility, for example	0.5 days	28
31	Configuration Integrity: Hardware, Software, Network	0.25 days	
32	Best Availability Proven Technology, Applicable "Gold Standards"	0.25 days	
33	Conformity with Scientific and Technical Standards	0.5 days	
34	Determine Operational Feasibility	1 day	28
35	Work Flows and Business Processes	0.5 days	
36	Staff and Skill Competencies vs. New Process	0.5 days	
37	Facility and Layout vs. New Process	1 day	
38	Machinery and Equipment vs. New Process	1 day	
39	Organization Structure vs. New Process	1 day	
40	Determine Economic Feasibility	1 day	28
41	Estimate Costs for Each Alternative	1 day	
42	Estimate 1-time Costs for Design and Development and Depic	1 day	
43	Estimate Recurring (O&M) Costs for Each Alternative	1 day	
44	Estimate Benefit Streams for Each Alternative	1 day	
45	Estimate Appropriate Measures of Return, e.g., ROI, NPV, IRI	1 day	
46	Estimate Contribution to Profit	1 day	
47	Estimate Cost Avoidances and Savings	1 day	
48	Estimate Performance and Quality Improvements	1 day	
49	Determine Compliance with Applicable Laws, Rules, and Regulation	1 day	30,34,40
50	Identify "Controlling Legal Authorities"	1 day	
51	Identify Requirements for Due Diligence	1 day	
52	Assess Each Alternative	1 day	
53	Prepare Report for Management	2 days	30,34,40,49
54	Transmittal Letter; Executive Summary	0.5 days	
55	Purpose and Scope	0.5 days	
56	Approach and Methodology	0.25 days	
57	Findings and Conclusions	2 days	
58	Recommendations and Next Steps	2 days	
59	Appendices and References to Working Papers	2 days	

Resource Utilization Plan

The resource utilization plan displays the distribution of people, equipment, material, supplies, and other assets. Ideally, this distribution is tied to specific activities and not just at the top levels in the work breakdown structure.

Budget Plan

The cost plan or budget is the financial expression of the work breakdown structure. The cost plan or budget depicts the costs likely to be committed, accrued, or obligated by work package for each interval in the schedule. In some organizations, the cost plan is balanced against a revenue projection plan to calculate net cash flows for the performing organization. Each organization has its own forms and procedures for displaying and analyzing project cost information.

Milestone Plan

The milestone plan indicates the key deliverables that arise during the life of the project, their due dates, the organization or department responsible for producing them, and the organization or department expecting their receipt as a condition of starting its own work.

Organization Plan

The project's organization plan clarifies the relationships between departments (sometimes called the *organizational breakdown structure*) and the work items established in the work breakdown structure. The purpose of the organization plan is to ensure that every work package has an owner or a champion, that no activity is orphaned, and that complex and subtle relationships among players are well understood.

One method is to use a spreadsheet to assign work packages (activities) to organizational units. These units may be internal or external to the performing organization. This allows you to establish with care what outside vendors or third parties own the project. The cells define the relationship that each organizational unit has to each work package. One

scheme to define these relationships uses the following nomenclature:

A—directly performs the work; is answerable for the quality of the end item

B—reviews work to determine adherence to quality standards

C—has the authority to approve intermediate deliverables

D—must be consulted prior to a decision; mandatory input

E—may be consulted prior to a decision

F—must be notified after a decision is made

X—may exercise veto power regarding a specific work product

O—may override the veto

Risk Management Plan

A *risk* is an “uncertain event or condition that, if it occurs, has an effect on at least one project objective” (scope, schedule, or budget). (See *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, p. 275. The risk management plan, evolving throughout the planning process, incorporates (1) risk identification; (2) qualitative and quantitative assessments; (3) strategies for prevention, detection, and mitigation of loss; and (4) recovery and restoration of functions. (See Chapter 13 for more information about managing risk.)

Communication Plan

The communication plan describes how the project manager will keep information flowing during the project. This plan should describe meetings and reports as well as the frequency

and content of reports sent to senior management, stakeholders, and the client. It should also describe the frequency and agenda for regular and exception meetings, such as team status meetings and senior management project reviews. You may wish to use a communication matrix like the one shown in Figure 9-4.

Figure 9-4 Communication Matrix.

What	Client	Customer	Team member A	Team member B
Formal status reports	monthly	quarterly	weekly	weekly
Phone calls and e-mail	as needed	as needed	as needed	as needed
Team meetings	minutes weekly	as needed	attends weekly	attends weekly
Status report on project website	daily	daily	daily	daily

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PART 4

**Executing,
Monitoring,
and Controlling**

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Executing Projects

ONCE APPROVED, THE INTEGRATED project plan becomes the basis for two closely related processes: execution and control. The central idea is that (1) work is authorized and performed according to the plan, (2) variances between plan and actual are detected promptly, (3) causes for the variance are identified, (4) alternative corrective actions are developed and assessed, (5) recommended corrective actions are approved and then implemented, and (6) plan documentation is updated to reflect the new reality. Control is designed to make reality conform to the plan and, where that is not possible, to make the new plan conform to reality.

Control tools include an approved baseline plan, current status information, completion estimates, current and future variances with impact assessment, alternative solutions with evaluation and recommendations, and approval from a change control board.

This chapter addresses ways to execute an approved project plan and control work in process, including the following:

- ▶ Determining the status of plan parameters
- ▶ Detecting current and future variances
- ▶ Preparing reports
- ▶ Developing alternative plans for corrective action
- ▶ Securing approvals
- ▶ Communicating revisions to the approved plans

Project Kick-Off Meeting

Once you have an approved and completed integrated project plan published and distributed, it is time for you to arrange for the project sponsor to host a project kick-off meeting as a public display that communicates the importance of the project, the confidence of the sponsor in you and your plan, and the level of authority with which you have been entrusted. The sponsor should invite everyone (at all levels in all organizations) who has a vital interest in the conduct or outcome of the project.

Project Control

Project control, like the supervision of routine operations, is done in two ways: formally and informally. Figure 10-1 illustrates each approach. It is important to use both methods of control.

Project Meetings

An important part of project control is to conduct regular project meetings. Although project status information is gathered

Figure 10-1 Types of Project Control.

Formal Control	Informal Control
■ Formal peer review results	■ Weekly status meetings
■ Q/A reports	■ Management by Wandering Around
■ Formal technical reviews	■ Action item list
■ Deliverables reviews and approvals	■ Informal peer reviews
■ Updated and distributed project plan	

and reported outside of meetings, the regular project meetings provide a forum to discuss project issues and exceptions. Best practice is to schedule the meetings on a regular basis at a set time. Don't try to resolve all issues in these meetings. When serious project problems arise, schedule separate resolution meetings with the necessary participants.

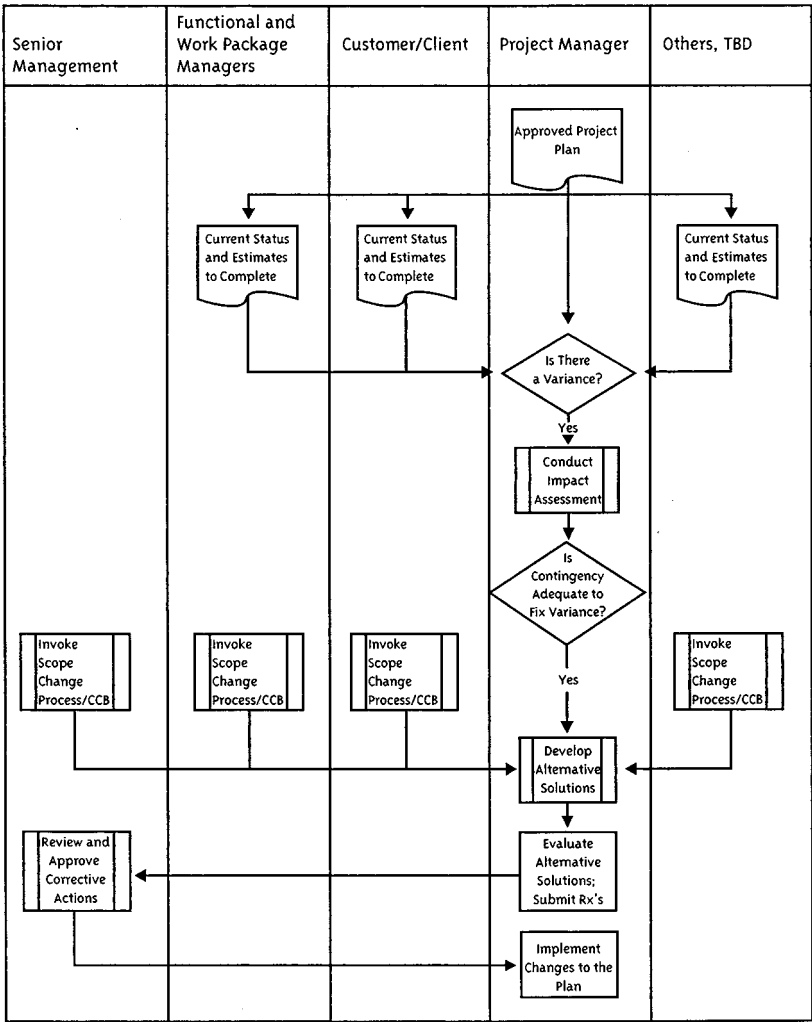
Project Control Process

Figure 10-2 shows a typical control process, which has the following ten steps:

1. Determine the most recently approved version of the execution plan.
2. Collect current status information for open work packages.
3. Collect estimates-to-complete for open work packages.
4. Determine current and forecast variances from the plan.
5. Determine the impact of variances to decide whether corrective action is required.
6. Identify alternatives for corrective action.
7. Select the preferred alternative.

120 EXECUTING, MONITORING, AND CONTROLLING

Figure 10-2 Project Control Process.



8. Secure necessary approvals and authorizations.
9. Update the plan.
10. Publish and distribute the revised plan.

Monitoring Project Work

The approved project plan is the foundation for monitoring and tracking work in progress. The current baseline plan, plus information on current status, helps answer five crucial questions:

1. What work should be accomplished to date (in terms of time, resources, costs, and milestones)? That is, what is the project's planned condition?
2. What work has been accomplished to date? That is, what is the actual condition of the project?
3. Where is the project heading and when will it get there? That is, what is the forecast state of the project if we take no corrective actions?
4. What are the current and forecast variances in the project?
5. What, if anything, should be done?

Consider the following maxim: *The level at which you plan is the level at which you thereafter control!* If your work breakdown structure defines the project to three levels, you cannot monitor and control progress at any greater level of detail. If your project budget is merely a lump sum for each phase or stage, then you cannot capture cost information at the level of discrete work packages. The same holds true for labor hours, equipment, supplies, travel, and so on.

Collecting Project Information

Project status can be determined in various ways. The key is to find a method that works for both you and your team members. Some techniques for determining project status include the following:

- ▶ *Documentation Walk-Through*. This is a formal review of documentation by subject matter experts.
- ▶ *Deliverable Review*. This is the process of testing deliverables against predetermined requirements and specifications.
- ▶ *Management by Walking Around*. This allows you to informally keep track of project conditions through casual discussions with team members and stakeholders.
- ▶ *Status Collection Templates*. Provide standard templates for team members to report their individual progress on assigned project activities.
- ▶ *Status Meeting*. This is a gathering for team members to share the status of their assigned activities with the project manager and other team members.

Project managers typically use a combination of status collection techniques to gain the best understanding of actual project status. One particularly effective combination is to use status collection templates to collect specific information, status meetings to discuss exceptions and issues, and management by walking around to confirm understanding and follow-up.

Schedule Importance

Schedule status becomes increasingly critical when time-to-market drives a project. This section of the chapter provides

an extended example of how to track a project's schedule. Let us start with basic information about an engineering project. The goal of the project is to design and prepare for manufacturing a new product: a left-handed doodad.

The work packages have been defined, the dependency relationships are clear, and their estimated durations have been agreed upon. The result is shown in Figure 10-3.

The total project duration is expected to be fifty-five days and the plan is punctuated with two key milestones. Item five is a critical design review after three work packages have been done. Item ten is a pre-production meeting held after the prototype has been built, tested, and repaired.

The resulting schedule is displayed as a Gantt chart in Figure 10-4. To use this view for control purposes, you must save it as a *baseline*. This creates a fixed position from which to track work and detect variances. Regardless of which project management software you select, your plan will show at least two bars for each work package: planned and current status.

Figure 10-5 shows the baseline schedule for our sample project.

We have decided to track progress on a weekly basis. In this example, we will track progress at the end of the second week. There are only three work packages that are open (on lines two, three, and four). We asked the activity managers, "How much more time do you need to complete your work?" Their responses were the following:

Electrical engineering reported, "I need a week to finish my assigned activity."

Mechanical engineering reported, "I'll be done in a few days."

Hydraulic engineering reported, "I need two weeks from today to get finished."

Figure 10-3 A Baseline Schedule Plan (Activity Sheet View).

ID	Task Name	Duration	Start	Finish	Predecessors
1	Project Doodad	55 days	Mon 10/8/01	Fri 12/21/01	
2	Design Electrical	15 days	Mon 10/8/01	Fri 10/26/01	
3	Design Mechanical	15 days	Mon 10/8/01	Fri 10/26/01	
4	Design Hydraulic	15 days	Mon 10/8/01	Fri 10/26/01	
5	Critical Design Review	0 days	Fri 10/26/01	Fri 10/26/01	2,3,4
6	Build Prototype	10 days	Mon 10/29/01	Fri 11/9/01	5
7	Test Prototype	5 days	Mon 11/12/01	Fri 11/16/01	6
8	Document Exceptions	5 days	Mon 11/19/01	Fri 11/23/01	7
9	Repair Punchlist Items	10 days	Mon 11/26/01	Fri 12/7/01	8
10	Pre-Production Meeting	0 days	Fri 12/7/01	Fri 12/7/01	9
11	Scale-Up	10 days	Mon 12/10/01	Fri 12/21/01	10

Figure 10-4 Project Schedule (Gantt Chart View).

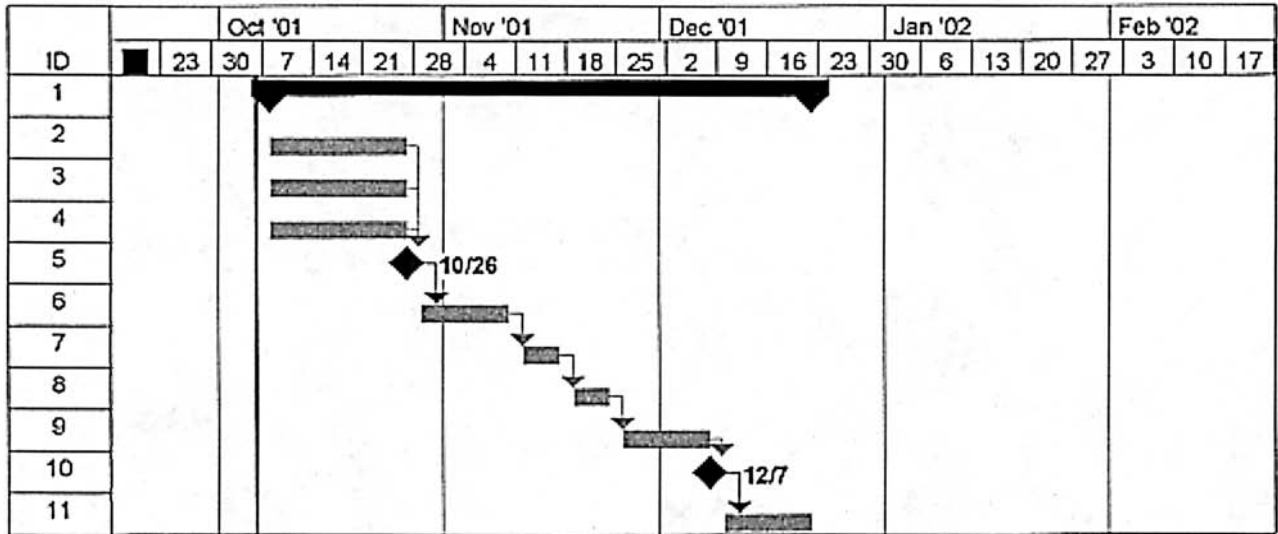
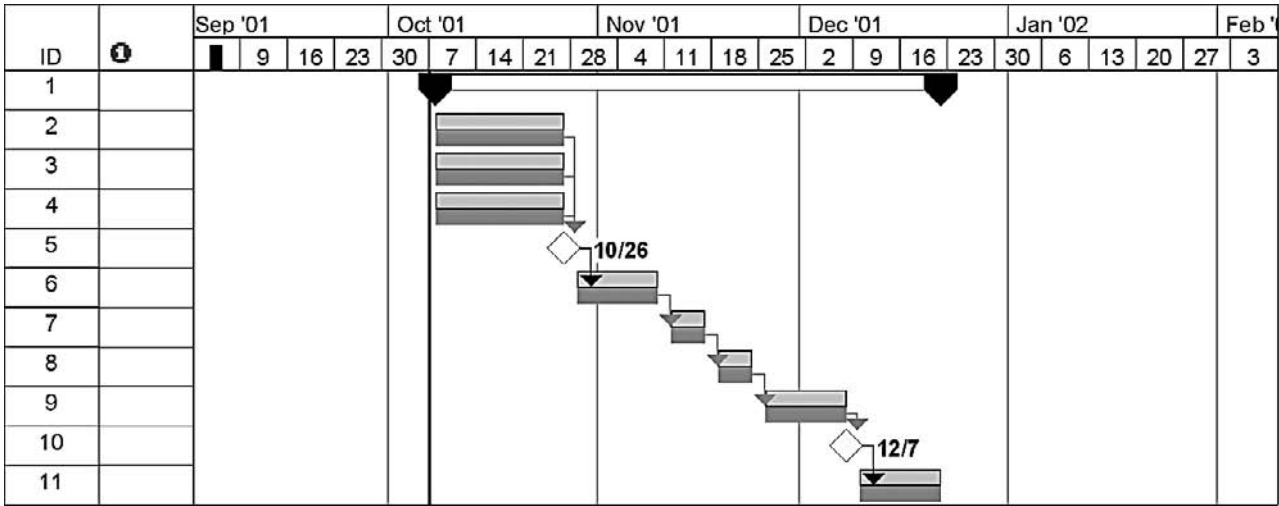


Figure 10-5 Project Baseline Schedule.



The software display with this information may look like Figure 10-6.

The open space (at the left) of lines two, three, and four conveys work done; the solid bars show duration remaining for each activity. This figure tells us that all three of the design work packages should be completed at the same time. At two weeks into a three-week effort, each work package should have a two-week open bar and a one-week solid bar. Instead, it appears that work package one is on schedule, work package two is ahead of schedule, and work package three is behind schedule and will be a full week late in making its deliverable.

A related method of displaying schedule progress uses the percent complete of the activity. That view would appear as depicted in Figure 10-7.

Knowing the status, however, is not enough. We need to understand the impact of the current status on the project's future. To do this, we assume that we do not use any corrective actions and that we do not change the dependency relationships among the activities. Figure 10-8 shows the results of this analysis.

- ▶ What will happen to the late finish date of the project?
- ▶ Is every activity still on the critical path?
- ▶ Which activities (suddenly) have float associated with them?

Labor Hours

Labor hours and cost reporting should follow the same general format. A sample tracking form appears in Figure 10-9.

For columns three to nine, the entries can be in labor hours (from a time tracking or labor distribution system) or in dollars (from an accounts payable, accrual, or commitment

Figure 10-6 Status Report of Work in Process.

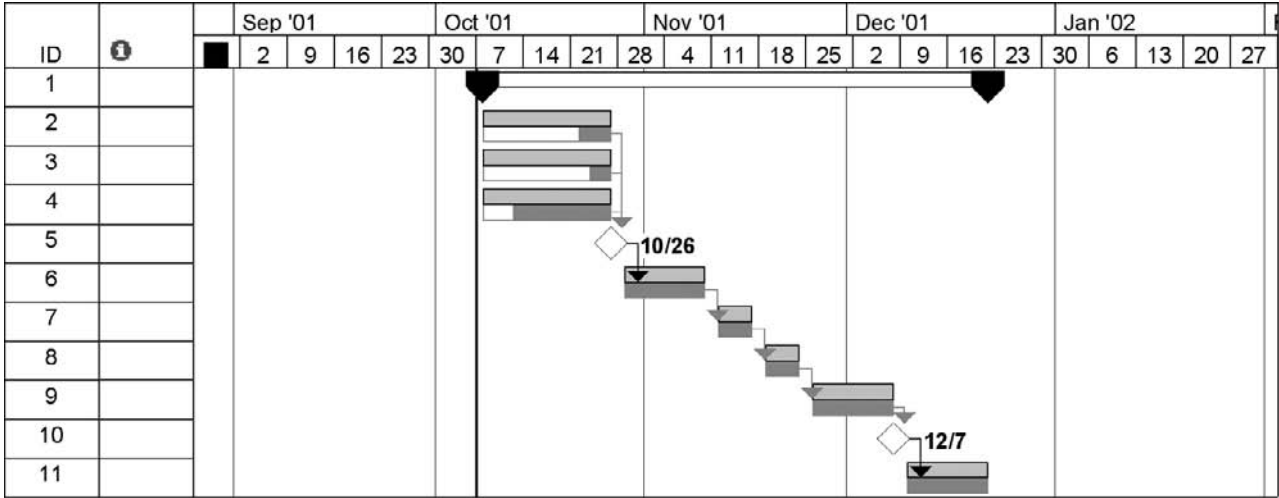


Figure 10-7 Schedule Status (Using Percent Complete).

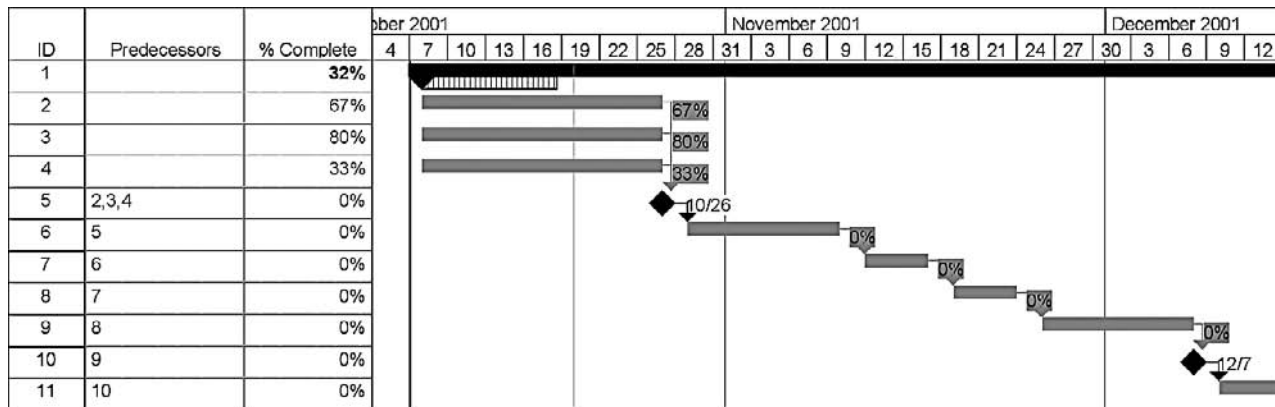


Figure 10-8 Impact Assessment of Schedule Variances (with No Corrective Actions).

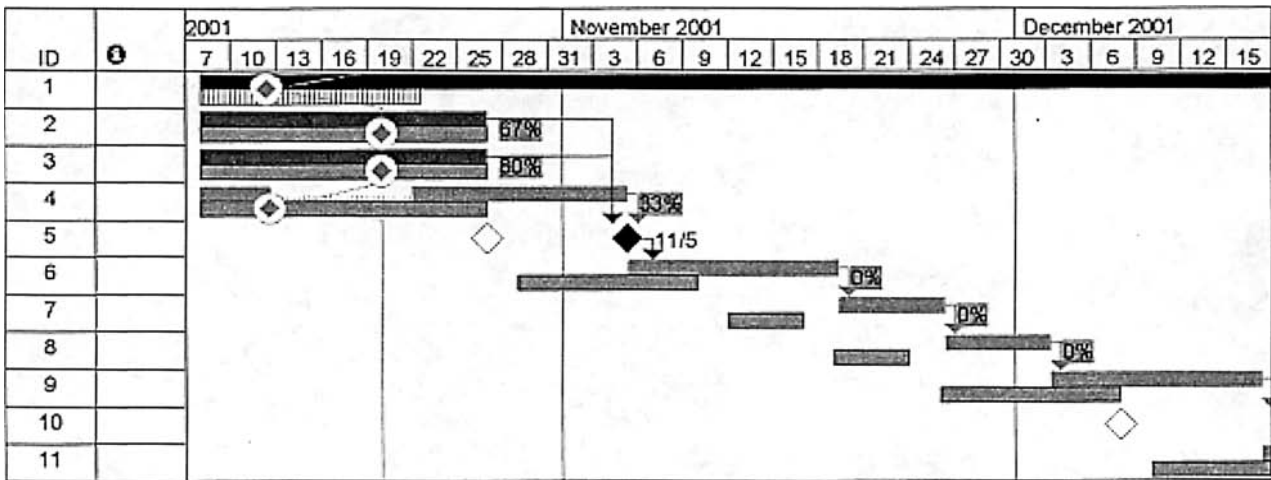


Figure 10-9 Detailed Labor Hours Tracking Form.

1 WBS	2 Name	3 PTD	4 ATD	5 VTD	6 ETC	7 E∞C	8 P∞C	9 V∞C
1.1								
1.2								
1.3								
1.4								
1.5								
1.6								
1.7								
1.8								
1.9								
1.10								
1.11								
Totals								
Source	Plan	Plan	LCR	(4-3)	WP Mgr	(4+6)	Plan	(8-7)

accounting system). This form is helpful with small or moderate-sized projects, but it would be cumbersome for larger projects. Therefore, it may be helpful to aggregate these data and display them as trend charts. A typical trend chart is shown in Figure 10-10.

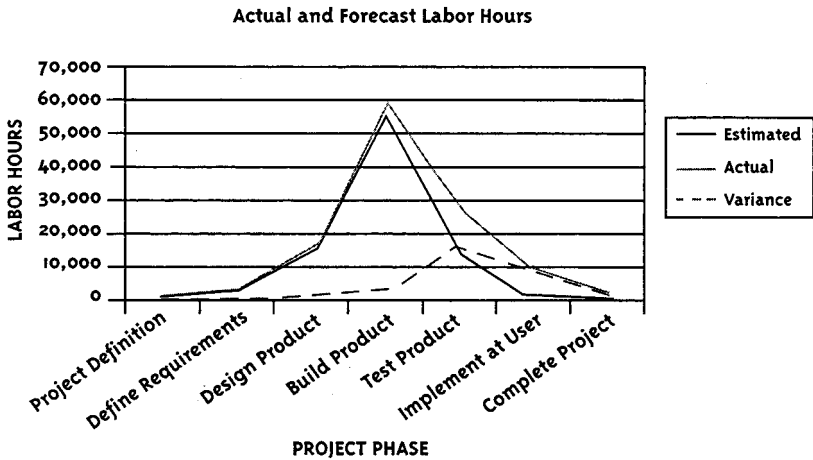
Data Analysis

There is a strong temptation to believe reports from computerized systems. However, project data must be analyzed carefully, not merely taken at face value. The following checklist may be helpful:

Sanity Check

- ▶ Does the report make sense?
- ▶ Is it plausible, timely, relevant, and complete?
- ▶ Does it show both breakdowns and breakthroughs?
- ▶ Are there any surprises? Does it match your experience?

Figure 10-10 Project Trend Report.



Significance Test

- ▶ Are the variances trivial or significant?
- ▶ Are they offsetting or reinforcing?

Corrective Actions

- ▶ Does the report itself suggest corrective actions?
- ▶ Do the suggestions comply with project drivers?
- ▶ Schedule-driven projects may require additional costs.
- ▶ Budget-driven projects may require rescheduling.
- ▶ Requirements-driven projects may require both time and cost adjustments.
- ▶ Resource-constrained projects may require rescheduling.
- ▶ Any project may require the expenditure of contingency.
- ▶ Corrective actions require collaborative effort, much like the original planning process.

Change Control

Change is the constant in a project manager's life. All projects of reasonable complexity will undergo some type of change during their life cycles, and the project manager's ability to manage that change will largely determine their success or failure. Establishing a formal process at the beginning of the project ensures that all change management recommendations and decisions are documented from the start. It is also important to prevent *scope creep* (undocumented and/or uncontrolled changes to scope). Too many project managers have found themselves at the end of a project not able to determine when, why, and how changes were made.

As a practical matter, the project manager must serve as gatekeeper for the change control process. A change control process includes the following steps:

1. Determine the current version of the execution plan.
2. Receive the change request.
3. Enter change control information into a log or journal.
4. Determine (in your role as gatekeeper) whether to process the request.
 - ▶ If no, communicate to the requestors the reasons for rejecting or deferring the request, log the decision, and stop the change control process.
 - ▶ If yes, assess the impact of the proposed change on scope, schedule, costs (personnel and expenses), utilization of resources and assets, risk, and the effect on other project or nonproject work.
5. If the assessment is acceptable to you and the requestor, prepare recommendations for implementation.

6. Submit recommendations along with impact assessment to management and/or your customer for review and approval.
7. Obtain approvals and/or make requested modifications.
8. Update project plans and create a new baseline.
9. Distribute updated plans (communicate the change).
10. Monitor and track against the new plan (baseline).

Sources of Change

Changes to the project may come from several sources. Try to anticipate changes from the following sources or reasons:

Scope

- ▶ Customer/user changes mind or identifies new requirements.
- ▶ Design review uncovers unsolvable problems.
- ▶ Market conditions change.
- ▶ Strategy changes or business priorities change in response to market forces, mergers, acquisitions, and divestitures.
- ▶ Organizational changes rearrange reporting relationships and hierarchies. People change positions or assume new roles and responsibilities.
- ▶ Technology changes.
- ▶ Public policy changes are caused by elections, statutes, or regulations.

Schedule (shortened timeline)

- ▶ Market conditions change.
- ▶ Management commitments change.

Budget (resources cut)

- ▶ Key team member gets pulled.
- ▶ Previously committed team member is no longer available.
- ▶ Expense budget is cut.

Regardless of the source, changes in time, cost, or scope require changes in the plan (baselines). Remember that when changes are made to one side of the project triangle (time, cost, or scope), they almost always have an effect on one or both of the other sides. If you use part of the contingency or management reserve, then you must update the execution plan. This still leaves intact the project's targets for technical quality, a late finish date, and a ceiling on expenditures.

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Monitoring and Controlling Projects

ONCE APPROVED, THE PROJECT management plan becomes the basis for implementation, which involves both the execution process and the monitoring and controlling process. The project plan is the roadmap for execution. The following are central precepts of project control:

- ▶ Work is authorized and performed according to the approved plan.
- ▶ Information is collected to determine the current status of the project.
- ▶ Variances between the plan and actual status are identified and analyzed.
- ▶ Causes for the variances are identified.
- ▶ If necessary, corrective actions are developed and assessed.

- ▶ Recommended corrective actions are reviewed, approved, and implemented.
- ▶ Project plans—including baselines—are updated and communicated.

Establishing a Project Baseline as a Control Point

The *baseline* is the most recently approved version of the project plan. There are baselines for each side of the project triangle: cost (budget), schedule (time), and scope. When discussed together, they are often referred to as *project performance baselines*. The practice of controlling and documenting changes to the baseline project plan is referred to as *project change management*.

Measuring Performance: Earned Value Analysis

Earned value analysis (also known as variance analysis) is a way to measure, evaluate, and control project performance. It compares the amount of work planned with what is actually accomplished to determine whether the project is on track. Earned value analysis uses various calculations and ratios to measure and report on the status and effectiveness of project work. Although earned value calculations are usually done by computer, it is important to know the basis of each calculation and understand what they mean.

The first step in earned value analysis is to determine the following three key values:

1. *Planned value* (PV) is the planned cost of work scheduled to be done in a given time period. The amount of PV is

determined by totaling the cost estimates for the activities scheduled to be completed in the time period. Planned value is also called the *budgeted cost of work scheduled* (BCWS). This information is the base from which we later monitor progress, discern variances, and initiate corrective actions. Planned value answers the question “What did we think would happen by this date and how much did we think it would cost?”

2. *Earned value* (EV) is the planned cost of work actually performed in a given time period. This is a measure of the dollar value of the work actually performed. The amount of EV is determined by totaling the cost estimates for the activities that were actually completed in the time period. Earned value is also called the *budgeted cost of work performed* (BCWP). Earned value answers the question “What really happened up to this point and how much did we think it was going to cost?”
3. *Actual cost* (AC) is the cost incurred to complete the work that was actually performed in a given time period. The amount of AC is determined by totaling the expenditures for the work performed in a given time period. It should include only the types of costs included in the budget. For example, if indirect costs were not included in the budget, they should not be included in AC calculations. Actual cost is also called the *actual cost of work performed* (ACWP). Actual cost answers the question “What really happened up to this point and how much did it cost?”

Once these values are determined, you can use them in various combinations to provide measures of whether work is being accomplished as planned.

Schedule variance ($SV = EV - PV$). Schedule variance is determined by subtracting the planned value from the

earned value. This calculation measures the difference between the planned and the actual work completed. A positive result means the project is ahead of schedule; a negative result means the project is behind schedule.

Cost variance ($CV = EV - AC$). Cost variance is determined by subtracting the actual cost from the earned value. It measures the difference between the planned (budgeted) cost and the actual cost of work completed. A positive result means the project is under budget; a negative result means the project is over budget.

Once these calculations are made, various indices or ratios can be used to evaluate the status and effectiveness of project work. These efficiency indicators provide valuable information that can be used to control the project. The two most commonly used indices are the schedule performance index and the cost performance index.

Schedule performance index ($SPI = EV/PV$). This is a ratio of work performed to work scheduled. The index is calculated by dividing the earned value by the planned value. This ratio is a measure of efficiency in the schedule. A value less than 1 means the project has accomplished less than what was planned and is behind schedule; a value greater than 1 means the project is ahead of schedule. Analyzing the SPI several times during the project provides an indication of how the project is performing compared to the project plan. This index may also be used to forecast the project completion date.

Cost performance index ($CPI = EV/AC$). This is a ratio of budgeted costs to actual costs. This index is calculated by dividing the earned value by the actual cost. This ratio is a measure of cost efficiency (how efficiently dollars are

being spent). A value less than 1 means the work is costing more than planned; a value greater than 1 means the work is being produced for less than planned. For example, a CPI of 0.67 means that for each \$1.00 spent on the project, we produce \$0.67 worth of value. Analyzing the CPI several times during the project provides an indication of the project's direction concerning costs.

These indices provide a quick snapshot of the project's efficiencies at a given point in time. However, they are more valuable when used periodically during the life of the project to track trends and take corrective action. These items can be displayed in reports, spreadsheets, histograms, or graphs. Figure 11-1 is a graph showing cumulative costs in terms of the planned value. Figure 11-2 shows the difference in cumulative costs based on early, scheduled, and late start dates.

Figure 11-1 Cumulative Costs Based on Planned Value.

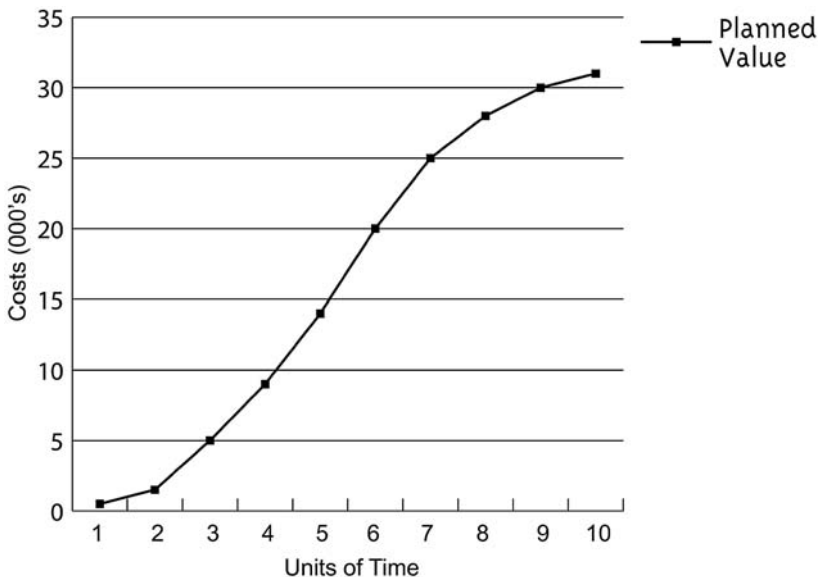
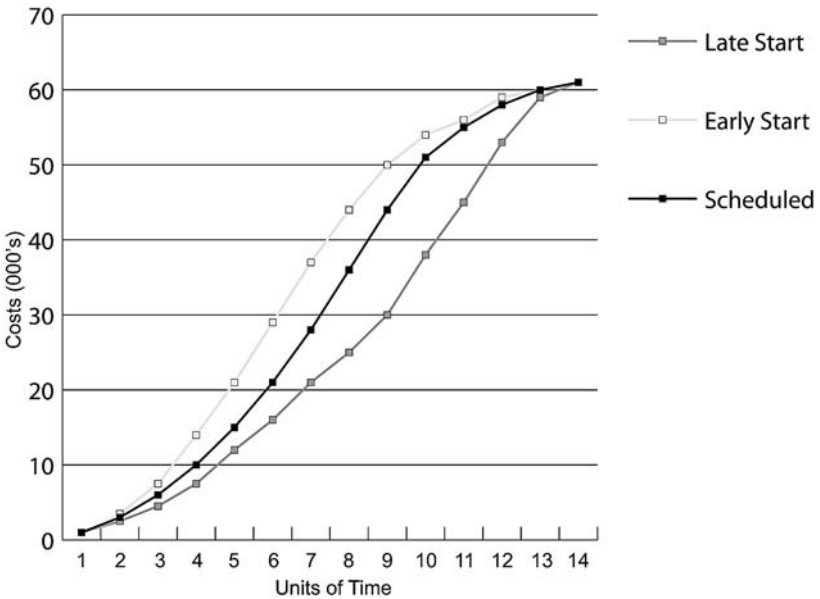


Figure 11-2 Cumulative Costs Based on Start Dates.



These indices also provide an element used in the following calculations to forecast the completion of the project:

Budget at completion (BAC) is the estimated total cost of the project when completed. It is calculated by totaling the cost of all activities outlined on the work breakdown structure.

Estimate to complete ($ETC = (BAC - EV)/CPI$). This is the expected additional cost needed to complete the project. It is calculated by subtracting the earned value (EV) from the budget at completion (BAC), then dividing the result by the cost performance index (CPI). This estimate shows the expected additional cost needed to finish the project, including adjustments to the BAC based on project performance to date.

Estimate at completion ($EAC = AC + ETC$). This is the expected total cost of the project when completed. It is calculated by adding the actual cost (AC) and the estimate to complete (ETC). This estimate includes adjustments to the BAC based on performance to date.

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Leading and Directing Project Teams

THIS CHAPTER FOCUSES ON the management and leadership skills needed for a project manager to effectively lead a project team.

Leading Others

When people are given authority, accept responsibility, and are held accountable for the results they achieve and the resources they expend, they are in positions of command. People in positions of command will be more successful if they can both manage and lead. Management is the application of intellect to the functions of planning, directing, organizing, staffing, controlling, and coordinating. Leadership is the art of influencing others to accomplish the objectives desired by the leader.

Leadership skills are essential for project managers because project managers must influence the behavior of others to accomplish project work. In fact, leadership is the predominant contributor to the success of the ad hoc project manager. In small projects, good leadership can succeed even in a climate of otherwise unskilled management.

In project management's comparatively brief history, there has been a clear shift in the relative importance of different skills for project manager success. We see that when selecting project managers, the leadership component is of significant value and that its relative importance is on the rise (see Figure 12-1).

A project manager has three major leadership roles (see Figure 12-2): communicate, motivate, and solve problems.

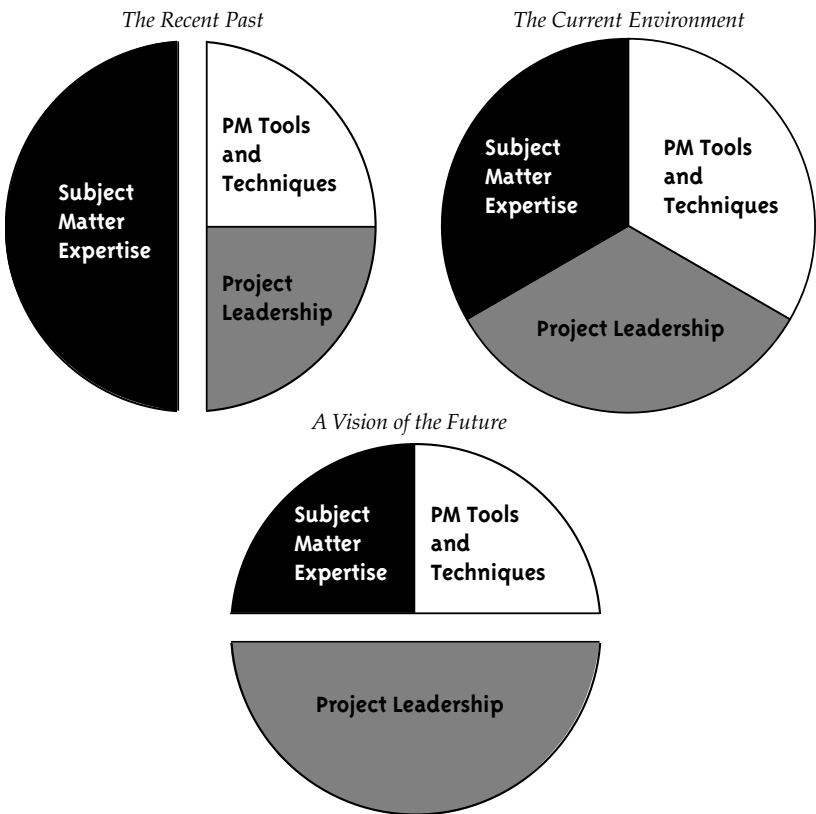
Communicate

The project manager's responsibility is to convey information and evoke responses that indicate understanding. Communication involves eight fundamental factors:

1. Intent
2. Sender
3. Encoder
4. Message
5. Medium
6. Decoder
7. Receiver
8. Effect

In the communication model shown in Figure 12-3, each element is distinguished by characteristics, roles, and behaviors. The sender is someone who has composed a message

Figure 12-1 Project Management Skills for Success.



to be shared. All receivers will share the message, but not all receivers may be members of the sender's target audience. Communication can be intercepted or misdirected. All that is needed to link receiver to sender is access to a common vehicle or means of communication. The message is the content.

The effect of the message depends upon three closely related elements:

1. The sender's ability to incorporate within the message those stimuli that will evoke the desired effect

Figure 12-2 Project Manager Leadership Roles.

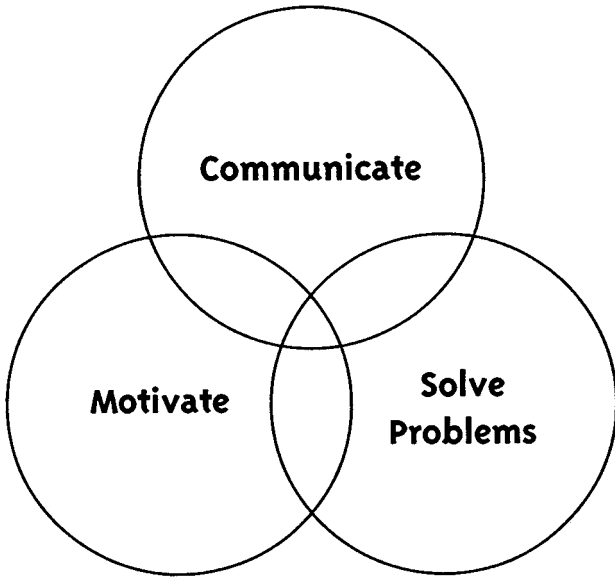
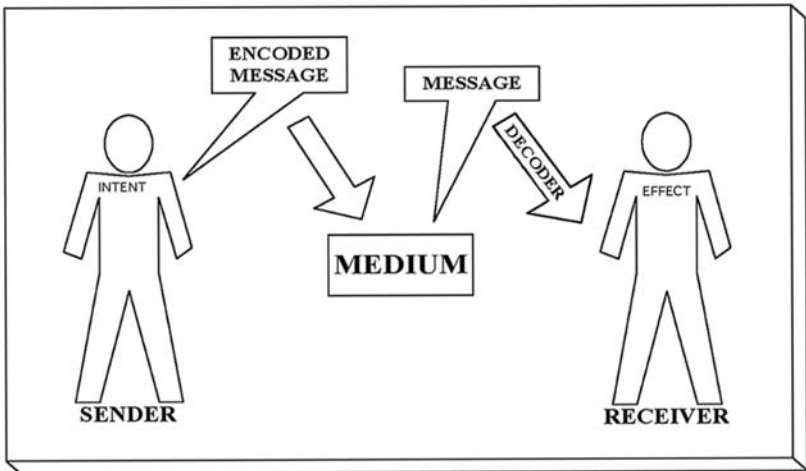


Figure 12-3 Communication Model.



2. The medium's distortion of the message
3. The receiver's sensitivity

For instance, if the sender desires to communicate to the receiver the message "Come here," the sender has nearly infinite options—each of which will likely evoke a different effect. The sender encodes the message in a language either understood or not understood by the receiver, realizing that the not-understood language will not evoke the desired effect.

The sender selects a medium to which the receiver has access. The sender could prepare the message for transmission by sound using voice directly over short distances, by enhancement using a megaphone, or by conversion and transmission by telephone or voice mail. The sender could prepare the message for transmission by sight using semaphore, sign language, a sign, a note, an e-mail, or a text message. The sender could use touch by sending the message using Braille. However, none of these will achieve the desired result unless the receiver has access to and the ability to use the same medium.

The effect or result will vary according to the sender's ability to compose, to encode, and to use the chosen medium. The effect also depends on the receiver's ability to use the same medium, to decode, and to comprehend.

Synchronous communication involves transmitting and receiving information in real time, such as face-to-face conversation, telephone, or instant messaging. *Asynchronous* communication involves some delay in the receiving of information by the receiver, such as with voice mail, e-mail, letter, or text message.

To communicate well is to write, speak, and listen well, along with the ability to read body language and other nonver-

bal cues. The use of tone, inflection, metaphors, and examples is also important in communicating effectively. One must be clear, concise, and complete to be understood. Leaders communicate person-to-person and with groups. Find ways to communicate that will appeal to the entire audience. That may mean drawing pictures, sending e-mail, talking over the telephone, or addressing an assembly. Using words and grammar incorrectly will lead to misunderstanding. The responsibility to overcome barriers to communication normally rests with the sender. However, in a leadership situation, the responsibility falls to the leader in all cases, whether one is sending or receiving.

Motivate

Motivation is the ability to stimulate another's performance in an activity. Motivation requires that you know yourself and the people you are trying to motivate. Several tools exist that will provide insight into individual personality and preferences. Exploring these instruments may enhance your knowledge of yourself and others.

Your professional competence is a necessary precondition to your credibility. Your ability and willingness to set the example is a motivator. Avoiding situations because you do not know how to act or because you are fearful will not endear you as a leader. By the same token, you do not have to be able to do all the jobs of your followers. You must be able to do your own job.

Your actions must also be beyond reproach. If you make an error, you must admit it readily, explain the results, and overcome the consequences. However, there are instances when a single error can damage your credibility to a degree that it cannot be regained. Reproachable behavior is contex-

tual—it varies between organizations and cultures. What is acceptable in one instance may well be damnable in another. In this era of globalization, there is increasing opportunity for cultural confrontation. Whether you have individuals from other cultures under your control or you are working in a culture foreign to your own, the opportunity for unintentional errors with unimaginable consequence is significant. Prepare yourself for diversity through knowledge and understanding.

Your presence is also needed as a leader. You must know what and why, who and how, and when and where. It makes you more able to respond to change, to learn from the past, to foresee potential risks, and to mitigate them. As a manager, be consistent and fair. Reward your subordinates publicly and correct them privately. Never pass a fault; never fail to praise. Your needs should be satisfied last as you strive to fulfill the needs of others. You need to give others the room to perform and to back them up when required.

Perhaps your greatest challenge as a project manager will be to motivate individuals in an organization. All of your understanding, credibility, good intentions, and effort may fail to motivate anyone when the organizational context creates irresolvable demotivators. A corporate climate of poor pay, lack of recognition, long hours, faulty tools, impractical bureaucracy, misguided prioritization, intolerance, or unreasonable expectations can quickly defeat your best efforts.

Solve Problems

Solving problems means overcoming the obstacles to success. It is the responsibility of the leader to solve the problems that cannot be solved by subordinates. It is also the responsibility of the leader to provide subordinates with the tools and techniques that will enable them to solve problems, thereby

minimizing the number of problems that are elevated for resolution.

Problem solving is part mechanics and part creativity. Mechanically, the process is to:

- ▶ State the aim
- ▶ State the problem
- ▶ Analyze the problem
- ▶ Create viable options
- ▶ Apply evaluation criteria
- ▶ Choose the best course of action
- ▶ Secure necessary approvals
- ▶ Implement the solution

Creativity is essential to the production of viable options. It may be that you find a solution only when you create synergy by bringing together a number of individuals. The collective solution may be more viable, workable, practical, and successful than that derived from the analysis of any one of the same people working alone. Synergy occurs when the whole is greater than the sum of the parts.

Directing Others

Leaders provide direction to others. It is inherent in the relationship and is a communicating and motivating activity. There are four simple, commonsense steps to giving direction to others: *plan*, *prepare*, *deliver*, and *confirm*.

To *plan* is to answer who, what, when, where, why, and how. To *prepare* is to put into place the conditions for success by arranging for the necessary resources, such as tools, equipment, facilities, funds, and people. To *deliver* is to express the

desired action so it will be fully understood and work can begin without delay. To *confirm* is to ensure that there has been understanding. In the simplest, yet all-inclusive form, this could be the template:

“In order to achieve [why], I need [who] to [what] at [where] by [when]. I have arranged for [tools, equipment, facilities, funds, or people] to be made available to you. It is [imperative, likely, desirable] that the work be undertaken [how]. Is there anything I need to clarify? Do you have any questions? Get back to me by [date] should you have any questions.”

This could now be delivered in person or by electronic or written means. You should choose personal delivery if your presence will add to the delivery of the message or if questions are likely to arise immediately. Choose electronic or written means if your presence is not required to reinforce the delivery, if the receiver will need time to digest the contents, or when the consequences demand complex instructions. In some cases, you may choose to deliver the direction personally while providing a hard copy. In all cases, the planning and preparation processes are important.

Managing Others

Management is also a motivating activity. There are three simple commonsense steps to managing people: *observe*, *react*, and *evaluate*. To *observe* is to watch the work or the results of the work while it is in progress. To *react* is to intervene when issues, problems, or new requirements arise and you need to make changes in your direction or in the work. To *evaluate* is to judge the results and feed this judgment back

to the individuals who have done the work in order to improve future work. You must actively manage to be aware of the need to correct either the direction given or the work undertaken.

Conducting Meetings

Because project managers are involved in *lots* of meetings, it is important to know how to conduct meetings efficiently. Meetings expend time and effort—yours and that of others. When you conduct a meeting, it's your responsibility to ensure that the time and effort expended returns value. Meetings are a mechanism of leadership but are dependent upon the functions of management. You must plan, organize, direct, staff, control, and coordinate in order to communicate, motivate, and solve problems. This is your orchestra and you are the conductor.

As a project manager, you will be required to conduct all types of meetings, including:

- ▶ Routine staff meetings
- ▶ Management briefings
- ▶ Interviews
- ▶ Critical design reviews and major milestone reviews
- ▶ Status-reporting meetings
- ▶ Meetings with clients
- ▶ Meetings with independent oversight and regulatory bodies
- ▶ Meetings with vendors, suppliers, and other third parties
- ▶ Quality control of intermediate and final deliverables
- ▶ Crisis meetings

This section reviews key elements that can help you conduct successful meetings of all types. Specifically, the concepts, tools, and techniques in this section will help you conduct meetings by determining participants, setting agendas, directing discussion, and summarizing results.

Planning for Meetings

It is important to plan for a meeting by doing the following:

- ▶ Establishing an objective prior to the meeting.
- ▶ Writing an agenda for the meeting. State the established objective. Describe the topics in sufficient detail and include estimated times for topics to be covered. For example, “Decide to accept or reject the marketing proposal attached to this agenda.”
- ▶ Determining the start and end time for the meeting.
- ▶ Determining the necessary participants and inviting only those needed to achieve the objective.
- ▶ Assigning a scribe to take minutes of the meeting, especially the decisions and assignments.
- ▶ Assigning a moderator or facilitator, if needed, in addition to the person conducting the meeting.
- ▶ Distributing the agenda and supporting documents to participants prior to the meeting. Give them sufficient time to review the documents and come prepared for discussion and action.

Conducting Meetings

Your role in conducting a meeting includes the following:

- ▶ Starting the meeting on time, according to schedule. Do not delay the start for latecomers.

- ▶ Stating the objective of the meeting and briefly reviewing the agenda.
- ▶ Following the agenda items. Encourage discussion of the topic at hand and discourage discussion of items not on the agenda. If a new issue is raised, offer to hold a separate meeting to address it.
- ▶ Summarizing the points discussed in the meeting, decisions made, and assignments given.

Following Up After Meetings

After the meeting has concluded, be sure to do the following:

- ▶ Distribute minutes of the meeting and lists of assignments as soon after the meeting as possible.
- ▶ Periodically hold meeting reviews to evaluate the effectiveness of your meetings. For example, you could distribute a questionnaire to request feedback.

Improving Meeting Effectiveness

The following questions may help you improve the effectiveness of your meetings.

Before:

- ▶ Is the meeting objective clear?
- ▶ Is this meeting necessary? Could the objective be achieved in some other way?
- ▶ Who must be in attendance to achieve the objective?
- ▶ Where will the meeting be held? Is this convenient for the attendees?

- ▶ When will the meeting be held? Is this convenient for the attendees?
- ▶ Who will take the minutes?
- ▶ What will the seating plan be? Is this ideal for the objective of the meeting?
- ▶ Will there be refreshments and what should they be?
- ▶ If audiovisual equipment is needed, has it been scheduled, and are you sure it will be set up on time?
- ▶ Can the agenda and supporting documents be distributed early enough to give participants sufficient time to review the documents and come prepared for discussion and action?
- ▶ Have there been pre-meeting discussions with selected participants to address the potentially contentious issues?

During:

- ▶ Is the meeting starting on time?
- ▶ Are the topics beginning and ending on time?
- ▶ When topics surface that are not on the agenda, are they being recorded for future action?
- ▶ At the end of the meeting, do you summarize the points discussed, decisions made, and assignments given?

After:

- ▶ Are minutes of the meeting and lists of assignments distributed soon after the meeting?
- ▶ How often do you request feedback from the participants on the effectiveness of your meetings?

Interviewing Others

An interview is a common tool for collecting information in project work. At the project's outset, interviews clarify goals, objectives, and requirements. Early in the execution phase of the work, interviews may help document workflows, operations, problems, and opportunities. In the control stages of a project, interviews are used to determine status, variances from the plan, and opportunities for corrective action. In addition to their use as fact-finding tools, interviews can reveal other important elements in a project. Specifically, they may point to personality and political conflicts, they may illuminate hidden agendas, and they may uncover potential breakdowns or breakthroughs early enough to intervene in a helpful way.

Interviews, like all meetings, have a specific purpose. Interviews are used to draw out as much information as possible on a specific topic. Interviews may be easier with a project team member who is readily available and with whom you already have a relationship and know the individual's personality and primary objectives. Interviews may be more difficult with a stakeholder you don't know who is not readily available. You may have only one or two opportunities to interview such a person. In this case, it will be important to prepare in advance, carefully target your questions, be flexible, and allow proper time to handle surprises that may come up during the interview.

Interview Checklist

Advanced preparation is key to successful interviewing. A preparation checklist is provided below:

- ▶ Make a complete list of potential interviewees.
- ▶ Know their job levels in the organization and their job functions.

- ▶ Decide whether to interview individually or in a group.
- ▶ Write questions tailored to the issue. Include both closed-ended and open-ended questions.
- ▶ Pretest your questions with similar parties within your own organization.
- ▶ Prepare your list of questions with sufficient space to record the answers.
- ▶ Prepare a separate file folder for each interview (person or group).
- ▶ Prepare for the interviews.
- ▶ Determine in advance the most appropriate location for the interview.

Technical Questions

When you have to ask technical questions, be sure you ask them of the individuals who have the technical understanding and experience to properly answer them. Ask these questions early in the interview because they are easier to answer, will put the interviewee at ease, and you will be sure to get them answered before running out of time.

General and Organizational Questions

Use general and organizational questions to draw out cultural, communication, and organizational issues. Senior managers should receive a higher proportion of these questions. When interviewing senior managers, keep organizational questions specific and strategic. End users and technical staff can handle questions worded more generally in this area. These people will gladly tell you what's going on.

Ask the general questions later in the interview, when the interviewee is more open. For most end users and technical

staff, the problem won't be getting them to open up; the problem may be in keeping them from running over their time.

Respect the time of the interviewee. Senior managers may offer you only fifteen minutes for an interview. Other project personnel may have more time available. Some may have a vested interest in "lobbying" you and may try to monopolize your time. You may want to prepare an exit strategy for each interview.

Becoming an Active Listener

Keep interviews as short as possible while still getting the information you need and giving the interviewee time to bring up all the issues. Technical staff and end users may view you as a potential rescuer and tell you all the things they believe management has done to them. Be wary of endless venting from interviewees. Listen to what is said as well as to what remains hidden. Ask open-ended questions in a variety of ways so you can confirm or validate responses. Periodically pause and use a technique called *reflecting*. For example, "Let me make sure I've understood your last point. You believe that departments X and Y have sharp conflicts regarding the location of the pilot plant. Is there anything we need to add to this so I've got a complete and balanced picture of this issue?"

During the Interview

Follow standard meeting etiquette during interviews. At the beginning, review the purpose of the interview from your point of view and ask the other person for his or her purpose. Also review the general procedure and time considerations. Ask easy, closed-ended questions first. Be flexible. Don't hesitate to rephrase a question to get the information you need. Different words mean different things to different people. If

you're not sure about an answer, paraphrase what you think you heard and ask for feedback. When dealing with technical staff and end users, be ready for an onslaught of issues they may be harboring.

After the interview, thank the interviewee for her time and honesty. Ensure her that her opinions are important and will be taken under consideration. Provide her with a means to forward more information to you if she thinks of anything after the interview process.

Consolidating Information After Interviews

It may be tempting to ignore the postinterview processing. A common belief is that after listening to all of the interviewees, you know exactly what's going on. Although this may be partially true, generating statistics and sample answers from the interviews will be highly revealing and also add credibility to the results. For technical questions, use a database or spreadsheet to consolidate answers. For open-ended questions, derive a consensus by reading responses and select one or two specific examples that demonstrate the consensus.

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Managing Risk

A RISK IS AN UNCERTAIN EVENT or condition that, if it occurs, has a positive or negative effect on the project objectives (scope, schedule, or budget). All projects have a certain degree of risk that needs to be managed. The project manager determines where risks are likely to affect the project, makes contingency plans for them, and responds to them when they occur.

The risk management plan, evolving throughout the planning process, incorporates (1) risk identification; (2) qualitative and quantitative assessments; (3) strategies for prevention, detection, and mitigation of loss; and (4) recovery and restoration of functions.

Projects are investments and the project manager is responsible for achieving specific benefits within targets of time, cost, asset utilization, and resource utilization. However, every investment comes with risks. No one can predict with certainty the source, timing, significance, or impact of problems.

This chapter describes the risk management processes of

identifying, analyzing, and responding to project risk. The purpose of risk management is to maximize the results of positive events and minimize the results of adverse events.

Identifying Risk

The first step in developing a risk management plan is to identify the potential risk events.

Considering Possible Sources of Risk

The following are major categories of risk:

- ▶ **Technical:** new breakthroughs, design errors or omissions
- ▶ **Administrative:** processes, procedures, changes in roles or responsibilities
- ▶ **Environmental:** culture of the organization, change in management or priorities, office politics
- ▶ **Financial:** budget cuts, cash flow problems, corporate unprofitability, unchecked expenditures, changing economic conditions
- ▶ **Resource availability:** specialized skills or critical equipment not available
- ▶ **Human:** human error, poor worker performance, personality conflicts, communication breakdown
- ▶ **Logistical:** inability to deliver materials or work face-to-face
- ▶ **Governmental:** legislated regulations
- ▶ **Market:** product failure in the marketplace, change in consumer expectations, new competitor products

Determining Likely Risks

To identify potential risks, simply ask, “What could go wrong?” Review the work breakdown structure for the proj-

ect, the cost estimates, and resource plans and consider what might happen that could cause any aspect of the project to deviate from the plans. Define specific risk events and describe what specifically might go wrong. For example, ground breaking may be delayed because of legal problems in securing the building permit. Describe the effect of each potential event. Identify what would cause the risk event to happen (often called triggers) and describe any conditions or signs that may warn you of the impending event.

Consider both internal and external events that could affect the project. Internal events are things under the control of the project team, such as work assignments or cost estimates. External events are things beyond the influence of the project team, such as technology shifts or changing economic conditions.

We typically think of risk as a negative event that causes harm or loss to the project. However, risk events can also include opportunities with positive outcomes. A change in economic conditions may increase the available labor force and allow you to hire more workers to complete the project sooner. Although a potentially positive outcome, you need to assess the impact on the project schedule and cost plans and determine your course of action.

You can never anticipate all possible risks, nor should you expend the effort to try to identify every conceivable problem. Simply identify those that are fairly likely. The cost of prevention should never exceed the cost of impact should the potential problems actually occur!

Conducting Ongoing Risk Identification

Risk identification is not a onetime event. Economic, organizational, and other factors will change during the course of the

project that may bring to light additional sources of risk. Risk identification should first be accomplished at the outset of the project, and then be updated on a regular basis throughout the life of the project.

Assessing and Prioritizing Risk

Once you have identified the potential risk events to be included in the plan, the next step is to estimate the probability of occurrence and determine the impact if the event were to occur.

You may wish to give greater analysis to potential risks associated with activities on the critical path, since a delay in these activities is more likely to delay the final outcome of the project. Also give attention to points in the network where activities converge, because these tend to have a greater degree of risk.

For each potential risk event, estimate its impact on the time, cost, scope, quality, and resources. Remember that a single risk event could have multiple effects. For example, the late delivery of a key component could cause schedule delays, cost overruns, and a lower-quality product.

To help prioritize the potential risks, categorize them in two dimensions: likelihood (or probability of occurring) and the consequences (impacts). Document the results in a table such as that shown in Figure 13-1. Focus primarily on risks with high impact and a high probability of occurring. Appearing in the top-right quadrant, these are critical risks that are more likely to happen and would have a serious consequence if they do.

In a highway construction project, potential equipment breakdowns may be one such risk. The impact is great because construction stops without functioning equipment. You can

Figure 13-1 Risk Probability vs. Impact.

		IMPACT		
		Low	Moderate	High
PROBABILITY	High			
	Moderate			
	Low			

influence the probability of such breakdowns by using reliable equipment and having good preventive maintenance plans.

Next, focus on risks with high impact but low probability. These appear in the top-left quadrant. In our example of a highway construction project, such a risk may be the threat of a union strike over a requested pay raise.

Such a potential risk has great impact because it would halt construction. But if there is a low probability of the union calling a strike, you could delegate this potential problem to company management and union representatives.

Contingency plans should be made for these types of risks because of their high impact.

Of lesser priority are the risk events that fall in the bottom two quadrants because their impact on the project is low. An example of a risk that may appear in the bottom-right quadrant (low impact but high probability) is late delivery of trees and bushes for landscaping along the roadside. The impact is low because traffic may begin using the highway even if the

landscaping is not yet completed. Your contingency plan may be to have an alternate vendor in place, ready to deliver the trees and bushes if the primary vendor fails.

Finally, consider the potential risk events in the bottom-left quadrant (low impact and low probability). An example of such a risk may be the late arrival of permanent signs for the highway. The probability of failure on the part of an experienced vendor may be low. The impact is also low because you can continue to use the temporary signs until the permanent ones are installed.

Along with these two factors of impact and probability, also consider your ability to do something about the potential risks, either in preventing them from happening or in responding to their impact when they do happen.

Responding to Risk

The purpose of risk response is to minimize the probability and consequences of negative events and maximize the probability and consequences of positive events.

Planning Responses to Risk

A response plan should be developed before the risk event occurs. Then, if the event should occur, you simply execute the plan already developed. Planning ahead allows you the time to carefully analyze the various options and determine the best course of action, so you are not forced to make a quick and perhaps not well-thought-out response to a threatening situation.

Possible Responses to Risk

In developing a response plan, consider ways to avoid the risk, transfer it to someone else, mitigate it, or simply accept it.

- ▶ *Avoiding*. It may be possible to eliminate the cause and, therefore, prevent the risk from happening. This may involve an alternative strategy for completing the project. For example, rather than assigning work to a new, less expensive contractor, you may choose to reduce the risk of failure by using a known and trusted contractor even though the cost may be higher. You can never avoid all risk, but you can try to eliminate as many causes as possible.
- ▶ *Transferring*. It may also be possible to transfer some risk to a third party, usually for the payment of a risk premium. For example, you can avoid the chance of a cost overrun on a specific activity by writing a fixed-price contract. In such a case, the contractor agrees to complete the job for a predetermined (higher) price and assumes the potential consequences of risk events. If the risk is low, you could choose to accept the risk and write a cost-plus contract, paying the contractor only the actual costs plus a predetermined profit. Other examples of risk transference include the purchase of insurance, bonds, guarantees, and warranties.
- ▶ *Mitigating*. Mitigation plans are steps taken to lower the probability of the risk event happening or to reduce the impact should it occur. For example, you can reduce the likelihood of a product failure by using proven technology rather than cutting-edge technology. Mitigation costs should be appropriate to the likelihood of the risk event and its potential impact on the project. Some mitigation strategies may not take a lot of effort but may have large payoffs in eliminating the potential for disaster. On a project with a tight deadline, the risk of delayed delivery of raw materials may be disastrous. If two vendors can provide materials at essentially the same price, but one has a much larger inventory and a significantly better history of on-time delivery, choos-

ing the vendor with the better track record may be an easy mitigation strategy with a potentially large payoff.

- ▶ *Accepting.* When there is a low likelihood of a risk event, when the potential impact on the project is low, or when the cost of mitigation is high, a satisfactory response may be to accept the risk. For example, midway into a project to reengineer a manufacturing plant to increase efficiency and output, the economy moves into a recession. The company chooses to proceed with the project anyway and accept the risk that lower sales may reduce the return on investment below what was expected.

Developing a Response Plan

After considering the options of avoiding, transferring, mitigating, or accepting the risk, the outcome of response planning is a risk management plan, contingency plans, and reserves. The risk management plan documents the procedures that will be used to manage risk throughout the project. It lists potential risk events, the conditions or signs that may warn of the impending event, and the specific actions to be taken in response. Contingency plans describe the actions to be taken if a risk event should occur. Reserves are provisions in the project plan to mitigate the impact of risk events. These are usually in the form of contingency reserves (funds to cover unplanned costs), schedule reserves (extra time to apply to schedule overruns), or management reserves (funds held by general management to be applied to projects that overrun).

After identifying your plans to avoid, transfer, mitigate, or accept the risk, you may need to add specific activities to the work breakdown structure and other plans.

Acting on the Response Plan

The project manager and other team members monitor the project throughout its life, looking for triggers and signs that may warn of impending risk events. When risk events happen, corrective action identified in the risk management plan is taken.

When an unplanned risk event occurs, a response must be developed and implemented. This is often called a workaround. After the response is implemented, the risk management plan should be reviewed and updated if necessary. It may also be necessary to adjust other project plans or the basic project objectives.

As changes in the project occur, it may be necessary to repeat the steps of identifying, assessing, and planning responses to risk.

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PART 5

Closing

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Closing a Project

CHAPTERS 10 AND 11 PRESENTED the processes, tools, and techniques that guide execution and control of a project. This chapter reviews the needs of the client, stakeholders, and team members regarding project closure. It discusses the steps necessary for completing project closure and describes techniques to enact those steps. Project closure is an important step that is often overlooked or poorly executed.

Project Closure: The Final Process

During project closure, all the project's activities are formally completed and the deliverables or results are turned over to the customer. Closure usually begins after the client has accepted the majority of the project deliverables. Sometimes a project will end prematurely or unsuccessfully. In either case, the project manager and team must obtain closure before moving on to their next assignment. Additionally, the team,

client, and stakeholders will be concerned both about the disposition of this project and their immediate future. The following situations are common:

- ▶ Team members are concerned about their next assignment.
- ▶ The client or user organization is concerned about loss of technical competence and operational skill when you leave the project.
- ▶ Management wants you to start the next project immediately.
- ▶ Functional managers want to know how their people performed.
- ▶ Everyone wants to know what lessons can be learned from this experience.

There are many benefits associated with project closure. One key benefit is to ensure that you have met expectations and another is to gather and document lessons learned so you can incorporate successes and avoid problems in future work.

A formal acceptance by the client ensures that the project is truly finished and helps give finality to the project. This can minimize continuing calls from the client regarding product usage, bugs, or other questions, and it helps the team obtain closure and move on to other work with minimal disruption from the previous project.

Additional objectives of project closure include:

- ▶ Communicating staff performance
- ▶ Closing out all financial reports
- ▶ Improving estimates for future projects
- ▶ Improving project methodologies

- ▶ Smoothing the release of staff
- ▶ Ensuring client and stakeholder satisfaction

Ensuring Project Requirements Are Met

Classically, project closure is defined as meeting (or exceeding) the defined project requirements. A project is deemed complete and successful, at least for the project manager, when all requirements have been completed. Figure 14-1 shows the levels of detail that were defined in the project planning phase. To adequately define project completion (and closure), it is important that the requirements were defined carefully, and that they are measurable and verifiable. Increasingly, client organizations require the project team to prove each and every requirement before final payment is made.

Proof can be provided by testing, analysis, inspection, or interpolation. The precise measures and methods used will depend on the project's context. Sometimes, proof of completion relies on physical or chemical testing. For other projects, we conduct accelerated life-cycle testing or simulate a system's performance. Occasionally, government rules dictate what constitutes completion and success. The essential point is that early definition of critical success factors and critical success measures gives us the project's *exit criteria*, helps to disci-

Figure 14-1 Goal Breakdown Structure (Reiterated).

Level	Definition
0	Project Goal (or Mission)
1	Project Objectives (Critical Success Factors)
2	Project Requirements (Critical Success Measures)
3	Specifications

pline the client's expectations, and helps control changes to project objectives.

Sometimes, a project manager will be faced with ill-defined requirements or client apathy regarding requirements. A plant manager might say, "I don't care how you do it, just reduce the failure rate of the widget line by 50 percent!" Here, the project manager still creates requirements, but closure cannot occur until the project objective has been met. This, of course, does not alleviate the project team from completing as-built documentation, training the line workers, and closing the project financials. Under these conditions, you must recognize that you are taking the role of the client and ensuring that the requirements will ultimately achieve the project objective.

How Projects Can End

All projects, by definition, must come to an end. How they get there will vary. In the book *Project Management: A Managerial Approach*, Jack R. Meredith and Samuel J. Mantel Jr. offer four useful categories to describe various project endings:

1. *Termination by Integration.* This is the most common and most complex type. All the assets and resources used in a project are redistributed among the existing elements of the organization. The output of the project becomes a standard part of operating systems and procedures. Transitional elements typically include the following business functions:
 - ▶ Personnel and human resources
 - ▶ Manufacturing, assembly, fabrication
 - ▶ Engineering

- ▶ Accounting and finance
 - ▶ Purchasing and procurement
 - ▶ Legal, regulatory affairs, general counsel
 - ▶ Information systems and technology
 - ▶ Marketing and sales
 - ▶ Distribution
 - ▶ Customer service
2. *Termination by Starvation.* The project ends because the money runs out. In reality, this is not termination at all.
 3. *Termination by Addition.* This is what happens when a project ends successfully and then migrates into the enterprise as a new business unit or product line. Project assets and resources migrate from the completed project to the new product business or division. In some companies, a deliberate career path is found as project managers successfully complete their work and become product managers.
 4. *Termination by Extinction.* These are projects brought to an end (often before completion) because they are unsuccessful, fail to meet end-user objectives, are superseded by technical advances that make the project obsolete, or because cost escalations destroy economic viability of the project or product. In this case, technical work on the project may be suspended, but administrative work and organizational arrangements must be made to dispose of the project itself. Checklists must be completed, a final report drafted, lessons learned disseminated throughout the organization, and key staff assigned to new work efforts.

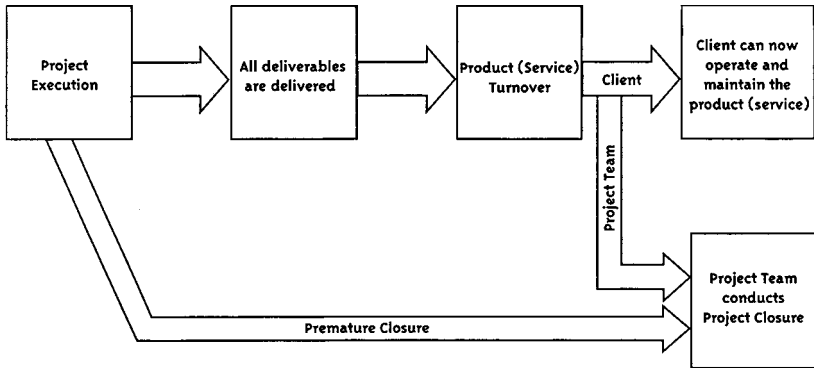
Not all projects end with successful objectives or requirements. Many end prematurely, as described in Figure 14-2. In

Figure 14-2 Reasons for Premature Project Closure.

<i>Scenario</i>	<i>Description</i>	<i>Detection and Prevention</i>
Project runs out of money or time, i.e., "starvation"	Cost and schedule are two legs of the project triangle.	Following proper project management methods, schedule and cost overruns should be highly anticipated. Project phase reviews are specifically designed to detect overruns and allow the project to shut down in an orderly fashion.
Project no longer needed	Changes within the client's organization result in loss of demand for the project.	This can occur suddenly or expectedly.
Political battle	An organization member (on either the client or performing team side) kills the project through political means.	Project management methodologies are designed to both prevent and detect project politics.
Catastrophic events	This includes such items as the client filing bankruptcy, sale of the company, etc.	Such events occur without warning.

these scenarios, the project team no longer needs to deliver product or services to the client (see Figure 14-3). However, this does not lessen the need for the project manager to conduct other project closure items as discussed throughout this chapter.

Figure 14-3 Process for Premature Project Closure.



Administrative Closure

Administrative closure involves bringing to completion all internal aspects of the project concerning team members, management, other stakeholders, financials, and equipment. The following processes ensure that no loose ends are left dangling:

- ▶ *Deliverable Turnover—Verification and Acceptance.* In this step, deliverables are reviewed and tested against previously determined requirements and are accepted by the customer with a formal sign-off.
- ▶ *Postcompletion Data.* In this step, you determine any variances in the schedule, cost (personnel and expenses), and scope (deliverables and requirements).
- ▶ *Follow-Up Maintenance and Warranties.* If applicable, hand off any hardware, software, or other equipment and review the coverage on warranties and the maintenance requirements.
- ▶ *Team Member Performance Reporting.* The project manager provides information to functional management on the performance of project team members during the life of the project.
- ▶ *Financials.* Ensure that all expenses are paid and project budgets are closed. Generate the necessary financial reports.
- ▶ *Releasing Staff.* Ensure a smooth transition for all staff to new assignments. Notify functional managers with sufficient lead time so that meaningful work assignments can be made.
- ▶ *Formal Closing Report.* Prepare a summary of the information above, including any open issues, and distribute it to appropriate stakeholders.

Contractual Closure

Contractual closure is similar to administrative closure except that it deals with project elements that were external to the organization. This is an element of procurement management. The following items would be outlined in the contractual closure procedure:

- ▶ Turnover of deliverables and all necessary supporting documentation
- ▶ Verification of work and deliverables
- ▶ Formal acceptance of deliverables per previously defined requirements
- ▶ Audit to document performance
- ▶ Final documentation that the contract is complete
- ▶ Final payment

Initiating Project Closure

Informal project closure usually begins just as the client accepts the major deliverables. In most projects, the presentation of additional deliverables follows this step. These include such items as training, hand-holding, completing the as-built documentation, and other deliverables.

One of the first steps in initiating project closure is to contact the team members' resource managers to prepare them for the closure. This includes two important actions: (1) the managers need to determine the team members' next assignments and (2) the project manager needs to communicate staff member performance to the resource managers. It is important to begin this step early. First, it may take time for the resource managers to plan the team members' actions and,

second, the staff may become concerned about their next assignments.

The project manager should meet with the team to review project closure issues such as the following:

- ▶ The team's new assignments
- ▶ Plans for lessons learned
- ▶ Assurance that all deliverables are presented and accepted
- ▶ Closure of administrative and financial information

The steps required for project closure are summarized in the checklist in Figure 14-4.

Lessons Learned

We discussed earlier in this chapter that one of the benefits of project closure is the provision of a methodology to prevent repeating mistakes. This includes identifying what went well and what went poorly during the project, documenting it, and communicating this information to everyone who may benefit from it.

The purpose of the lessons learned process is to capture best practices and improvement areas upon the completion of a project, major milestone, or substantial event, so that problems can be addressed and successes repeated in the future.

The following are sources for identifying lessons learned:

- ▶ *Change Log and Change Management Forms.* The change logs and associated change management forms are excellent tools for developing improvement plans. Each change is a result of an alteration to the plan. If there were no project changes, all projects would be on time, on budget, and all goals would be met. The change management system,

Figure 14-4 Project Closure Checklist.

Item	Responsibility	Due Date	
		Scheduled	Actual
Project			
Have all activities in the project plan been completed?			
Have all work orders been completed?			
Have all contracts been completed?			
Have all outstanding commitments been resolved?			
Has the client or customer accepted the final products?			
Are all deliverables completed?			
Has agreement been reached with the client on the disposition of any remaining deliverables?			
Have external certifications and authorizations been signed and approved?			
Have all audits been completed and issues resolved?			
Have ongoing maintenance procedures been activated?			
Finances			
Have all payments been made to vendors and contractors?			
Have all costs been charged to the project?			
Have project accounts been closed?			
Have remaining project funds been returned?			
Project documentation			
Have project plans and supporting documentation been revised to reflect the "as-built" condition?			
Have final project reports been prepared and distributed?			
Has the project plan been archived with supporting data?			
Have "lessons learned" been documented, shared with appropriate people, and archived with the project plans?			
Personnel			
Are all parties aware of the pending closeout?			
Has effort been recognized and rewarded?			
Have project personnel been reassigned?			
Resources			
Has excess project material been dealt with?			
Have project facilities, equipment, and other resources been reallocated?			

therefore, provides a history of all areas where project teams, stakeholders, project managers, senior management, and clients can improve.

- ▶ *Project Reviews During and at the Conclusion of the Project.* This may include interviews, questionnaires, or other formal and informal reviews with the project team, client, and stakeholders, which can also yield excellent ideas.
- ▶ *Written Notes Made During the Project.* Frequently, during a project someone will recognize a way to improve the pro-

cess. This often occurs during problem-solving meetings. Someone will say, for example, “If we had interviewed the procurement manager, this never would have happened!” Experienced project managers will write these comments down and place them in a special section of the project book.

Once these improvement opportunities are identified, it is imperative that they be communicated to everyone who may benefit from them. If the organization has a defined methodology, the project manager formulates a final report that includes both project successes and ideas for methodology adjustments. The methodology owners gather this information and make appropriate changes. For other organizations, the project manager may simply document these ideas and disseminate them through status meetings with colleagues or through e-mail.

Finance and Administration Records

After the major deliverables are completed, the project manager and team accumulate final sets of actual data for the project. These include costs, work, and final product documentation. Ensure that final, actual data on activities are recorded. This information should be kept for reference in estimating future projects. Capture the final project costs and other financial information. Complete the financial reports required by your organization and submit them for approval. Ensure this step is done early enough to allow time for the finance group to provide feedback and handle requests for changes. Finally, archive all information in your organization’s formal archive.

Performance Reporting

This action is needed for all staff members who have spent a large amount of time on the project and don't report directly to you. When team members have worked on a project for an extended period, their direct managers may not have appropriate insight into their performance, making it difficult to establish appropriate raises, promotions, or demotions. To solve this issue, the project manager presents reports to these managers regarding performance. This also offers the project manager more authority. When team members know that you are going to report their performance to their manager, they will be motivated to perform better.

Staff Release

One of the final steps in closing a project is to release the remaining staff. This step should be planned early and communicated to the staff members to relieve their concerns for the future. One technique that may be employed for larger projects is to make the dismissal formal, either through a meeting where the project manager thanks the team or through a team celebration. This provides the team members with final closure and allows them to proceed to their next assignments without lingering concerns.

At the outset, the project creates the team. At closure, the team created the project!

Learning Resources

Recommended Reading

- Dinsmore, Paul C. and Jeannette Cabanis-Brewin. *The AMA Handbook of Project Management* (AMACOM, American Management Association, New York, 2010).
- Frame, J. Davidson. *The New Project Management* (Jossey-Bass, San Francisco, 2002).
- Kerzner, Harold. *Project Management: A Systems Approach to Planning, Scheduling, and Controlling* (10th Edition) (John Wiley & Sons, New York, 2009).
- Lewis, James P. *Fundamentals of Project Management* (AMACOM, American Management Association, New York, 2006).
- Meredith, Jack R. and Samuel J. Mantel Jr. *Project Management: A Managerial Approach* (7th Edition) (John Wiley & Sons, New York, 2009).
- PMI Standards Committee. *A Guide to the Project Manage-*

- ment Body of Knowledge (PMBOK® Guide)* (Project Management Institute, Newtown Square, Pennsylvania, 2008).
- Richman, Larry. *Improving Your Project Management Skills* (AMACOM, American Management Association, New York, 2010).
- Richman, Larry. *Project Management Step-by-Step* (AMACOM, American Management Association, New York, 2002).

Organizations

- Project Management Institute (PMI®) (14 Campus Boulevard, Newtown Square, PA 19073-3299 USA, phone: 610-356-4600, www.pmi.org, e-mail: customercare@pmi.org) establishes project management standards, provides seminars, educational programs, and the PMP® professional certification. Founded in 1969, this professional organization has over a half million members and credential holders from over 170 countries.
- International Project Management Association (IPMA) (P.O. Box 1167, 3860 BD Nijkerk, The Netherlands, phone: +31 33 247 3430, www.ipma.ch, e-mail: info@ipma.ch) is a nonprofit organization founded in 1965 that is an international umbrella organization for national project management associations from over forty countries worldwide. It represents its members on the international level. IPMA provides standards and certification programs.
- American Management Association (1601 Broadway, New York, NY 10019, phone: 877-566-9441, www.amanet.org e-mail: customerservice@amanet.org) is a world leader in professional development, advancing the skills of individuals, teams, organizations and government agencies. AMA promotes the goals of individuals and organizations through a comprehensive range of solutions, including over 140 business seminars, blended learning, Webcasts

and podcasts, conferences, books, white papers, articles, and more. AMA's publishing arm, AMACOM, is one of the world's largest publishers of books on project management.

George Washington University, in association with Educational Services Institute (phone: 202-994-1212, e-mail: mspminfo@gwu.edu), offers a Master of Science degree in project management.

University of Phoenix (phone: 866-766-0766, www.phoenix.edu) has campuses in many states and online programs. It offers a Bachelor of Science degree in project management.

ProjectWorld (phone: 888-670-8200, www.ProjectWorld.com) hosts events that combine a practical education in project management with a world-class exposition hall to meet the needs of today's project and business professionals.

Websites

American Management Association, www.amanet.org

Project Management Institute, Inc., www.pmi.org

The Standish Group International, www.standishgroup.com

Ganttthead.com, www.ganttthead.com

PMboulevard, www.pmboulevard.com

@task, www.attask.com

Whatis.com, whatis.techtarget.com

The Improvement Encyclopedia, www.syque.com/improvements/a_encyclopedia.htm

Value Based Management.net, www.valuebasedmanagement.net

Project Management Center, www.projectman.org/

Project Connections, www.ProjectConnections.com

ProjectManagement.com, www.projectmanagement.com

PM Forum, www.pmforum.org

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Glossary

Activity. A unit of work performed during a project. An activity usually has a duration, a cost, and resource requirements. Also called *task*.

Activity estimate sheet. A form used to gather information needed to estimate a project activity.

Activity-on-node. A diagramming method that shows the activities in a node (box) with arrows showing the dependencies. Also called *precedence diagramming method*.

Actual cost (AC). The cost incurred to complete the work that was actually performed in a given time period. Also called *actual cost of work performed (ACWP)*.

Alternative course of action review. A review to identify other things that could be done to solve the problem or take advantage of the opportunity instead of the approach being taken by the proposed project.

Analogous estimate. A method of estimating that uses the

actual costs and durations of previous, similar projects as the basis for estimating the current project. Also called *top-down estimating*.

Baseline. The original schedule or cost plan for the project, including approved changes. This is the basis from which actual performance is measured to determine variances.

Benchmarking. The process of defining a standard or point of reference to measure quality or performance.

Bottom-up estimate. A method of estimating that sums the cost and duration of the individual work packages.

Budget at completion (BAC). The estimated total cost of the project when completed.

Budgeted cost of work performed (BCWP). See *earned value (EV)*.

Budgeted cost of work scheduled (BCWS). See *planned value (PV)*.

Budgeting. The process of allocating the cost estimates to work items to establish a cost baseline for measuring project performance.

Cause-and-effect diagram. A graphical representation of the relationships that exist between factors. Used to explore a wide variety of factors and the relationships among them that may cause them. Also called a *fishbone diagram*.

Change control. A formal process to manage proposed changes to the project plan. Includes processes for submitting, evaluating, approving, and communicating changes.

Client. The person or group that requests a project.

Conceptual review. A review to determine whether the project fits within the organization's goals and whether the project will solve the stated problem or appropriately take advantage of the current opportunity.

Contingency plan. A plan that describes the actions to be taken if a risk event should occur.

Contingency reserve. See *reserves*.

Contract, cost-plus. See *cost-plus contract*.

Contract, cost-reimbursable. See *cost-plus contract*.

Contract, firm-fixed-price. See *fixed-price contract*.

Contract, fixed-price. See *fixed-price contract*.

Contract incentives. Additional payments included in contract terms, such as completing work before a given date or controlling costs to a given level.

Contract, time-and-materials. See *cost-plus contract*.

Control charts. Graphs that display periodic results along with established control limits. They are used to determine whether a process is in control or in need of adjustment.

Cost. The money and resources required to complete a project.

Cost budgeting. See *budgeting*.

Cost control. The process of comparing actual expenditures to the baseline cost plans to determine variances, evaluate possible alternatives, and take the appropriate action.

Cost performance index (CPI). A ratio that measures cost efficiency by comparing budgeted costs to actual costs. In earned value analysis, the budgeted cost of work performed divided by the actual cost of work performed.

Cost-plus contract. A contract in which the vendor agrees to do the work for the cost of time and materials, plus an agreed amount of profit. Also called *cost-plus-fixed-fee*, *cost-reimbursable*, or *time-and-materials contract*.

Cost-reimbursable contract. See *cost-plus contract*.

Cost variance (CV). The difference between the planned and actual cost of an activity. In earned value analysis, the difference between the budgeted cost of work performed and the actual cost of work performed.

CPM. See *critical path method*.

Crashing the schedule. Taking action to decrease the total

project duration after analyzing the options to determine how to get the maximum compression for the least cost.

Critical activity. An activity on the critical path.

Critical path. The path through the network that takes the longest total time, and therefore determines the earliest possible time the project can be completed. All activities on this path generally have zero float, meaning that the early and late start (and early and late finish) are the same.

Critical path method (CPM). A technique used to estimate project duration. It analyzes which sequence of activities (which path) has the least amount of scheduling flexibility (the least amount of float).

Customer. A person or group that will use the result of the project (the product, service, process, or plan).

Deliverable. Something delivered at the end of a project, such as a product, service, process, or plan.

Duration. The number of work periods (such as hours, days, or weeks) required to complete an activity. Does not include holidays or other nonworking periods. Not the same as *effort*.

Early finish. The earliest date an activity can end.

Early start. The earliest date an activity can begin.

Earned value (EV). The planned cost of work actually performed in a given time period. Also called *budgeted cost of work performed (BCWP)*.

Earned value analysis. A method of measuring and evaluating project performance. It compares the amount of work planned with what is actually accomplished to determine whether the project is on track. Earned value analysis is also known as *variance analysis*.

Effort. The number of labor units required to complete an activity. Also called *work effort*. Not the same as *duration*.

- Enterprise portfolio management.** Managing all projects of the organization as a portfolio.
- Estimate at completion (EAC).** The expected total cost of the project when completed, including adjustments to the original estimate based on project performance to date. In earned value analysis, $AC + ETC$.
- Estimate to complete (ETC).** The expected additional cost needed to complete the project, including adjustments to the original estimate based on project performance to date. In earned value analysis, $(BAC - EV)/CPI$.
- Exception report.** A report that shows only major deviations from the project plan, rather than all deviations.
- Fast-tracking.** Compressing the project schedule by changing the sequence of activities to allow activities to be done in parallel (at the same time) or to allow some overlap.
- Feasibility study.** A review to determine whether the project can realistically be accomplished.
- Finish-to-finish activity relationship.** A dependency between activities where one activity must finish before the other can finish.
- Finish-to-start activity relationship.** A dependency between activities where one activity must finish before the other can begin.
- Firm-fixed-price contract.** See *fixed-price contract*.
- Fishbone diagram.** See *cause-and-effect diagram*.
- Fixed-price contract.** A contract in which the vendor agrees to do the total work for a fixed price. Also called *firm-fixed-price contract* or *lump-sum contract*.
- Float.** The time an activity can slip without delaying the project finish date. It is equal to the difference between the early start and late start (or the difference between the early finish and late finish). Also known as *slack*, *total float*, and *path float*. See also *free float*.

- Flowchart.** A quality control tool that provides information about process flow.
- Free float.** The amount of time an activity can slip without delaying the early start of any activity that immediately follows it. See also *float*.
- Functional manager.** A person assigned to manage a specific function (such as accounting, manufacturing, or marketing) and to provide technical direction. Also called *resource manager*.
- Functional organization.** A hierarchical organizational structure where each functional division has its own project managers who operate independently from project managers in other divisions.
- Gantt chart.** A bar chart of schedule information, typically with dates across the horizontal axis, activities listed down the vertical axis, and activity durations shown as horizontal bars under the appropriate dates.
- Incentives.** See *contract incentives*.
- Integration management.** The processes required to ensure that the various elements of the project are properly coordinated.
- Internal rate of return.** A profitability measure that represents an average rate of return for the project, expressed as a percentage.
- Lag.** The time delay between the start or finish of one activity and the start or finish of another activity. When expressed as a negative number, lag indicates an overlap in the activities and is also called *lead*.
- Late finish.** The latest date an activity can end and still allow the project to be completed on time.
- Late start.** The latest date an activity can begin and still allow the project to be completed on time.

- Lead.** The time overlap between the start or finish of one activity and the start or finish of another activity. See also *lag*.
- Logic network diagram.** See *network diagram*.
- Lump-sum contract.** See *fixed-price contract*.
- Management reserves.** See *reserves*.
- Matrix organizational structure.** An organizational structure that is a blend of functional and project. The project team reports both to a project manager (who provides project management skills) and to a functional manager (who provides specific job-related skills).
- Milestone.** An activity that defines the completion of a major deliverable or group of activities. A milestone has no duration, cost, or resource requirements.
- Milestone schedule.** A schedule that includes only significant (milestone) activities. Also called a *summary schedule*.
- Mitigation plans.** Steps taken to lower the probability of the risk event happening or to reduce the impact should it occur.
- Network diagram.** A graphical flow plan of the activities that must be accomplished to complete the project. It shows the planned sequence of steps, time requirements, interdependencies, and interrelationships. Also called *precedence diagram*.
- Objectives.** The statement of cost, time, and scope required to complete a project.
- Opportunity cost.** The cost of choosing one alternative (project) and, therefore, giving up the potential benefits of another alternative (project).
- Parallel activities.** Two or more activities that occur at the same time. Also called *concurrent* or *simultaneous activities*.
- Parametric estimate.** A method of estimating that uses math-

ematical parameters (such as a dollar amount per square foot) to predict project costs.

Pareto chart. A bar chart with elements arranged in descending order of importance, generally by magnitude of frequency, cost, or time. Used to focus attention on the most critical issues.

Pareto Principle. A vital few elements (20 percent) account for the majority (80 percent) of the problems.

Path float. See *float*.

Payback period. The number of periods (usually years) until cumulative revenues exceed cumulative costs, and, therefore, the project has “turned a profit.”

Percent complete. A method of reporting where the amount of work completed on an activity is expressed as a percentage of the total work required for the activity.

PERT. See *Program evaluation and review technique*.

Planned value (PV). The planned cost of work scheduled to be done in a given time period. Also called *budgeted cost of work scheduled (BCWS)*.

Portfolio. A collection of projects or programs that are managed together and usually prioritized against larger strategic organizational objectives.

Precedence diagram. See *network diagram*.

Precedence diagramming method (PDM). A network diagramming method that shows the activities in a node (box) with arrows showing the dependencies. Also called *activity-on-node*.

Predecessor activity. An activity that occurs before another activity in a project.

Preliminary risk review. An initial review of the potential risks involved in a project to determine whether the expected benefits of the project are worth the risk.

- Program.** A group of related projects that are managed together for increased benefit and control.
- Program evaluation and review technique (PERT).** A technique used to estimate project duration. It uses the critical path method and a weighted average of estimates for each activity. See also *Three-Point Estimate*.
- Program management.** The centralized or coordinated management of a program (or group of related projects). Programs are often tied to larger organizational objectives.
- Project.** “A temporary endeavor undertaken to create a unique product, service, or result.” A project has a definite beginning and end. (See *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, p. 4.)
- Project charter.** A document that formally authorizes the project, explains the business need the project addresses, states the project objectives (time, cost, and scope), and defines the approvals and authority granted by the client or senior management.
- Project closure.** Formal steps taken at the conclusion of a project to get acceptance of the final product, close project records, and reallocate personnel and other resources.
- Project management.** A set of principles, methods, and techniques used to effectively plan and control project work.
- Project manager.** The person assigned to manage a specific project, and expected to meet the approved objectives of the project, including project scope, budget, and schedule.
- Project objectives.** See *objectives*.
- Project organization.** An organizational structure in which an autonomous division of project managers is responsible for planning, controlling, managing, and reporting the progress of all projects in the organization.
- Project plan.** A document or Web site that contains the project charter, schedules, project scope statement, resource

plans, budget plans, risk management plans, monitoring and control plan, change control processes, project evaluation plan, project reporting plan, project closure plan, etc.

Project scope statement. The documented narrative description of the scope of a project.

Quality assurance. The process of evaluating project performance to ensure compliance with quality standards.

Reserves. Provisions in the project plan to mitigate the impact of risk events. Usually in the form of contingency reserves (funds to cover unplanned costs), schedule reserves (extra time to apply to schedule overruns), or management reserves (funds held by general management to apply to projects that overrun).

Resource control. The process of comparing actual performance to the resource plans to determine variances, evaluate possible alternatives, and take the appropriate action.

Resource histogram. A chart showing the commitment of resources over a period of time.

Resource leveling. Taking action to minimize the peaks when resources are overallocated.

Resource manager. See *functional manager*.

Resources. Funds, personnel, equipment, facilities, or materials needed to complete an activity or a project.

Responsibility assignment matrix. A chart that relates skill requirements to people (or groups of people).

Return on assets. A measure of net profit divided by total assets.

Return on investment. A measure of net profit divided by total investment.

Return on sales. A measure of net profit divided by total sales.

Risk management. The process of identifying possible risks,

making preventive and contingency plans, and executing those plans when risk events occur.

Risk management plan. A plan that documents the procedures that will be used to manage risk throughout the project.

Risk review, preliminary. See *preliminary risk review*.

Rolling wave estimate. A method of estimating that provides a gross estimate for the entire project and periodically calculates detailed estimates for the next short period of time.

Rule of Seven. A rule of thumb in control charting indicating that when seven or more points in a row occur on the same side of the mean, or when they tend in the same direction—even though they may be within the control limits—they should be investigated.

Schedule performance index (SPI). A ratio that measures schedule efficiency by comparing work performed to work scheduled. In earned value analysis, the budgeted cost of work performed divided by the budgeted cost of work scheduled.

Schedule reserves. See *reserves*.

Schedule variance (SV). The difference between the scheduled and actual completion of an activity. In earned value analysis, the difference between the budgeted cost of work scheduled and the budgeted cost of work performed.

Scope. A description of the features and functions of the end products or services to be provided by the project.

Scope control. The process of comparing actual performance to the scope statement to determine variances, evaluate possible alternatives, and take the appropriate action.

Scope creep. The tendency for scope to increase during the course of the project without proportionate increases in time or cost.

Scope statement. A narrative description of the project objec-

tives, including justification for the project, a description of the product or service to be created, and a list of the project deliverables.

Scope verification. Verifying that all project deliverables have been accomplished as agreed upon.

Sequential activities. Two or more activities that occur one after the other. Also called *consecutive activities*.

Simulation estimate. A method of estimating that calculates multiple costs or durations with different sets of assumptions.

Slack. See *float*.

Stakeholders. People who are affected by or have an interest in the project, including clients, senior management, middle management, functional managers, project managers, project team members, customers, and vendors.

Start-to-finish activity relationship. A dependency between activities where one activity must begin before the other can finish.

Start-to-start activity relationship. A dependency between activities where one activity must begin before the other can begin.

Statement of work. A narrative description of the work to be accomplished. A general statement of work may apply to the entire project, while a more specific statement of work may apply to a project activity or the work of an individual team member.

Successor activity. An activity that occurs after another activity in a project.

Summary schedule. A schedule that includes only significant (milestone) activities. Also called a *milestone schedule*.

Task. See *activity*.

Team members. The people who work with the project man-

ager directly or indirectly to accomplish project goals and complete project activities.

Three-point estimate. A weighted estimating formula that uses three points: *most likely* (m), *optimistic* (o), and *pessimistic* (p), with an emphasis on the most likely. The formula is $(o + 4m + p)/6$.

Time. The time required to complete a project.

Time-and-materials contract. See *cost-plus contract*.

Time control. The process of comparing actual schedule performance to the baseline schedule to determine variances, evaluate possible alternatives, and take the appropriate action.

Total float. See *float*.

Trend analysis. Using mathematical techniques to forecast future outcomes based on historical results.

Trigger. An occurrence or a condition that causes an event to happen.

Unit-price contract. A contract in which the vendor agrees to a preset amount per unit of service (for example, \$90 per hour).

Workaround. The response to an unplanned risk event.

Work breakdown structure. A hierarchical breakdown of activities and end products that organizes and defines all work to be completed in a project.

Work effort. The number of labor units required to complete an activity. Also called *effort*. Not the same as *duration*.

Work packages. The deliverables in the lowest level of the work breakdown structure. A work package may be divided into the specific activities to be performed.

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