

November 2003

Dear Professional Colleague,

Since the Project Management Institute (PMI®) last published A *Guide to the Project Management Body of Knowledge (PMBOK® Guide)* in 2000, the publication continues to receive widespread acclaim. The *PMBOK® Guide* serves as a reference for anyone interested in project management by focusing on knowledge and practices applicable to “most projects most of the time”.

The general consensus is that the *PMBOK® Guide* is valuable and useful. In fact, the *PMBOK® Guide* has become the de facto global, standard for project management. And, its acceptance as an official project management standard is evidenced in its adoption by the American National Standards Institute (ANSI) as an American National Standard. In addition, it has been adopted by The Institute of Electrical and Electronic Engineers (IEEE) as a project management standard for its profession and by Standards Australia, which republished it as a handbook.

Two Thousand Three marks the ‘Twentieth Anniversary’ of PMI® volunteers’ first attempt to distill the project management body of knowledge. PMI originally published the findings of the PMI Ethics, Standards and Accreditation (ESA) Project team in a report in 1983. Building on that work, PMI volunteers published the *PMBOK Standard* in 1987. The publication of A *Guide to the Project Management Body of Knowledge* in 1996 was the next step in the evolution. The current *PMBOK® Guide* – 2000 Edition refined the first edition and continued PMI’s commitment to continuously refresh and improve this important reference. PMI is committed to expanding the Project Management Body of Knowledge by publishing additional standards. Since the *PMBOK® Guide* – 2000 Edition was published, PMI has published four additional Standards (*Practice Standard for Work Breakdown Structures*, *Government Extension to the PMBOK® Guide*, *Project Manager Competency Development Framework*, *Construction Extension to the PMBOK® Guide* (Provisional Standard)) and adopted a fifth (*US DoD Extension to the PMBOK® Guide*).

With over 1,000,000 copies of the *PMBOK® Guide* in circulation, PMI has received thousands of valuable recommendations for improvements. As a result of those inputs, and the expansion of the body of knowledge, PMI volunteers, under the project leadership of Dennis Bolles, PMP, have stepped forward once again to support the profession by preparing an updated version of the *PMBOK® Guide*.

In accordance with PMI’s Project Management Standards Setting Policy and Procedures, the updated version is enclosed as an *Exposure Draft* for your review and comment. Your thorough review of the entire document and your submission of any recommended additions, deletions, or corrections are encouraged. Please submit your comments by following the procedures and using the on line forms which follow this letter. Any suggestion(s) that you submit regarding this *Exposure Draft* will be reviewed carefully; and you will be informed of the resultant decision.

Thank you for your commitment to the project management profession and your support for PMI.

Sincerely,



Debbie O’Bray, CIM
2003 Chair – PMI Board of Directors

Preface to the *Exposure Draft of A Guide to the Project Management Body of Knowledge* - Third Edition

This exposure draft document is proposed to supercede *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* – 2000 Edition.

The scope of the project to update the *PMBOK® Guide* – 2000 Edition was to:

- Change the criteria for the inclusion of material from “generally accepted on most projects most of the time” to “generally recognized as good practice on most projects most of the time.” (Generally recognized meaning that the knowledge and practices described are applicable to most projects most of the time, and that there is widespread consensus about their value and usefulness.).
- Add new material reflecting the growth of the knowledge and practices in the field of project management by documenting those practices, tools, techniques, and other relevant items that are generally recognized as good practice.
- Expand the emphasis on and treatment of the Process Groups.
- Expand the treatment of integration and more appropriately convey its importance to a project.
- Expand treatment of the Initiation Process Group to more accurately describe the front-end of the project and the start of each phase when appropriate.
- Evaluate all processes to ensure that they are properly placed, complete and clear.
- Review all text to make sure it is clear, complete and relevant.
- Ensure consistent terminology and placement of project inputs, outputs and tools and techniques. Identify the origin of all inputs and the destination of all outputs.
- Change text where possible to improve the translatability of the document and consider changing words and phrases with negative cultural connotations.
- Expand the index and glossary.
- Correct existing errors in the predecessor document.

The *PMBOK® Guide* 2004 Update Project Team has complied with their charter as described above. As part of PMI’s standards setting process, once a project team has completed an exposure draft of their work PMI makes that exposure draft available to the profession and other interested parties for comment and recommendations for further improvement. To assist practitioner and other interested parties, who may be familiar with the *PMBOK® Guide* – 2000 Edition, we have summarized the major differences here.

1. Across the entire document, when a new process was introduced, or as appropriate, we changed process names to a verb/noun format for clarity.
2. Generally changed to present tense/active voice writing style
3. Clarified distinction between project life cycles and product life cycles.
4. Increased the defined processes from 39 to 44.
5. All graphics are now numbered as either a table or figure.

6. Expanded the focus on the Process Groups and processes versus the knowledge areas.
7. Moved and renamed Chapter 3, “Project Management Processes for a Project” to a new Section II, “The Standard for Project Management of a Project”. As part of this change we extensively revised Chapter 3 on project management processes to clearly indicate that the processes, inputs and outputs called out in the chapter are the basis of the standard for project management of a single project. We mapped the project management processes to show the integration of the processes. We added six processes and renamed 14.
8. Described the requirement to address the five Process Groups and their constituent processes on each project.
9. Increased the emphasis of the Initiating Process Group and Closing Process Group.
10. Added Monitoring to the existing Controlling Process Group and increased the emphasis on the new Monitoring and Controlling Process Group.
11. Revised and expanded the discussion of integration within Chapter 4 and its importance to project management and the success of a project. This change provides more details on the interrelationships of the processes, including a project’s initiating and closing processes.
12. General management skills were combined into one section of Chapter 1.
13. A project team should have competency in many areas; therefore, a section that identifies areas of expertise needed by the project team was added.
14. We expanded the section on related endeavors to provide further elaboration on portfolio management and described the different uses of a Project Management Office within organizations.
15. We added information in the scope chapter to better define the project charter, scope management plan and the role of a configuration management system. The process on scope management initiation was deleted, but the developing of the project’s scope statement was augmented in Chapter 4 and further clarified in Chapter 5.
16. We expanded the discussion and importance of Work Breakdown Structure (WBS) process in Chapter 5 including the addition of a new section on WBS and added tools and techniques for creating the WBS.
17. We added sub-sections in Chapter 6 to provide information on project cost estimates, resource leveling and progress reporting to reflect how these processes influence the project’s schedule. Graphics were added to further clarify the use of arrow diagramming method and precedence diagramming method.
18. We added information in Chapter 7 regarding the process of controlling costs, including the sections on tools and techniques, contingency activities and contingency management. Resource planning was deleted, but the process of planning for human resources was further defined in Chapter 9.
19. We moved and expanded the section on Earned Value within Chapter 7 to further define its use. We moved the section on resource planning.

20. Minor updates were made to Chapter 8 but several new sub-sections were added to augment the information already contained therein.
21. Chapter 10 now includes information on feedback and status review meetings to show the importance of these processes in project communication.
22. Sub-sections were added in Chapter 11 to provide information on risk categories, assumptions, probability, impact and list of potential responses. A new diagram on Risk Breakdown Structures was introduced.
23. The last section in Chapter 11 includes a repeat of risk management processes to indicate that the risk processes should be repeated throughout the project life cycle.
24. Chapter 12 includes some title changes, but was updated primarily to reflect the project team as the buyer of materiel, products, goods and services for the project and as either the buyer of the project or the seller of the project under a contract.
25. The glossary was significantly revised and augmented. Some terms have been categorized to avoid confusion.
26. We added the following processes:
 - Develop Project Charter (Section 4.1)
 - Develop Project Scope Statement (Section 4.2)
 - Monitor and Control Project Work (Section 4.5)
 - Close Project (Section 4.7)
 - Create Work Breakdown Structure (Section 5.3)
 - Activity Resource Estimating (Section 6.3)
 - Manage Project Team (Section 9.4)
27. All of the process inputs, tools and techniques and outputs have been revised to support the improved integration and mapping of the processes.

You are invited to download an Adobe PDF® of the Exposure Draft of the *PMBOK® Guide* – Third Edition and review it in detail. After reviewing the exposure draft, if you have recommendations for further improvements please provide those recommendations to the *PMBOK® Guide* 2004 Update Project Team for their consideration using the process outlined on the PMI Web site.

Dennis Bolles, PMP
Project Manager
PMBOK® Guide 2004 Update Project Team

Steve Fahrenkrog, PMP
PMI Standards Manager

Chapter 1

Introduction

The Project Management Body of Knowledge (PMBOK[®]) is the sum of knowledge within the profession of project management. As with other professions such as law, medicine and accounting, the body of knowledge rests with the practitioners and academics that apply and advance it. The complete project management body of knowledge includes proven traditional practices that are widely applied and innovative practices that are emerging in the profession. The body of knowledge includes both published and unpublished material. The PMBOK[®] is constantly evolving.

This chapter defines several key terms and provides an overview of the rest of the Guide in the following major sections:

- 1.1 Purpose of This Guide**
- 1.2 What Is a Project?**
- 1.3 What Is Project Management?**
- 1.4 The PMBOK[®] Guide Structure**
- 1.5 Areas of Expertise**
- 1.6 Related Endeavors**

1.1 PURPOSE OF THIS GUIDE

The primary purpose of *A Guide to the Project Management Body of Knowledge (PMBOK[®] Guide)* is to identify the major elements of the body of knowledge that are generally recognized as good practice. *Identify* means to provide a general overview as opposed to an exhaustive description. *Generally recognized* means that the knowledge and practices described are applicable to most projects most of the time, and that there is widespread consensus about their value and usefulness. *Good practice* implies that there is general agreement that the correct application of these skills, tools and techniques can enhance the chances of success over a wide range of different projects. This does not mean that the knowledge described should always be applied uniformly on all projects; the project management team is always responsible for determining what is appropriate for any given project.

The PMBOK[®] Guide also provides and promotes a common lexicon for talking, writing and applying project management. Such a standard lexicon is an essential element of a profession.

The Project Management Institute uses this document as a basic, but not the sole, project management reference for its professional development programs including:

- Project Management Professional (PMP[®]) certification.
- Certified Associate in Project Management (CAPM[™]) certification.
- Accreditation of educational programs in project management.

As a basic reference, this Guide is neither comprehensive nor all-inclusive. Appendix E discusses application area extensions, while Appendix F lists sources of further information on project management.

This standard addresses only single projects. There are other PMI standards on programs, portfolios, organizational project management maturity and project manager competency that address what is generally recognized as good practices in those areas. Some of the material in those other standards impacts single projects. For example, part of the PMI organizational project management maturity standard describes how various activities and their associated standards are merged into a cohesive whole that supports the organization's business strategy through consistent, predictable and successful project execution. The other PMI standards should be consulted for additional information and understanding of the broader context in which projects are accomplished.

Standards do not address all details of every topic. A standard addresses major items that have been shown to represent good practice. Topics or activities that are not mentioned should not be considered unimportant. There are several reasons why a topic may not be included in a standard: it may be included within some other related standard, it may be too general so that there is nothing uniquely applicable to project management, or there is insufficient consensus on a topic. The lack of consensus means there are variations in the profession regarding how, when or where within the organization, as well as who within the organization, should perform that specific activity. The project management team or organization must decide how the activities are going to be addressed.

1.1.1 The Audience for this Guide

This document provides a basic reference for anyone interested in the profession of project management. This includes, but is not limited to:

- Senior executives
- Program Managers and managers of project managers
- Project managers and other project team members
- Members of a Project Management Office
- Customers and other project stakeholders
- Functional managers with employees assigned to project teams
- Educators teaching project management and related subjects
- Consultants and other specialists in project management and related fields
- Trainers developing project management educational programs
- Research scientists analyzing project management.

1.2 WHAT IS A PROJECT?

1.2.1 Project Characteristics

A project is a temporary endeavor undertaken to create a unique product, service, or result.

.1 Temporary

Temporary means that every project has a definite beginning and a definite end. The end is reached when the project's objectives have been achieved, or it becomes clear that the project objectives will not or cannot be met, or the need for the project no longer exists and the project is terminated. Temporary does not necessarily mean short in duration; many projects last for several years. In every case, however, the duration of a project is finite; projects are not ongoing efforts.

In addition, temporary does not generally apply to the product or service created by the project. Most projects are undertaken to create a lasting result. For example, a project to erect a national monument will create a result expected to last centuries. In addition, projects may often have intended and unintended social, economic and environmental impacts that far outlast the projects themselves.

The temporary nature of projects may apply to other aspects of the endeavor as well:

- The opportunity or market window is usually temporary—some projects have a limited time frame in which to produce their product or service
- The project team, as a functioning unit, seldom outlives the project—a team created for the sole purpose of performing the project will perform that project, and then the team is disbanded and reassigned when the project is complete.

.2 Unique Product, Service or Result

Projects involve creating something that has not been done in exactly the same way before and which is, therefore, *unique* and distinct. Projects create:

- A product or artifact that is produced, is quantifiable and can be either an end item in itself or a component item
- A capability to perform a service, such as business functions supporting production or distribution
- A result, such as new knowledge. For example, a research and development project develops knowledge that can be used to determine whether or not a trend is present or a new process will benefit society.

.3 Progressive Elaboration

Progressive elaboration is a characteristic of projects that accompanies the concepts of temporary and unique. Progressive elaboration means developing thoroughly in steps, and continuing steadily by increments. For example, the project scope will be broadly described early in the project, and made more explicit and detailed as the project team develops a better and more complete understanding of the objectives and deliverables. Progressive elaboration should not be confused with scope creep (Section 5.4).

Progressive elaboration of project specifications must be carefully coordinated with proper project scope definition, particularly if the project is performed under contract. When properly defined, the scope of the project—the work to be done—should be controlled as the project and product specifications are progressively elaborated. The relationship between product scope and project scope is discussed further in the introduction to Chapter 5.

The following examples illustrate progressive elaboration in two different application areas.

Example 1. Development of a chemical processing plant begins with process engineering to define the characteristics of the process. These characteristics are used to design the major processing units. This information becomes the basis for engineering design, which defines both the detail plant layout and the mechanical characteristics of

the process units and ancillary facilities. All of this results in design drawings that are elaborated to produce fabrication and construction drawings. During construction, interpretations and adaptations are made as needed and subject to proper approval. This further elaboration of the deliverables is captured in as-built drawings, and final operating adjustments are made during testing and turnover.

Example 2. The product of an economic development project may initially be defined as: “Improve the quality of life of the lowest income residents of community X.” As the project proceeds, the products may be described more specifically as, for example: “Provide access to food and water to 500 low income residents in community X.” The next round of progressive elaboration might focus exclusively on increasing agriculture production and marketing, with provision of water deemed to be a secondary priority to be initiated once the agricultural component is well under way.

1.2.2 Projects vs. Operational Work

Organizations perform work to achieve a set of objectives. Generally, work can be categorized as either projects or operations, although the two sometimes overlap. They share many of the following characteristics:

- Performed by people
- Constrained by limited resources
- Planned, executed and controlled.

Projects and operations differ primarily in that operations are ongoing and repetitive, while projects are temporary and unique.

The objectives of projects and operations are fundamentally different. The purpose of a project is to attain its objective and then terminate. Conversely, the objective of an ongoing operation is to sustain the business. Projects are different because the project concludes when its specific objectives have been attained, while operations adopt a new set of objectives and the work continues.

Projects are undertaken at all levels of the organization and they can involve a single person or many thousands. Their duration ranges from a few weeks to several years.

Projects can involve one or many organizational units, such as joint ventures and partnerships. Examples of projects include:

- Developing a new product or service
- Effecting a change in structure, staffing, or style of an organization
- Designing a new transportation vehicle
- Developing or acquiring a new or modified information system
- Constructing a building or facility
- Building a water system for a community in a developing country
- Running a campaign for political office
- Implementing a new business procedure or process
- Responding to a contract solicitation.

1.2.3 Projects and Strategy

Projects are a means of organizing activities that cannot be addressed within the organization’s normal operational limits. Projects are therefore often utilized as a means

of achieving an organization's strategic plan, whether the project team is employed by the organization or is a contracted service provider.

Projects are typically authorized as a result of one or more of the following strategic considerations:

- A market demand (e.g., an oil company authorizes a project to build a new refinery in response to chronic gasoline shortages)
- A business need (e.g., a training company authorizes a project to create a new course in order to increase its revenues)
- A customer request (e.g., an electric utility authorizes a project to build a new substation to serve a new industrial park)
- A technological advance (e.g., an electronics firm authorizes a new project to develop a new generation of video game player after the introduction of the corresponding new game format)
- A legal requirement (e.g., a paint manufacturer authorizes a project to establish guidelines for the handling of a new toxic material).

1.3 WHAT IS PROJECT MANAGEMENT?

Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements. Project management is accomplished through the use of the processes of initiating, planning, executing, monitoring and controlling, and closing. The project manager is the individual responsible for managing the project.

Managing involves:

- Identifying requirements
- Establishing clear and achievable objectives
- Balancing the competing demands for quality, scope, time and cost
- Adapting the specifications plans and approach to the different concerns and expectations of the various stakeholders.

Project managers often talk of a *triple constraint*—project scope, time and cost—in managing competing project requirements. Project quality is affected by balancing these three factors (Chapters 5 through 7). High quality projects deliver the required product or service within scope, on time and within budget. The relationship among these factors is such that if any one of the three factors changes, at least one other factor must change.

Project managers must also manage projects in response to uncertainty. Project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective.

The project management team has a professional responsibility to its stakeholders including: customers, the performing organization and the public. PMI members adhere to a “Code of Ethics” and Project Management Professionals (PMP®) adhere to a “Code of Professional Conduct.” Project team members who are PMI members and/or PMPs are obligated to adhere to the current versions of these codes.

It is important to note that many of the processes within project management are iterative in nature because of the existence of, and necessity for, progressive elaboration in a project throughout the project’s life cycle; that is, as a project management team learns more about a project, they can manage to a greater level of detail.

The term *project management* often describes an organizational approach to the management of ongoing operations. This approach, more properly called *management by projects*, treats many aspects of ongoing operations as projects to ensure the application of proven project management techniques. Although an understanding of project management is critical to an organization that is managing by projects, a detailed discussion of the approach itself is outside the scope of this Guide.

1.4 THE PMBOK® GUIDE STRUCTURE

The *PMBOK® Guide* is organized into three sections.

1.4.1 Section I: The Project Management Framework

Section I, The Project Management Framework, provides a basic structure for understanding project management.

Chapter 1, **Introduction**, defines key terms and provides an overview for the rest of the *PMBOK® Guide*.

Chapter 2, **Project Life Cycle and Organization**, describes the environment in which projects operate. The project management team must understand this broader context; managing the day-to-day activities of the project is necessary, but not sufficient to ensure success.

1.4.2 Section II: The Standard for Project Management of a Project

Section II, The Standard for Project Management of a Project, specifies all the processes that are required to manage a project.

Chapter 3, **Project Management Processes for a Project**, describes the five required Project Process Groups for any project. This chapter describes the multi-dimensional nature of project management.

1.4.3 Section III: The Project Management Knowledge Areas

Section III, The Project Management Knowledge Area Processes, organizes the 44 processes from Chapter 3 into nine knowledge areas as described below.

Chapter 4, **Project Integration Management**, describes the processes and activities that support the various elements of project management, which are identified, defined, combined, unified and coordinated within the Project Process Groups.

Chapter 5, **Project Scope Management**, describes the processes involved in ascertaining that the project includes all the work required, and only the work required, to complete the project successfully. It consists of scope planning, scope definition, create work breakdown structure (WBS), scope verification and scope control processes.

Chapter 6, **Project Time Management**, describes the processes concerning the timely completion of the project. It consists of activity definition, activity sequencing, activity resource estimating, activity duration estimating, schedule development and schedule control processes.

Chapter 7, **Project Cost Management**, describes the processes involved in planning, controlling, and managing costs so that the project is completed within the approved budget. It consists of cost estimating, cost budgeting and cost control processes.

Chapter 8, **Project Quality Management**, describes the processes involved in assuring that the project will satisfy the objectives for which it was undertaken. It consists of quality planning, perform quality assurance, and perform quality control processes.

Chapter 9, **Project Human Resource Management**, describes the processes needed to make the most effective use of the people involved with the project. It consists of human resource planning, acquire project team, develop project team and manage project team processes.

Chapter 10, **Project Communications Management**, describes the processes concerning the timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information. It consists of communications planning, information distribution, performance reporting and manage stakeholders processes.

Chapter 11, **Project Risk Management**, describes the processes concerned with conducting risk management on a project. It includes the processes of risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control processes.

Chapter 12, **Project Procurement Management**, describes the processes required to purchase or acquire materiel, products, goods and services, as well as contract management processes. It consists of plan purchases and acquisitions, plan contracting, request seller responses, select sellers, contract administration and contract closure processes.

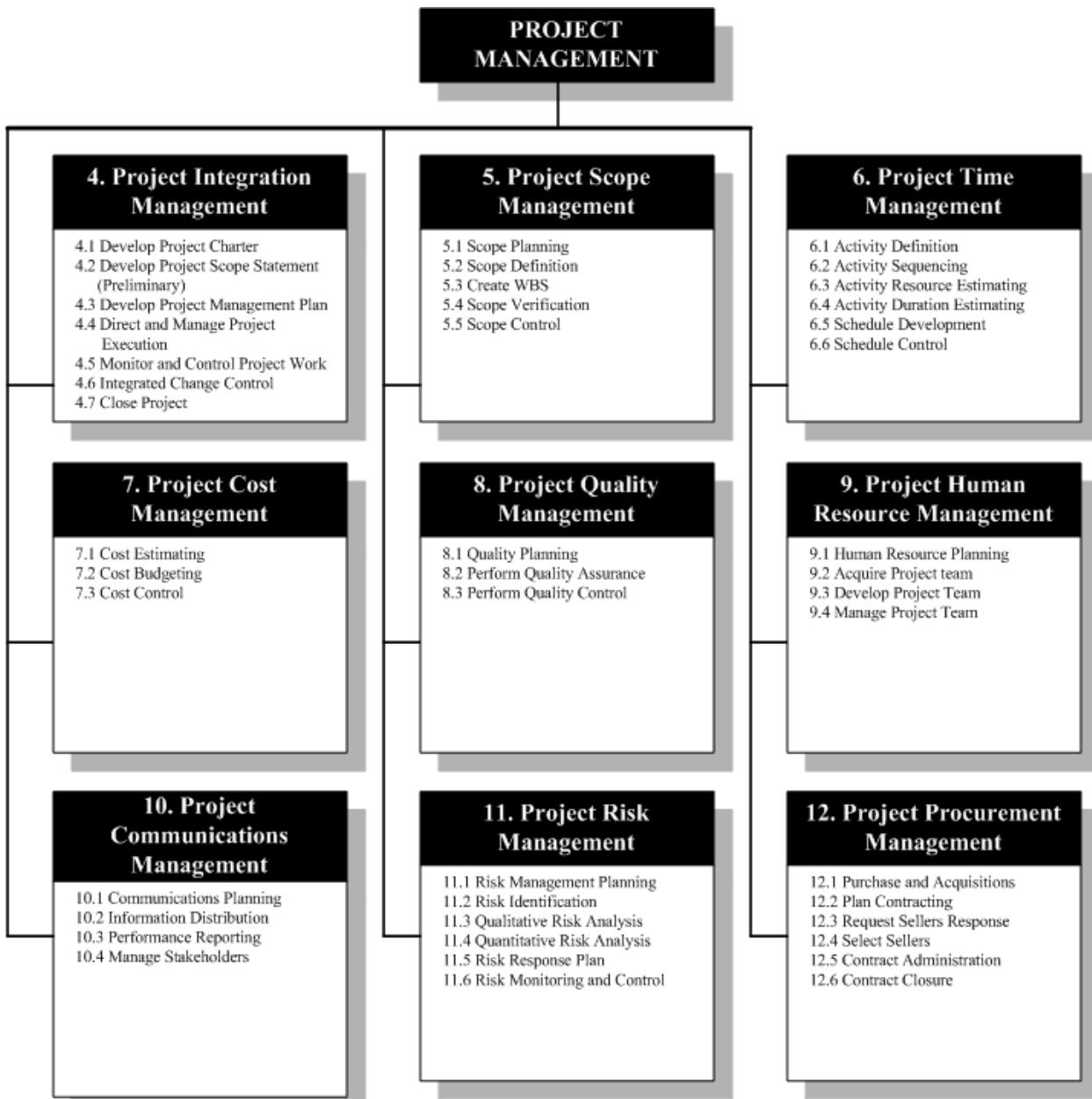


Figure 1-1 Overview of Project Management Knowledge Areas and Project Management Processes

1.5 AREAS OF EXPERTISE

Many of the techniques for managing projects are unique to project management, such as work breakdown structures, critical path analysis and earned value management.

However, these techniques alone are not sufficient for effective project management.

Effective management requires that the project management team understand and use at least five areas of expertise:

- The project management body of knowledge
- Application area knowledge, standards and regulations
- Project environment knowledge
- General management knowledge and skills
- Soft skills or human relations skills.

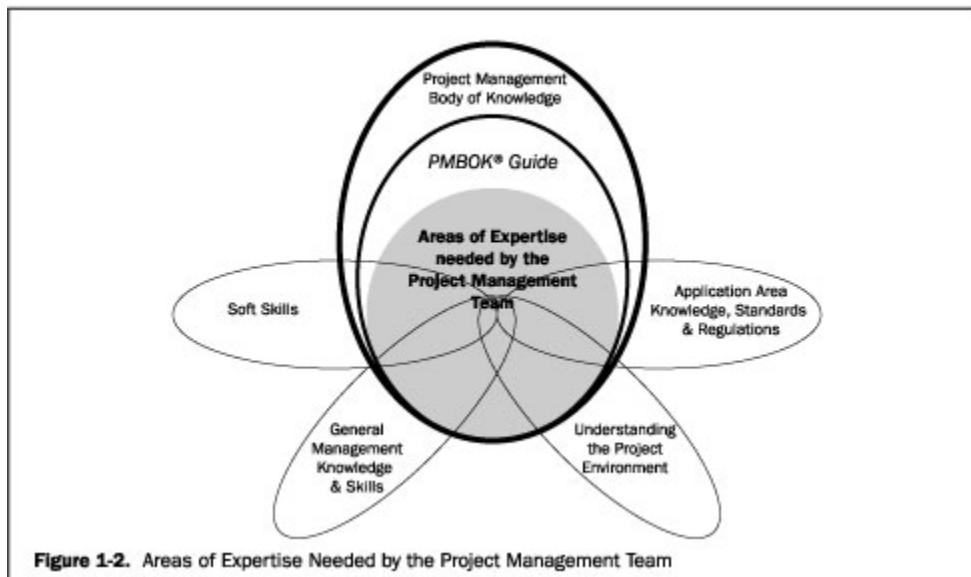
Figure 1-2 illustrates the relationship among these five areas of expertise. Although they appear as discrete elements, they generally overlap; none can stand alone. Effective project teams integrate them into all aspects of their project. It is not necessary for every project team member to be an expert in all five areas. In fact, it is unlikely that any one person will have all the knowledge and skills needed for the project.

1.5.1 Project Management Body of Knowledge

The Project Management Body of Knowledge (PMBOK[®]) describes knowledge unique to the project management field and overlaps other management disciplines, as shown in Figure 1-2. The *PMBOK[®] Guide* is a subset of the larger PMBOK[®].

The knowledge of project management described in the *PMBOK[®] Guide* consists of:

- Project life cycle definition (Chapter 2)
- Five Project Process Groups (Chapters 3)
- Nine Knowledge Areas (Chapters 4-12).



1.5.2 Application Area Knowledge, Standards and Regulations

Application areas are categories of projects that have common elements significant in such projects, but are not needed or present in all projects. Application areas are usually defined in terms of:

- Functional departments and supporting disciplines, such as legal, production and inventory management, marketing, logistics and personnel
- Technical elements, such as software development, water and sanitation engineering, and construction engineering
- Management specializations, such as government contracting, community development and new product development.
- Industry groups, such as automotive, chemical, agriculture and financial services.

Each application area generally has a set of accepted standards and practices, often codified in regulations. The International Organization for Standardization (ISO) differentiates between standards and regulations as follows (ISO, 1994):

- A standard is a “document established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.” Some examples of standards are computer diskette sizes and the thermal stability specifications of hydraulic fluids.
- A regulation is a government-imposed requirement, which lays down product, process or service characteristics, including the applicable administrative provisions, with which compliance is mandatory. Building codes are an example of regulations.

There is a vast gray area between standards and regulations. For example:

- Standards often begin as guidelines that describe a preferred approach and later, with widespread adoption, become *de facto* regulations.
- Different organizational levels can mandate compliance, such as when a government agency, the management of the performing organization, or the project management team establish specific policies and procedures.

A more detailed discussion of project management application areas appears in Appendix E.

1.5.3 Understanding the Project Environment

The project management team should consider the project in its social, political, and physical environmental contexts.

- *Social environment.* The team needs to understand how the project affects people and how people affect the project. This may require an understanding of aspects of the economic, demographic, educational, ethical, ethnic, religious and other characteristics of the people whom the project affects or who may have an interest in the project. The project manager should also examine the organizational culture and determine whether project management is recognized as a valid profession.
- *Political environment.* Some team members may need to be familiar with applicable international, national, regional and local laws, customs and political climate that could affect the project.

- *Physical environment.* If the project will affect its physical surroundings, some team members should be knowledgeable about the local ecology and physical geography that could affect the project or be affected by the project.

1.5.4 General Management Knowledge and Skills

General management encompasses planning, organizing, staffing, executing and controlling the operations of an ongoing enterprise. It includes supporting disciplines such as:

- Financial management and accounting
- Purchasing and procurement
- Sales and marketing
- Contracts and commercial law
- Manufacturing and distribution
- Logistics and supply chain
- Strategic planning, tactical planning and operational planning
- Organizational structures, organizational behavior, personnel administration, compensation, benefits and career paths
- Health and safety practices.

General management provides much of the foundation for building project management skills. They are often essential for the project manager. On any given project, skill in any number of general management areas can be required. General management literature documents these skills, and their application is fundamentally the same on a project.

1.5.5 Soft Skills

Soft skills include the management of interpersonal relationships. Soft skills include:

- Effective communication: the exchange of information
- Influencing the organization: the ability to “get things done”
- Leadership: developing a vision and strategy, and aligning people to achieve it
- Motivation: energizing people to achieve high levels of productivity and to overcome barriers to change
- Negotiation and conflict management: conferring with others to come to terms with them or to reach an agreement
- Problem solving: the combination of problem definition and decision-making.

1.6 RELATED ENDEAVORS

In the broader context, project management includes related endeavors such as program and portfolio management. These apply the same basic skills as managing a project, but are performed on different levels. Frequently, there is a hierarchy of strategic plan, portfolio, program, project and subproject, in which a program consisting of several associated projects will contribute to the achievement of a strategic plan. These related undertakings are described below.

1.6.1 Programs and Program Management

A program is a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work outside of the scope of the discrete projects in the program. For example:

- A new car model program can be broken up into projects for the design and upgrades of each major component (for example, transmission, engine, interior, exterior) while the ongoing manufacturing occurs on the assembly line.
- Many electronics firms have program managers who are responsible for both individual product releases (projects) and the coordination of multiple releases over a period of time (an ongoing operation).

Programs also involve a series of repetitive or cyclical undertakings. For example:

- Utilities often speak of an annual “construction program,” a regular, ongoing operation that involves many projects.
- Many nonprofit organizations have a “fundraising program,” an ongoing effort to obtain financial support involving a series of discrete projects, such as a membership drive or an auction.
- Publishing a newspaper or magazine is also a program with the periodical itself as an ongoing effort, but each individual issue managed as a project. This is an example of where general operations can become management by projects (Section 1.3).

In contrast with project management, program management is the centralized coordinated management of a program to achieve the program's strategic objectives and benefits.

1.6.2 Portfolios and Portfolio Management

A portfolio is a collection of projects or programs and other work that are grouped together to facilitate effective management of that work to meet strategic business objectives. The projects or programs in the portfolio may not necessarily be interdependent or directly related. Funding and support can be assigned on the basis of risk/reward categories, specific lines of business, or general types of projects, such as infrastructure and internal process improvement.

Organizations manage their portfolios based on specific goals. One goal of portfolio management is to maximize the value of the portfolio by careful examination of candidate projects and programs for inclusion into the portfolio, and the timely exclusion of projects not meeting the portfolio's strategic objectives. Other goals are to balance the portfolio among incremental and radical investments and for efficient use of resources. Senior managers or senior management teams typically take on the responsibility of portfolio management for an organization.

1.6.3 Subprojects

Projects are frequently divided into more manageable components or subprojects, though they can be referred to as projects and managed as such. Subprojects are often contracted to an external enterprise or to another functional unit in the performing organization.

Examples include:

- Subprojects based on the project process, such as a single phase in the project life cycle

- Subprojects according to human resource skill requirements, such as plumbers or electricians needed on a construction project
- Subprojects involving specialized technology, such as the automated testing of computer programs on a software development project.

On very large projects, the subprojects can consist of series of smaller projects.

1.6.4 Project Management Office

A Project Management Office (PMO) is an organizational unit to centralize and coordinate the management of projects under its domain. A PMO can also be referred to as a “Program Management Office,” “Project Office,” or “Program Office.” A PMO oversees the management of projects, programs, or a combination of both. The projects administered by the PMO do not necessarily have a specific relationship other than their mutual management. But, in many organizations, those projects are indeed grouped or are related in some manner (Refer to Sections 1.6.1 and 1.6.2). The PMO focuses on the coordinated planning, prioritization and execution of projects and subprojects that are tied to the parent organization’s or client’s overall business objectives.

Since there is no consensus on what PMOs must entail, they can operate on a continuum from providing project management support functions in the form of training, software, standardized policies and procedures, and templates to actual direct management and results of the projects. A specific PMO can receive delegated authority to act as an integral stakeholder and a key decision maker during the initiation stage of each project, can have the authority to make recommendations, or can terminate projects to keep the business objectives consistent. In addition, the PMO can be involved in the selection, management and redeployment, if necessary, of shared project personnel and, where possible, dedicated project personnel.

Some of the key features of a PMO include, but are not limited to:

- Shared and coordinated resources across all PMO projects
- Identification and development of project management methodology, best practices and standards
- Clearinghouse and management for project policies, procedures, templates and other shared documentation
- Centralized configuration management for all PMO projects
- Centralized repository and management for both shared and unique risks for all projects
- Central office for operation and management of project tools, such as enterprise-wide project software
- Central coordination of communication management across projects
- A mentoring platform for project managers
- Central monitoring of all PMO project timelines and budgets, usually at the enterprise level
- Coordination of overall project quality standards between the project manager and any internal or external quality personnel or standards organization.

Differences between project management and a PMO include the following:

- Project managers and PMOs pursue different objectives and, as such, are driven by different requirements. All efforts must be aligned with the strategic needs of the organization.

- A project manager is responsible for delivering specific project objectives within the constraints of the project, while a PMO is an organizational structure with specific mandates that can include an enterprisewide perspective.
- The project manager focuses on the specified project objectives, while the PMO manages major program scope changes and can view them as potential opportunities to better achieve business objectives.
- The project manager controls the assigned project resources to best meet project objectives, while the PMO optimizes the use of shared organizational resources across all projects.
- The project manager manages the scope, schedule, cost and quality of the products of the work packages, while the PMO manages overall risk, overall opportunity and all project interdependencies.

The structure, function, and use of any PMO within an organization varies based upon the *application areas* involved and the *portfolios, programs, or projects* being addressed. There is *generally recognized* value and usefulness in utilizing a PMO in the *project management* of the organization's projects. However, there is no generally recognized single construct of a PMO within the context of project management.

Chapter 2

Project Life Cycle and Organization

Projects and project management are carried out in an environment broader than that of the project itself. The project management team must understand this broader context so they can select the life cycle phases, tools and processes that appropriately fit the project. This chapter describes some key aspects of the project management context. The topics included here are:

- 2.1 The Project Life Cycle
- 2.2 Project Stakeholders
- 2.3 Organizational Influences

2.1 THE PROJECT LIFE CYCLE

Project managers or the organization can divide projects into *phases* to provide better management control with appropriate links to the ongoing operations of the performing organization. Collectively, these phases are known as the *project life cycle*. Many organizations identify a specific set of life cycles for use on all of their projects.

2.1.1 Characteristics of the Project Life Cycle

The project life cycle defines the phases that connect the beginning of a project to its end. For example, when an organization identifies an opportunity to which it would like to respond, it will often authorize a feasibility study to decide whether it should undertake the project. The project life cycle definition can help the project manager clarify whether to treat the feasibility study as the first project phase or as a separate, stand-alone project. Where the conclusion of such a preliminary effort is not clearly identifiable, it is best to treat such efforts as a separate project.

The phase sequence defined by most project life cycles generally involves some form of technology transfer or handoff, such as from requirements to design, from construction to operations, or from design to manufacturing. Deliverables from one phase are usually reviewed for technical accuracy and approved before work starts on the next phase. However, it is not uncommon for a phase to begin prior to the approval of the previous phase's deliverables when the risks involved are deemed acceptable. This practice of overlapping phases is an example of the management technique called *fast tracking*.

There is no single best way to define an ideal project life cycle. Some organizations have established policies that standardize all projects with a single life cycle, while others allow the project management team to choose the most appropriate life cycle for their context. Further, industry common practices will often lead to the use of a preferred life cycle.

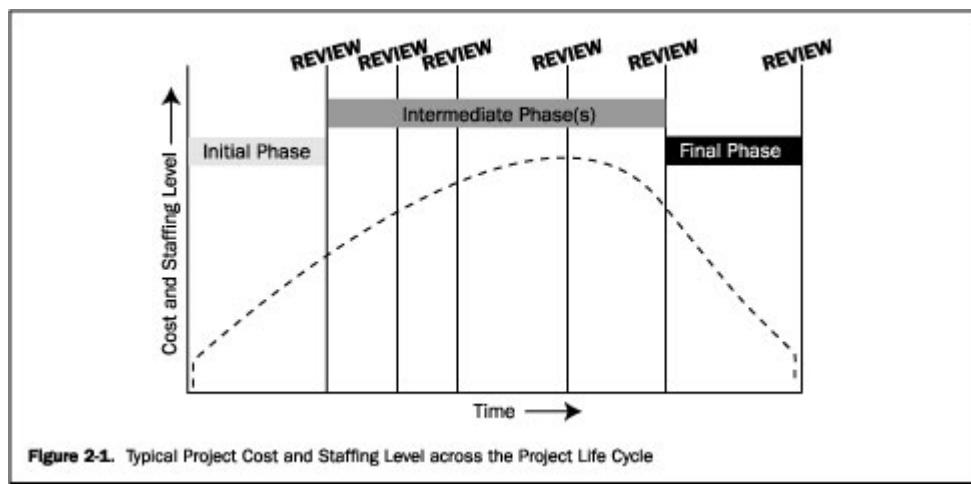
Project life cycles generally define:

- What technical work to do in each phase (for example, in which phase should the architect's work be performed?)
- When the deliverables are to be generated in each phase and how each deliverable is reviewed, verified and validated
- Who is involved in each phase (for example, concurrent engineering requires that the implementers be involved with requirements and design)
- How to control and approve each phase.

Project life cycle descriptions can be very general or very detailed. Highly detailed descriptions of life cycles can include forms, charts and checklists to provide structure and control.

Most project life cycles share a number of common characteristics:

- Cost and staffing levels are low at the start, peak during the intermediate phases and drop rapidly as the project draws to a conclusion. Figure 2-1 illustrates this pattern.



- The level of uncertainty is highest and, hence, risk of failing to achieve the objectives is highest at the start of the project. The certainty of completion generally gets progressively better as the project continues.
- The ability of the stakeholders to influence the final characteristics of the project's product and the final cost of the project is highest at the start, and gets progressively lower as the project continues. Figure 2-2 illustrates this. A major contributor to this phenomenon is that the cost of changes and error correction generally increases as the project continues.

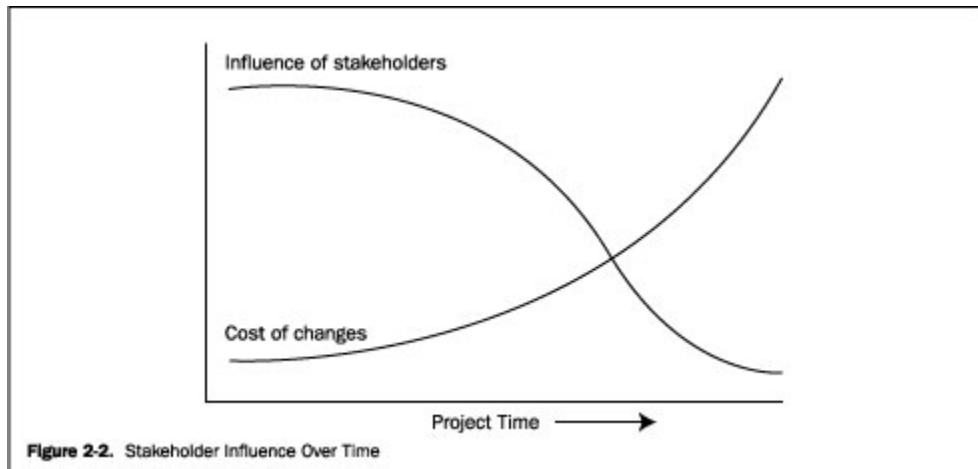


Figure 2-2. Stakeholder Influence Over Time

Although many project life cycles have similar phase names with similar deliverables, few life cycles are identical. Some can have four or five phases, but others may have nine or more. Single application areas are known to have significant variations. One organization's software development life cycle can have a single design phase, while another can have separate phases for architectural and detailed design. Subprojects can also have distinct project life cycles. For example, an architectural firm hired to design a new office building is first involved in the owner's definition phase while doing the design, and in the owner's implementation phase while supporting the construction effort. The architect's design project, however, will have its own series of phases from conceptual development, through definition and implementation, to closure. The architect can even treat designing the facility and supporting the construction as separate projects, each with their own set of phases.

2.1.2 Characteristics of Project Phases

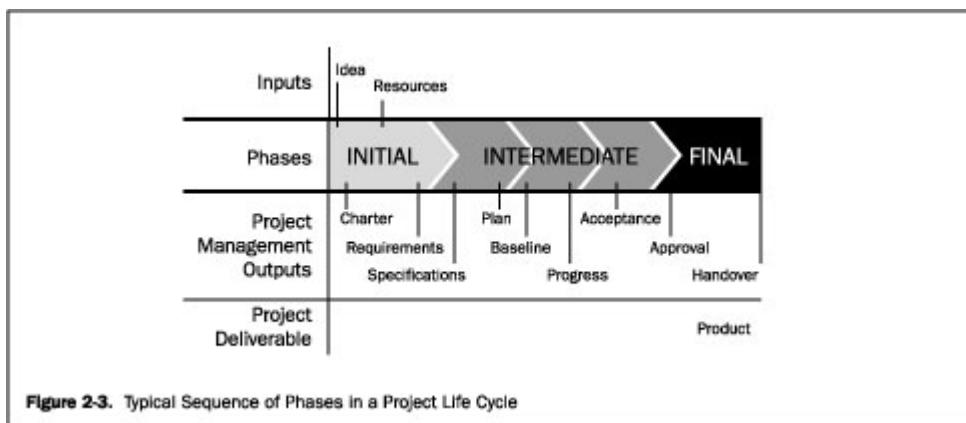
The completion and approval of one or more deliverables characterizes a project phase. A deliverable is a measurable, verifiable work product such as a specification, feasibility study report, detail design document, or working prototype. Some deliverables can correspond to the project management process, whereas others are the end products or components of the end products for which the project was conceived. The deliverables, and hence the phases, are part of a generally sequential process designed to ensure proper control of the project, and to attain the desired product or service, which is the objective of the project.

In any specific project, for reasons of size, complexity, level of risk and cash flow constraints, phases can be further subdivided into subphases. Each subphase is aligned to one or more specific deliverables for monitoring and control.

The end of a project phase is generally marked by a technical or design review of the work accomplished and the deliverables to decide acceptance, whether extra work is still required, or whether the phase should be considered closed. A management review is often held to reach a decision to start the activities of the next phase without closing the current phase, e.g., when the project manager chooses fast tracking as the course of action. Similarly, a phase can be closed without the decision to initiate any other phases. For example:

- When the project ends or when the risk is deemed too great for the project to be allowed to continue
- An information technology company chooses an iterative life cycle where more than one phase of the project might progress simultaneously. Requirements for a module can be gathered, analyzed, designed and constructed, and while analysis of a module is being done, the requirements gathering of another module could also start in parallel.

Formal phase completion does not include authorizing the subsequent phase. For effective control, each phase is formally initiated to produce a phase-dependent output specifying what is allowed and expected for that phase, as shown in Figure 2-3. A phase-end review can be held with the explicit goals of obtaining authorization to close the current phase and to initiate the subsequent one. Sometimes both authorizations can be gained at one review. These phase-end reviews are often called phase exits, or kill points.



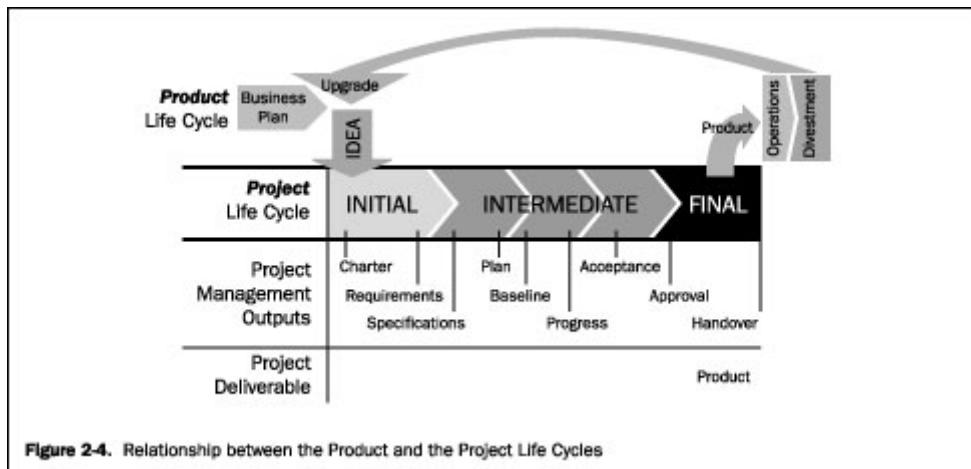
2.1.3 Project Life Cycle and Product Life Cycle Relationships

Many projects are linked to the ongoing work of the performing organization. In some organizations, a project is only formally approved following completion of a feasibility study, a preliminary plan, or some other equivalent form of analysis; in these cases, the preliminary planning or analysis takes the form of a separate project. For example, additional phases could come from developing and testing a prototype prior to initiating the project for the development of the final product. Some types of projects, especially internal service or new product projects, can be initiated informally for a limited amount of time to secure formal approval for additional phases or tasks.

The driving forces that create the stimuli for a project are typically referred to as problems, opportunities, or business requirements. The effect of these pressures is that management generally must prioritize this request with respect to the needs and resource demands of other potential projects.

The project life cycle definition will also identify which transitional actions at the end of the project are included or not included, in order to link the project to the ongoing operations of the performing organization. Examples would be when a new product is released to manufacturing, or a new software program is turned over to marketing. Care should be taken to distinguish the *project* life cycle from the *product* life cycle. For example, a project undertaken to bring a new desktop computer to market is only one aspect of the product life cycle. Figure 2-4 illustrates these ideas. In some application

areas, such as new product development or software development, organizations consider the project development life cycle as part of the product life cycle.



2.2 PROJECT STAKEHOLDERS

Project stakeholders are individuals and organizations that are actively involved in the project, or whose interests may be affected as a result of project execution or project completion; they may also exert influence over the project and its results. The project manager must identify the stakeholders, determine their requirements and, to the extent possible, manage their influence in relation to the requirements to ensure a successful project. Figure 2-5 illustrates the relationship between stakeholders and the project team.

Stakeholders have varying levels of responsibility and authority when participating on a project. These can range from occasional contributions in surveys and focus groups to full project sponsorship by providing financial and political support. Stakeholders who ignore this responsibility can have a damaging impact on the project objectives. Sometimes, stakeholder identification can be difficult. For example, some would argue that an assembly-line worker whose future employment depends on the outcome of a new product-design project is a stakeholder.

Key stakeholders on every project include:

- Project manager—the individual responsible for managing the project.
- Customer/User—the individual or organization that will use the project's product. There may be multiple layers of customers. For example, the customers for a new pharmaceutical product can include the doctors who prescribe it, the patients who take it and the insurers who pay for it. In some application areas, customer and user are synonymous, while in others, customer refers to the entity acquiring the project's results and users are those who will directly use the project's product.
- Performing organization—the enterprise whose employees are most directly involved in doing the work of the project.
- Project team members—the group that is performing the work of the project.
- Sponsor—the individual or group that provides the financial resources, in cash or in kind, for the project.

- Influencers—individuals or groups that are not directly related to the acquisition or the use of the project’s product, but due to their position in the customer organization can influence, positively or negatively, the course of the project.
- PMO—if it exists in the performing organization where the PMO has direct or indirect responsibility for the outcome of the project.

In addition to these, there are many different names and categories of project stakeholders—internal and external, owners and funders, sellers and contractors, team members and their families, government agencies and media outlets, individual citizens, temporary or permanent lobbying organizations, and society at large. The naming or grouping of stakeholders is primarily an aid to identifying which individuals and organizations view themselves as stakeholders. Stakeholder roles and responsibilities can overlap, such as when an engineering firm provides financing for a plant that it is designing.

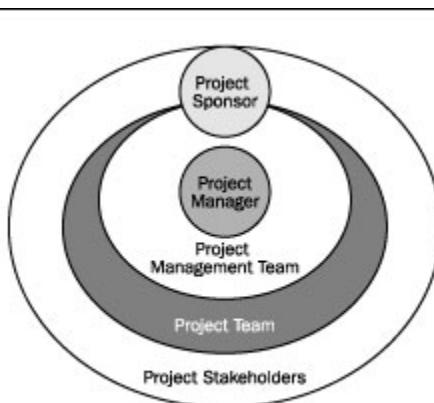


Figure 2-5. The Relationship between Stakeholders and the Project

Project managers must manage stakeholder expectations, which can be difficult, because stakeholders often have very different or conflicting objectives. For example:

- The manager of a department that has requested a new management information system may desire low cost, the system architect may emphasize technical excellence and the programming contractor may be most interested in maximizing its profit.
- The vice president of research at an electronics firm may define new product success as state-of-the-art technology, the vice president of manufacturing may define it as world-class practices and the vice president of marketing may be primarily concerned with the number of new features.
- The owner of a real estate development project may be focused on timely performance, the local governing body may desire to maximize tax revenue, an environmental group may wish to minimize adverse environmental impacts and nearby residents may hope to relocate the project.

In general, differences among stakeholders should be resolved in such a way to preserve, as far as possible, customer satisfaction. However, this does not mean that the needs and expectations of other stakeholders can or should be disregarded. Finding

appropriate resolutions to such differences can be one of the major challenges of project management.

2.3 ORGANIZATIONAL INFLUENCES

Projects are typically part of an organization that is larger than the project—corporations, government agencies, healthcare institutions, international bodies, professional associations and others. Even when the project is internal (joint ventures, partnering), the project will still be influenced by the organization or organizations that initiated it. The maturity of the organization with respect to its project management systems, culture, style, organizational structure and project management office can also influence the project. The following sections describe key aspects of these larger organizational structures that are likely to influence the project.

2.3.1 Organizational Systems

Project-based organizations are those whose operations consist primarily of projects. These organizations fall into two categories:

- Organizations that derive their revenue primarily from performing projects for others under contract—architectural firms, engineering firms, consultants, construction contractors and government contractors.
- Organizations that have adopted *management by projects* (Section 1.3). These organizations tend to have management systems in place to facilitate project management. For example, their financial systems are often specifically designed for accounting, tracking and reporting on multiple, simultaneous projects.

Non project-based organizations often lack management systems designed to support project needs efficiently and effectively. The absence of project-oriented systems usually makes project management more difficult. In some cases, non project-based organizations will have departments or other subunits that operate as project-based organizations with systems to support them. The project management team should be aware of how their organization's structure and systems affect the project. For example, if the organization rewards its functional managers for charging staff time to projects, then the project management team might need to implement controls to ensure that assigned staff members are used effectively on the project.

2.3.2 Organizational Cultures and Styles

Most organizations have developed unique and describable cultures. These cultures are reflected in:

- Their shared values, norms, beliefs and expectations
- Their policies and procedures
- Their view of authority relationships
- Numerous other factors.

Organizational cultures often have a direct influence on the project. For example:

- A team proposing an unusual or high-risk approach is more likely to secure approval in an aggressive or entrepreneurial organization.

- A project manager with a highly participative style is apt to encounter problems in a rigidly hierarchical organization, while a project manager with an authoritarian style will be equally challenged in a participative organization.

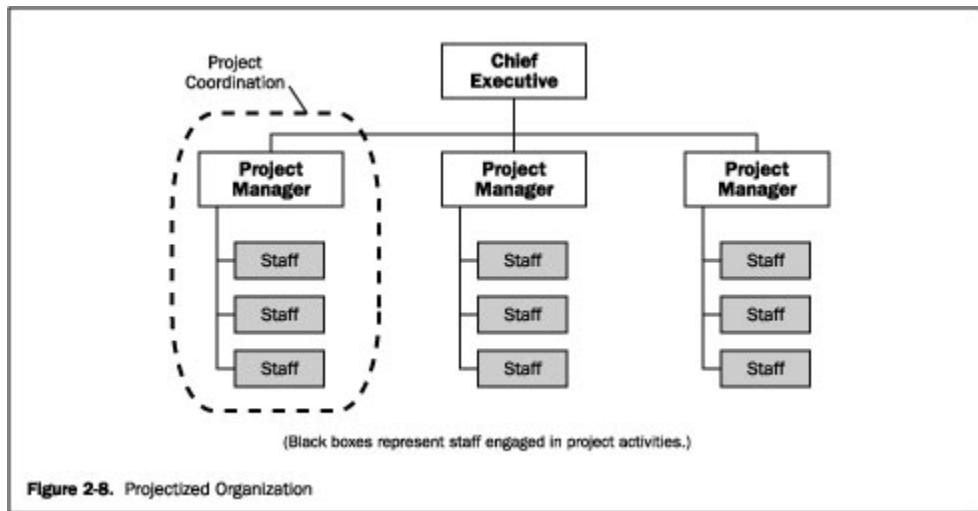
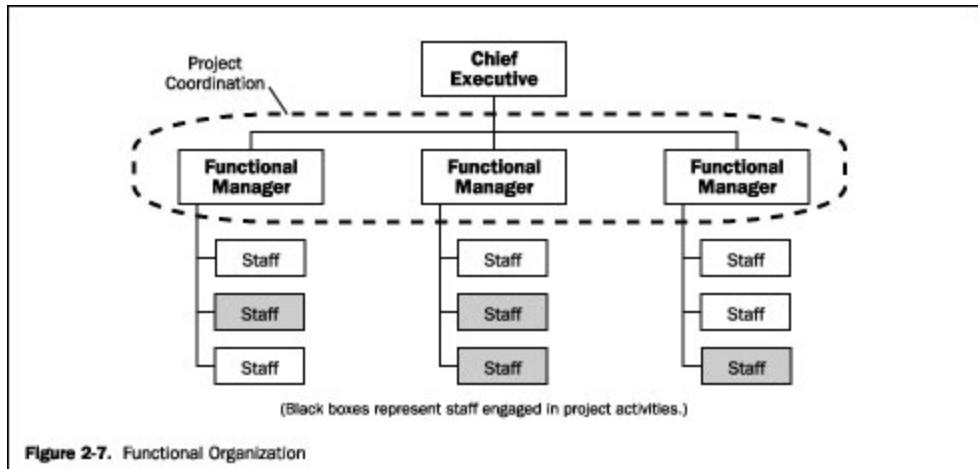
Project Characteristics	Organization Structure	Functional	Matrix			Projectized
			Weak Matrix	Balanced Matrix	Strong Matrix	
Project Manager's Authority	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total	
Resource Availability	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost Total	
Who controls the project budget	Functional Manager	Functional Manager	Mixed	Project Manager	Project Manager	
Project Manager's Role	Part-time	Part-time	Full-time	Full-time	Full-time	
Common Titles for Project Manager's Role	Project Coordinator/Project Leader	Project Coordinator/Project Leader	Project Manager/Project Officer	Project Manager/Program Manager	Project Manager/Program Manager	
Project Management Administrative Staff	Part-time	Part-time	Part-time	Full-time	Full-time	

Figure 2-6. Organizational Structure Influences on Projects

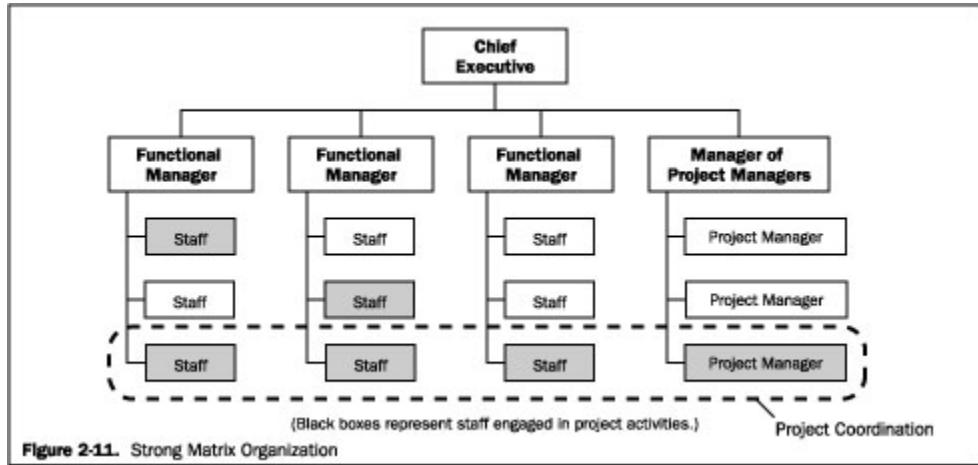
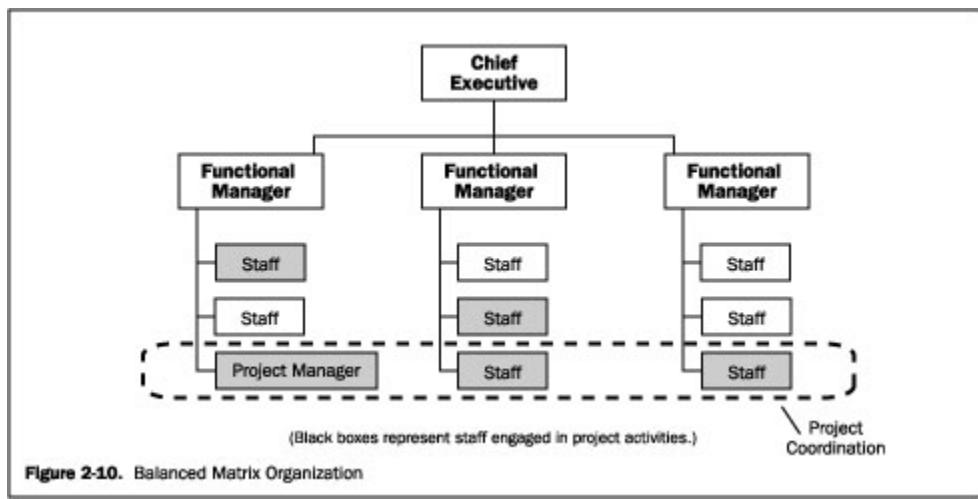
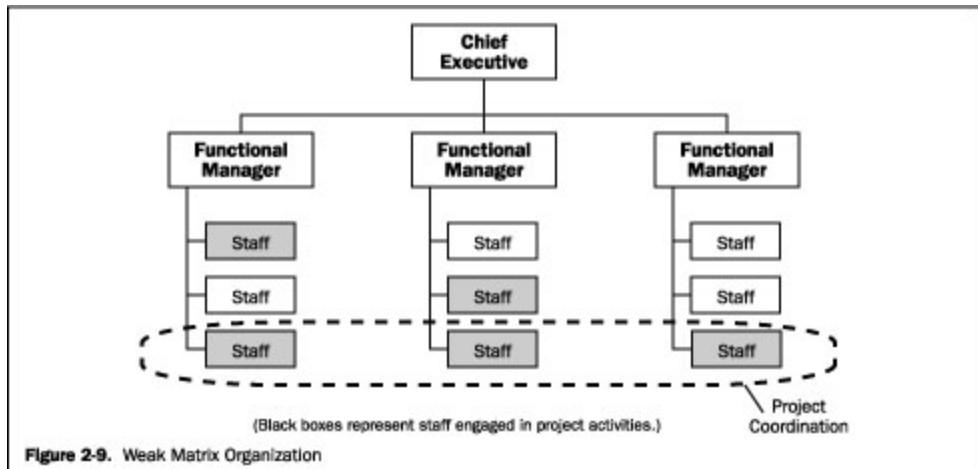
2.3.3 Organizational Structure

The structure of the performing organization often constrains the availability of resources in a spectrum from functional to projectized, with a variety of matrix structures in between. Figure 2-6 shows key project-related characteristics of the major types of organizational structures.

The classic *functional organization*, shown in Figure 2-7, is a hierarchy where each employee has one clear superior. Staff members are grouped by specialty, such as production, marketing, engineering and accounting at the top level. Engineering may be further subdivided into functional organizations that support the business of the larger organization, such as mechanical and electrical. Functional organizations still have projects, but the scope of the project is usually limited to the boundaries of the function. The engineering department in a functional organization will do its project work independent of the manufacturing or marketing departments. When new product development is undertaken in a purely functional organization, the design phase, often called a *design project*, includes only engineering department staff. Then, when questions about manufacturing arise, they are passed up the organizational hierarchy to the department head, who consults with the head of the manufacturing department. The engineering department head then passes the answer back down the hierarchy to the engineering functional manager.



At the opposite end of the spectrum is the *projectized organization*, shown in Figure 2-8. In a projectized organization, team members are often collocated. Most of the organization's resources are involved in project work and project managers have a great deal of independence and authority. Projectized organizations often have organizational units called departments, but these groups either report directly to the project manager or provide support services to the various projects.



Matrix organizations, as shown in Figures 2-9 through 2-11, are a blend of functional and projectized characteristics. Weak matrices maintain many of the characteristics of a functional organization and the project manager role is more that of a coordinator or expeditor than that of a manager. In similar fashion, strong matrices have many of the

characteristics of the projectized organization and can have full-time project managers with considerable authority and full-time project administrative staff.

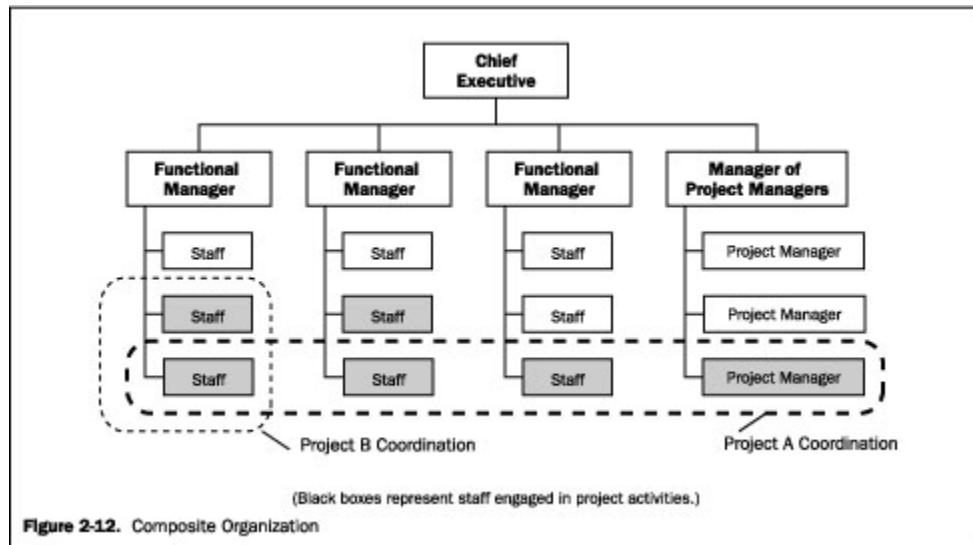


Figure 2-12. Composite Organization

Most modern organizations involve all these structures at various levels, as shown in Figure 2-12 (Composite Organization). For example, even a fundamentally functional organization may create a special project team to handle a critical project. Such a team may have many of the characteristics of a project in a projectized organization. The team may include full-time staff from different functional departments, may develop its own set of operating procedures and may operate outside the standard, formalized reporting structure.

Although the term *Tight Matrix* can be found in some project management texts and study guides, it is not commonly used. *Tight Matrix* does not refer to a particular type of organizational or management structure, but rather is a term used in place of “collocation” or “war room,” where the project team members are physically located in proximity, often in the same room (Section 9.3).

2.3.4 The Role of the PMO in Organizational Structures

Many organizations realize the benefit of developing and implementing a PMO (Section 1.5). This is often true of those organizations employing a matrix organizational structure and almost always true of those employing a projectized organizational structure, especially when the parent organization is involved with the simultaneous management of multiple and/or sequential projects.

A PMO can exist in any of the organizational structures, including those with a *functional organization*, with increasing likelihood of occurrence toward the rightmost columns in Figure 2-5.

A PMO's function in an organization may range from an advisory influence, limited to the recommendation of specific policies and procedures on individual projects, to a formal grant of authority from executive management. In such cases, the PMO may, in turn, delegate its authority to the individual project manager. In such an instance, the full-time project manager's authority becomes total with respect to the individual project and is only superseded by that of the PMO. The project manager will have administrative

support from the PMO either through dedicated staff or through a shared staff member. The project team members will either be dedicated to the project, or might include staff members who are shared with other projects and, in turn, are managed by the PMO.

Project team members will report either directly to the project manager or, if shared, to the PMO management. The project manager reports directly to the PMO management. Additionally, the flexibility of the PMO's centralized management can offer the project manager a greater opportunity for advancement within the organization. Specialty project team members can also be exposed to alternative project management career options in organizations with PMOs.

Note that if a PMO exists, Figure 2-7 would have an additional box, labeled PMO, between the Project Manager layer and the Chief Executive layer.

2.3.5 Project Management System

The Project Management System is the tools, techniques, methodologies, resources, and procedures to manage a project. The system is documented in the Project Management Plan and its content will vary depending upon the application area, organizational influence, complexity of the project, and availability of existing systems.

A project management system, which can be formal or informal, aids a project manager in effectively guiding a project to completion. A project management system is a set of processes and the related control functions that are consolidated and combined into a functioning, unified whole.

Chapter 3

Project Management Processes for a Project

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Program Management and Portfolio Management apply project management knowledge and techniques, and also apply the project management processes. Project management is accomplished through processes, which receive inputs and generate outputs, using tools and techniques.

In addition to managing the execution of a project, the project team must also:

- Comply with product requirements
- Balance the competing demands for scope, time, cost, quality, and risk to produce a quality product
- Adapt the product specifications, plans, and approach to management systems to meet different needs and manage expectations of the various stakeholders.

There is insufficient consensus, globally or across industry groups, about activities related to projects to allow detailed aspects of project management to be documented as a standard. This standard documents information needed to initiate, plan, execute, monitor and control, and close a single project. This section identifies those processes that have been recognized as good practice on most projects. Good practice means a general agreement that the application of those project management processes has been shown to enhance the chances of success over a wide range of different projects. **This does not mean that the knowledge, skills, and processes described should always be applied uniformly on all projects; the project manager, in collaboration with the project team, is always responsible for determining what processes are appropriate for any given project.** In fact, project managers and their teams are advised to carefully consider explicitly addressing each process and its constituent inputs and outputs. Project managers and their teams should use this chapter as a high level guide for those items they must consider in managing their project.

A process is a set of interrelated actions and activities that are performed to achieve a pre-specified set of results. The project management processes common to most projects most of the time are associated with each other by being performed for a similar singular purpose. The purpose is to initiate, plan, execute, monitor and control, or close the project. These processes interact with each other. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases.

Project management is an integrative undertaking. Failure to take action during one process will usually affect that process and other related processes. Project management integration requires each process to be appropriately aligned and connected with the other processes to facilitate their coordination. These interactions often require tradeoffs

between project requirements and objectives. For example, a scope change will almost always affect project cost, but the scope change may or may not affect team morale or product quality. The specific performance tradeoffs will vary from project to project and organization to organization. Successful project management includes actively managing these interactions to successfully meet stakeholder needs and manage their expectations.

This standard describes the multi-dimensional nature of project management processes in terms of the integration between the processes, the interactions within them, and the purposes they serve. These processes are aggregated into groups, defined as the Project Process Groups:

- Initiating Process Group
- Planning Process Group
- Executing Process Group
- Monitoring and Controlling Process Group
- Closing Process Group.

This chapter provides information about project management as a number of interlinked processes, and includes the following major sections:

- 3.1 Project Management Processes
- 3.2 Project Management Process Groups
- 3.3 Process Interactions
- 3.4 Project Management Process Mapping.

3.1 PROJECT MANAGEMENT PROCESSES

The project management processes are thought of and presented as discrete elements with well-defined interfaces; however, in practice they overlap and interact in ways that are not completely detailed here. Most experienced project management practitioners recognize more than one way to manage a project. The specifics for a project are given as objectives that must be accomplished based on complexity, risk, size, time frame, project team's experience, amount of historical information, the organization's project management maturity, industry and application area. The required Project Process Groups and their constituent processes are guides to apply appropriate project management knowledge and skills during the life of the project. The project manager and the project team are responsible for determining what required processes will be employed, by whom, and the degree of rigor that will be applied to the execution of those processes to achieve the desired project objective.

An underlying concept for the interaction among the project management processes, as defined by Shewart and modified by Deming, is the Plan-Do-Check-Act cycle (ASQ Handbook, pages 13 – 14, American Society for Quality, 1999). This cycle is linked by the results produced – the result of one part of the cycle becomes the input to another. See Figure 3-1.

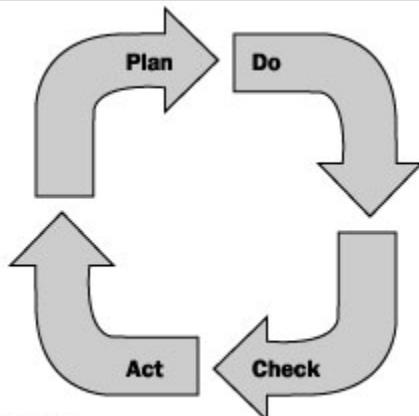


Figure 3-1. The Plan-Do-Check-Act Cycle

The integrative nature of the project management processes is more complex than the basic plan-do-check-act cycle. However, the cycle can be applied to the interrelationships within and among the Project Process Groups. The Planning Process Group corresponds to the “plan” component of the plan-do-check-act cycle. The Execute Process Group corresponds to the “do” component and the Monitoring and Control Process Group corresponds to the “check/act” components. In addition, since management of a project is a finite effort, the Initiating Process Group starts these cycles and the Closing Process Group ends them. The integrative nature of project management recognizes the Monitoring and Controlling Process Group interaction with every aspect of the plan-do-check-act cycle. See Figure 3-2.

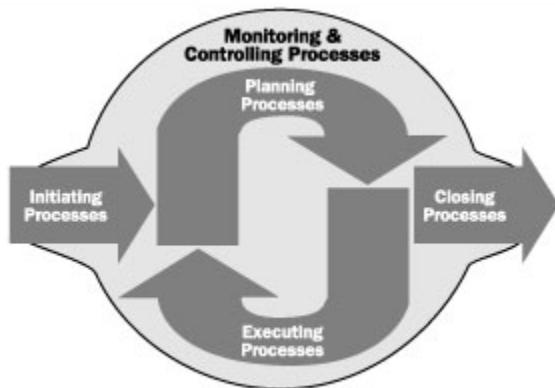


Figure 3-2. Project Management Process Groups Mapped to the Plan-Do-Check-Act Cycle

3.2 PROJECT MANAGEMENT PROCESS GROUPS

This section identifies and describes the five Project Process Groups required for any project. These five Project Process Groups have clear dependencies and are performed in the same sequence on each project. They are independent of application areas or industry focus. Individual Project Process Groups are often iterated prior to completing the project. Constituent processes also can have interactions both within a Project Process Group and between Project Process Groups. The Project Process Groups are:

- **Initiating Process Group** defines and authorizes the project or phase.
- **Planning Process Group** defines and refines objectives and plans the best alternative courses of action to attain the objectives and scope that the project or phase was undertaken to address.
- **Executing Process Group** integrates people and other resources to carry out the project management plan for the project or phase.
- **Monitoring and Controlling Process Group** requires that progress is regularly measured and monitored to identify variances from the project management plan, so that corrective action can be taken when necessary to meet project or phase objectives.
- **Closing Process Group** formalizes acceptance of the product, service, or result and brings the project or phase to an orderly end.

An individual process defines and constrains how the inputs are used to produce the outputs for that Project Process Group. A Project Process Group includes the project processes that are linked by the respective inputs and outputs—the result or outcome of one process becomes the input to another. Figure 3-3 indicates the Project Process Groups' interactions. The Monitoring and Controlling Process Group, for example, not only monitors and controls the work being done during the current Project Process Group, but also monitors and controls the entire project effort. The Monitoring and Controlling Process Group must also provide feedback to previous phases of the project to implement corrective or preventive actions to bring the project into compliance with the Project Management Plan. Figure 3-3 does not show all of the interactions indicated in Figure 3-2 for the Monitoring and Controlling Process Group.

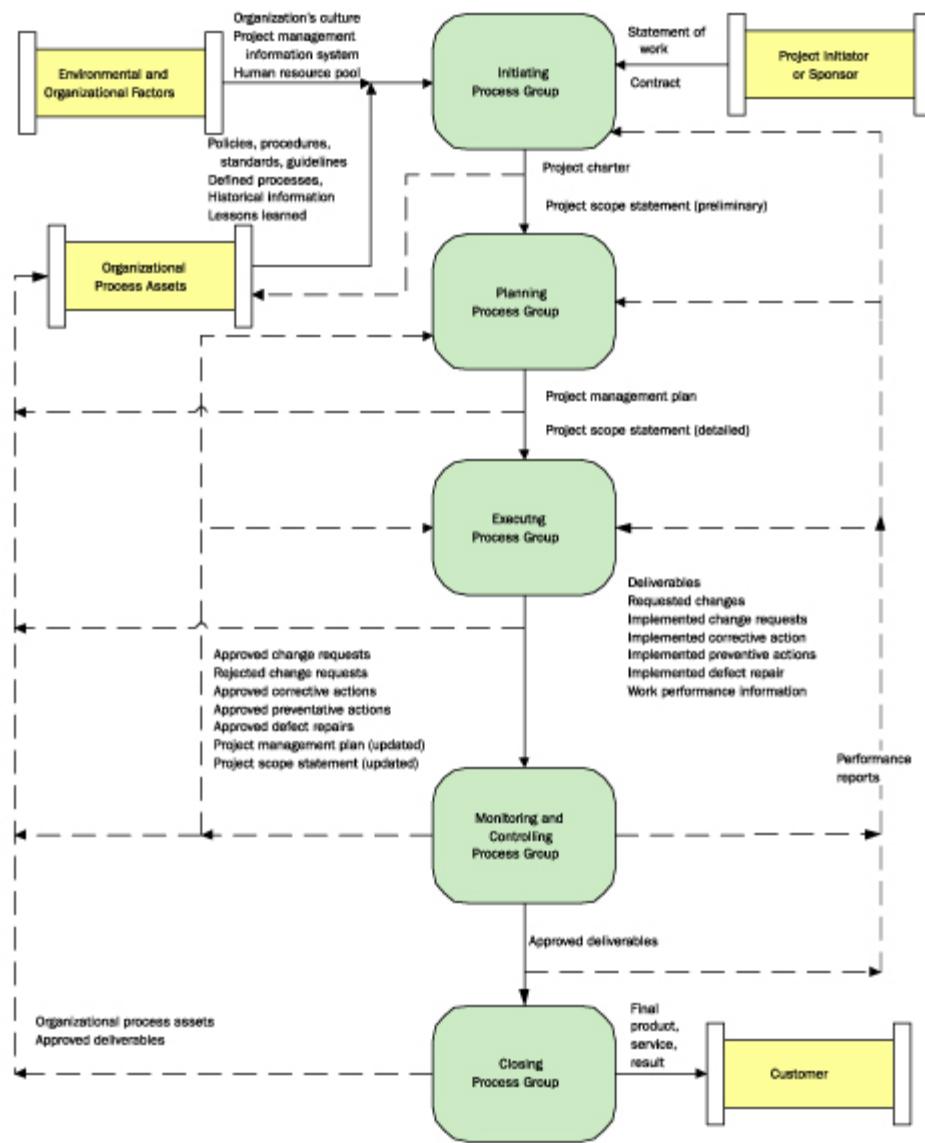
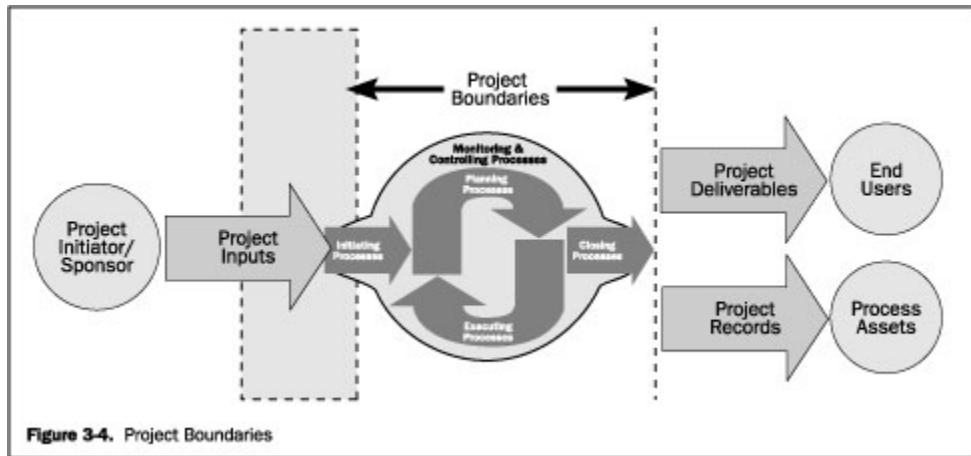


Figure 3-3. High Level Summary of Project Process Group's Dataflow

3.2.1 Initiating Process Group

The Initiating Process Group consists of the processes required to formally authorize the start of a new project. Many initiating type processes are often done outside the project's scope of control by the organization, program, or portfolio processes (Figure 3-4). For example, before beginning the Initiation Process Group activities, the organization's business needs or requirements are documented. Then, the feasibility of the new undertaking is established and clear descriptions of the project objectives, including deliverables, are developed as a contractual document or statement of work. This documentation also contains a basic description of the project scope, estimate of project duration, and a forecast of the resources for the performing organization's investment. The framework of the project can be clarified by documenting the project selection

processes involved. The relationship of the project to the organization's strategic plan identifies the management responsibilities within the performing organization.



The initial scope description and the resources that the performing organization(s) are willing to invest are further refined during the initiation process within the project's boundary. If not already assigned, the project manager will be selected. Initial assumptions and constraints will also be documented. This information is captured in the Project Charter and, when it is approved, the project becomes officially authorized. Although the Project Charter can be written by the project management team, approval and funding are handled outside the project boundaries.

As part of the Initiating Process Group of the project, many large or complex projects are divided into phases. At the beginning of each phase, the project scope and objectives are reevaluated. The entry criteria for the phase are verified, including the availability of required resources. A decision is then made as to whether or not the project is ready to start the next phase, or whether the project should be delayed or discontinued. Repeating the initiation processes at the start of each phase helps to keep the project focused on the business need that the project was undertaken to address. Repeating the initiation processes also enables the project to be halted if the business need no longer exists, or if the project is not able to satisfy that business need.

Involving the stakeholders during both project and phase initiation generally improves the probability of satisfying customer requirements and expectations, and helps get project buy-in or shared ownership by the stakeholders. Such buy-in is critical to project success. The result of the Initiating Process Group starts a project, (Figure 3-5), whereas the output defines the project's purpose, identifies objectives, and authorizes the project manager to start the project.

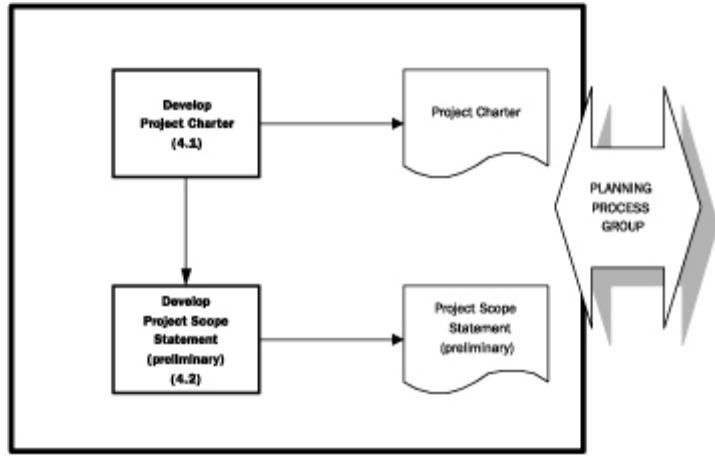


Figure 3-5. Initiating Process Group

The Initiating Process Group includes:

.1 Develop Project Charter

This process is primarily concerned with authorizing the project. It is the process necessary for documenting the business needs and the new product or service that is intended to satisfy those needs. This chartering links the project to the ongoing work of the organization and authorizes the project. Projects are chartered and authorized outside of the project by the company, or a program or portfolio management body.

Inputs	Outputs
.1 Contract .2 Project statement of work .3 Environmental and organizational factors .4 Organizational process assets	.1 Project charter

Table 3-1. Develop Project Charter Inputs and Outputs

.2 Develop Project Scope Statement (Preliminary)

This is the process necessary for producing a preliminary high-level definition of the project using the Project Charter with other inputs to the initiating processes. This process addresses and documents the product requirements, boundaries of the project, methods of acceptance and high-level scope control.

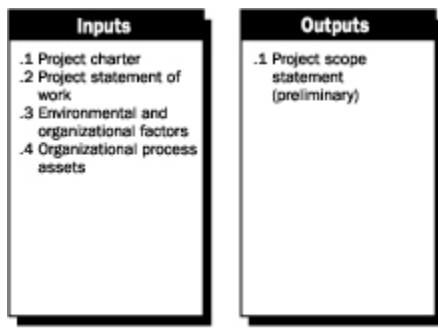


Table 3-2. Develop Preliminary Project Scope Statement
Inputs and Outputs

3.2.2 Planning Process Group

The Planning Process Group consists of those processes that define and mature the project scope, develop the Project Management Plan, and identify and schedule the project activities that occur within the project. The Planning Process Group facilitates the project team's documentation of the processes and interactions that the project management team determines are needed to plan and manage a successful project for the organization. This Project Process Group asynchronously gathers information from many sources with each having varying levels of completeness and confidence. As new project information is discovered, additional dependencies, requirements, risks, opportunities, assumptions, and constraints will be identified or resolved. The multi-dimensional nature of project management causes repeated feedback loops for additional analysis; as more project information or characteristics are gathered and understood, follow-on actions may be required. Significant changes to the project occurring throughout the project life trigger a need to revisit one or more of the planning processes and, possibly, some of the initiating processes.

The frequency of planning iterations can also be affected if the project is divided into phases. For example the Project Management Plan developed as an output of the Planning Process Group, will have an emphasis on exploring all aspects of the scope, technology, risks, and costs. Updates arising from approved changes during project execution may significantly impact parts of the Project Management Plan. Project Management Plan updates provide greater precision with respect to schedule, costs, and resource requirements to meet the defined project scope as a whole. Updates for a phase can be limited to the activities and any issues associated with the execution of that specific phase. This progressive detailing of the Project Management Plan is often called “rolling wave planning,” indicating that planning is an iterative and ongoing process (Figure 3-6).

The project team should involve all stakeholders in project planning. Every stakeholder has skills and knowledge that can be leveraged in developing the Project Management Plan and any constituent plans. The project team must create an environment in which all of the stakeholders can contribute appropriately.

Guidelines, either set by the organization or established by the project team, identify when the planning effort ends, since the feedback and refinement process cannot continue indefinitely. These guidelines will be affected by the nature of the project, the established

project boundaries, appropriate monitoring and controlling, and performance parameters set by the organization.

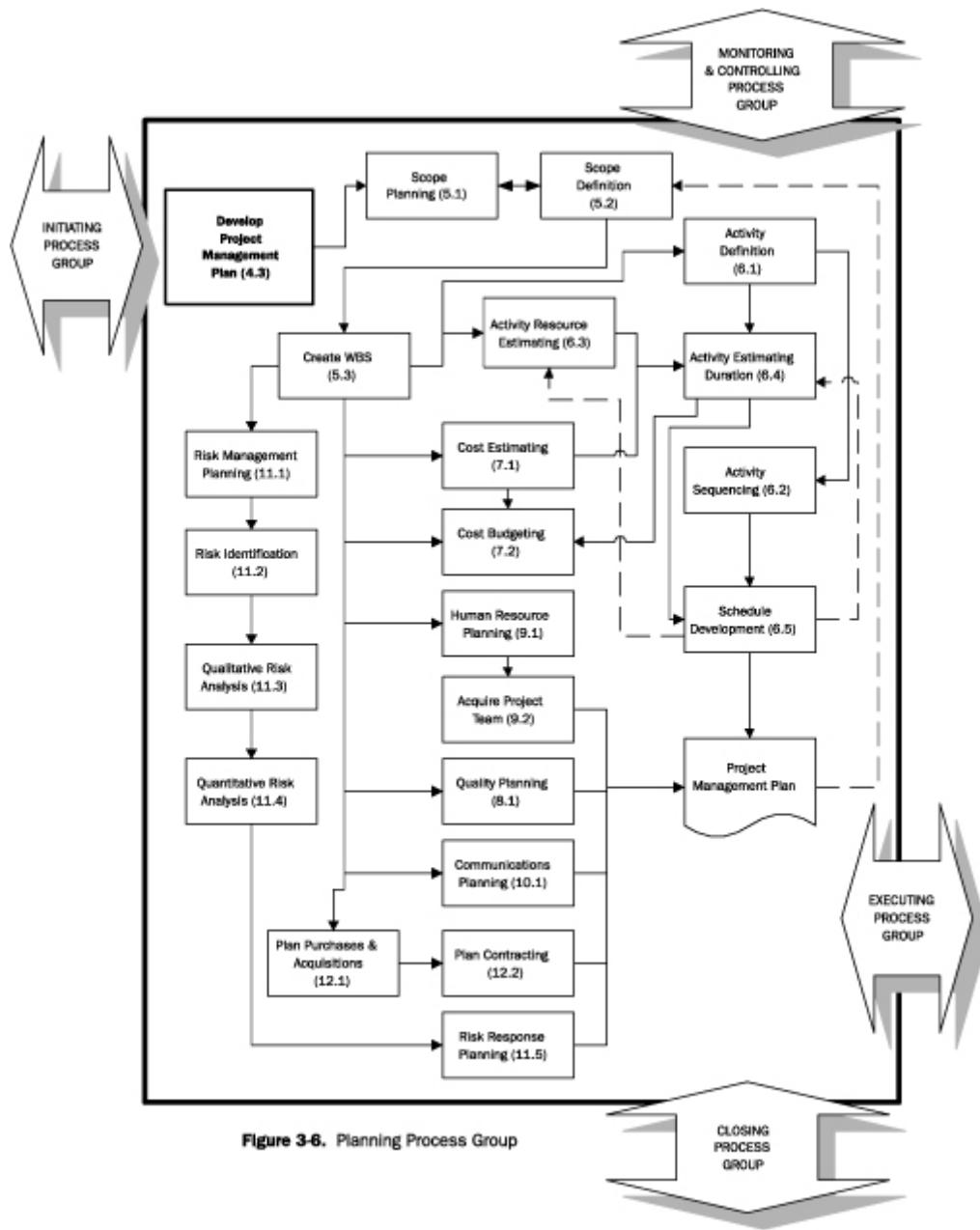


Figure 3-6. Planning Process Group

Other interactions among the processes within the Planning Process Group can be more dependent on the nature of the project. For example, on some projects there will be little or no identifiable risk until after most of the planning has been done, and the team recognizes that the cost and schedule targets are aggressive, thus involving considerable risk.

The Planning Process Group facilitates project planning across multiple processes. The following list identifies the required processes addressed during the planning

process. The results of replanning are documented as updates to the Project Management Plan. The Planning Process Group includes:

.1 Develop Project Management Plan

This is the process necessary for defining, preparing, integrating, and coordinating all constituent plans into a Project Management Plan. The Project Management Plan becomes the primary source of information for how the project will be executed, monitored and controlled.

Inputs	Outputs
<ul style="list-style-type: none">.1 Project charter.2 Project scope statement (preliminary).3 Project management processes.4 Forecasts.5 Environmental and organizational factors.6 Organizational process assets.7 Work performance information	<ul style="list-style-type: none">.1 Project management plan

Table 3-3. Develop Project Management Plan Inputs and Outputs

.2 Scope Planning

This is the process necessary for creating a Scope Management Plan that documents how the scope will be defined, verified, and controlled, and how the Work Breakdown Structure will be created and defined.

Inputs	Outputs
<ul style="list-style-type: none">.1 Project charter.2 Project scope statement (preliminary).3 Organizational process assets.4 Environmental and organizational factors.5 Project management plan	<ul style="list-style-type: none">.1 Scope management plan

Table 3-4. Scope Planning Process Inputs and Outputs

.3 Scope Definition

This is the process necessary for developing a detailed project scope statement as the basis for future project decisions.

Inputs	Outputs
<ul style="list-style-type: none">.1 Project charter.2 Project scope management plan.3 Organizational process assets.4 Approved change requests	<ul style="list-style-type: none">.1 Project scope statement (detailed).2 Project management plan (updates)

Table 3-5. Scope Definition Inputs and Outputs

.4 Create Work Breakdown Structure (WBS)

This is the process necessary for subdividing the major project deliverables and project work into smaller, more manageable components.

Inputs	Outputs
.1 Project scope statement (detailed) .2 Project management plan	.1 Work breakdown structure and dictionaries .2 Project management plan (updates)

Table 3-6. Create WBS Inputs and Outputs

.5 Activity Definition

This is the process necessary for identifying the specific activities that must be performed to produce the various project deliverables.

Inputs	Outputs
.1 Work breakdown structure and dictionary .2 Project scope statement .3 Organizational process assets .4 Project management plan	.1 Activity list .2 Activity list attributes .3 Work breakdown structure and dictionary (updates) .4 Milestone list

Table 3-7. Activity Definition Inputs and Outputs

.6 Activity Sequencing

This is the process necessary for identifying and documenting interactivity dependencies.

Inputs	Outputs
.1 Activity list .2 Activity list attributes .3 Project scope statement .4 Milestone list	.1 Project schedule network diagrams .2 Activity list (updates) .3 Project management plan and scope statement (updates)

Table 3-8. Activity Sequencing Inputs and Outputs

.7 Activity Resource Estimating

This is the process necessary for estimating resources required for each activity.

Inputs	Outputs
.1 Activity list .2 Activity list attributes .3 Organizational policies .4 Resource availability	.1 Activity resource requirements .2 Resource requirements supporting detail .3 Activity list (updates)

Table 3-9. Activity Resource Estimating Inputs and Outputs

.8 Activity Duration Estimating

This is the process necessary for estimating the number of work periods that will be needed to complete individual activities.

Inputs	Outputs
.1 Activity list .2 Activity list attributes .3 Project scope statement .4 Project cost estimates .5 Activity resource requirements .6 Resource availability .7 Organizational process assets .8 Risk register	.1 Activity duration estimates .2 Activity list (updates) .3 Activity list attributes (updates)

Table 3-10. Activity Duration Estimating Inputs and Outputs

.9 Schedule Development

This is the process necessary for analyzing activity sequences, activity durations, and resource requirements to create the project schedule.

Inputs	Outputs
.1 Project scope statement .2 Project schedule network diagrams .3 Activity duration estimates .4 Activity resource requirements .5 Resource availability .6 Risk register .7 Activity list attributes .8 Resource calendars	.1 Project schedule .2 Project schedule supporting detail .3 Schedule management plan (updates) .4 Resource requirements (updates)

Table 3-11. Schedule Development Inputs and Outputs

.10 Cost Estimating

This is the process necessary for developing an approximation of the costs of the resources needed to complete project activities.

Inputs	Outputs
.1 Project charter .2 Project scope statement .3 Project management plan .4 Work breakdown structure and dictionary .5 Time management plan .6 Staffing management plan .7 Risk register .8 Environmental and organizational factors .9 Organizational process assets	.1 Activity cost estimates .2 Activity cost supporting detail

Table 3-12. Cost Estimating Process Inputs and Outputs

.11 Cost Budgeting

This is the process necessary for aggregating the estimated costs of individual activities or work packages to establish a cost baseline.

Inputs	Outputs
.1 Activity cost estimates .2 Work breakdown structure and dictionary .3 Project schedule .4 Project charter .5 Project management plan	.1 Cost baseline .2 Project funding requirements .3 Project management plan (updates)

Table 3-13. Cost Budgeting Process Inputs and Outputs

.12 Quality Planning

This is the process necessary for identifying which quality standards are relevant to the project and determining how to satisfy them.

Inputs	Outputs
.1 Project charter .2 Project management plan .3 Project scope statement .4 Organizational process assets .5 Environmental and organizational factors	.1 Quality management plan .2 Quality metrics .3 Quality checklists .4 Process improvement plan .5 Project management plan (Updated)

Table 3-14. Quality Planning Process Inputs and Outputs

.13 Human Resource Planning

This is the process for identifying and documenting project roles, responsibilities and reporting relationships, as well as creating the staffing management plan.

Inputs	Outputs
.1 Activity resource estimates .2 Environmental and organizational factors .3 Project management plan	.1 Roles and responsibilities .2 Project organization charts .3 Staffing management plan

Table 3-15. Human Resource Planning Inputs and Outputs

.14 Acquire Project Team

This is the process necessary for obtaining the human resources needed to complete the project.

Inputs	Outputs
.1 Roles and responsibilities .2 Project organization charts .3 Staffing management plan .4 Environmental and organizational factors .5 Organizational process assets	.1 Project staff assignments .2 Resource calendars .3 Staffing management plan (updates) .4 Resource availability

Table 3-16. Acquire Project Team Inputs and Outputs

.15 Communications Planning

This is the process necessary for determining the information and communications needs of the stakeholders: who are they, what is their level of interest and influence on the project, who needs what information, when they will need it and how it will be given to them.

Inputs	Outputs
.1 Organizational process assets .2 Project charter .3 Project management plan .4 Project scope statement	.1 Communications management plan

Table 3-17. Communications Planning Inputs and Outputs

.16 Risk Management Planning

This is the process necessary for deciding how to approach and conduct the risk management activities for a project.

Inputs	Outputs
.1 Project charter .2 Project scope statement .3 Project management plan .4 Organizational process assets .5 Environmental and organizational factors	.1 Risk management plan

Table 3-18. Risk Management Planning Inputs and Outputs

.17 Risk Identification

This is the process necessary for determining which risks might affect the project and documenting their characteristics.

Inputs	Outputs
.1 Project charter .2 Project scope statement .3 Project management plan .4 Organizational process assets .5 Environmental and organizational factors	.1 Risk register .2 Project management plan (updates)

Table 3-19. Risk Identification Inputs and Outputs

.18 Qualitative Risk Analysis

This is the process necessary for prioritizing risks for subsequent further analysis or action by assessing and combining their probability and impacts.

Inputs	Outputs
.1 Project management plan .2 Organizational process assets .3 Work performance information .4 Project scope statement	.1 Risk register (updates)

Table 3-20. Qualitative Risk Analysis Inputs and Outputs

.19 Quantitative Risk Analysis

This is the process necessary for analyzing numerically the effect on overall project objectives of identified risks.

Inputs	Outputs
.1 Project management plan .2 Organizational process assets .3 Risk register	.1 Risk register (updates)

Table 3-21. Quantitative Risk Analysis Inputs and Outputs

.20 Risk Response Planning

This is the process necessary for developing options and actions to enhance opportunities and to reduce threats to project objectives.

Inputs	Outputs
.1 Project management plan .2 Risk management plan .3 Risk register	.1 Risk register (updates) .2 Risk-related contractual agreements

Table 3-22. Risk Response Planning Inputs and Outputs

.21 Plan Purchases and Acquisitions

This is the process necessary for determining what to purchase or acquire and when.

Inputs	Outputs
.1 Project charter .2 Project scope statement .3 Project management plan .4 Work breakdown structure and dictionary .5 Environmental and organizational factors .6 Organizational process assets .7 Risk register	.1 Procurement management plan .2 Contract statement of work .3 Make-or-buy decisions .4 Project management plan (updates)

Table 3-23. Plan Purchases and Acquisitions Inputs and Outputs

.22 Plan Contracting

This is the process necessary for documenting material, products, goods and services requirements, and identifying potential sellers.

Inputs	Outputs
<ul style="list-style-type: none"> .1 Procurement management plan .2 Contract statements of work .3 Project management plan .4 Make-or-buy decisions 	<ul style="list-style-type: none"> .1 Procurement documents .2 Evaluation criteria .3 Contract statement of work (updates)

Table 3-24. Plan Contracting Inputs and Outputs

3.2.3 Executing Process Group

The Executing Process Group consists of those required processes needed to complete the work defined in the Project Management Plan to accomplish the project's objectives. This Project Process Group involves coordinating people and resources, as well as integrating and performing the activities of the project or phase in accordance with the Project Management Plan. This Project Process Group also addresses the scope defined in the project scope statement and implements approved changes (Figure 3-7).

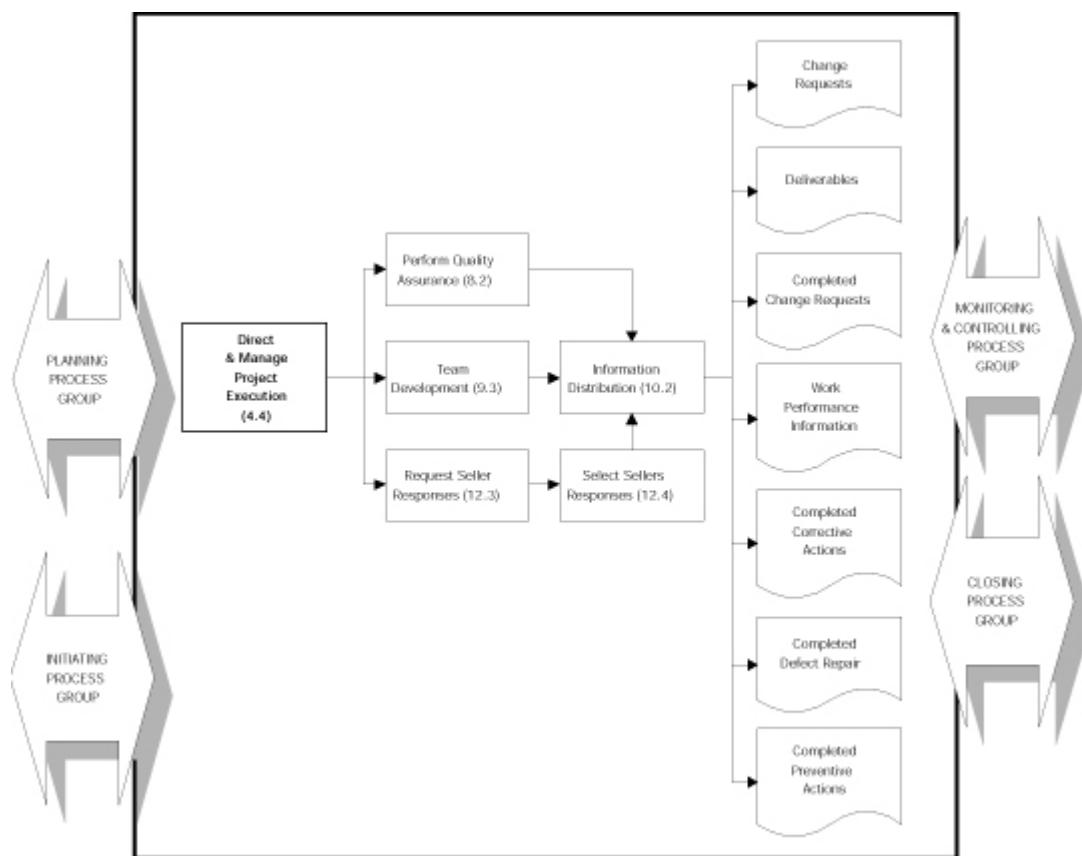


Figure 3-7. Executing Process Group

Normal execution variances will cause some replanning. These variances can include activity durations, resource productivity and availability, and unanticipated errors. Such changes may or may not affect the Project Management Plan and can require a performance analysis. The results can trigger a change request that, if approved, would modify the Project Management Plan and possibly require establishing a new project baseline. The vast majority of the project's budget will be expended in performing these processes. The Executing Process Group includes:

.1 Direct and Manage Project Execution

This is the process necessary for directing the various technical and organizational interfaces that exist in the project to execute the activities defined in the Project Management Plan. The deliverables are produced as outputs from the work processes performed as defined in the Project Management Plan. Information on the completion status of the deliverables and what work has been accomplished is collected as part of project execution and fed into the performance reporting process.

Inputs	Outputs
<ul style="list-style-type: none"> .1 Project management plan .2 Approved corrective actions .3 Approved preventive actions .4 Approved change requests .5 Approved defect repair .6 Validated defect repair 	<ul style="list-style-type: none"> .1 Deliverables .2 Requested changes .3 Implemented change requests .4 Implemented corrective actions .5 Implemented preventive actions .6 Implemented defect repair .7 Work performance information

Table 3-25. Direct and Manage Project Execution Inputs and Outputs

.2 Perform Quality Assurance

This is the process necessary for applying the planned, systematic quality activities (such as audits or peer reviews) to ensure that the project will employ all processes needed to meet all stakeholder expectations.

Inputs	Outputs
<ul style="list-style-type: none"> .1 Quality management plan .2 Quality metrics .3 Process improvement plan .4 Work performance information .5 Approved change requests .6 Quality control measurements 	<ul style="list-style-type: none"> .1 Requested changes .2 Recommended corrective actions .3 Organizational process assets (updates) .4 Project management plan (updates)

Table 3-26. Perform Quality Assurance Process Inputs and Outputs

.3 Develop Project Team

This is the process necessary for developing individual and group competencies to enhance project performance.

Inputs	Outputs
.1 Project staff assignments .2 Staffing management plan	.1 Team performance assessment

Table 3-27. Develop Project Team Inputs and Outputs

.4 Information Distribution

This is the process necessary for making needed information available to project stakeholders in a timely manner.

Inputs	Outputs
.1 Work performance information .2 Communications management plan	.1 Project management plan (updates) .2 Organizational process assets (updates)

Table 3-28. Information Distribution Inputs and Outputs

.5 Request Seller Responses

This is the process necessary for obtaining information, quotations, bids, offers, or proposals, as appropriate.

Inputs	Outputs
.1 Procurement documents .2 Organizational process assets	.1 Qualified sellers list .2 Procurement document package .3 Proposals

Table 3-29. Request Seller Responses Inputs and Outputs

.6 Select Sellers

This is the process necessary for reviewing offers, choosing amongst potential sellers, and negotiating a written contract with the seller.

Inputs	Outputs
<ul style="list-style-type: none"> .1 Proposals .2 Evaluation criteria .3 Organizational process assets .4 Risk register .5 Risk-related contractual agreements .6 Qualified sellers list .7 Procurement document package 	<ul style="list-style-type: none"> .1 Selected sellers .2 Contract .3 Contract management plan .4 Resource availability

Table 3-30. Select Sellers Inputs and Outputs

3.2.4 Monitoring and Controlling Process Group

The Monitoring and Controlling Process Group consists of those processes performed to monitor project execution so that corrective action can be taken, when necessary, to control the execution of the project or phase. The key benefit of this Project Process Group is that project performance is monitored and measured regularly to identify variances from the Project Management Plan. The Monitoring and Controlling Process Group also includes recommending preventive action in anticipation of possible problems and controlling changes. The Monitoring and Controlling Processes Group includes, for example:

- Monitoring the ongoing project activities against the project management plan and the project performance baseline
- Influencing the factors that circumvent integrated change control so that only approved changes are implemented.

This continuous monitoring provides the project team insight into the health of the project or phase, and highlights any areas that require additional attention. The Monitoring and Controlling Process Group, for example, not only monitors and controls the work being done during the current Project Process Group, but also monitors and controls the entire project effort. The Monitoring and Controlling Process Group must also provide feedback to previous phases of the project, in order to implement corrective or preventive actions to bring the project into compliance with the Project Management Plan. When variances jeopardize the project objectives, appropriate project management processes within the Planning Process Group are revisited. This review can result in recommended updates to the Project Management Plan. For example, a missed activity finish date can require adjustments to the current staffing plan, reliance on overtime, or tradeoffs between budget and schedule objectives. Figure 3-8 indicates the process interactions that are essential to this Project Process Group.

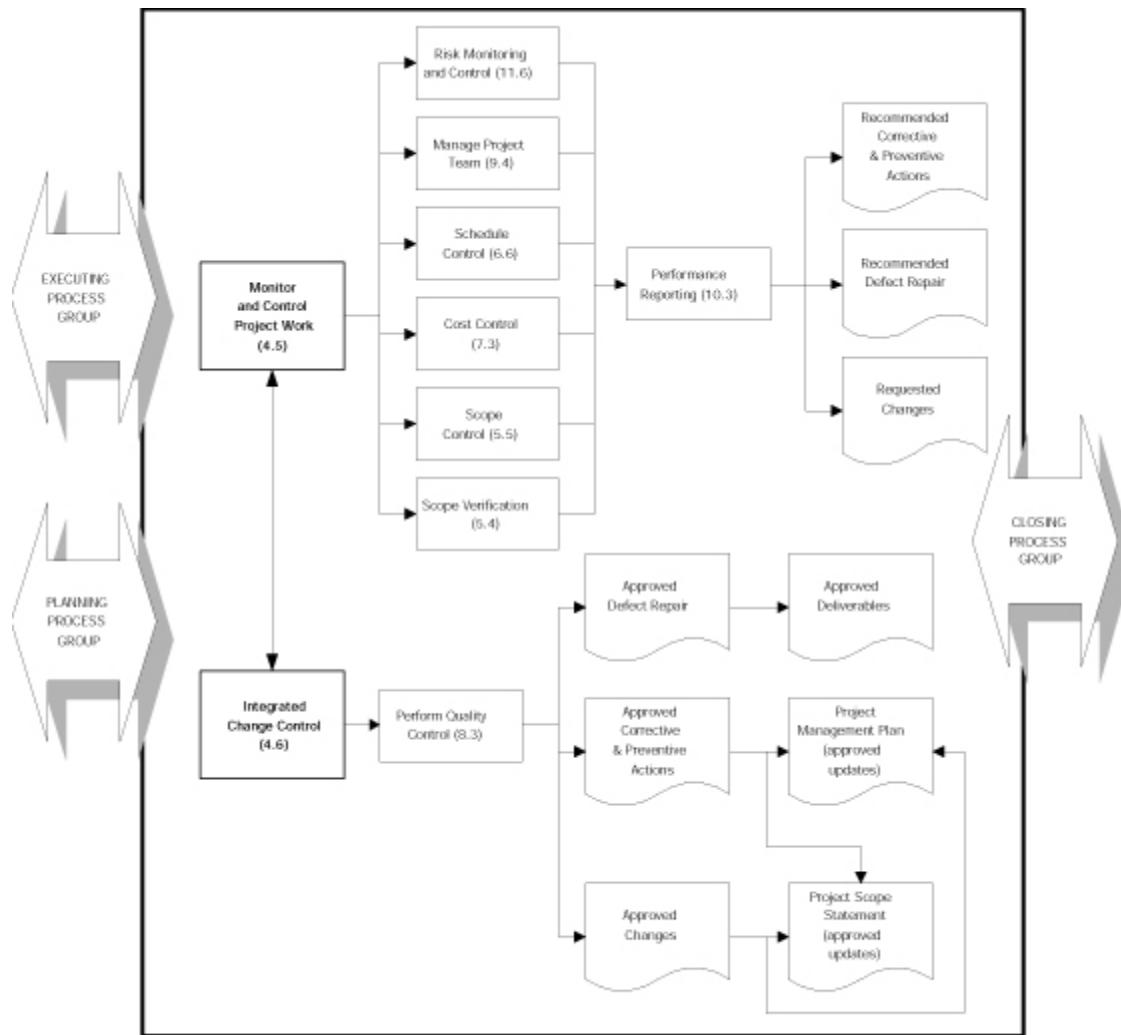


Figure 3-8. Monitoring & Controlling Process Group

The Monitoring and Controlling Process Group includes:

.1 Monitor and Control Project Work

This is the process necessary for collecting, measuring, and disseminating performance information, and assessing measurements and trends to effect process improvements.

This process includes the monitoring of risks, to make sure they are identified, their status is reported, and that appropriate risk plans are being executed. Monitoring includes status reporting, progress measurement, and forecasting. Performance reports provide information on the project's performance on scope, schedule, cost, and risk.

Inputs	Outputs
.1 Project management plan .2 Work performance information .3 Performance reports .4 Rejected change requests	.1 Recommended corrective actions .2 Recommended preventive actions .3 Performance reports .4 Forecasts .5 Recommended defect repair .6 Requested changes

Table 3-31. Monitor and Control Project Work Inputs and Outputs

.2 Integrated Change Control

This is the process necessary for controlling factors that create changes to make sure those changes are beneficial, determining whether a change has occurred, and managing the approved changes, including when they occur. This process is performed at every project phase, from project initiation through project closure.

Inputs	Outputs
.1 Project management plan .2 Requested changes .3 Work performance information .4 Recommended preventive action .5 Recommended corrective action .6 Recommended defect repair .7 Deliverables	.1 Approved changes .2 Rejected change requests .3 Project management plan (updates) .4 Project scope statement (updates) .5 Approved corrective actions .6 Approved preventive actions .7 Approved change requests .8 Approved defect repair .9 Deliverables (approved)

Table 3-32. Integrated Change Control Inputs and Outputs

.3 Scope Verification

This is the process necessary for formalizing acceptance of the completed project scope.

Inputs	Outputs
.1 Scope management plan .2 Deliverables .3 Product scope documentation .4 Work breakdown structure and dictionary	.1 Verified scope .2 Work breakdown structure and dictionary (updates)

Table 3-33. Scope Verification Inputs and Outputs

.4 Scope Control

This is the process necessary for controlling changes to the project scope.

Inputs	Outputs
.1 Scope management plan .2 Work breakdown structure and dictionary .3 Performance reports .4 Work performance information .5 Approved change requests	.1 Requested changes .2 Recommended corrective action .3 Organizational process assets (updates) .4 Project management plan (updates) .5 Work breakdown structure and dictionary (updates)

Table 3-34. Scope Control Inputs and Outputs

.5 Schedule Control

This is the process necessary for controlling changes to the project schedule.

Inputs	Outputs
.1 Project schedule .2 Performance reports .3 Approved change requests .4 Schedule management plan	.1 Project schedule (updates) .2 Requested changes .3 Recommended corrective action .4 Organizational process assets

Table 3-35. Schedule Control Inputs and Outputs

.6 Cost Control

This is the process necessary for influencing the factors that create additional costs and controlling changes to the project budget.

Inputs	Outputs
.1 Performance reports .2 Approved change requests .3 Cost baseline .4 Project funding requirements	.1 Project management plan (update) .2 Required corrective action .3 Estimate at completion .4 Requested changes .5 Organizational process assets (updates)

Table 3-36. Cost Control Process Inputs and Outputs

.7 Perform Quality Control

This is the process necessary for monitoring specific project results to determine if they comply with relevant quality standards, and identifying ways to eliminate causes of unsatisfactory performance.

Inputs	Outputs
.1 Quality management plan .2 Quality metrics .3 Quality checklists .4 Organizational process assets .5 Work performance information .6 Approved change requests .7 Product, service, or result	.1 Recommended corrective actions .2 Recommended preventive actions .3 Requested changes .4 Recommend defect repair .5 Validated defect repair .6 Project management plan (updates) .7 Quality control measurements .8 Organizational process assets (updates)

Table 3-37. Perform Quality Control Inputs and Outputs

.8 Manage Project Team

This is the process necessary for tracking individual and team performance, providing feedback, resolving issues, and coordinating changes to enhance project performance.

Inputs	Outputs
.1 Project staff assignments .2 Roles and responsibilities .3 Project organization charts .4 Staffing management plan .5 Performance reports .6 Team performance assessment .7 Organizational process assets	.1 Staffing management plan (updates) .2 Requested changes .3 Organizational process assets (updates)

Table 3-38. Manage Project Team Inputs and Outputs

.9 Performance Reporting

This is the process necessary for collecting and disseminating performance information. It includes status reporting, progress measurement and forecasting.

Inputs	Outputs
.1 Work performance information .2 Project management plan .3 Forecasts .4 Approved change requests .5 Deliverables	.1 Performance reports .2 Forecasts .3 Requested changes .4 Project management plan (updates) .5 Recommended corrective action .6 Organizational process assets

Table 3-39. Performance Reporting Inputs and Outputs

.10 Manage Stakeholders

This is the process necessary for managing communications to satisfy the needs of, and resolve issues with, project stakeholders.

Inputs	Outputs
.1 Project management plan .2 Communications management plan .3 Organizational process assets	.1 Resolved issues .2 Communications management plan (updates) .3 Organizational process assets (updates)

Table 3-40. Manage Stakeholders Inputs and Outputs

.11 Risk Monitoring and Control

This is the process necessary for tracking identified risks, monitoring residual risks, identifying new risks, executing risk response plans, and evaluating their effectiveness throughout the project life cycle.

Inputs	Outputs
.1 Project management plan .2 Work performance information .3 Approved change requests	.1 Recommended corrective action .2 Requested changes .3 Risk register (updates) .4 Organizational process assets (update)

Table 3-41. Risk Monitoring and Control Inputs and Outputs

.12 Contract Administration

This is the process necessary for managing the contract and the relationship between the buyer and seller, reviewing and documenting how a seller is performing or has performed—to establish required corrective actions and provide a basis for future use of the seller—managing contract-related changes and, when appropriate, managing the contractual relationship with the outside buyer of the project.

Inputs	Outputs
.1 Contract .2 Performance reports .3 Approved change requests .4 Work performance information .5 Selected sellers	.1 Organizational process assets (updates) .2 Requested changes .3 Recommended corrective actions .4 Contract documentation

Table 3-42. Contract Administration Inputs and Outputs

3.2.5 Closing Process Group

The Closing Process Group includes the processes required to formally terminate all activities of a project or phase, and hand off the completed product to others or close a

cancelled project. This Project Process Group, when completed, requires that the defined procedures are completed across all the Project Management Process Groups to close the project or phase, i.e., hand off the completed or cancelled project or phase, as appropriate, and formally establish that the project or phase is finished, thereby closing out the project or phase. See Figure 3-9.

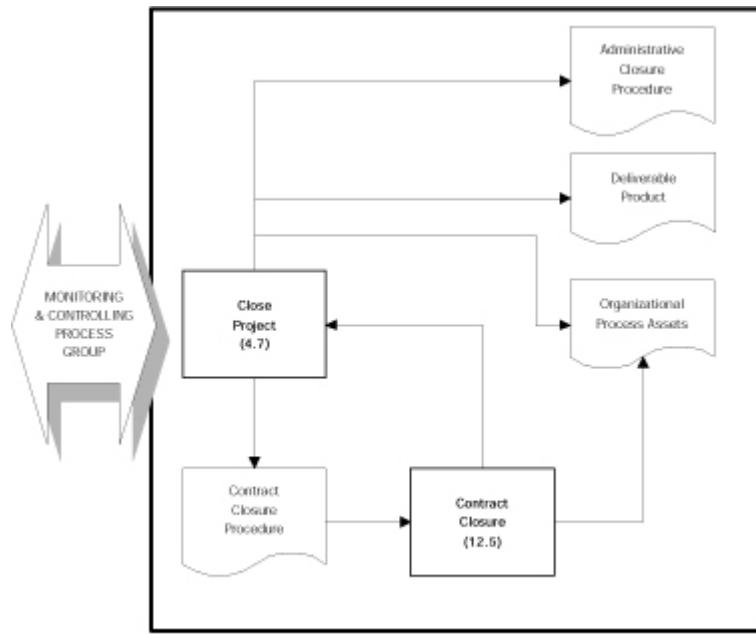


Figure 3-9. Closing Process Group

The Closing Process Group includes:

.1 Close Project

This involves documenting the procedures required to execute the administrative closure of a project or phase, and preparing the contract closeouts necessary to settle any purchase or acquisition agreements, as well as performing the formal project closure.

Inputs	Outputs
<ul style="list-style-type: none"> .1 Project charter .2 Project scope statement .3 Project management plan .4 Contract documentation .5 Organizational process assets .6 Environmental and organizational factors .7 Work performance information .8 Deliverables (approved) 	<ul style="list-style-type: none"> .1 Administrative closure procedure .2 Contract closure procedure .3 Final product, service or result .4 Environmental and organizational factors (updates) .5 Organizational process assets (updates)

Table 3-43. Close Project Inputs and Outputs

.2 Contract Closure

This is the process necessary for completing and settling each contract, including the resolution of any open items.

Inputs	Outputs
<ul style="list-style-type: none"> .1 Contract documentation .2 Contract closure procedure 	<ul style="list-style-type: none"> .1 Organizational process assets (updates)

Table 3-44. Contract Closure Inputs and Outputs

3.3 PROCESS INTERACTIONS

Project Process Groups are linked by the results they produce—the result or output of one process generally becomes an input to another process or is an end result of the project. Between the Project Process Groups and among the processes themselves, the links are iterated. The Planning Process Group provides the Executing Process Group a documented Project Management Plan early, and often provides Project Management Plan updates as the project progresses. In addition, the Project Process Groups are seldom either discrete or one-time events; they are overlapping activities that occur at varying levels of intensity throughout the project. Figure 3-10 illustrates how the Project Process Groups interact and the level of overlap at varying times within a project. When the project is divided into phases, the Project Process Group interactions also cross phases, such that closing one phase provides an input to initiating the next. For example, closing a design phase requires customer acceptance of the design document. Simultaneously, the design document defines the product description for the ensuing execution phase.

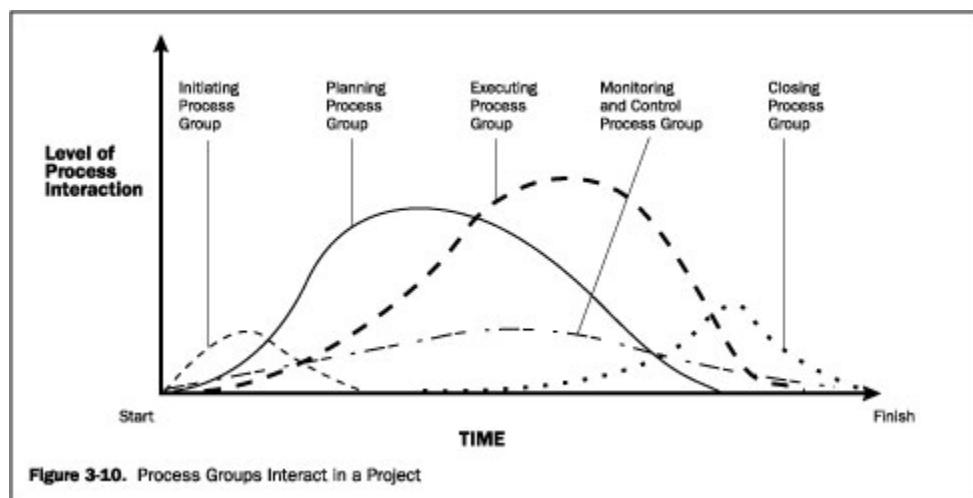
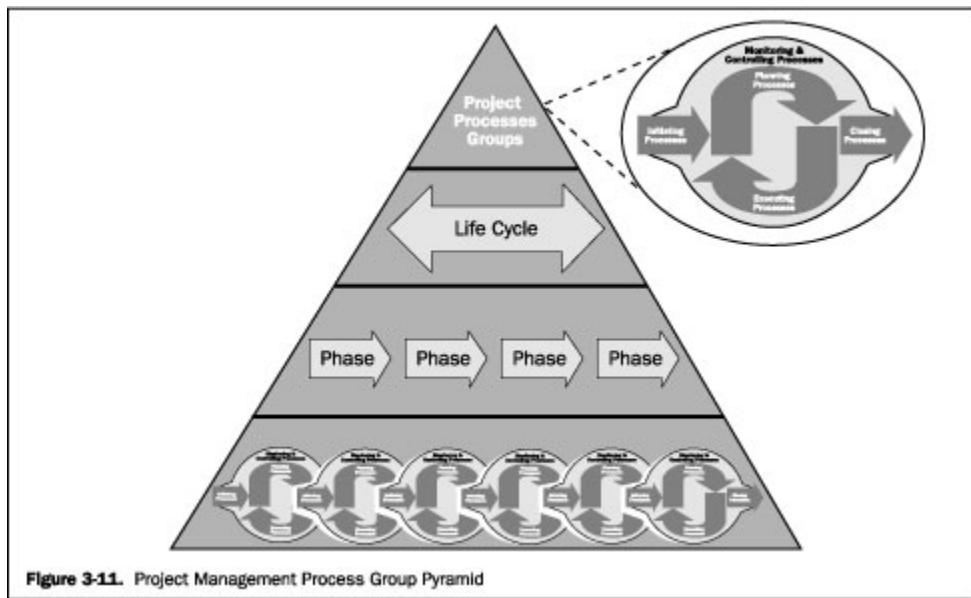


Figure 3-10. Process Groups Interact in a Project

If a project is divided into phases, the processes within each phase are often repeated throughout the project's life to effectively drive the project to completion. The Project Process Groups and their relationships, whether within a project or within the phases of a project, are illustrated in Figure 3-11.



However, just as not all of the processes will be needed on all projects, not all of the interactions will apply to all projects. For example:

- Projects that are dependent on unique resources (commercial software development, and biopharmaceuticals) can define roles and responsibilities prior to scope definition, since what can be done will be dependent on who is available to do it.
- Some process outputs can be predefined as constraints. For example, management can specify a target completion date, rather than allowing that date to be determined by the planning process. An imposed completion date can increase project risk, add cost and compromise quality, or, in extreme cases, require a significant change in scope.

3.4 PROJECT MANAGEMENT PROCESS MAPPING

Table 3-45 reflects the mapping of the 44 project management processes within the five Project Process Groups and the nine project management Knowledge Areas. Each of the required project management processes and project management integration processes are shown in the Project Process Group where most of the activity takes place. For instance, when a process that normally takes place during planning is revisited or updated during execution, it is still the same process that was performed in the planning process - not an additional, new process.

Project Management Process Groups Knowledge Areas	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
4. Project Integration Management	Develop Project Charter (4.1) Develop Project Scope Statement (preliminary) (4.2)	Develop Project Management Plan (4.3)	Direct and Manage Project Execution (4.4)	Monitor and Control Project Work (4.5) Integrated Change Control (4.6)	Close Project (4.7)
5. Project Scope Management		Scope Planning (5.1) Scope Definition (5.2) Create WBS (5.3)		Scope Verification (5.4) Scope Control (5.5)	
6. Project Time Management		Activity Definition (6.1) Activity Sequencing (6.2) Activity Resource Estimating (6.3) Activity Duration Estimating (6.4) Schedule Development (6.5)		Schedule Control (6.6)	
7. Project Cost Management		Cost Estimating (7.1) Cost Budgeting (7.2)		Cost Control (7.3)	
8. Project Quality Management		Quality Planning (8.1)	Perform Quality Assurance (8.2)	Perform Control Quality (8.3)	
9. Project HR Management		Human Resource Planning (9.1) Acquire Project Team (9.2)	Develop Project Team (9.3)	Manage Project Team (9.4)	
10. Project Communications Management		Communications Planning (10.1)	Information Distribution (10.2)	Performance Reporting (10.3) Manage Stakeholders (10.4)	
11. Project Risk Management		Risk Management Planning (11.1) Risk Identification (11.2) Qualitative Risk Analysis (11.3) Quantitative Risk Analysis (11.4) Risk Response Planning (11.5)		Risk Monitoring and Control (11.6)	
12. Project Procurement Management		Plan Purchases and Acquisitions (12.1) Plan Contracting (12.2)	Request Seller Responses (12.3) Select Sellers (12.4)	Contract Administration (12.5)	Contract Closure (12.6)

Table 3-45. Project Process Groups and Required Project Management Knowledge Area Mapping

Chapter 4

Project Integration Management

The Project Integration Management knowledge area includes the *processes* and *activities* needed to identify, define, combine, unify and coordinate the various processes and *activities* of *project management* within the *Project Process Groups*. In the *project management* context, integration includes characteristics of unification, consolidation, articulation, and integrative actions that are crucial to project completion, successfully meeting *stakeholder* needs, and managing their expectations. Integration, in the context of managing a *project*, is making choices about where to concentrate *resources* and *effort* on any given day, anticipating potential issues, dealing with the issues before they become critical, and coordinating the *work* for the overall project good. The integration effort also involves making trade-offs among competing *objectives* and alternatives. The project management processes are usually presented as discrete components with well-defined interfaces, while, in practice, they overlap and interact in ways that cannot be completely detailed in the *PMBOK® Guide*.

The need for integration in project management becomes evident in situations where individual *processes* interact. For example: a cost estimate needed for a contingency plan involves integration of *Project Cost Management* processes, *Project Time Management* processes, and *Project Risk Management* processes; or, when additional *risks* associated with various staffing alternatives must be identified, then one or more those processes must be revisited. The project *deliverables* also need to be integrated with ongoing operations of either the *performing organization*, or the *buyer's organization*, or with long-term strategic planning that takes future problems and opportunities into consideration.

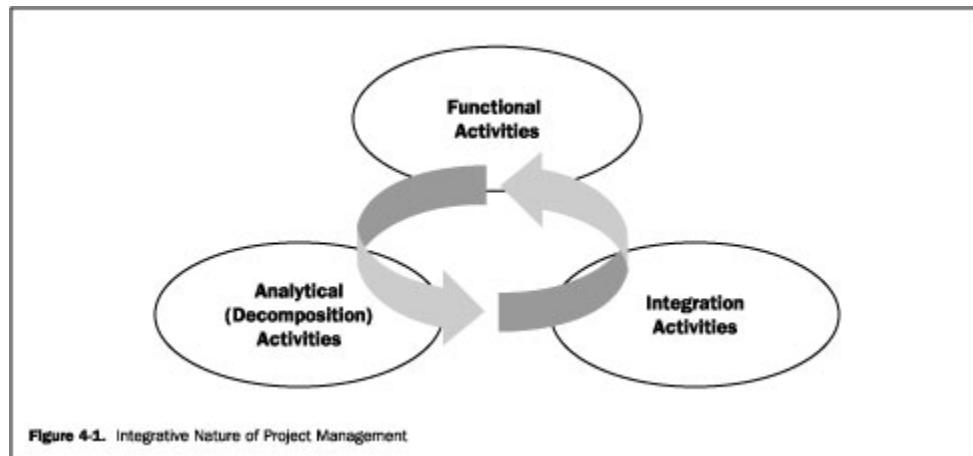
Most experienced project management practitioners know there is no single way to manage a project. They apply *project management knowledge*, *skills*, and required *processes* in different orders and degrees of rigor to achieve the desired project performance. However, the perception that a particular process is not required does not mean that it should not be addressed. The *project manager* and *project team* must address every process, and the level of implementation for each process must be determined for each specific project.

The integrative nature of projects and project management can be better understood if we think of the other *activities* performed while completing a project. For example, some activities performed by the *project management team* could be to:

- Analyze and understand the *scope*. This includes the product *requirements*, *criteria*, *assumptions*, *constraints*, *stakeholders' expectations*, and other influences related to a project, and how each will be managed or addressed within the project.
- Understand how to take the identified information and transform it into a *project management plan* using a structured approach, as described in this chapter.

- Take appropriate action to have the project performed in accordance with the planned *scope* and the planned set of *integrated processes*.
- Document the *product requirements* and specific *criteria*.
- Prepare the *work breakdown structure* and plan project execution.
- Measure and monitor project status, *processes*, and *products*.
- Analyze project *risks*.

The relationship among the integration activities within project management is shown in Figure 4-1.



Among the processes in the *Project Process Groups*, the links are often iterated. The *Planning Process Group* provides the *Executing Process Group* with a documented *project management plan* early in the project and then provides documented updates to the project management plan if changes occur as the project progresses.

Integration is primarily concerned with integrating the processes within the Project Process Groups that are required to accomplish project *objectives*. Figure 4-2 provides an overview of the major project management integrative processes. Figure 4-3 provides a process flow diagram of those processes and their inputs, outputs, and other related *knowledge area processes*. The integrative processes in project management include:

- 4.1 Develop Project Charter** – developing the *project charter* that formally authorizes a *project*.
- 4.2 Develop Project Scope Statement (Preliminary)** – developing the preliminary *project scope statement* that provides a high-level scope narrative.
- 4.3 Develop Project Management Plan** – defining the actions necessary to define, prepare, integrate and coordinate all subsidiary plans into a *Project Management Plan*.
- 4.4 Direct and Manage Project Execution** – executing the work defined in the Project Management Plan to achieve the project's objectives.
- 4.5 Monitor and Control Project Work** – *monitoring* and *controlling* the processes required to initiate, plan, execute and close a *project* to meet the performance *objectives* defined in the *Project Management Plan*.
- 4.6 Integrated Change Control** – reviewing all *change requests*, approving changes, and *controlling* changes to the *deliverables* and *organizational process assets*.

4.7 Close Project – finalizing all *activities* across all of the Project Process Groups to formally close the *project or phase*.

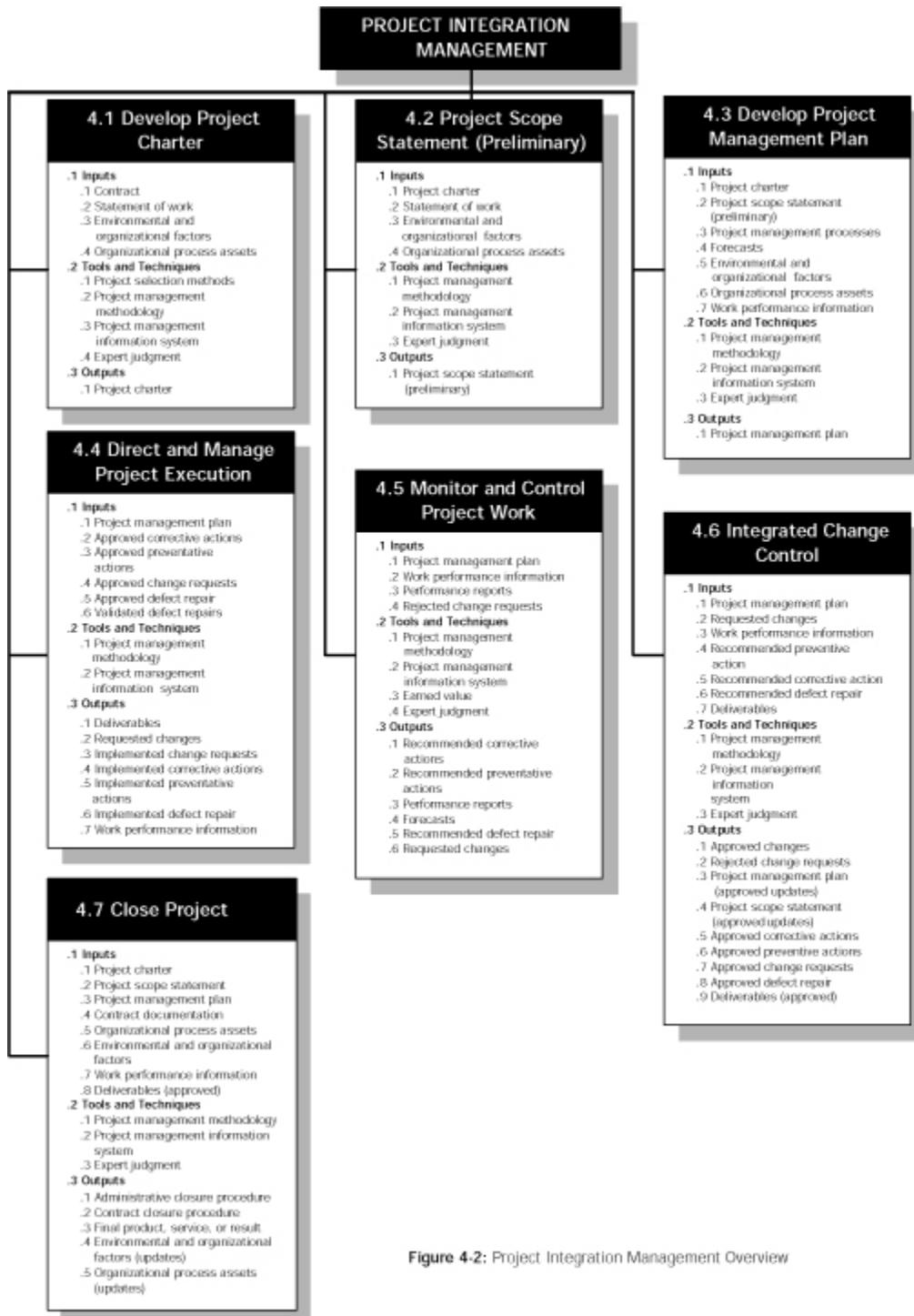


Figure 4-2: Project Integration Management Overview

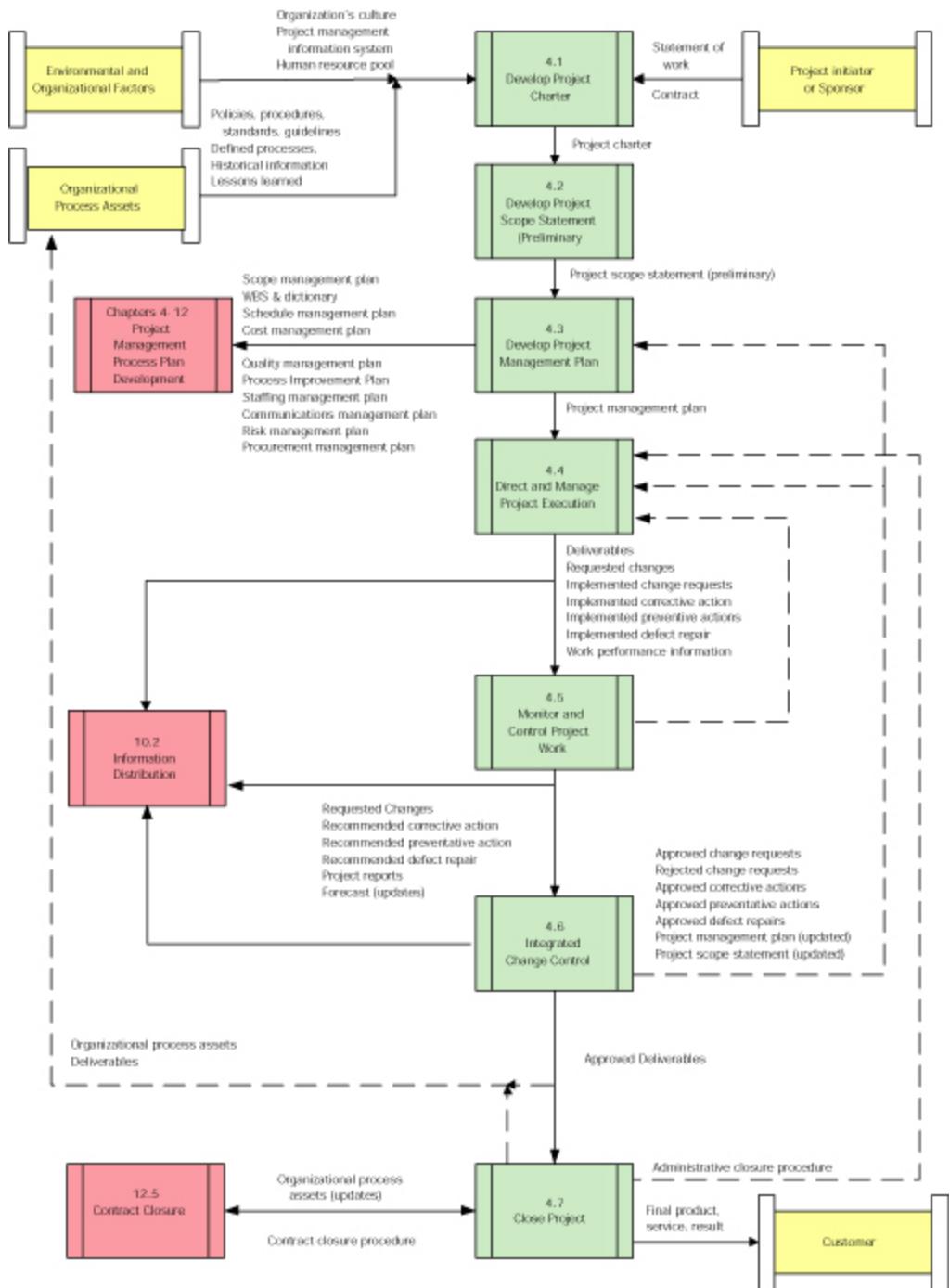


Figure 4-3: Project Integration Management Process Flow Diagram

4.1 DEVELOP PROJECT CHARTER

The *project charter* is the document that formally authorizes a *project*. The project charter is issued by a project *initiator* or *sponsor* external to the *project organization*, and at a level, within the organization authorizing the project, that is appropriate to funding project needs. The project charter provides the *project manager* with the authority to apply organizational *resources* to project *activities*. A project manager is identified and assigned as early in the project as is feasible. The project manager should always be assigned prior to the start of planning, and preferably while the project charter is being developed.

Chartering a project links the project to the ongoing work of the *performing organization*. In some organizations, a project is not formally chartered and initiated until completion of a needs assessment, feasibility study, preliminary plan, or some other equivalent form of analysis that was initiated separately. Projects are usually chartered and authorized outside of the project organization by an enterprise, a government agency, a company, a program organization, or a portfolio organization, as a result of one or more of the following:

- A market demand, such as a car company authorizing a project to build more fuel-efficient cars in response to gasoline shortages
- A business need, such as a training company authorizing a project to create a new course to increase its revenues
- A customer request, such as an electric utility authorizing a project to build a new substation to serve a new industrial park
- A technological advance, such as an electronics firm authorizing a new project to develop a video game player after advances in computer memory
- A legal requirement, such as a paint manufacturer authorizing a project to establish guidelines for handling toxic materials
- A social need, such as a nongovernmental organization in a developing country authorizing a project to provide potable water systems, latrines, and sanitation education to low-income communities suffering from high rates of cholera.

These stimuli can also be called problems, opportunities, or business *requirements*. The central theme of all these stimuli is that management must make a decision about how to respond and what projects to authorize and charter. Project selection methods involve measuring value or attractiveness to the project owner and may include other organizational decision criteria. Project selection also applies to choosing alternative ways of executing the project.

Project charter development is primarily concerned with documenting the business needs, project justification, current understanding of the *customer's* requirements, and the new *product, service, or result* that are intended to satisfy those needs. The project charter should address the following information, either directly or by reference to other documents:

- Business needs or product requirements that the project is undertaken to address
- Project purpose or justification
- *Stakeholder* needs and expectations
- Summary *milestone schedule*
- Stakeholder influences

- *Functional organizations*
- Organizational, environmental, and external *assumptions*
- Organizational, environmental, and external *constraints*
- Business case justifying the project, including return on investment
- Summary *budget*.

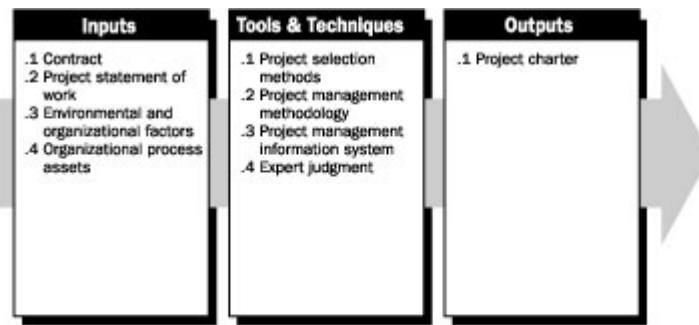


Figure 4-4. Develop Project Charter Overview

4.1.1 Develop Project Charter: Inputs

.1 Contract (When Applicable)

A contract from the customer's acquiring organization.

.2 Statement of Work (SOW)

The *statement of work* is a narrative description of *products or services* to be supplied by the project. For internal projects, the project *initiator* or *sponsor* provides the statement of work based on business needs, or product or service *requirements*. For external projects, the statement of work can be received from the *customer* as part of a bid document, for example, *request for proposal*, *request for information*, request for bid, or as part of a *contract*. The SOW indicates a:

- Business need - an organization's business need can be based on needed training, market demand, technological advance, legal requirement, or governmental standard.
- *Product scope description* - documents the product requirements and characteristics of the product or service that the project will be undertaken to create. The product requirements will generally have less detail during the initiation process and more detail during later processes, as the product characteristics are progressively elaborated. These requirements should also document the relationship among the products or services being created and the business need or other stimulus that causes the need. While the form and substance of the product requirements document will vary, it should always be detailed enough to support later project planning.
- Strategic plan - all projects support the organization's strategic goals—the strategic plan of the performing organization should be considered as a factor in project selection decisions.

.3 Environmental and Organizational Factors

When developing the Project Charter, any and all of the organization's *environmental and organizational factors and systems* that surround and influence the project's success must be considered. This includes items such as:

- Organizational or company culture and structure
- Infrastructure, for example, existing facilities and capital equipment
- Existing human resources, for example, *skills, disciplines, and knowledge* (design, development, legal, contracting and purchasing)
- Personnel administration, for example, hiring and firing guidelines, employee performance reviews, and training records
- Marketplace conditions
- *Stakeholder* risk tolerances
- Industry *risk* study information and risk databases
- *Project management information systems*, for example an automated tool suite, such as a scheduling software tool combined with a *configuration management system*.

.4 Organizational Process Assets

When developing the *Project Charter* and subsequent project documentation, any and all of the organization's *organizational process assets* that are used to influence the project's success can be drawn from this source. Any and all of the organizations involved in the project can have formal and informal enterprise plans, policies, procedures, guidelines, and management *systems* whose effects must be considered. Organizational process assets also represent the organizations' learning and *knowledge*, for example information from previous projects. Organizational process assets can be organized differently, depending on a combination of the type of industry, organization, and *application area*. For example, the organizational process assets could be grouped into two categories:

- a. Organization's *processes* and *procedures* for conducting work:
 - Organizational standard processes, such as standards, policies (safety and health policy; project management policy), standard product and *project life cycles*, quality policies and procedures, (e.g., process audits, improvement targets, audit checklists, and standardized process definitions for use in the organization)
 - Standardized guidelines, templates, work instructions, proposal evaluation criteria, risk templates, and performance measurement criteria.
 - Guidelines and criteria for tailoring the organization's set of standard processes to satisfy the specific needs of the project.
 - Organization communication requirements for example, specific communication technology available, allowed communication media, and retention requirements.
 - Project closure guidelines or requirements for example, final project audits, project evaluations, product validations, and guidelines for acceptance criteria.
 - Financial controls procedures for example, time reporting, required expenditure and disbursement reviews, accounting codes, and standard contract provisions.
 - Issue and defect management procedures defining issue and defect controls, issue and defect identification and resolution, and action item tracking.
 - Governmental or industry standards for example, regulatory agency regulations, product standards, quality standards, workmanship standards.
 - Change control procedures including the steps by which official company standards, policies, plans, and procedures, and any project documents will be modified and how any changes will be approved and validated.

- Risk control procedures including risk categories, probability definition and impact, and probability and impact matrix.
 - Procedures for issuing work authorizations that are a subset of the overall *project management information system*.
- b. Organizational corporate knowledge base:
- Process measurement database used to collect and make available measurement data on processes and products.
 - Lessons learned knowledge base containing for example information about both the results of previous project selection decisions and previous project performance.
 - Historical information (project files, records, documents, and all project closure information and documentation), including information from the risk management effort. For example, identified risk events, the planned response actions, and any impact.
 - Issue and defect management database containing issue and defect status, control, issue and defect resolution, and action item results.
 - Configuration management knowledge base containing the versions and baselines of all official company standards, policies, and procedures, and any project documents.
 - Financial database containing information such as labor hours, incurred costs, budgets, and any project cost over-runs.

4.1.2 Develop Project Charter: Tools and Techniques

.1 Project Selection Methods

Project selection methods are used to determine which project the performing organization will select. These methods generally fall into one of two broad categories:

- Benefit measurement methods that are comparative approaches, scoring models, benefit contribution, or economic models.
- Mathematical models that use linear, nonlinear, dynamic, integer, and multi-objective programming algorithms. Optimization tools can be used to search for the optimal combination of decision variables.

Some methods are often referred to as decision models. Decision models include generalized techniques (decision trees, forced, and others), field analysis.

.2 Project Management Methodology

A project management methodology defines a set of project *process groups*, their related *processes* and the related *control* functions that are consolidated and combined into a functioning unified whole. A project management methodology can be either a formal or an informal method that aids a *project management team* in effectively developing a project charter that defines the project.

.3 Project Management Information System

Project management information system (PMIS) is a standardized set of automated tools available within the organization and integrated into a *system*. The PMIS is used by the *project management team* to support generation of a project charter, facilitate feedback as the document is refined, control changes to the project charter, and release the approved document.

.4 Expert Judgments

Expert judgment is often used to assess the inputs needed to develop the project charter. Such judgment and expertise is applied to any technical and management details during this process. Such expertise is provided by any group or individual with specialized knowledge or training, and is available from many sources, including:

- Other units within the performing organization
- Consultants
- Stakeholders, including customers
- Professional and technical associations
- Industry groups.

4.1.3 Develop Project Charter: Outputs

.1 Project Charter

Described in Section 4.1.

4.2 DEVELOP PROJECT SCOPE STATEMENT (PRELIMINARY)

The *project scope statement* is the definition of the project – what needs to be done. The Develop Project Scope Statement (Preliminary) Process addresses and documents the characteristics and boundaries of the *project* and its associated *products* and *services* as well as the methods of acceptance and *scope control*. A project scope statement includes:

- Project and scope *objectives*.
- Product or service *requirements* and characteristics.
- Project boundaries.
- Project *deliverables*.
- Product acceptance *criteria*.
- Project *constraints*.
- Project *assumptions*.
- Initial project organization.
- Initial defined *risks*.
- *Schedule milestones*.
- Order of magnitude *cost estimate*.
- Project configuration management requirements.
- Approval requirements.

The initial project scope statement is developed from information provided by the *initiator* or *sponsor*. The project scope statement is further refined by the *project management team* in the *scope definition process* (Section 5.2). The project scope statement content will vary depending upon the *application area* and complexity of the *project* and can include some or all of the *components* identified above.

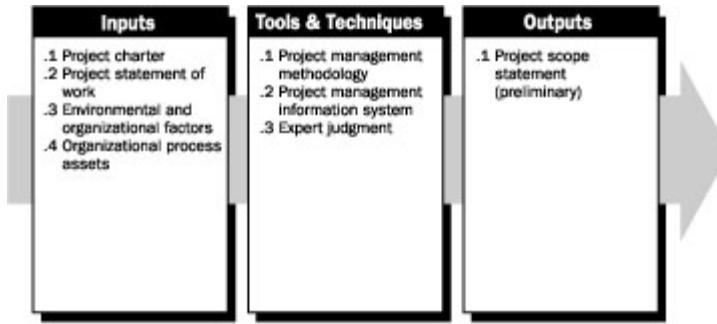


Figure 4-5. Develop Preliminary Project Scope Statement Overview

4.2.1 Develop Project Scope Statement (Preliminary): Inputs

.1 Project Charter

Described in Section 4.1.

.2 Statement of Work (SOW)

Described in Section 4.1.

.3 Environmental and Organizational Factors

Described in Section 4.1.

.4 Organizational Process Assets

Described in Section 4.1.

4.2.2 Develop Project Scope Statement (Preliminary): Tools and Techniques

.1 Project Management Methodology

Project management methodology aids a *project management team* in developing and controlling changes to the preliminary *project scope statement*.

.2 Project Management Information System

Project management information system is used by the project management team to support generation of a preliminary *project scope statement*, facilitate feedback as the document is refined, control changes to the project scope statement, and release the approved document.

.3 Expert Judgment

Expert judgment is applied to any technical and management details to be included in the preliminary project scope statement.

4.2.3 Develop Project Scope Statement (Preliminary): Outputs

.1 Project Scope Statement (Preliminary)

Described in Section 4.2.

4.3 DEVELOP PROJECT MANAGEMENT PLAN

The Develop Project Management Plan Process includes the actions necessary to define, prepare, integrate, and coordinate all constituent plans into a *Project Management Plan*. The Project Management Plan content will vary depending upon the *application area* and complexity of the *project*. This process results in a Project Management Plan that is updated and revised through the *Integrated Change Control Process*. The Project

Management Plan defines how the project is executed, monitored, and controlled. The Project Management Plan documents:

- The *processes* selected by the *project management team*.
- The level of implementation of each selected process as determined by the project management team.
- The descriptions of the *tools* and *techniques* to be used for accomplishing those processes.
- The selected *project life cycle* and associated *project phases*.
- How the selected processes will be used to manage the specific project. Including the dependencies and interactions among those processes and the essential *inputs* and *outputs*.
- How work will be executed to accomplish the project *objectives*.
- How changes will be *monitored* and *controlled*.
- How the configuration management will be performed.
- How the integrity of the project management *baselines* will be maintained.
- The need and *techniques* for communication among stakeholders.
- Key management reviews for content, extent, and timing, to facilitate addressing open issues and pending decisions.

The Project Management Plan can be either summarized or detailed and can be composed of one or more subsidiary plans. These subsidiary plans include:

- Scope management plan (Section 5.1).
- Schedule management plan (Section 6.0).
- Cost management plan (Section 7.0).
- Quality management Plan (Section 8.1).
- Process improvement plan (Section 8.1).
- Staffing management plan (Section 9.1).
- Communication management plan (Section 10.1).
- Risk management plan (Section 11.1).
- Procurement management plan (Section 12.1).

Each of these plans could be included if needed and are detailed to the extent required by the specific project.

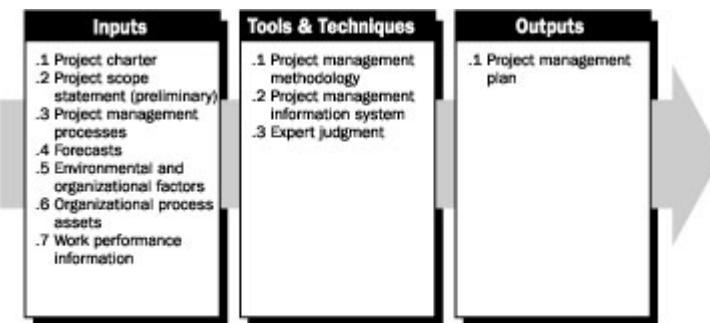


Figure 4-6. Develop Project Management Plan Overview

4.3.1 Develop Project Management Plan: Inputs

.1 Project Charter

Described in Section 4.1.

.2 Project Scope Statement (Preliminary)

Described in Section 4.2.

.3 Project Management Processes

Described in Chapter 5 through Chapter 12.

.4 Forecasts

Forecasts include *estimates* or predictions of conditions and *events* in the project's future based on information and *knowledge* available at the time of the forecast. *Forecasts* are updated and re-issued based on *work performance information* provided as the *project* is executed. The information is about the projects past performance and any information that could impact the project in the future, for example *estimate at completion* and *estimate to complete*.

.5 Environmental and Organizational Factors

Described in Section 4.1.

.6 Organizational Process Assets

Described in Section 4.1.

.7 Work Performance Information

Information on the status of the project activities being performed to accomplish the project work is routinely collected as part of the project management plan execution. This information includes, but is not limited to:

- Schedule progress showing status information through the *data date*.
- Which *deliverables* have been completed and which have not?
- Which *schedule activities* have started and which have finished?
- To what extent are quality standards being met?
- What *costs* have been authorized and incurred?
- What are the *estimates to complete* for the scheduled activities?
- What is the percent physically complete of the scheduled activities?
- What *lessons learned* have been documented and posted to the *lessons learned knowledge base*?

4.3.2 Develop Project Management Plan: Tools and Techniques

.1 Project Management Methodology

Project management methodology aids a *project management team* in developing and controlling changes to the *Project Management Plan*.

.2 Project Management Information System

Project management information system is used by the *project management team* to support generation of the Project Management Plan, facilitate feedback as the document is developed, control changes to the project management plan, and release the approved document.

.3 Expert Judgment

Expert judgment is applied to develop technical and management details to be included in the Project Management Plan.

4.3.3 Develop Project Management Plan: Outputs

.1 Project Management Plan

Described in Section 4.3.

.2 Configuration Management System

The configuration management system is a subsystem of the overall *project management information system* (Section 4.1). The *system* includes the process for submitting proposed changes, tracking systems for reviewing and approving proposed changes, defined approval levels for authorizing changes, and a method to validate approved changes. In most *application areas*, the *configuration management system* includes the *change control system*. The configuration management system is also a collection of formal documented procedures used to apply technical and administrative direction and surveillance to:

- Identify and document the functional and physical characteristics of a product or component.
- Control any changes to such characteristics.
- Record and report each change and its implementation status.
- Support the audit of the products or components to verify conformance to requirements.

.3 Change Control System

The change control system is a collection of formal documented procedures that define how project deliverables and documentation are controlled, changed, and approved. The *change control system* is a subsystem of the configuration management system. For example for information technology systems, a change control system includes the specifications (scripts, source code, data definition language, etc) for each software *component*.

4.4 DIRECT AND MANAGE PROJECT EXECUTION

The Direct and Manage Project Execution Process requires the *project manager* and the *project team* to perform multiple actions to execute the Project Management Plan to accomplish the work defined in the *project scope statement*. Some of those actions are:

- Perform *activities* to accomplish project or phase *objectives*.
- Expend effort and spend funds to accomplish the project or phase objectives.
- Staff, train, and manage the *project team* members assigned to the project or phase.
- Obtain quotations, bids, offers, or proposals as appropriate.
- Select *sellers* by choosing from among potential sellers.
- Obtain, manage, and use *resources* including materials, tools, equipment and facilities.
- Implement the planned methods and standards.
- Create, verify, and validate project or phase *deliverables*.
- Manage *risks* and implement risk response activities.
- Manage sellers.
- Adapt to approved changes in the project's *scope*, plans, and environment.

- Establish and manage project communication channels that are both external and internal to the *project team*.
- Collect project or phase data and report cost, schedule, technical, and quality progress and status information to facilitate *forecasting*.
- Collect and document *lessons learned* and implement approved process improvement activities.

The *project manager*, using the *project management team*, directs the performance of the planned project activities and manages the various technical and organizational interfaces that exist within the project. The Direct and Manage Project Execution Process is most directly affected by the project *application area*. *Deliverables* are produced as *outputs* from the *processes* performed to accomplish the project *work* planned and scheduled in the *project management plan*. *Work performance information* on the completion status of the deliverables and what has been accomplished is collected as part of project execution and fed into the *performance reporting process* (Section 10.3). Although the products, services or results of the project are frequently in the form of tangible deliverables such as buildings, roads, etc., intangible deliverables, such as training, can also be provided.

Project execution also requires implementation of:

- Approved *corrective actions* to bring anticipated project performance in line with the Project Management Plan.
- Approved *preventive actions* to reduce the probability of potential negative consequences.
- Approved *defect repair* requests to correct product defects found by the quality process.

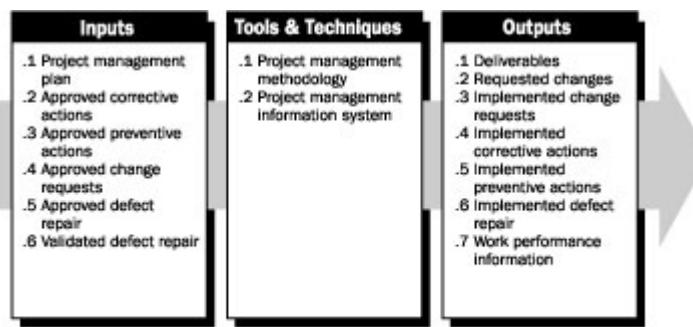


Figure 4-7. Direct and Manage Project Execution Overview

4.4.1 Direct and Manage Project Execution: Inputs

.1 Project Management Plan

Described in Section 4.3.

.2 Approved Corrective Actions

Approved *corrective actions* are documented authorized directions required to bring expected future project performance into conformance with the *project management plan* (Section 4.3).

.3 Approved Preventive Actions

Approved *preventive actions* are documented authorized directions that reduce the probability of negative consequences associated with project *risks*.

.4 Approved Change Requests

Approved *change requests* are the documented authorized changes to expand or contract project scope, modify policies, project management plans, or procedures, modify cost or budget, or revise schedules. Approved change requests are scheduled for implementation by the *project team*.

.5 Approved Defect Repair

The approved *defect repair* is the documented authorized requests for product correction for a defect found during the quality inspection and the audit process.

.6 Validated Defect Repair

Notification that re-inspected repaired items have either been accepted or rejected.

4.4.2 Direct and Manage Project Execution: Tools and Techniques

.1 Project Management Methodology

Project management methodology aids a *project management team* in executing the *project management plan*.

.2 Project Management Information System

Project management information system is used by the project management team to execute the *activities* planned in the project management plan.

4.4.3 Direct and Manage Project Execution: Outputs

.1 Deliverables

A deliverable is any unique and verifiable *product, result*, or capability to perform a *service* identified in the project management planning documentation that must be produced and provided to complete the project.

.2 Requested Changes

Changes requested to expand or reduce *project scope*, to modify policies or *procedures*, to modify project *cost* or *budget*, or to revise the *project schedule* are often identified while project work is being performed. Requests for a change can be direct or indirect, externally or internally initiated, and legally or contractually mandated or optional (Section 4.6).

.3 Implemented Change Requests

Approved *change requests* that have been implemented by the *project management team* during project execution and signed off for acceptance.

.4 Implemented Corrective Actions

The approved *corrective actions* that have been implemented by the project management team to bring expected future project performance into conformance with the *project management plan*.

.5 Implemented Preventive Actions

The approved *preventive actions* that have been implemented by the project management team to reduce the consequences of project *risks*.

.6 Implemented Defect Repair

Approved product *defect* corrections that have been implemented by the project management team during project execution.

.7 Work Performance Information

Described in section 4.3.

4.5 MONITOR AND CONTROL PROJECT WORK

The Monitor and Control Project Work Process is performed to monitor project initiating, planning, executing and closing. Corrective or preventive actions are taken to control the project performance. Monitoring is an aspect of project management performed from project inception through completion. Monitoring includes collecting, measuring, and disseminating performance information and assessing measurements and trends to effect process improvements. Continuous monitoring gives the *project management team* insight into the health of the *project* and identifies any areas that can require special attention. The Monitor and Control Project Work Process is concerned with:

- Comparing actual project performance against the *project management plan*.
- Regulating the flow of requested changes.
- Documenting the complete impact of requested changes.
- Releasing only approved changes for incorporation into project products or services and their related configuration and planning documentation.
- Influencing the factors that circumvent *integrated change control* so that only approved changes are implemented.
- Managing the approved changes when and as they occur.
- Determining that an approved change has been implemented.
- Providing information to support status reporting, progress measurement, and forecasting.
- Providing *forecasts* to update current cost and current schedule information.
- Assessing performance to determine whether any corrective or preventive actions are indicated and then recommending those actions as necessary.
- Analyzing, tracking, and monitoring project *risks* to make sure the risks are identified, their status is reported, and that appropriate risk response plans are being executed.

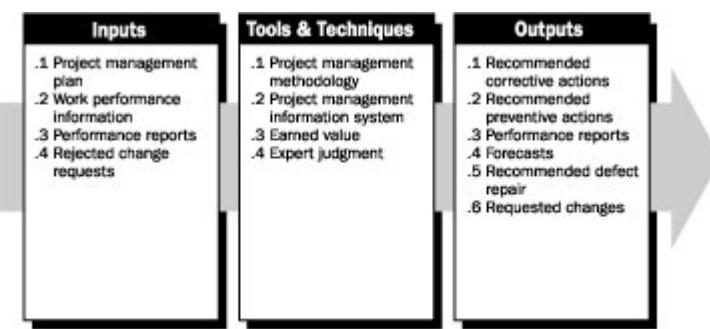


Figure 4-8. Monitor and Control Project Work Overview

4.5.1 Monitor and Control Project Work: Inputs

.1 Project Management Plan

Described in Section 4.3.

.2 Work Performance Information

Described in Section 4.3.

.3 Performance Reports

Described in Section 10.3.

.4 Rejected Change Requests

Change requests, their supporting documentation, and their change review status showing a disposition of rejected.

4.5.2 Monitor and Control Project Work: Tools and Techniques

.1 Project Management Methodology

Project management methodology aids a *project management team* in monitoring and controlling the project work being performed in accordance with the *project management plan*.

.2 Project Management Information System

Project management information system (PMIS) is used by the project management team to monitor and control the execution of the *activities* planned and scheduled in the *project management plan*. The PMIS is also used to establish new forecasts as needed.

.3 Earned Value Management

Measures the performance of the project as it moves from initiating through to closing. The *earned value management* methodology also provides a means to forecast future performance based upon past performance.

.4 Expert Judgment

Expert judgment is used by the project management team to monitor and control project work.

4.5.3 Monitor and Control Project Work: Outputs

.1 Recommended Corrective Actions

Corrective actions are documented recommendations required to bring expected future project performance into conformance with the *project management plan* (Section 4.3).

.2 Recommended Preventive Actions

Preventive actions are documented recommendations that reduce the probability of negative consequences associated with project risks

.3 Project Reports

Status reports, schedule reports, cost reports, performance reports, and configuration status reports (Section 10.3).

.4 Forecasts

Described in Section 4.3.

.5 Recommended Defect Repair

Defects, recommended for correction, which are found during the quality inspection and audit process.

.6 Requested Changes

Described in Section 4.4.

4.6 INTEGRATED CHANGE CONTROL

The Integrated Change Control Process is performed from *project* inception through completion and is applied during all project *phases*. *Change control* is necessary because projects seldom run exactly according to the *project management plan*. The *project scope*

statement, the *project management plan*, and other project *deliverables* must be maintained by continuously managing changes, either by rejecting changes or by approving changes so the approved changes are incorporated into a revised project *component*. The Integrated Change Control Process includes the following change management activities in differing levels of detail based upon the completion of project execution:

- Identifying that a change needs to occur.
- Managing each identified change.
- Maintaining the integrity of all *baselines*.
- Controlling and updating the *scope*, *cost*, *budget*, *schedule*, and quality requirements based upon approved changes.
- Coordinating changes across the entire project. For example, a proposed schedule change will often affect cost, risk, quality, and staffing.
- Controlling project quality to standards based on quality reports.
- Maintaining an accurate, timely information base concerning the project's product(s) and their associated documentation through the *project* completion.

Proposed changes can require new or revised cost estimates, *schedule activity* sequences, schedule dates, resource requirements, analysis of risk response alternatives, or other adjustments to the *project management plan*, *project scope statement*, or other project *deliverables*. The *configuration management system* with its *change control system* provides a standardized, effective and efficient process to centrally manage changes within a project. Configuration management with change control includes the identifying, documenting, and controlling changes to the deliverables in the project *baselines*. The applied level of change control is dependent upon the *application area*, the complexity of the specific project, contract requirements, and the context and environment in which the project is performed.

Project-wide application of the *configuration management system*, including change control processes, accomplishes three main objectives:

- Establishes an evolutionary method to consistently identify and request changes to established baselines and to assess the value and effectiveness of those changes.
- Provides opportunities to continuously validate and improve the project through considering the impact of each change.
- Provides the mechanism for the project management team to consistently communicate all changes to the project *stakeholders*.

Some of the configuration management activities that include the *integrated change control* process are:

- Configuration Identification - providing the basis from which the configuration of products are defined and verified; products and documents are labeled; changes are managed; and accountability is maintained.
- Configuration Status Accounting - capturing, storing, and accessing configuration information needed to manage products and product information effectively.
- Configuration Verification and Audits - establishing that the performance and functional requirements defined in the configuration documentation have been achieved by the design and that the design has been accurately documented in the configuration documentation.

Every documented requested change must be either accepted or rejected by some authority within the *project management team* or an external organization representing the initiator or sponsor or buyer. Many times the *integrated change control process* includes a *change control board* structure responsible for approving and rejecting the requested changes. The roles and responsibilities of these boards are clearly defined within the change control and configuration control procedures and are agreed to by all key *stakeholders*. Many large organizations provide for a multi-tiered board structure, separating responsibilities between the boards. If the project is being provided under a contract, then some proposed changes can also need to be approved by the *buyer* (Section 12.5).

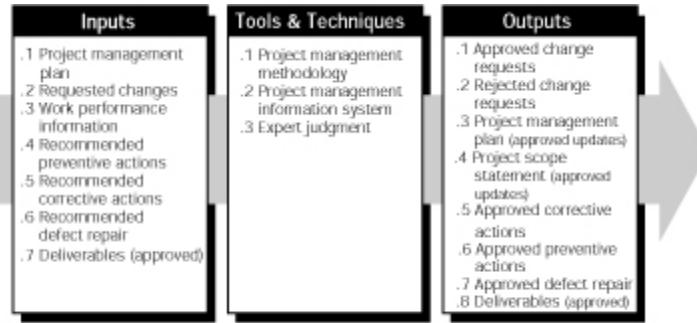


Figure 4-9. Integrated Change Control Overview

4.6.1 Integrated Change Control: Inputs

.1 Project Management Plan

Described in Section 4.3.

.2 Requested Changes

Described in Section 4.4.

.3 Work Performance Information

Described in Section 4.3.

.4 Recommended Preventive Actions

Described in Section 4.5.

.5 Recommended Corrective Actions

Described in Section 4.5.

.6 Recommended Defect Repair

Described in Section 4.5.

.7 Deliverables

Described in Section 4.4.

4.6.2 Integrated Change Control: Tools and Techniques

.1 Project Management Methodology

Project management methodology aids a *project management team* in implementing *integrated change control* for the *project*.

.2 Project Management Information System

Project management information system is used by the project management team to implement integrated change control for the project, facilitate feedback for the project, and control changes across the project.

.3 Expert Judgment

Expert judgment is used by the project management team to control and approve all requested changes to any aspect of the project.

4.6.3 Integrated Change Control: Outputs

.1 Approved Change Requests

Described in Section 4.4.

.2 Rejected Change Requests

Described in Section 4.5.

.3 Project Management Plan (Approved Updates)

Described in Section 4.3.

.4 Project Scope Statement (Approved Updates)

Described in Section 4.2.

.5 Approved Corrective Actions

Described in Section 4.4.

.6 Approved Preventive Actions

Described in Section 4.4.

.7 Approved Defect Repair

Described in Section 4.4.

.8 Deliverables (Approved)

Described in Section 4.4 and approved by the *integrated change control process*.

4.7 CLOSE PROJECT

The Close Project Process involves performing the project closure portion of the *project management plan*. This process includes finalizing all *activities* completed across all the Project Process Groups to formally close the *project* or *phase*, and transfer the completed or cancelled project or phase as appropriate. The Close Project Process also establishes the procedures to coordinate activities needed to verify and document the project *deliverables*, to coordinate and interact to formalize acceptance of those deliverables by the *customer* or *sponsor*, and to investigate and document the reasons for actions taken if a project is terminated before completion. Two procedures are used to establish the interactions necessary to perform the closure activities across the entire project.

- The administrative closure procedure covers the whole project and planning and preparing the phase closures as each phase is completed. This procedure details all the activities, interactions, and the related roles and responsibilities of the *project team* members and other *stakeholders* involved in executing the administrative closure procedure for the project or any of its phases. Performing the administrative closure process also includes integrated activities needed to collect project or phase records, analyze project success or failure, gather *lessons learned* for each project phase, and archive project or phase information for future use by the performing organization.
- The contract closure procedure includes all activities and interactions needed to settle and close any contract, purchase, or acquisition agreement established for the project, as well as defining those contract related activities supporting the formal administrative closure of the project. This procedure involves both *product verification* (all work completed correctly and satisfactorily) and administrative closure (updating of contract records to reflect final results and archiving of such

information for future use). The contract terms and conditions can also prescribe specific procedures for contract closure that must be part of this procedure. Early termination of a contract is a special case of contract closure that could involve, for example, the inability to deliver the product, a budget overrun, or lack of required resources.

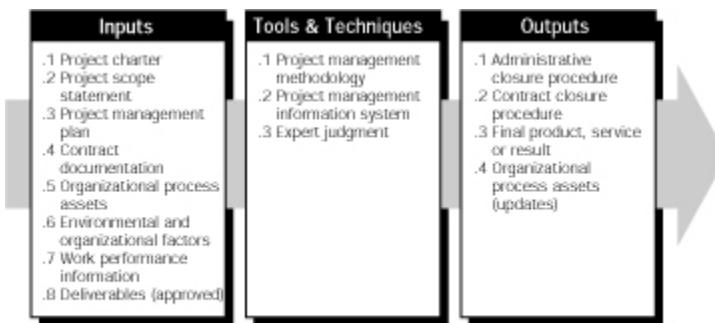


Figure 4-10. Close Project Overview

4.7.1 Close Project: Inputs

.1 Project Charter

Described in Section 4.1.

.2 Project Scope Statement

Described in Section 4.2.

.3 Project Management Plan

Described in Section 4.3.

.4 Contract Documentation

Contract documentation is a major input used to perform the *contract closure process* and includes the contract itself, changes to the contract, and other seller documentation such as technical approach or product description. Additionally, part of the contract or one of its subsidiary documents defines deliverable acceptance criteria and procedures (Section 12.7).

.5 Organizational Process Assets

Described in Section 4.1.

.6 Environmental and Organizational Factors

Described in Section 4.1.

.7 Work Performance Information

Described in Section 4.4.

.8 Deliverables (Approved)

Described in Section 4.4 approved by the integrated change control process.

4.7.2 Close Project: Tools and Techniques

.1 Project Management Methodology

Project management methodology aids a *project management team* in performing both administrative and contract closure procedures for the project or phase, if the project is divided into phases.

.2 Project Management Information System

Project management information system is used by the project management team to perform both administrative and contract closure procedures across the project or phases, if the project is divided into phases.

.3 Expert Judgment

Expert judgment is applied in developing and performing both the administrative and contract closure procedures.

4.7.3 Close Project: Outputs

.1 Administrative Closure Procedure

This procedure contains all the *activities* and the related roles and responsibilities, and identifies the *project team* members involved in executing the administrative closure procedure for the project or any of its phases. The steps to transfer the project products or services to operation and production are developed and established. The procedure provides a step-by-step methodology for administrative closure that addresses:

- Actions and activities to define the *stakeholder approval requirements* for all levels of *deliverables* and changes.
- Actions and activities in other required project *processes* that are necessary to:
 - Confirm that the project has met all stakeholders' mandatory requirements.
 - Verify that all deliverables have been provided and accepted.
 - Validate that any completion and exit criteria have been met.
- Actions and activities necessary to satisfy completion or exit *criteria* for the project or its phases.

.2 Contract Closure Procedure

This procedure is developed to provide a step-by-step methodology for contract closure that addresses the terms and conditions of the contacts and any required completion or exit criteria. This procedure contains all the activities and the related responsibilities, and identifies the *project team* members and other *stakeholders* involved in the *contract closure process*, for project contract, purchase, and acquisition agreements. The actions performed formally close all contacts associated with the completed project or a specific completed phase.

.3 Final Product, Service, or Result

Delivery of the final *product, service, or result* that the project was authorized to produce.

.4 Organizational Process Assets (Updates)

Closure should include development of a numerical listing and location of project documentation using the *configuration management system* identified in Section 4.3.

- **List of Project Documentation**

Formal confirmation has been received from the *customer* or *sponsor* or *buyer* that the project or phase has met customer *requirements* and *specifications* for the project's product, service, or result. The customer or sponsor has formally accepted the project or phase deliverables.

- **Project Closure Documents**

Project closure documents consist of formal documentation indicating completion of the project and the transfer of the completed project deliverables to others, such as an operations group. If the project was terminated prior to completion, the

formal documentation indicates why the project was terminated and the transfer of the cancelled project to others.

- **Historical Information**

Historical information and *lessons learned* information are transferred to the *lessons learned knowledge base* for use by future *projects*.

Chapter 5

Project Scope Management

Project Scope Management includes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully. Scope management is primarily concerned with defining and controlling what is and is not included in the project. Figure 5-1 provides an overview of the Project Scope Management processes, and Figure 5-2 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes.

5.1 Scope Planning—creating a Scope Management Plan that documents how the scope will be defined, verified, and controlled and how the Work Breakdown Structure (WBS) will be created and defined.

5.2 Scope Definition—developing a detailed project scope statement as the basis for future project decisions.

5.3 Create WBS—subdividing the major project deliverables and project work into smaller, more manageable components.

5.4 Scope Verification—formalizing acceptance of the completed project scope.

5.5 Scope Control—controlling changes to the project scope.

These processes interact with each other and with the processes in the other knowledge areas as well. Each process can involve effort from one or more individuals or groups of individuals, based on the needs of the project. Each process generally occurs at least once in every project or phase.

Although the processes are presented here as discrete components with well-defined interfaces, in practice they can overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapters 3 and 4.

In the project context, the term scope can refer to:

- Product scope—the features and functions that characterize a product or service.
- Project scope—the work that must be done to deliver a product with the specified features and functions.

This chapter focuses on the processes used to manage project scope as well as product scope. These processes and their associated tools and techniques vary by application area, and are usually defined as part of the project life cycle (Section 2.1) and documented in the scope management plan.

A project generally results in a single product, but that product can include subsidiary components, each with its own separate, but interdependent, product scope. For example, a new telephone system would generally include four subsidiary components—hardware, software, training, and implementation.

Completion of the project scope is measured against the project management plan, but completion of the product scope is measured against the product requirements. Scope management needs to be well integrated so that the work of the project will result in delivery of the specified product.

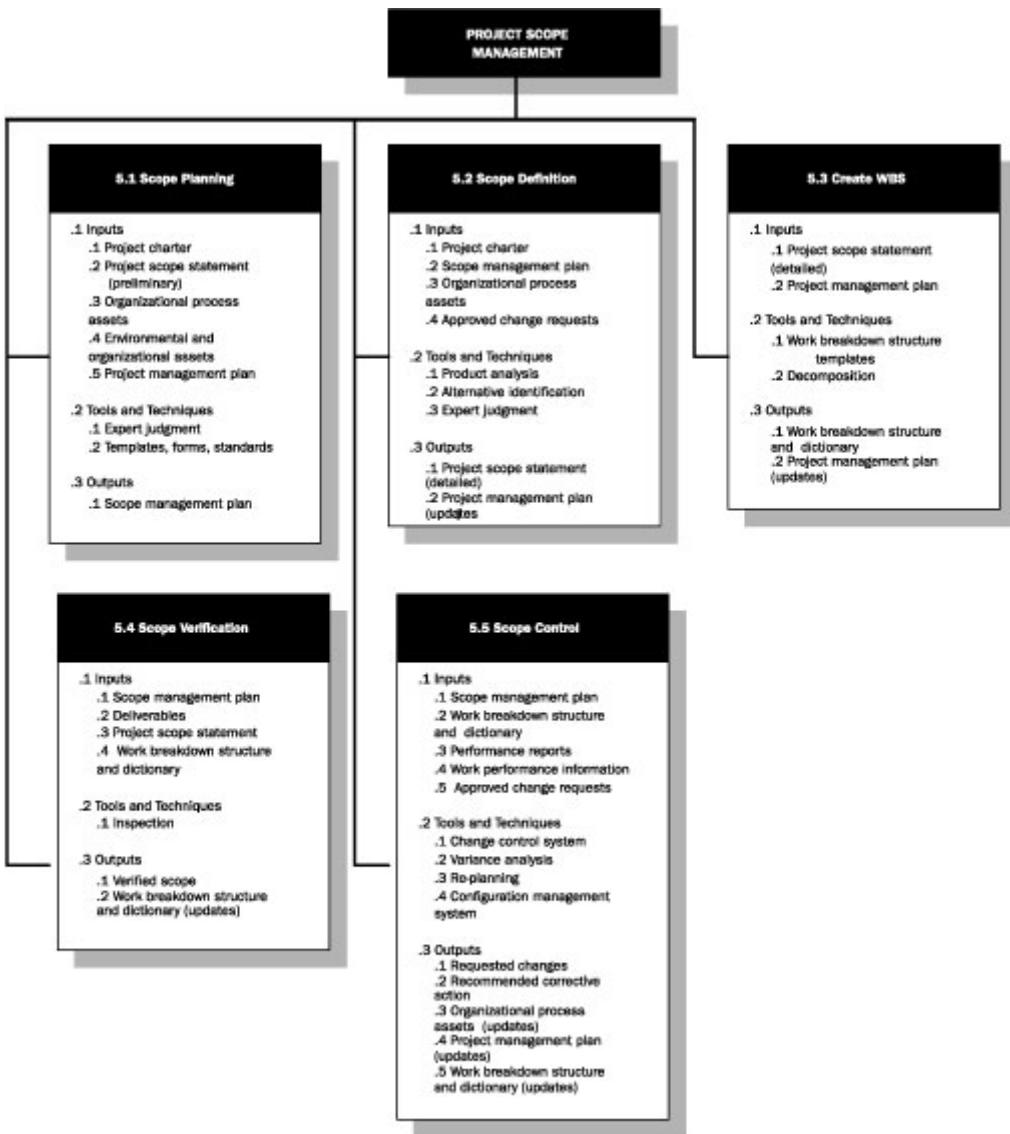


Figure 5-1. Project Scope Management Overview

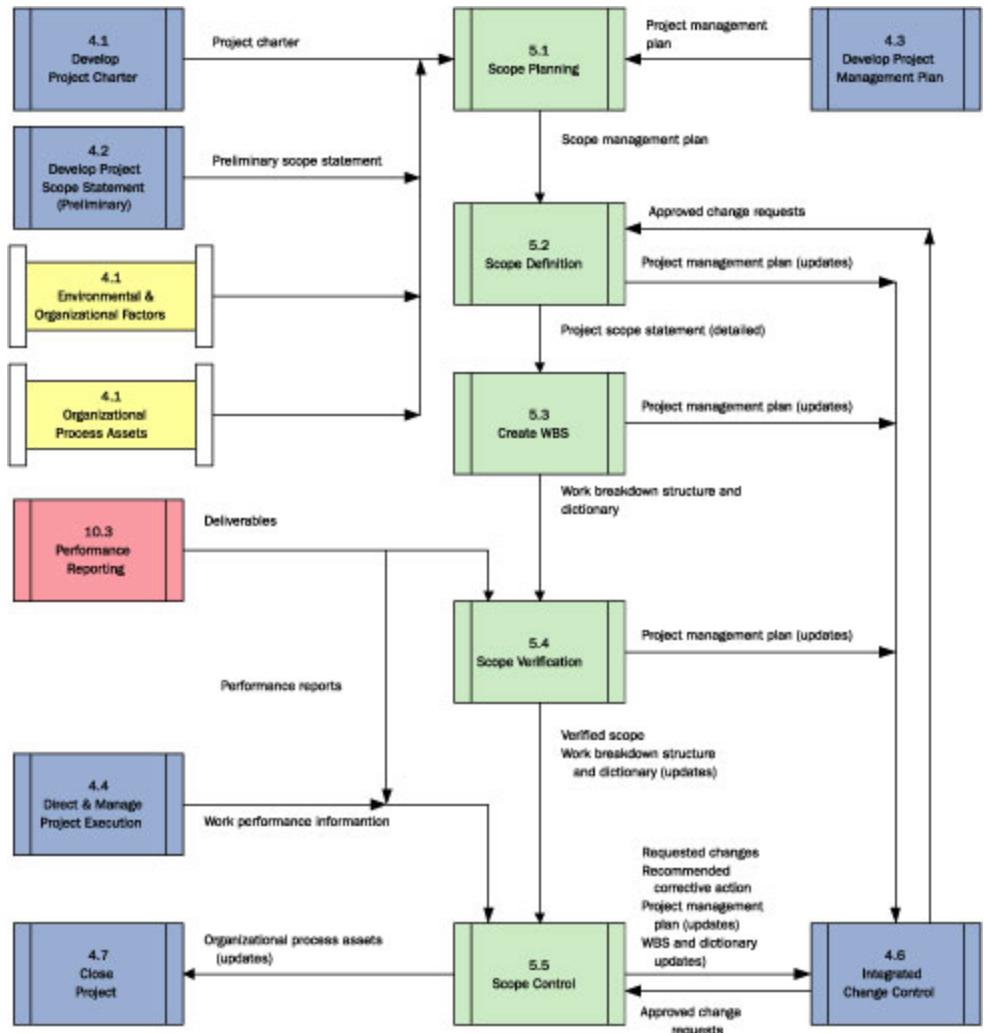


Figure 5-2. Project Scope Management Process Flow Diagram

5.1 SCOPE PLANNING

Defining and managing the project scope influences the project's overall success. Each project requires a careful balance of tools, data sources, methodologies, processes and procedures, and other factors to ensure that the effort expended on scoping activities is commensurate with the project's size, complexity and importance. For example, a critical project could merit formal, thorough and time-intensive scoping activities, while a routine project could require substantially less documentation and scrutiny. The project management team documents decisions in the scope management plan. The scope management plan is a planning tool describing how the team will define the scope, develop the detailed scope statement, define and develop the work breakdown structure, verify the scope, and control the scope.

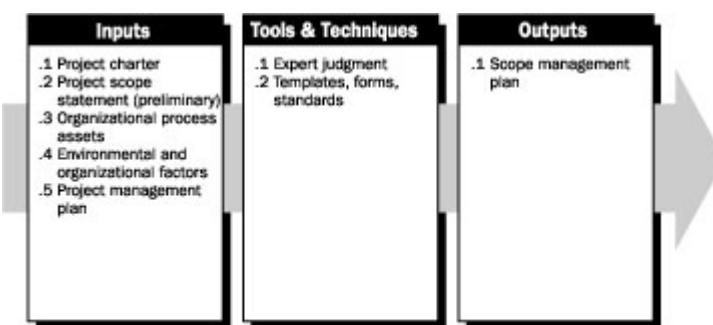


Figure 5-3. Scope Planning Process Overview

5.1.1 Scope Planning: Inputs

.1 Project Charter

Described in Section 4.1.

.2 Project Scope Statement (Preliminary)

Described in Section 4.2.

.3 Organizational Process Assets

Organizational process assets (Section 4.1) are the formal and informal policies, procedures, and guidelines that could impact how the project's scope is managed. Those of particular interest to scope planning are:

- Organizational policies as they pertain to scope planning and management.
- Organizational procedures related to scope planning and management.
- Historical information about previous projects, which should be considered during scope planning. Information may be located in prior projects' lesson learned project archives.

.4 Environmental and Organizational Factors

Environmental and organizational factors include information about the organizations' culture, infrastructure, tools, human resources, personnel policies, and marketplace conditions that could affect how scope is managed.

.5 Project Management Plan

Described in Section 4.3.

5.1.2 Scope Planning: Tools and Techniques

.1 Expert Judgment

Expert judgment is used in developing detailed scope statements, work breakdown structures, and scope management plans.

.2 Templates, Forms, and Standards

Templates, forms, and standards include work breakdown structure templates, change control forms, and scope change control forms.

5.1.3 Scope Planning: Outputs

.1 Scope Management Plan

The scope management plan provides guidance on how project scope will be managed by the project management team. The components of a scope management plan include:

- A process to describe the preparation of a detailed scope statement based upon the preliminary project scope statement (Section 4.2)
- A process that enables the creation of the WBS from the detailed project scope statement
- A process that specifies how formal verification or acceptance of the completed project deliverables and its companion WBS will be obtained
- A process to control how requests for changes to the detailed project scope statement will be processed. This process is directly linked to integrated change control (Section 4.6).

A scope management plan is contained in, or is a subsidiary of, the project management plan (Section 4.3). The scope management plan can be informal and broadly framed, or formal and highly detailed, based on the needs of the project.

5.2 SCOPE DEFINITION

The preparation of a detailed project scope statement builds upon the major deliverables, assumptions, and constraints that are documented in the preliminary project scope statement (Section 4.2) during initiation, and is critical to project success. During planning, the project scope is described with greater specificity because more information about the project is known. The assumptions and constraints are examined for completeness, with additional assumptions and constraints added as necessary. The project team and other stakeholders, who have additional insight into the project scope statement, can perform and prepare the analysis.

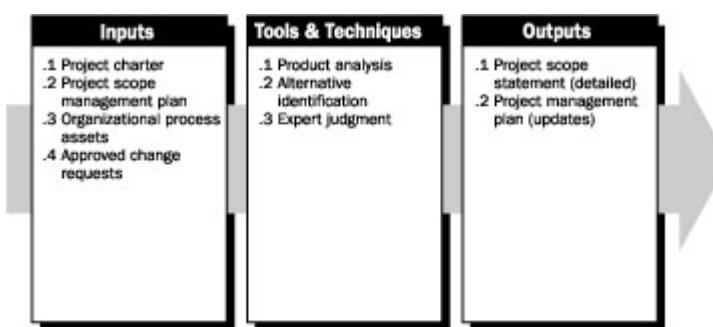


Figure 5-4. Scope Definition Overview

5.2.1 Scope Definition: Inputs

.1 Project Charter

Described in Section 4.1. If charters or preliminary scope statements are not used in a performing organization, comparable information needs to be acquired or developed and then used to develop the detailed project scope statement.

.2 Project Scope Management Plan

Described in Section 5.1.

.3 Organizational Process Assets

Described in Section 4.1.

.4 Approved Change Requests

Approved change requests (Section 4.6) can trigger a change to project quality, scope, cost, or schedule. Change requests are often identified while the work of the project is ongoing, and can occur in many forms: oral or written, direct or indirect, externally or internally initiated, legally or contractually mandated, or optional.

5.2.2 Scope Definition: Tools and Techniques

.1 Product Analysis

Each application area has one or more generally accepted methods for translating project objectives into tangible deliverables. Product analysis includes techniques such as product breakdown, systems analysis/engineering, value engineering, value analysis, and functional analysis.

.2 Alternatives Identification

Identifying alternatives is a technique used to generate different approaches to the work of the project. A variety of general management techniques are often used here, the most common of which are brainstorming and lateral thinking.

.3 Expert Judgment

Each application area has experts who can be used to define the project scope statement.

5.2.3 Scope Definition: Outputs

.1 Project Scope Statement (Detailed)

The project scope statement describes, in detail, the project's deliverables and the work required to create those deliverables. The scope statement also provides a common understanding among all project stakeholders, describes the project's major objectives, enables the team to perform more detailed planning, guides the teams' work during execution, and provides the baseline for evaluating whether client requests for changes or additional work fall within or outside the project's boundaries. The detailed scope statement includes, either directly or by reference to other documents:

- **Project and Scope Objectives.** These objectives include the measurable success criteria of the project. Projects may have a wide variety of business, cost, schedule, technical and quality objectives. Project objectives can also include cost, schedule, and quality targets. Project objectives need to have an attribute such as cost, a metric such as United States dollars, and an absolute or relative value such as less than 1.5 million. Unqualified objectives such as customer satisfaction entail high risk to successful accomplishment.
- **Product Scope Description.** This section describes the characteristics of the product, service or result that the project was undertaken to create. The

requirements will generally have less detail in early phases, and more detail in later phases as the product characteristics are progressively elaborated. While the form and substance of the requirements will vary, it should always provide sufficient detail to support later project planning.

- **Project Boundaries.** Boundaries explicitly define what's included in and excluded from the project.
- **Project Deliverables.** Deliverables include both the outputs that comprise the product of the project, as well as ancillary outputs such as project management reports and documentation. Depending on the project scope statement, the deliverables may be described at a summary level or in great detail.
- **Product Acceptance Criteria.** This section defines the process for accepting product deliverables.
- **Project Constraints.** This section describes and lists the specific constraints associated with the scope and can limit the team's options. For example, a predefined budget or any imposed dates (schedule milestones) that are issued by the customer or organization should be included. When a project is performed under contract, contractual provisions will generally be constraints. The constraints listed in the project scope statement are typically more numerous and more detailed than the constraints listed in the project charter.
- **Project Assumptions.** This section describes and lists the specific assumptions associated with the scope, and the potential impact of those assumptions if they prove to be false. Project teams frequently identify, document and validate assumptions as part of their planning process. The assumptions listed in the project scope statement are typically more numerous and more detailed than the assumptions listed in the project charter.
- **Initial Project Organization.** The members of the team, as well as stakeholders, are identified. The organization of the project is also documented in this section.
- **Initial Defined Risks.** This section includes the known risks.
- **Schedule Milestones.** The customer or organization can impose dates on the project team. These dates can be considered as schedule milestones, and should be addressed in this section or addressed as a constraint.
- **Order of Magnitude Cost Estimate.** The project's cost estimate includes the project costs, resources and durations, and is usually preceded by a modifier. The cost estimate includes some indication of accuracy, such as order-of-magnitude or conceptual (Section 7.1).
- **Project Configuration Management Requirements.** This section describes the level of configuration management and change control to be implemented on the project.
- **Approval Requirements.** This section includes approval requirements that can be mandated by any stakeholder. Approval requirements can be applied to project objectives, deliverables and work.

.2 Project Management Plan (Updates)

The project management plan should be updated to include changes to the scope management plan that result from changes to the scope definition process. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

5.3 CREATE WBS

The work breakdown structure (WBS) is a deliverable-oriented hierarchy of decomposed project components that organizes and defines the total scope of the project. The WBS is a representation of the detailed project scope statement that specifies the work to be accomplished by the project. The elements comprising the WBS assist the stakeholders in viewing the end product of the project. The work at the lowest-level WBS component is estimated, scheduled, and tracked.

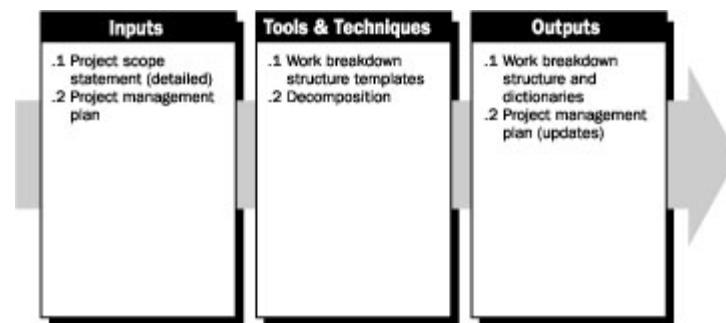


Figure 5-5. Create WBS Overview

5.3.1 Create WBS: Input

.1 Project Scope Statement (Detailed)

Described in Section 5.2.

.2 Project Management Plan

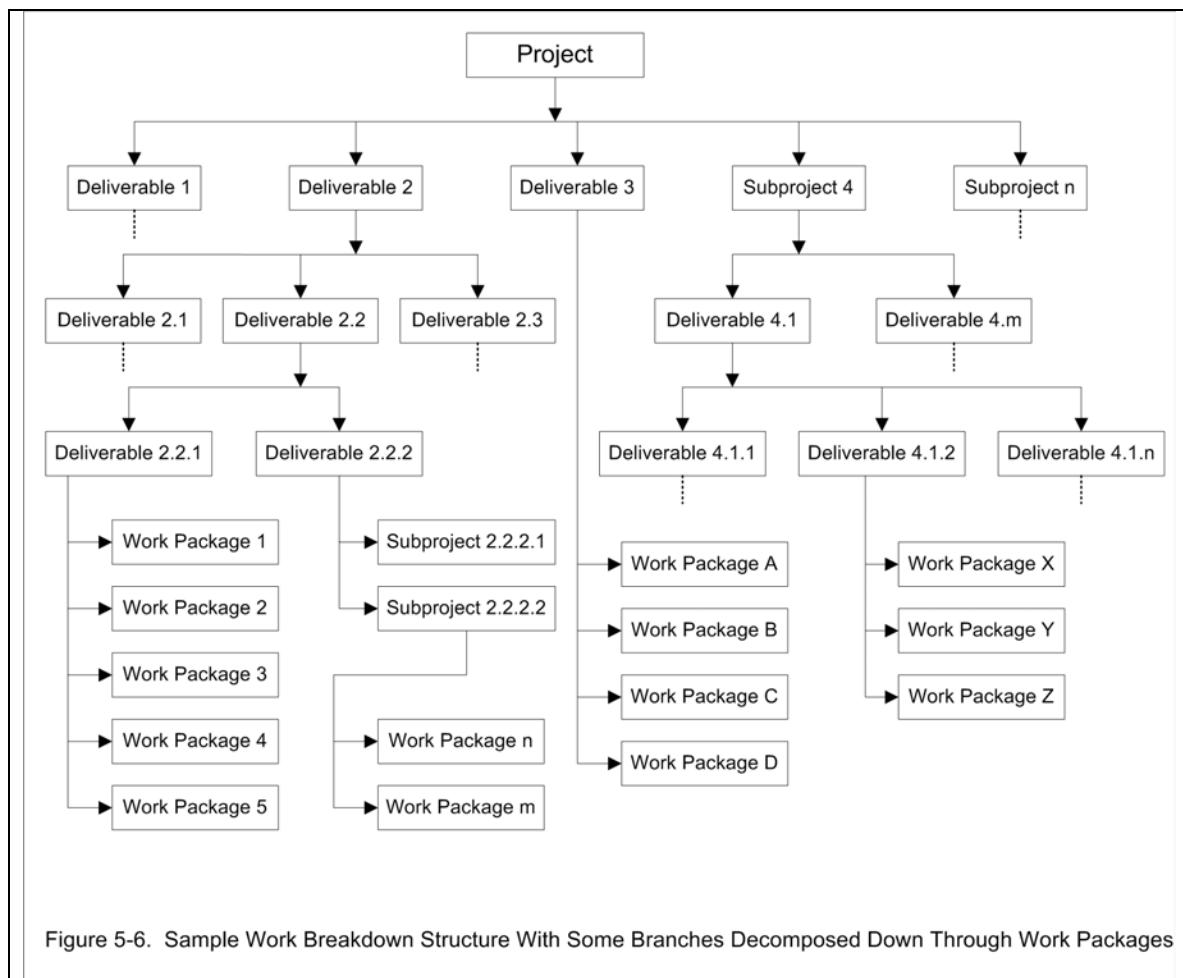
Described in Section 4.3.

5.3.2 Create WBS: Tools and Techniques

.1 Work Breakdown Structure Templates

A WBS (Section 5.3) from a previous project can often be used as a template for a new project. Although each project is unique, a WBS can often be reused since most projects will resemble another project to some extent. For example, most projects within a given organization will have the same or similar project life cycles and will, thus, have the same or similar deliverables required from each phase. Many application areas or performing organizations have standard WBS templates.

In 2001, the Project Management Institute (PMI) published its *Practice Standard for Work Breakdown Structures*, that provides guidance in the generation, development, and application of Work Breakdown Structures. This PMI publication contains industry-specific examples of WBSs that can be tailored to specific projects in a particular industry area. A portion of a WBS generic example, with some branches of the WBS decomposed down through the work package level, is shown in Figure 5-6.



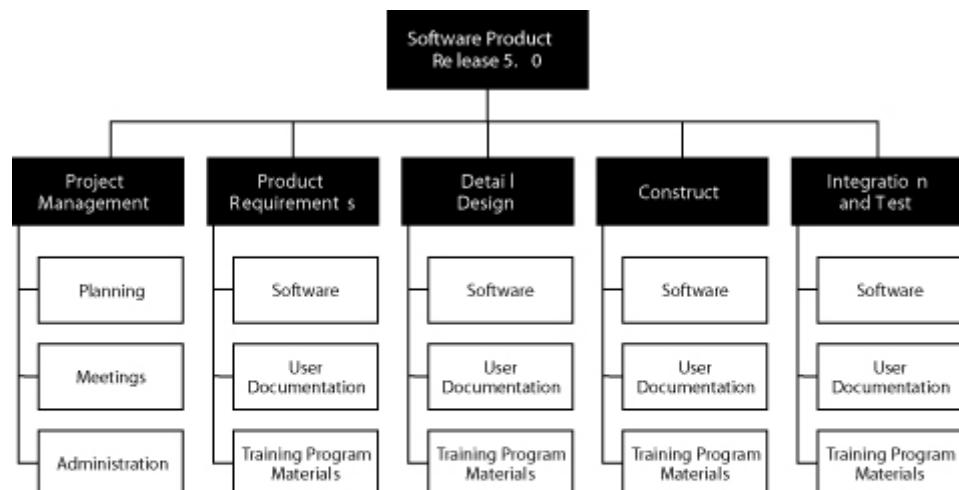
.2 Decomposition

Decomposition is the subdivision of project deliverables into smaller, more manageable components until the deliverables are defined to the work package level. The work package level is the point at which cost and schedule can be reliably estimated, and will support managing activities throughout the project life cycle.

Decomposition may not be possible for a deliverable or subproduct that will be produced far into the future. The project management team must wait until the deliverable or subproduct is clarified. Different deliverables can have different levels of decomposition. To arrive at a manageable effort (i.e., a work package), some deliverables need to be decomposed to the next level, while others need more levels of decomposition. The amount of effort assigned to a work package can depend on the time frame of the project. The level of detail of work packages will vary with the size and complexity of the project.

Decomposition involves addressing the following steps:

- Identifying major *deliverables* of the *project*, including project management deliverables and those deliverables acquired by *contract*.
- Decomposing the deliverables and associated project *work* into a WBS, which can take a number of forms:
 - Using the major deliverables as the first level of decomposition as shown in Figure 5-6.
 - Using the phases of the *project life cycle* as the first level of decomposition with the project deliverables inserted at the second level as shown in Figure 5-7.
 - Using different approaches within each branch of the WBS as illustrated in Figure 5-8.
 - Using a combination of major deliverables and subprojects as illustrated in Figure 5-6, where the subprojects may be developed by organizations outside the project team. For example, in some application areas, the project WBS can be defined and developed in multiple parts such as a project summary WBS with multiple subprojects within the WBS that can be contracted out.



This WBS is illustrative only. It is not intended to represent the full project scope of any specific project, nor to imply that this is the only way to organize a WBS on this type of project.

Figure 5-7. Sample Work Breakdown Structure Organized by Phase

- Decomposing each deliverable or subproject into its fundamental *components*. The components are defined in terms of how the work of the project will actually be accomplished, performed, and managed. The components of the WBS represent verifiable *products*, *results*, or *services*. For example, the project management component of status reporting could include weekly status reports, while a manufacturable product might include several individual components plus the final assembly.

- Verifying the correctness of the decomposition. The lower-level WBS components should be those that are necessary and sufficient for completion of the decomposed deliverable. Each component should be clearly and completely defined, and be able to be scheduled, budgeted, and assigned to a specific performing organizational unit that accepts responsibility for the component's completion.

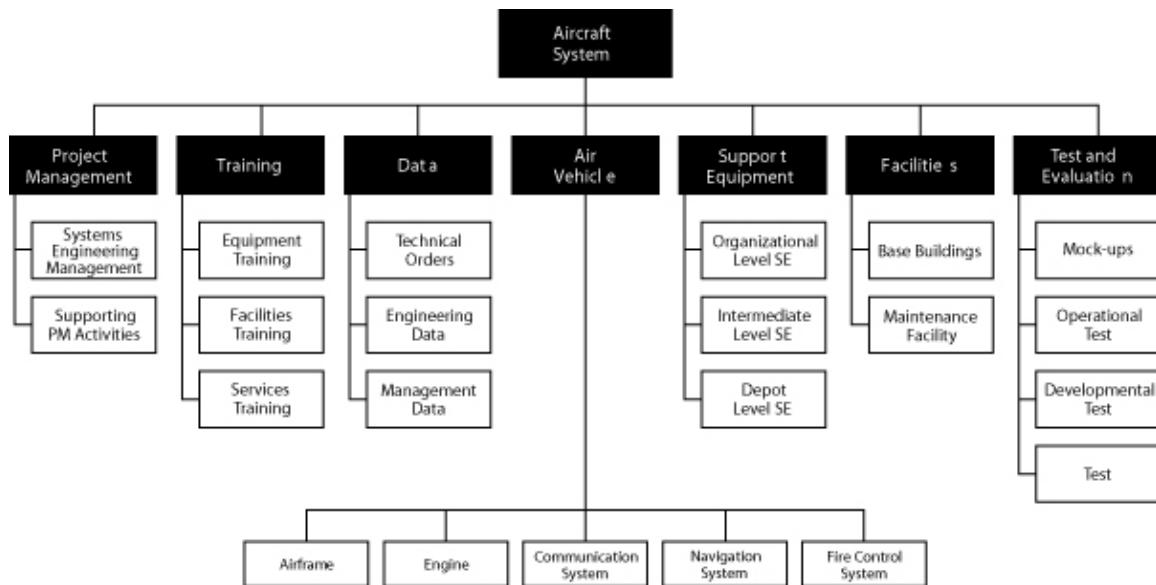


Figure 5-8. Sample Work Breakdown Structure for Defense Material Items

5.3.3 Create WBS: Outputs

.1 Work Breakdown Structure and Dictionary

Each work package in a WBS is generally assigned a unique identifier; these identifiers provide a structure for hierarchical summation of costs and resources. These work packages are then decomposed into activities for the project schedule (Section 6.1).

The detail of the elements contained in a Work Breakdown Structure, including work packages, can be described in a WBS dictionary. A WBS dictionary is a companion document to the WBS that describes each WBS element. For each WBS element, the WBS dictionary includes a statement of work, a list of associated activities, and a list of milestones. Other information can include the responsible organization, start and end dates, resources required, an estimate of cost, charge number, contract information, quality requirements, and technical references to facilitate performance of the work. Each WBS element should be cross-referenced, as appropriate, to other WBS elements in the WBS dictionary.

The WBS should not be confused with other kinds of breakdown structures used to present project information. Other structures used in some application areas include:

- Organizational Breakdown Structure (Section 9.1), which provides a hierarchically organized depiction of the project organization arranged so that the work packages can be related to the performing organizational units
- Bill of Materials, which presents a hierarchical tabulation of the physical assemblies, subassemblies, and components needed to fabricate a manufactured product
- Risk Breakdown Structure (Section 11.1), which is a hierarchically organized depiction of the identified project risks arranged by risk category.

.2 Project Management Plan (Updates)

If changes result from the Create WBS process, the project management plan may need to be updated to include changes from the scope management plan. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

5.4 SCOPE VERIFICATION

Scope verification is the process of obtaining the stakeholders' formal acceptance of the completed project scope. Verifying the scope includes reviewing deliverables and work results to ensure that all were completed satisfactorily. If the project is terminated early, the scope verification process should establish and document the level and extent of completion. Scope verification differs from quality control (Section 8.3) in that it is primarily concerned with acceptance of the work results, while quality control is primarily concerned with the correctness of the work results. These processes are generally performed in parallel to assure both acceptance and correctness.

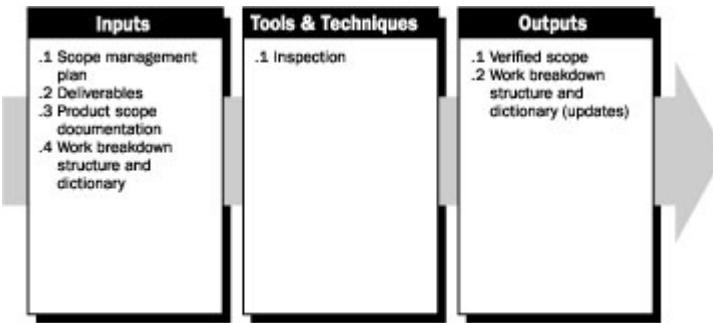


Figure 5-9. Scope Verification Overview

5.4.1 Scope Verification: Inputs

.1 Scope Management Plan

Described in Section 5.1.

.2 Deliverables

The deliverables are those that have been fully or partially completed, and are an output of the Direct and Manage Project Execution process (Section 4.4).

.3 Project Scope Statement

The project scope statement (Section 5.2) includes the product scope description that describes the project's product to be reviewed.

.4 Work Breakdown Structure and Dictionary

The WBS and dictionary (Section 5.3) aid in defining the scope, and need to be used to verify that the work results are part of the project.

5.4.2 Scope Verification: Tools and Techniques

.1 Inspection

Inspection includes activities such as measuring, examining, and verifying to determine whether results meet stakeholder needs and expectations. Inspections are variously called reviews, product reviews, audits and walkthroughs; in some application areas, these different terms have narrow and specific meanings.

5.4.3 Scope Verification: Tools and Techniques

.1 Verified Scope

Verified scope includes documentation received from the customer or sponsor, acknowledging approval of the project's deliverables. Such acceptance is conditional, especially if received at the end of a phase.

.2 Work Breakdown Structure and Dictionary (Updates)

The WBS and dictionary (Section 5.3) aid in the definition of scope and are updated from the results of the scope verification process.

5.5 SCOPE CONTROL

Scope control is concerned with influencing the factors that create scope changes, assuring all requested changes are processed according to the project integrated change control (Section 4.6) and managing the actual changes when they occur. Scope control is thoroughly integrated with the other control processes (Section 4.5). Uncontrolled changes are often referred to as scope creep. Change should be viewed as inevitable, thereby mandating some type of change control process.

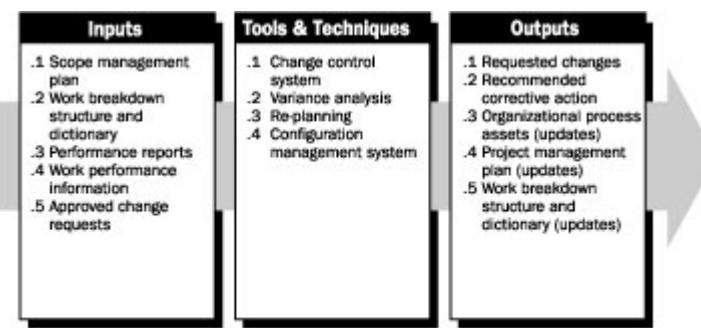


Figure 5-10. Scope Control Overview

5.5.1 Scope Control: Inputs

.1 Scope Management Plan

Described in Section 5.1.

.2 Work Breakdown Structure and Dictionary

The WBS and dictionary (Section 5.3) defines the project's scope baseline.

.3 Performance Reports

Performance reports (Section 10.3) provide information on scope performance, such as interim deliverables that have been completed.

.4 Work Performance Information

Described in Section 4.4.

.5 Approved Change Requests

A scope change is any modification to the agreed-upon project scope as defined by the approved WBS. Accepted scope changes often require adjustments to cost, time, quality, schedule, or other project objectives.

5.5.2 Scope Control: Tools and Techniques

.1 Change Control System

A scope change control methodology, documented in the scope management plan, defines the procedures by which the project scope can be changed. The plan includes the documentation, tracking systems, and approval levels necessary for authorizing changes. The change control system is integrated with any system in place to control project scope, such as a configuration management system (Section 4.5). When the project is managed under a contract, the change control system should also comply with all relevant contractual provisions.

.2 Variance Analysis

Project performance measurements (Sections 7.3 and 10.3) are used to assess the magnitude of variation. Important aspects of scope control include determining the cause of variance relative to the baseline and deciding whether corrective action is required.

.3 Replanning

Scope changes can require modifications to the WBS and dictionary (Section 5.3) or the project scope statement. These modifications can trigger an update to the project management plan (Section 4.3).

.4 Configuration Management System

Formal configuration management systems (Section 4.5) provide procedures for providing the status of the deliverables and that proposed changes are thoroughly considered and documented before approving a change to the project.

5.5.3 Scope Control: Outputs

.1 Requested Changes

The results of scope control can generate requested changes, which are processed according to the project integrated change control (Section 4.6).

.2 Recommended Corrective Action

Corrective action is any step taken to bring expected future project performance in line with the project plan.

.3 Organizational Process Assets (Updates)

The causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned from scope change control should be documented and updated in the historical database.

.4 Project Management Plan (Updates)

Depending upon the nature of the change, the corresponding baseline document may be revised and reissued to reflect the approved change and form the new baseline for future changes. Requested changes (additions, modification, revisions) to the project

management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

.5 Work Breakdown Structure and Dictionary (Updates)

The WBS and dictionary aid in the definition of scope and should be used to verify that the work results are part of the project.

Chapter 6

Project Time Management

Project Time Management includes the processes required to accomplish timely completion of the project. Figure 6-1 provides an overview of the Project Time Management processes and Figure 6-2 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes. The Project Time Management processes include the following:

- 6.1 Activity Definition** - identifying the specific activities that must be performed to produce the various project deliverables.
- 6.2 Activity Sequencing** - identifying and documenting interactivity dependencies.
- 6.3 Activity Resource Estimating** - estimating resources required for each activity.
- 6.4 Activity Duration Estimating** - estimating the number of work periods that will be needed to complete individual activities.
- 6.5 Schedule Development** - analyzing activity sequences, activity durations, and resource requirements to create the project schedule.
- 6.6 Schedule Control** - controlling changes to the project schedule.

These processes interact with each other and with the processes in the other knowledge areas, as well. Each process can involve effort from one or more individuals or groups of individuals based on the needs of the project. Each process generally occurs at least once in every project life cycle phase.

Although the processes are presented here as discrete elements with well-defined interfaces, in practice they can overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapters 3 and 4.

On some projects, especially smaller ones, activity sequencing, activity duration estimating, and schedule development are so tightly linked that they are viewed as a single process that can be performed by an individual over a relatively short period of time. These processes are presented here as distinct processes because the tools and techniques for each are different.

Although not shown here as a discreet process, the work involved in performing the six processes of Project Time Management is preceded by a planning effort by the project management team. This planning effort sets out the format and establishes criteria for developing and controlling the project schedule. The Project Time Management planning function produces a schedule management plan that is a contained in or is a subsidiary plan of the project management plan (Section 4.3). The schedule management plan may be formal or informal, highly detailed or broadly framed, based on the needs of the project.

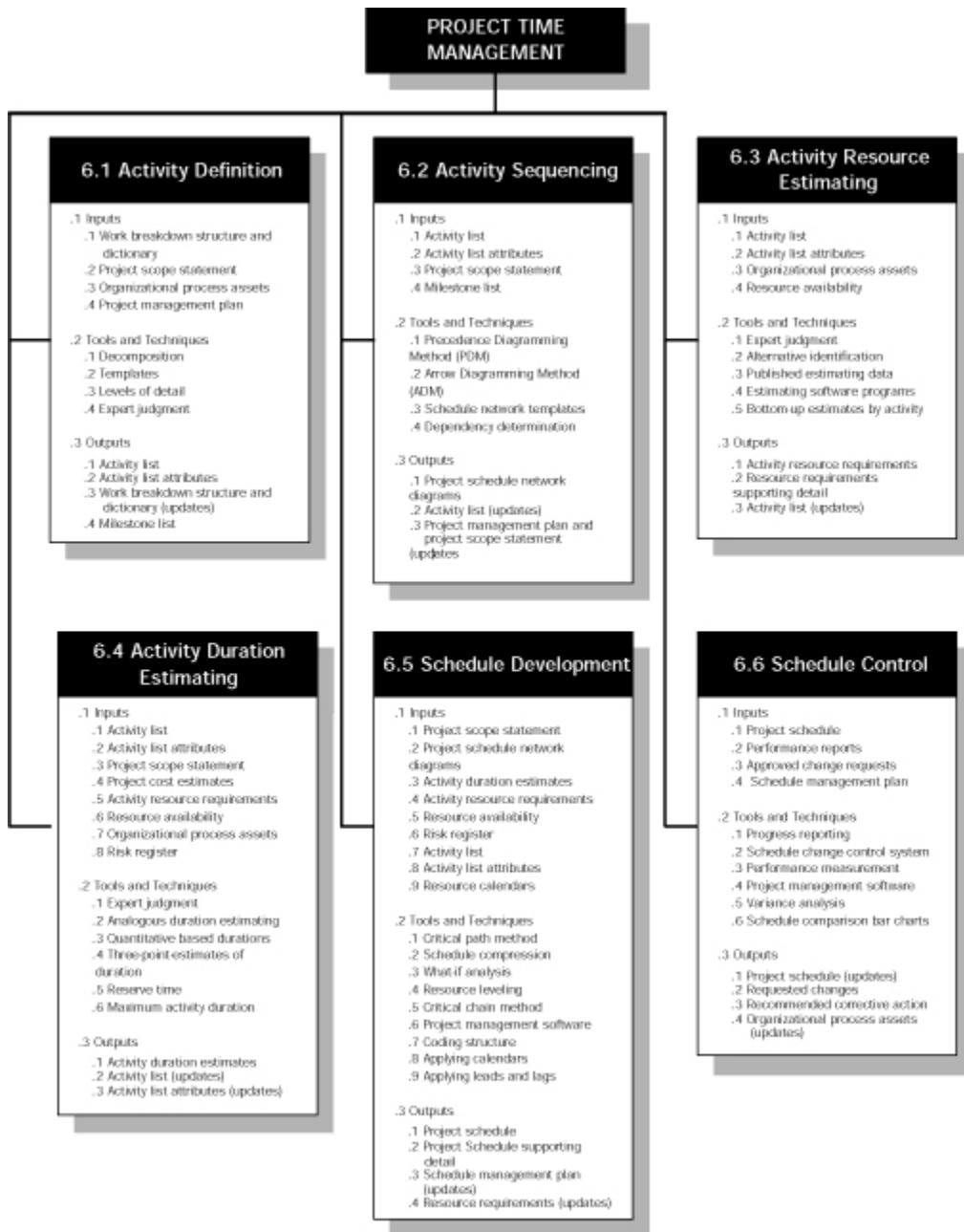


Figure 6-1. Project Time Management Overview

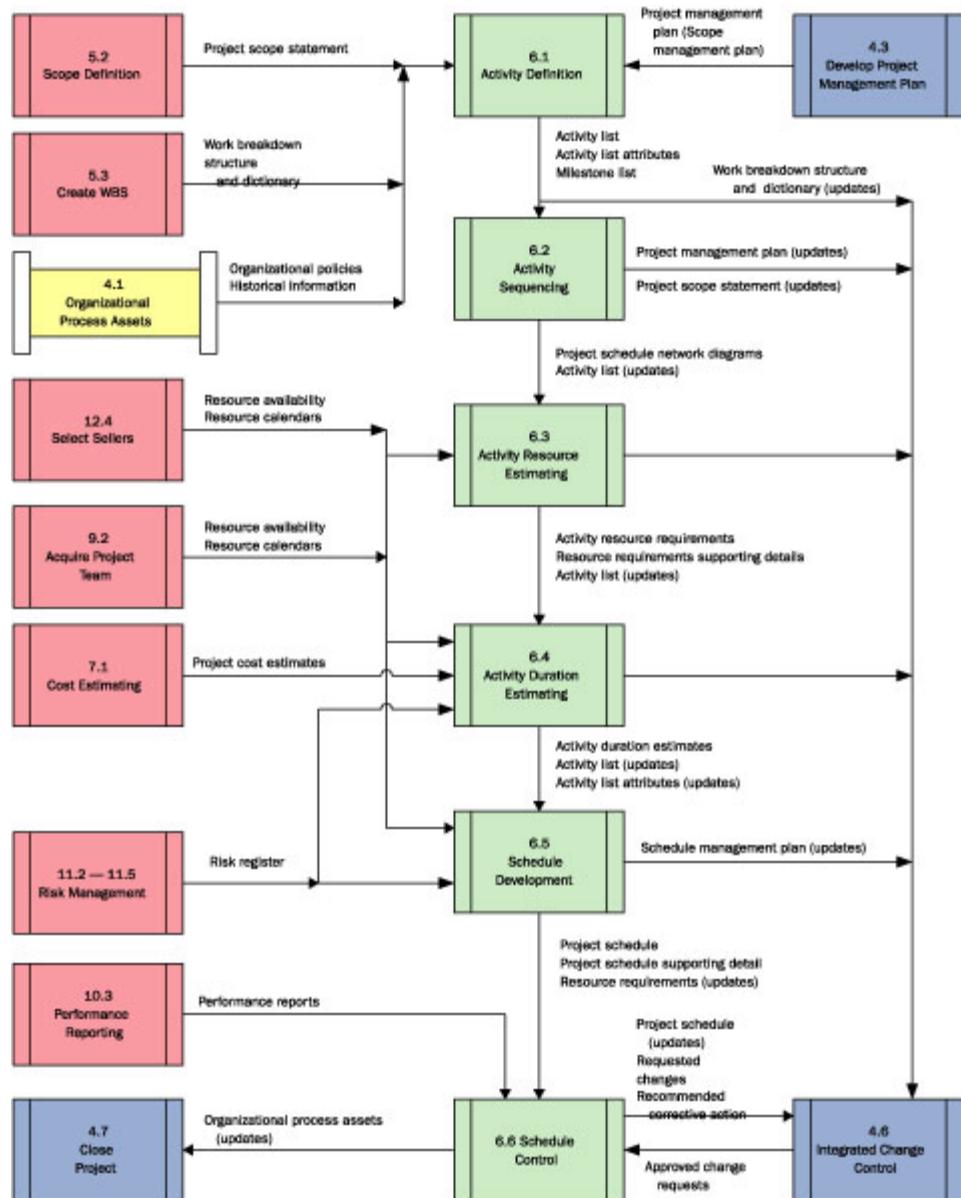


Figure 6-2. Project Time Management Process Flow Diagram

6.1 ACTIVITY DEFINITION

Defining the activities involves identifying and documenting the work that must be performed to produce the deliverables identified at the lowest level in the Work Breakdown Structure (WBS). Implicit in this process is the need to define the activities such that the project objectives will be met.

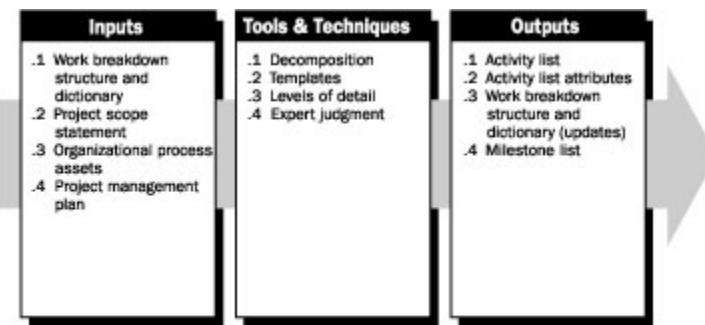


Figure 6.3. Activity Definition Overview

6.1.1 Activity Definition: Inputs

.1 Work Breakdown Structure (WBS)

The WBS is the primary input to activity definition (Section 5.3).

.2 Project Scope Statement

The work scope, product scope description, deliverables, constraints, and assumptions documented in the project scope statement need to be considered explicitly during activity definition (Section 5.2). Constraints are factors that will limit the project management team's options, such as the use of desired maximum activity durations and milestones required either by management or contract. Assumptions (Section 5.2) are items that are considered to be true for schedule planning, such as holidays, work hours per week, and time of the year that construction will be performed.

.3 Organizational Process Assets

The existing formal and informal activity planning-related policies, procedures, and guidelines (Section 4.1) need to be considered in developing the activity definitions. The lessons-learned knowledge base contains historical information regarding activities lists used by previous, similar projects that can be considered when defining project activities (Section 4.1).

6.1.2 Activity Definition: Tools and Techniques

.1 Decomposition

Decomposition involves subdividing project work packages into smaller, more manageable components to provide better estimates and management control. The technique of decomposition (Section 5.3), as it relates to activity definition, defines the final outputs as activities rather than as deliverables. The WBS and the activity list can be developed either sequentially or concurrently, with the WBS being the basis for development of the final activity list. Deliverables of the WBS are decomposed into the activities required to produce the deliverables by the project team members responsible for each deliverable.

.2 Templates

An activity list or a portion of an activity list from a previous project is often usable as a template for a new project. The activity information in the templates can also contain a list of resource skills and their required hours of effort, identification of risks, expected deliverables, and other descriptive information. Templates can also be used to identify typical milestone activities.

.3 Levels of Detail

Activities can exist at various levels of detail in the project's life cycle. During early strategic planning, when information is less defined, activities might be kept at the "milestone" level. The WBS reflects the scope evolution as it becomes more detailed and the activity detail increases until the work package level is reached. For control and management communication, the broader, more comprehensive summary activity, sometimes referred to as a hammock, is used between milestones or across multiple work packages.

.4 Expert Judgment

People who are experienced and skilled in developing detailed scope statements, WBSs, and project schedules can provide expertise in defining activities.

6.1.3 Activity Definition: Outputs

.1 Activity List

The activity list is a comprehensive list including all of the activities that will be performed on the project. The activity list can be organized as an extension to the WBS to help ensure that the list is complete. The activity list does not include any activities that are not required as part of the project scope. The activity list includes scope of work descriptions for each activity in sufficient detail to ensure that project team members understand what is to be accomplished. The scope of work of each activity defines what work is required to be completed. The activity's scope of work can be in physical terms, such as linear feet of pipe to be installed, designated placement of concrete, number of drawings, lines of computer program code, or chapters in a book.

.2 Activity List Attributes

The activity list attributes include: identified assumptions, constraints, person responsible for performing the work, geographic area or building where the work has to be performed, WBS classification, and activity type.

These attributes are used for schedule network development and selection, ordering, and sorting of the planned activities in various ways for the users. The amount of additional detail varies by application area.

.3 Work Breakdown Structure and Dictionary (Updates)

The WBS (Section 5.3) is updated to reflect any changes resulting from the activity definition process.

.4 Milestone List

The list of milestone activities identifies all milestones and indicates whether the milestone is mandatory, required by the contract, or optional, based on historical information. The milestone list is a subset of the Project Management Plan (Section 4.3).

6.2 ACTIVITY SEQUENCING

Activity sequencing involves identifying and documenting the logical precedence relationships among activities. Activities need to be logically sequenced with proper precedence relationships to support later development of a realistic and achievable schedule. Sequencing can be performed by using project management software or by using manual techniques. Manual and automated techniques can also be used in combination.

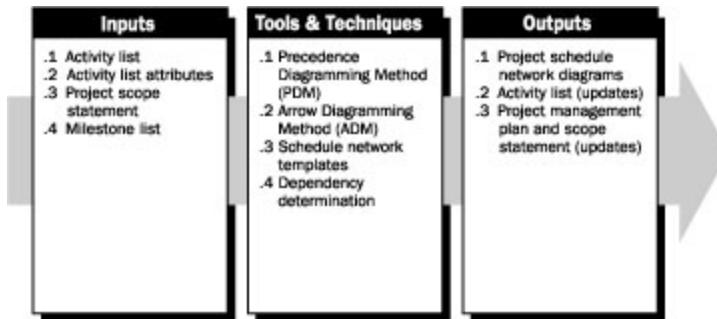


Figure 6-4. Activity Sequencing Overview

6.2.1 Activity Sequencing: Inputs

.1 Activity List

Described in Section 6.1.

.2 Activity List Attributes

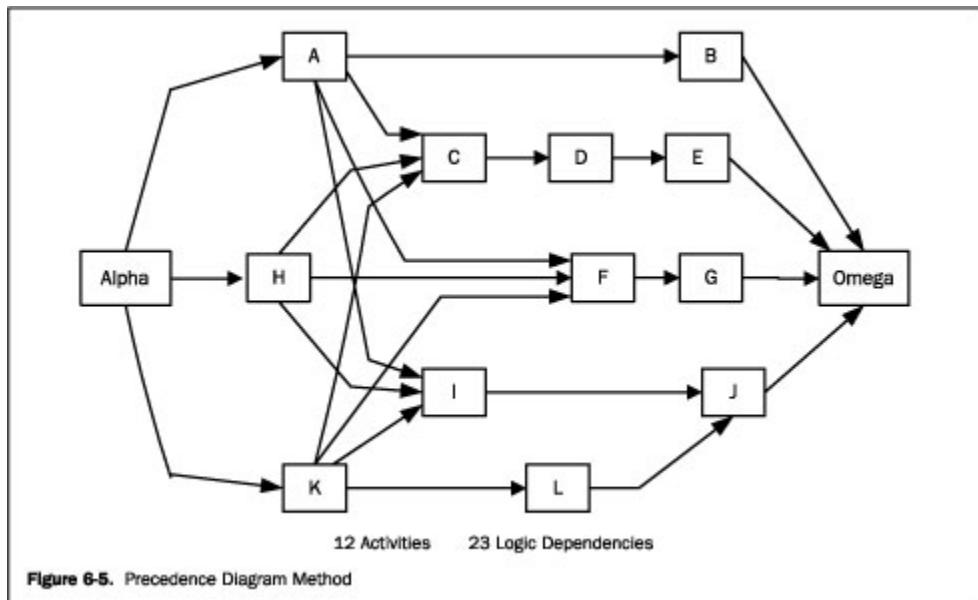
Described in Section 6.1.

.3 Project Scope Statement

Product characteristics often affect activity sequencing, such as the physical layout of a plant to be constructed, or subsystem interfaces on a software project. While these effects are often apparent in the activity list, the product scope description should generally be reviewed to ensure accuracy (Section 4.2).

.4 Milestone List

Described in Section 6.1.



6.2.2 Activity Sequencing: Tools and Techniques

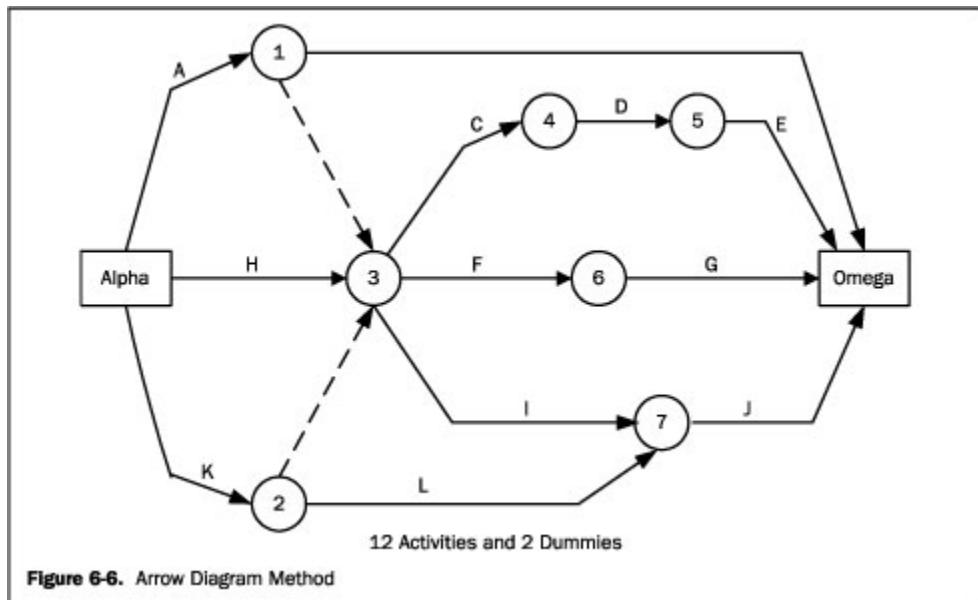
.1 Precedence Diagramming Method (PDM)

PDM is a method of constructing a project schedule network diagram that uses boxes or rectangles, referred to as nodes, to represent activities, and connects them with arrows that show the dependencies. Figure 6-5 shows a simple schedule network logic diagram drawn using PDM. This technique is also called activity-on-node (AON), and is the method used by most project management software packages.

PDM includes four types of dependencies or precedence relationships:

- *Finish-to-Start* - the initiation of the work of the successor depends upon the completion of the work of the predecessor.
- *Finish-to-Finish* - the completion of the work of the successor depends upon the completion of the work of the predecessor.
- *Start-to-Start* - the initiation of the work of the successor depends upon the initiation of the work of the predecessor.
- *Start-to-Finish* - the completion of the successor is dependent upon the initiation of the predecessor.

In PDM, finish-to-start is the most commonly used type of precedence relationship. Start-to-finish relationships are rarely used. Using start-to-start, finish-to-finish, or start-to-finish relationships can produce unexpected results if these types of relationships have not been consistently implemented.



.2 Arrow Diagramming Method (ADM)

ADM is a method of constructing a project schedule network diagram that uses arrows to represent activities, and connects them at nodes to show their dependencies. Figure 6-6 shows a simple network logic diagram drawn using ADM. This technique is also called activity-on-arrow (AOA) and, although less prevalent than PDM, is still used in teaching schedule network theory and in some application areas, such as forensic delay analysis. ADM uses only finish-to-start dependencies and can require the use of “dummy” activities to define all logical relationships correctly.

.3 Schedule Network Templates

Standardized schedule network templates can be used to expedite the preparation of schedule network diagrams of project activities. They can include an entire project or only a portion of it. Portions of a project schedule network are often referred to as a subnetwork or a fragment network. Subnetwork templates are especially useful when a project includes several identical or nearly identical features, such as floors on a high-rise office building, clinical trials on a pharmaceutical research project, coding program modules on a software project, or the start-up phase of a development project.

.4 Dependency Determination

Three types of dependencies are used to define the sequence among the activities.

- **Mandatory dependencies.** The project management team determines which dependencies are mandatory during the process of establishing the sequence of activities. Mandatory dependencies are those that are inherent in the nature of the work being done. Mandatory dependencies often involve physical limitations, such as on a construction project, where it is impossible to erect the superstructure until after the foundation has been built; or on an electronics project, where a prototype must be built before it can be tested. Mandatory dependencies are also sometimes referred to as hard logic.
- **Discretionary dependencies.** The project management team determines which dependencies are discretionary during the process of establishing the sequence of activities. Discretionary dependencies should be used with care and fully

documented, since they can create arbitrary float values and can limit later scheduling options. Discretionary dependencies are sometimes referred to as preferred logic, preferential logic, or soft logic. Discretionary dependencies are usually established based on knowledge of:

- Best practices within a particular application area
- Some unusual aspect of the project where a specific sequence is desired, even though there are other acceptable sequences
- Preferred activity sequences based upon previous experience on a successful project performing the same type of work.
- **External dependencies.** The project management team identifies external dependencies during the process of establishing the sequence of activities. External dependencies are those that involve a relationship between project activities and non-project activities. For example, the testing activity in a software project can be dependent on delivery of hardware from an external source, or environmental hearings may need to be held before site preparation can begin on a construction project. This input can be based on historical information (Section 4.1) from previous projects of a similar nature or from seller contracts or proposals (Section 12.4).

6.2.3 Activity Sequencing: Outputs

.1 Project Schedule Network Diagrams

Project schedule network diagrams are schematic displays of the project's activities and the logical relationships referred to as dependencies, among them. Figures 6-5 and 6-6 illustrate two different approaches to drawing a project network diagram. A project schedule network diagram can be produced manually or by using project management software. The network diagram can include full project details, or have one or more summary activities. A summary narrative accompanies the diagram that describes the basic approach used to sequence the activities. Any unusual activity sequences within the network are fully described.

.2 Activity List (Updates)

In much the same manner that the activity definition process can generate updates to the WBS, preparation of project schedule network diagrams might reveal instances where an activity must be divided, or otherwise redefined, to diagram the correct logical relationships, which results in a revision to the activity list.

.3 Project Management Plan and Project Scope Statement (Updates)

Updates to the Project Management Plan (Section 4.3) and Project Scope Statement (Section 4.2) are developed depending upon the nature of the changes and impact they can have on other plans. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

6.3 ACTIVITY RESOURCE ESTIMATING

Estimating activity resources involves determining what physical resources (people, equipment, materials) and what quantities of each resource should be used, and when the resource would be available to perform project activities. It must be closely coordinated with cost estimating (Section 7.1). For example:

- A construction project team will need to be familiar with local building codes. Such knowledge is often readily available from local sellers. However, if the local labor pool lacks experience with unusual or specialized construction techniques, the additional cost for a consultant might be the most effective way to secure knowledge of the local building codes.
- An automotive design team should be familiar with the latest in automated assembly techniques. The requisite knowledge might be obtained by hiring a consultant, by sending a designer to a seminar on robotics, or by including someone from manufacturing as a member of the project team.

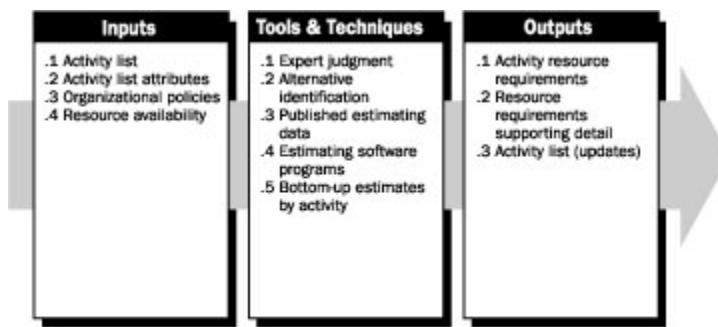


Figure 6-7. Activity Resource Estimating Overview

6.3.1 Activity Resource Estimating: Inputs

.1 Activity List and Supporting Details

The activity list and supporting detail are used for organizing and estimating the resource requirements for each resource. The activity definition process provides the primary data input for use in organizing and estimating those resources that are required for each activity.

.2 Organizational Process Assets

Policies of the performing organization regarding staffing and the rental or purchase of supplies and equipment must be considered during activity resource estimating (Section 4.1). Historical information regarding what types of resources were required for similar work on previous projects should be reviewed, if available (Section 4.1).

.3 Resource Availability

Knowledge of which resources, such as people, equipment, and material, are potentially available is necessary for estimating the resource types to be used. This knowledge includes consideration of various geographical locations from which the resources are expected to originate. The amount of detail and the level of specificity of the resource descriptions can vary. For example, during the early phases of an engineering design project, the pool might include “junior and senior engineers” in large numbers. During later phases of the same project, however, the pool can be limited to those individuals who are knowledgeable about the project as a result of having worked on the earlier phases. All assumptions made regarding the availability of each resource need to be documented, including the amount and type of the resource and the time periods of availability (Sections 9.2 and 12.4).

6.3.2 Activity Resource Estimating: Tools and Techniques

.1 Expert Judgment

Expert judgment will often be required to assess the inputs to this process. Any group or individual with specialized knowledge in resource planning and estimating can provide such expertise.

.2 Alternatives Identification

Many activities have alternative methods of accomplishment. They include using various levels of resource capability or skills, different size or type of machines, different tools (hand versus automated), outsourcing, etc.

.3 Published Estimating Data

Several companies routinely publish updated production rates and unit costs of resources for an extensive array of labor trades, materials, and equipment for different countries and geographical locations within countries.

.4 Estimating Software Programs

Project management software has the capability to help plan, organize, and manage resource pools. Depending upon the sophistication of the software, resource availabilities and rates can be defined, as well as various resource application calendars.

.5 Bottom-up Estimates by Activity

When a complex activity cannot be estimated with a reasonable degree of confidence, the work within the activity is decomposed into more detail. The resource needs of each piece of work are estimated, and these estimates are then aggregated into a total quantity for each of the activity's resources. Activities may or may not have dependencies between them that can affect the application and use of resources. If there are dependencies, this pattern of resource usage needs to be reflected in the estimated requirements of the activity and documented.

6.3.3 Activity Resource Estimating: Outputs

.1 Activity Resource Requirements

The output of the activity resource estimating process is a description of the types and quantities of resources required for each activity in a work package. These requirements can then be aggregated to determine the estimated resources for each work package.

Resource requirements for higher-level components of the WBS can be calculated based on the lower-level values. The schedule development process (Section 6.5) determines when the resources are needed.

.2 Resource Requirements Supporting Detail

The documentation for each activity includes the basis of estimate for each resource, as well as the assumptions that were made in determining which resources are to be applied, and what quantity of those resources are to be used.

.3 Activity List (Updates)

If activity lists are used, the activity resource estimating process can result in both addition and deletion of planned activities within the list.

6.4 ACTIVITY DURATION ESTIMATING

The process of estimating activity durations uses information on activity scope, required resource types, and estimated resource quantities. The inputs for the estimates of duration originate from the person or group on the project team who is most familiar with the

nature of the work content in the specific activity. The duration estimate is progressively elaborated, and the process considers the quality and availability of the input data. For example, as the project engineering and design work evolves, more detailed and precise data is available, and the accuracy of the duration estimates improves. Thus, the duration estimate can be assumed to be progressively more accurate and of known quality.

Activity duration estimating requires that: a) the amount of effort required to complete the activity be estimated, b) the assumed amount of resources to be applied to complete the activity be estimated, and c) the number of work periods needed to complete the activity be determined. All data and assumptions that support the estimating of durations need to be documented for each duration estimate.

Estimating the number of work periods required to complete an activity can require consideration of elapsed time as a requirement related to a specific type of work. Most project management scheduling software will handle this situation by using alternative work-period calendars that are usually identified by the resources that require specific work periods. The activities to which the resources are assigned will then be worked according to the appropriate calendars.

Overall project duration can be estimated using the tools and techniques presented here, but it is more properly calculated as the output of schedule development (Section 6.5).

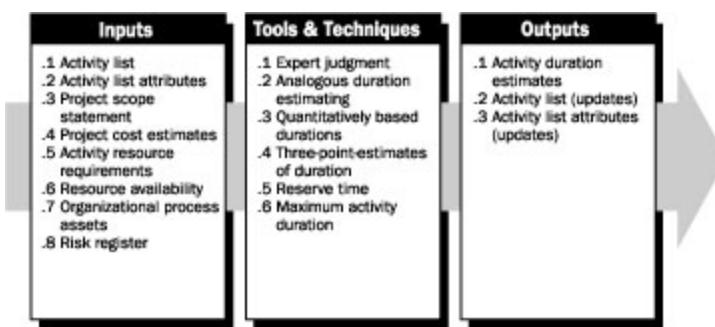


Figure 6-8. Activity Duration Estimating Overview

6.4.1 Activity Duration Estimating: Inputs

.1 Activity List

Described in Section 6.1.

.2 Activity List Attributes

Described in Section 6.1.

.3 Project Scope Statement

The constraints and assumptions from the project scope statement (Section 5.2) need to be considered when estimating the activity durations. An example of an assumption to be considered would be reporting periods for the duration of the project that could dictate maximum activity durations, e.g., two reporting periods.

.4 Project Cost Estimates

Many project cost estimates (Section 7.1) are developed in sufficient detail to provide estimated resource quantities for each activity in the project activity list.

.5 Activity Resource Requirements

The estimated activity resource requirements (Section 6.3) will have an effect on the duration of the activity, since the resources assigned to the activity and the availability of those resources will significantly influence the duration of most activities. For example, two people working together may be able to complete a design activity in half the time it takes either of them individually, while a person working half time on an activity will generally take at least twice as much time as the same person working full time. However, as additional resources are added, projects can experience a reduction in efficiency. This inefficiency in turn, could result in a production increase being less than the equivalent percentage increase in resources applied.

.6 Resource Availability

The availability, capabilities and skills of the human resources, and the type, capability, quantity and availability of equipment resources, and type, quantity and availability of materiel resources will significantly influence the duration of most activities. For example, if a senior and junior staff member are assigned full time, a senior staff member can generally be expected to complete a given activity in less time than a junior staff member (Section 9.1).

.7 Organizational Process Assets

Historical information (Section 4.1) on the likely durations of many categories of activities is often available from one or more of the following sources:

- **Project Files.** One or more of the organizations involved in the project may maintain records of previous project results that are detailed enough to aid in developing duration estimates. In some application areas, individual team members may maintain such records.
- **Commercial Databases.** Duration estimating databases and other historical reference data and information is often available commercially. These databases tend to be especially useful when activity durations are not driven by the actual work content (e.g., how long it takes concrete to cure; how long a government agency usually takes to respond to certain types of requests).
- **Project Team Knowledge.** The individual members of the project team may remember previous results or estimates. While such recollections may be useful, they are generally far less reliable than documented results.

.8 Risk Register

The project team considers information on identified project risks (Section 11.2) when producing estimates of activity durations. The project team considers the extent to which the effects of risks are included in the baseline duration estimate for each activity, in particular those risks with ratings of high probability or high impact.

6.4.2 Activity Duration Estimating: Tools and Techniques

.1 Expert Judgment

Durations are often difficult to estimate because of the number of factors that can influence them, such as resource levels or resource productivity. Expert judgment, guided by historical information, can be used whenever possible. If such expertise is not available the estimates are uncertain and risky (Chapter 11).

.2 Analogous Duration Estimating

Analogous duration estimating, also called top-down duration estimating, means using the actual duration of a previous, similar activity as the basis for estimating the duration

of a future activity. It is frequently used to estimate project duration when there is a limited amount of detailed information about the project (e.g., in the early phases). Analogous estimating is a form of expert judgment.

Analogous duration estimating is most reliable when the previous activities are similar in fact and not just in appearance, and the project team members preparing the estimates have the needed expertise.

.3 Quantitatively Based Durations

Estimating the basis for activity durations can be quantitatively determined by

multiplying the quantity of work performed by the productivity rate. For example:

Engineering/design effort: number of drawings times hours per drawing

Cable installation: meters of cable times labor hours per meter

These total resource quantities are then multiplied by the labor hours per work period or the production capability per work period and divided by the number of those resources being applied to determine activity duration in work periods. For example, total human resource labor hours times work hours per work period divided by number of that specific human resources that can be applied.

.4 Three-Point Estimates of Duration

The accuracy of the activity duration estimate can be improved by considering the risk in the original estimate. Three-point estimates are based on completing three types of estimates:

- **Most likely.** The duration of activity given the resources likely to be assigned, their productivity, realistic expectations of availability for the activity, dependencies on other participants, and interruptions on the type of activities.
- **Optimistic.** The duration is based on a best-case scenario of what is described in the most likely estimate.
- **Pessimistic.** The duration is based on a worse case scenario of what is described in the most likely estimate.

An activity duration estimate can be constructed by using some average of the three estimated durations that average will often provide a more accurate estimate than the single point most likely estimate.

.5 Reserve Time

Project teams can choose to incorporate additional time referred to as time reserve, contingency, or buffer, into the overall schedule as recognition of schedule risk. Reserve time can be a percentage of the estimated activity duration, a fixed number of work periods, or developed by quantitative schedule risk analysis (Section 11.4). The reserve time can be used completely or partially, or can later be reduced or eliminated, as more precise information about the project becomes available. Such reserve time should be documented along with other data and assumptions.

.6 Maximum Activity Duration

Experts recommend the maximum duration for any scheduled activity not exceed one reporting cycle. Exceptions might include submittals, reviews and similar non-deliverable activities that often have durations specified by contract or within the performing organization's policies.

6.4.3 Activity Duration Estimating: Outputs

.1 Activity Duration Estimates

Activity duration estimates are quantitative assessments of the likely number of work periods that will be required to complete an activity. Activity duration estimates should always include some indication of the range of possible results. For example:

- 2 weeks \pm 2 days to indicate that the activity will take at least eight days and no more than twelve (assuming a five-day workweek).
- 15 percent probability of exceeding three weeks to indicate a high probability—85 percent—that the activity will take three weeks or less.

.2 Activity List (Updates)

If activity lists are used, the activity duration estimating process can result in both addition and deletion of planned activities within the list.

.3 Activity List Attributes (Updates)

Assumptions made in developing the activity duration estimates are documented.

6.5 SCHEDULE DEVELOPMENT

Project schedule development determines planned start and finish dates for project activities and is an iterative process. Schedule development can require that duration estimates and resource estimates be reviewed and revised to create an approved project schedule that can serve as a baseline against which progress can be tracked. Schedule development continues throughout the project as work progresses, the project management plan changes and new risks are identified.

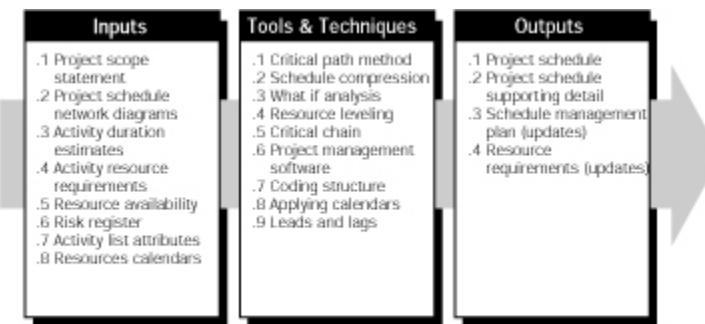


Figure 6-9. Schedule Development Overview

6.5.1 Schedule Development: Inputs

.1 Project Scope Statement

The project scope statement can contain assumptions and constraints that can impact the development of the project schedule (Section 5.2). Assumptions are those documented schedule-related factors that, for schedule development purposes, are considered to be true, real or certain.

There are two major categories of time constraints considered during schedule development:

- Imposed dates on activity starts or finishes can be used to restrict the start or finish to occur either no earlier than a specified date or no later than a specified date. While several constraints are typically available in project management software, the “Start No Earlier Than” and the “Finish No Later Than” constraints are the most commonly used. Date constraints include such situations as agreed

upon contract dates, a market window on a technology project, weather restrictions on outdoor activities, government-mandated compliance with environmental remediation, and delivery of material from parties not represented in the project schedule.

- The project sponsor, the project customer, or other stakeholders often dictate key events or major milestones affecting the completion of certain deliverables by a specified date. Once scheduled, these dates become expected and they can be moved only through approved changes. Milestones can also be used to indicate interfaces with work outside of the project. Such work is typically not in the project database, and milestones with constraint dates can provide the appropriate schedule interface.

.2 Project Schedule Network Diagrams

Described in Section 6.2.

.3 Activity Duration Estimates

Described in Section 6.4.

.4 Activity Resource Requirements

Described in Section 6.3.

.5 Resource Availability

Described in Section 6.3.

.6 Risk Register

Described in Sections 11.1 through 11.5.

.7 Activity List Attributes

Described in Section 6.1.

.8 Resource Calendars

Described in Section 9.2 and 12.4.

6.5.2 Schedule Development: Tools and Techniques

.1 Critical Path Method

Critical path method calculates the theoretical early and late start and finish times for all project activities without regard for any resource limitations. The resulting times are not necessarily the schedule, but rather indicate the time periods within which the activity could be scheduled given resource limits and other known constraints. Calculated early and late times are the same on the critical path since float, which provides schedule flexibility, is zero. On non-critical paths, the schedule flexibility is measured by the difference between early and late times, and is termed total float.

.2 Schedule Compression

Schedule compression shortens the project schedule without changing the project scope to meet schedule constraints, imposed dates, or other schedule objectives. Schedule compression techniques include:

- **Crashing.** Schedule compression technique in which cost and schedule tradeoffs are analyzed to determine how to obtain the greatest amount of compression for the least incremental cost. Crashing does not always produce a viable alternative and can result in increased cost.
- **Fast tracking.** Schedule compression technique in which activities are performed in parallel that normally would be done in sequence. An example would be to construct the foundation for a building before the all the architectural drawings

are complete. Fast tracking can result in rework and increased risk. This approach can require work to be performed without completed detailed information, such as engineering drawings. It results in trading cost for time, and increases the risk of achieving the shortened schedule.

.3 What-If Analysis

This is an analysis of the question “What if the situation represented by scenario “X” happens?” Schedule logic network can be used to compute the different scenarios, such as delaying a major component delivery, extending specific engineering durations, or introducing external factors such as a strike, or a change in the permitting process. The outcome of the what-if analysis can be used to assess the feasibility of the schedule under adverse conditions, and in preparing contingency and response plans to overcome or mitigate the impact of unexpected situations. Simulation involves calculating multiple project durations with different sets of activity assumptions. The most common technique is Monte Carlo Analysis (Section 11.4), in which a distribution of possible durations is defined for each activity and used to calculate a distribution of possible results for the total project.

.4 Resource Leveling

Resource leveling is a scheduling technique used to address activities that need to be performed in a limited time frame to meet specified delivery dates and to address the situation where shared or critical required resources are only available at certain times or are only available in limited quantities. This resource usage leveling approach can cause the original critical path to change.

Critical path calculation (Section 6.5) produces a preliminary early-start schedule and late start schedule that can require more resources during certain time periods than are available, or can require changes in resource levels that are not manageable. Allocating scarce resources to critical path activities first can be used to develop a schedule that reflects such constraints. Resource leveling often results in a projected schedule duration that is longer than the preliminary schedule. This technique is sometimes called the resource-based method, especially when implemented using schedule optimization project management software. Resource reallocation from non-critical to critical activities is a common way to bring the project schedule back on track, or as close as possible, to its originally intended overall duration. Utilization of extended hours, weekends, or multiple shifts can also be considered to reduce the durations of critical activities. Productivity increases based on the use of different technologies or machinery such as, reuse of computer code, automatic welding, electrical pipe cutters, and other automated processes are another way to shorten durations that have extended the preliminary schedule. Some projects can have a finite and critical project resource, requiring that this resource be scheduled in reverse from the project ending date, which is known as reverse resource allocation scheduling.

.5 Critical Chain

Critical chain is another technique that modifies the project schedule to account for limited resources. Critical chain mixes deterministic and probabilistic approaches. Initially, the schedule network is built using activity logic, required dependencies, and defined constraints as input. Then, the critical path is calculated. After the critical path is identified, resource availability is entered and the resource driven result is determined.

The result often alters the critical path. Critical chain recognizes the critical path as a moving target, which must be managed.

Critical chain adds duration buffers that are non-work activities to maintain focus on the planned activity durations. Consequently, in lieu of managing schedule float, Critical Chain focuses on managing buffer activity durations and the resources applied to planned activities. Optimistic estimates for the durations are used, and once the buffer activities are determined, the planned schedule activities are scheduled to their latest possible dates.

.6 Project Management Software

Project management scheduling software is widely used to assist with schedule development. Other software might be capable of interacting directly or indirectly with project management software to carry out the requirements of other knowledge areas such as estimating cost by time period (Section 7.1), simulation of schedules in quantitative risk analysis (Section 11.4). These products automate the calculation of the mathematical forward path and backward pass critical path analysis and resource leveling, and thus allow for rapid consideration of many schedule alternatives. They are also widely used to print or display the outputs of developed schedules.

.7 Coding Structure

The activities should have a coding structure that will allow sorting and extractions based on different attributes assigned to the activities, such as responsibility, geographic area or building, project phase, schedule level, resource type, activity type, and WBS classification.

.8 Applying Calendars

Project work period calendars and resource application calendars identify periods when work is allowed. Project calendars affect all activities. For example, some resources will work only during normal business hours, while others will work three full shifts.

Resource calendars affect a specific resource or category of resources. For example; a project team member might be unavailable, such as on vacation or in a training program; a labor contract can limit certain workers to certain days of the week; or it is not possible to work on the site during certain periods of the year because of weather.

.9 Leads and Lags

The project management team determines the dependencies (Section 6.2) that may require a lead or a lag to accurately define the relationship. A lead allows an acceleration of the successor activity. A lag directs a delay in the successor activity. For example, to account for a ten-day curing period for concrete, a ten-day lag could be used, which would mean the successor activity cannot start until ten days after the predecessor is completed. The use of leads or lags by unskilled personnel can distort the schedule. The use of leads and lags needs to be limited and their related assumptions need to be documented.

6.5.3 Schedule Development: Outputs

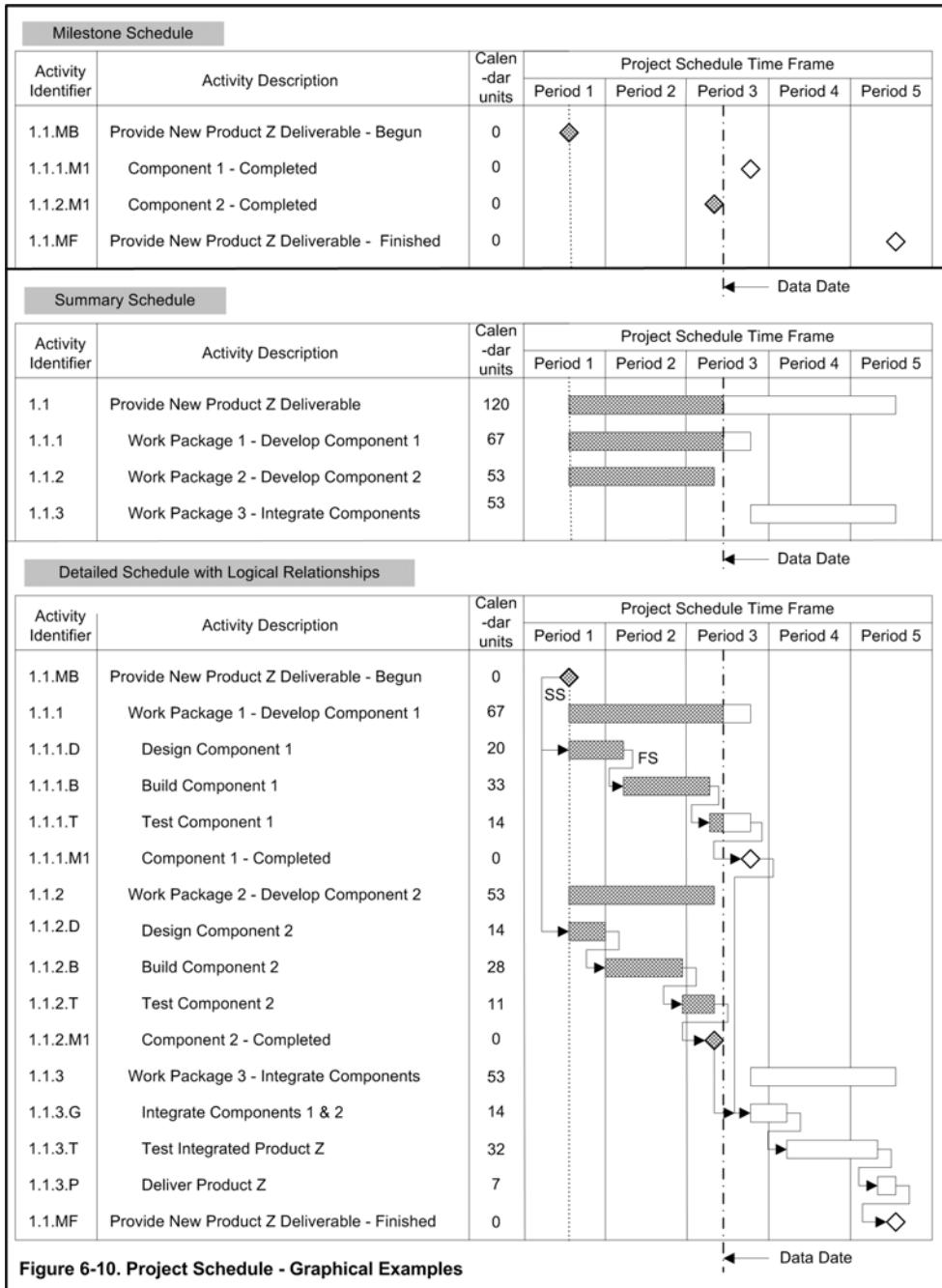
.1 Project Schedule

The project schedule includes at least planned start and planned finish dates for each activity. If resource planning is done at an early stage, then the project schedule would remain preliminary until resource assignments have been confirmed. This step usually happens no later than the completion the project management plan (Section 4.3). The project schedule can be presented in summary form sometimes referred to as the master

or milestone schedule, or in detail. Although it can be presented in tabular form, it is more often presented graphically, using one or more of the following formats:

- **Project Schedule Network Diagrams.** These charts with activity date information usually show both the project logic and the project's critical path activities.
- **Bar Charts.** These charts with bars representing activities show activity start and end dates, as well as expected durations, and sometimes show dependencies. Bar charts are relatively easy to read, and are frequently used in management presentations.
- **Milestone Charts.** These charts are similar to bar charts, but only identify the scheduled start or completion of major deliverables and key external interfaces.

Figure 6-10 gives, for a simple project schedule, the graphical display of a Milestone Schedule, a Summary Schedule, and a Detailed Schedule that also visually shows the relationships among the three different levels of schedule presentation.



.2 Project Schedule Supporting Detail

Supporting detail for the project schedule includes at least the documentation of all identified assumptions and constraints. The amount of additional detail varies by application area. Information frequently supplied as supporting detail includes, but is not limited to:

- Resource requirements, by time period, often in the form of a resource histogram.
- Alternative schedules such as, best case or worst case, not resource leveled, resource leveled, with or without imposed dates.
- Schedule contingency reserves.

For example:

- On a construction project, supporting detail will most likely include such items as resource histograms, cash-flow projections, and order and delivery schedules.
- On an electronics design project, it will most likely include human resource histograms.

.3 Schedule Management Plan (Updates)

The schedule management plan (Section 4.3) is updated to reflect results of the project schedule development and any changes in how the schedule will be managed.

.4 Resource Requirement (Updates)

Resource leveling can have a significant effect on preliminary estimates of the types and quantities of resources required. If resource-leveling results change the project resource requirements then the resource requirements updates are documented in the schedule management plan.

6.6 SCHEDULE CONTROL

Schedule control is concerned with:

- Determining the current status of the schedule.
- Influencing the factors that create schedule changes.
- Determining that the schedule has changed.
- Managing the actual changes when and as they occur.

Schedule control is a portion of the integrated change control process (Section 4.6).

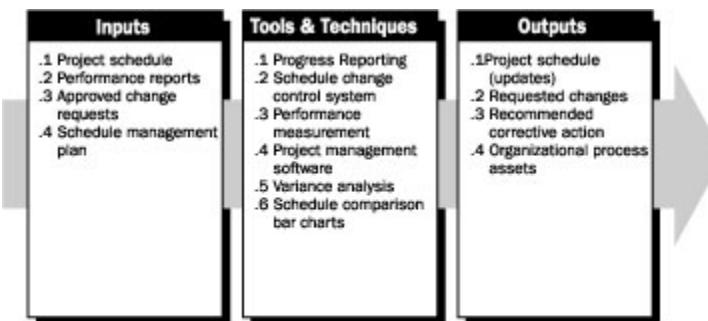


Figure 6.10. Schedule Control Overview

6.6.1 Schedule Control: Inputs

.1 Project Schedule

The project schedule (Section 6.5) used for control is the approved project schedule, which is referred to as the project schedule baseline. The project baseline schedule is a component of the project management plan (Section 4.3). It provides the basis for measuring and reporting schedule performance.

.2 Performance Reports

Performance reports (Section 10.3), which provide information on schedule performance, such as which planned dates have been met and which have not. Performance reports may also alert the project team to issues that may cause schedule performance problems in the future.

.3 Approved Change Requests

Only approved change request that have been previously submitted through the change control system are used to update the project schedule (Section 4.6).

.4 Schedule Management Plan

Described in Section 6.5.

6.6.2 Schedule Control: Tools and Techniques

.1 Progress Reporting

The reporting of progress and current schedule status includes information such as the actual start and finish dates and remaining durations for unfinished activities. If progress measurement, such as earned value, is also used then the percent complete of in-progress activities can also be included. To facilitate the periodic reporting of project progress, a form created for consistent use across various project elements can be used throughout the project life cycle. The form can be paper based or electronic.

.2 Schedule Change Control System

A schedule change control system defines the procedures by which the project schedule can be changed. It includes the paperwork, tracking systems, and approval levels necessary for authorizing changes. Schedule change control is operated as part of the integrated change control system (Section 4.6).

.3 Performance Measurement

Performance measurement techniques (Section 7.3) help to assess the magnitude of any schedule variations that do occur. An important part of schedule control is to decide if the schedule variation requires corrective action. For example, a major delay on any activity not on the critical path may have little effect on the overall project, while a much shorter delay on a critical or near-critical activity may require immediate action.

.4 Project Management Software

Project management software provides the ability to track planned dates versus actual dates and to forecast the effects of schedule changes, real or potential, which makes it a useful tool for schedule control.

.5 Variance Analysis

Performance of the schedule variance analysis during the schedule-monitoring process is a key function of schedule control. Comparing target schedule dates with the actual/forecast start and finish dates provides useful information for the detection of deviations and for the implementation of corrective actions in case of delays. The float variance is also an essential planning component to evaluate project time-performance. Particular attention has to be given to critical and non-critical activities such as, analyzing the ten non-critical paths in order of ascending float values.

.6 Schedule Comparison Bar Charts

To facilitate analysis of schedule progress, it is convenient to use a comparison bar chart, which displays two bars for each scheduled activity. One bar shows the current status and the other shows the status of the prior schedule update. This shows graphically where the schedule has progressed as planned or where further slippage has occurred.

6.6.3 Schedule Control: Outputs

.1 Project Schedule (Updates)

A schedule update is any modification to the schedule information that is used to manage the project. Appropriate stakeholders are notified of significant changes as they occur.

Schedule updates might or might not require adjustments to other components of the project management plan.

Revisions are a special category of schedule updates. Revisions are changes to the schedule start and finish dates in the approved project schedule. These changes are generally incorporated in response to approved scope changes or changes to estimates. New target schedules are developed to display approved revisions to the work plan. In some cases, schedule delays can be so severe that development of a new target schedule is needed to provide realistic data for directing the work and measuring performance and progress.

Development of a revised baseline for a project can only occur as a result of a significant revision in the project scope and approved changes. Care must be taken to save the original project schedule before creating the new baseline, to prevent loss of historical data for the project schedule. Preparing and issuing a new baseline should only be used as a last resort in controlling the schedule.

.2 Requested Changes

Schedule variance analysis, the review of progress reports, and the results of performance measures can result in requested changes to the project schedule.

.3 Recommended Corrective Actions

Corrective action is anything done to bring expected future schedule performance in line with the approved project schedule. Corrective action in the area of time management often involves expediting, such as special actions taken to ensure completion of an activity on time or with the least possible delay. Corrective action frequently requires root-cause analysis to identify the cause of the variation. Schedule recovery from the variance can be planned and executed using activities delineated later in the schedule and the analysis may therefore need to also address activities other than the activity causing the deviation.

.4 Organizational Process Assets

Lessons learned documentation of the causes of variances, the reasoning behind the corrective actions chosen, and other types of lessons learned from schedule control is documented, so that they become part of the historical database for both the project and other projects of the performing organization.

Chapter 7

Project Cost Management

Project Cost Management includes the processes involved in planning, controlling, and managing costs so that the project can be completed within the approved budget. Figure 7-1 provides an overview of the following three processes, while Figure 7-2 provides a process flow view of those processes and their inputs, outputs, and other related knowledge area processes:

- 7.1 Cost Estimating** - developing an approximation of the costs of the resources needed to complete project activities.
- 7.2 Cost Budgeting** - aggregating the estimated costs of individual activities or work packages to establish a cost baseline.
- 7.3 Cost Control** - influencing the factors that create additional costs and controlling changes to the project budget.

These processes interact with each other and with the processes in the other knowledge areas as well. Each process can involve effort from one or more individuals or groups of individuals, based on the needs of the project. Each process generally occurs at least once in every project life cycle phase. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they can overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapters 3 and 4.

Project Cost Management is primarily concerned with the cost of the resources needed to complete project activities. However, Project Cost Management should also consider the effect of project decisions on the cost of using the product. For example, limiting the number of design reviews can reduce the cost of the project at the expense of an increase in the customer's operating costs. This broader view of Project Cost Management is often called life cycle costing. Life cycle costing, together with value engineering techniques, is used to reduce cost and time, improve quality and performance, and optimize decision-making.

In many application areas, predicting and analyzing the prospective financial performance of the project's product is done outside the project. In others, such as capital facilities projects, Project Cost Management also includes this work. When such predictions and analyses are included, Project Cost Management will include additional processes and numerous general management techniques, such as return on investment, discounted cash flow, and investment payback analysis.

Project Cost Management should consider the information needs of the project stakeholders. Different stakeholders will measure project costs in different ways and at different times. For example, the cost of an acquired item can be measured when the acquisition decision is made (committed), the order is placed, the item is delivered, the actual cost is incurred, or the actual cost is recorded for project accounting purposes.

On some projects, especially smaller ones, cost estimating and cost budgeting are so tightly linked that they are viewed as a single process that can be performed by a single

individual over a relatively short period of time. These processes are presented here as distinct processes because the tools and techniques for each are different. The ability to influence cost is greatest at the early stages of the project, and this is why early scope definition is critical (Section 5.2).

Although not shown here as a discrete process, the work involved in performing the three processes of Project Cost Management is preceded by a planning effort by the project management team. This planning effort sets out the format and establishes the criteria for planning, structuring, and controlling the project costs.

For example:

- Activity cost estimates will adhere to a rounding of the data to a prescribed order of magnitude level (\$100, \$1000) based on the scope of the activities and will or will not include an amount for contingencies.
- The unit of measure must be decided such as person-hours, person-days, week, lump sum, etc. for each of the resources.
- Project Cost Budgets will adhere to a rounding of the value of each WBS component or work package suitable for the magnitude of the project (\$1000, \$5000, \$10,000). Typically, the cost accounting for a WBS component or work package is called a “Control Account (CA).” A scheme for the numbering of the Control Account code must be planned and how the Control Account will interface with the organization’s accounting system. If “planning packages” (known work but without detailed activities) cost estimates are included in the Control Account, the project team should make a decision as to how they will be budgeted.
- Project Cost Control planning items can include: variance thresholds for costs or other indicators (i.e., person-days, volume of product) at designated time points over the duration of the project; Earned Value computation formulas for the Estimate to Complete and Estimate at Completion; Earned value credit criteria (0-100, 0-50-100, etc.); and at what WBS level will the Earned Value analysis(s) be done.

The project management team will also develop the formats for the various cost reports and documentation for each of the three cost management processes.

All of the above, as well as other information are included in the Cost Management Plan either as text within the body of the plan or as appendices. A cost management plan can be formal or informal, highly detailed or broadly framed, based on the needs of the project stakeholders. The cost management plan is contained in or a subsidiary plan of the project management plan (Section 4.3).

Attention to the cost management planning effort should occur early in the project planning stage and set the framework for each process so that performance of the three cost management processes will be efficient and coordinated.

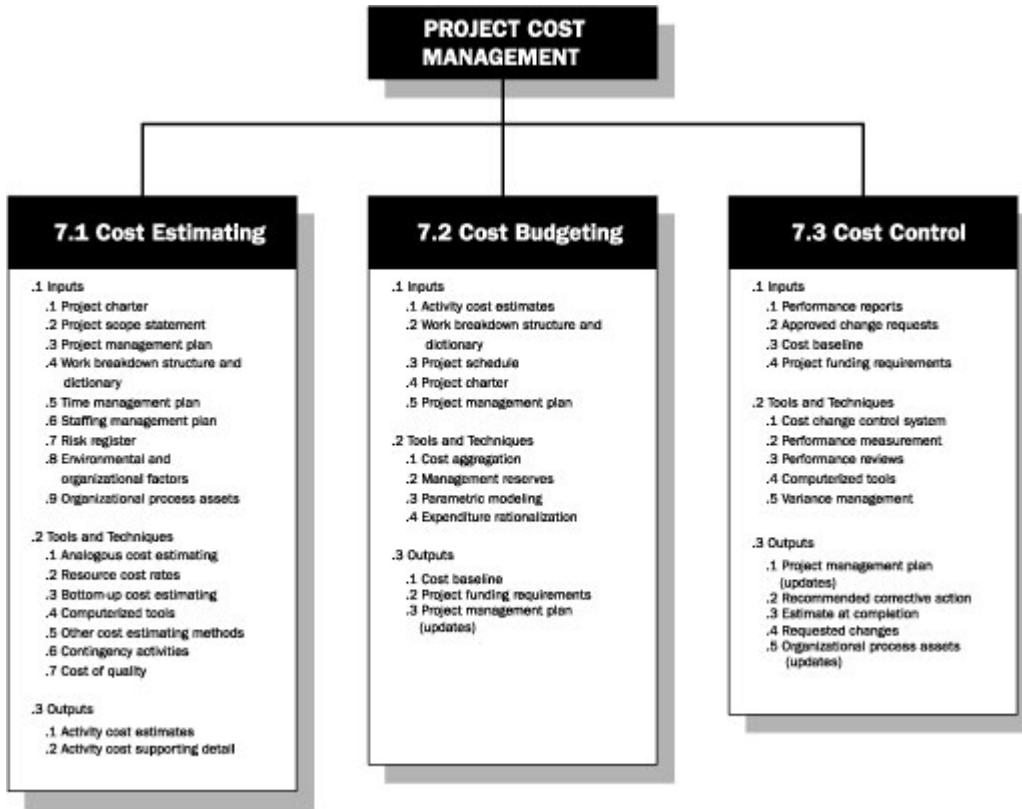


Figure 7-1. Project Time Management Overview

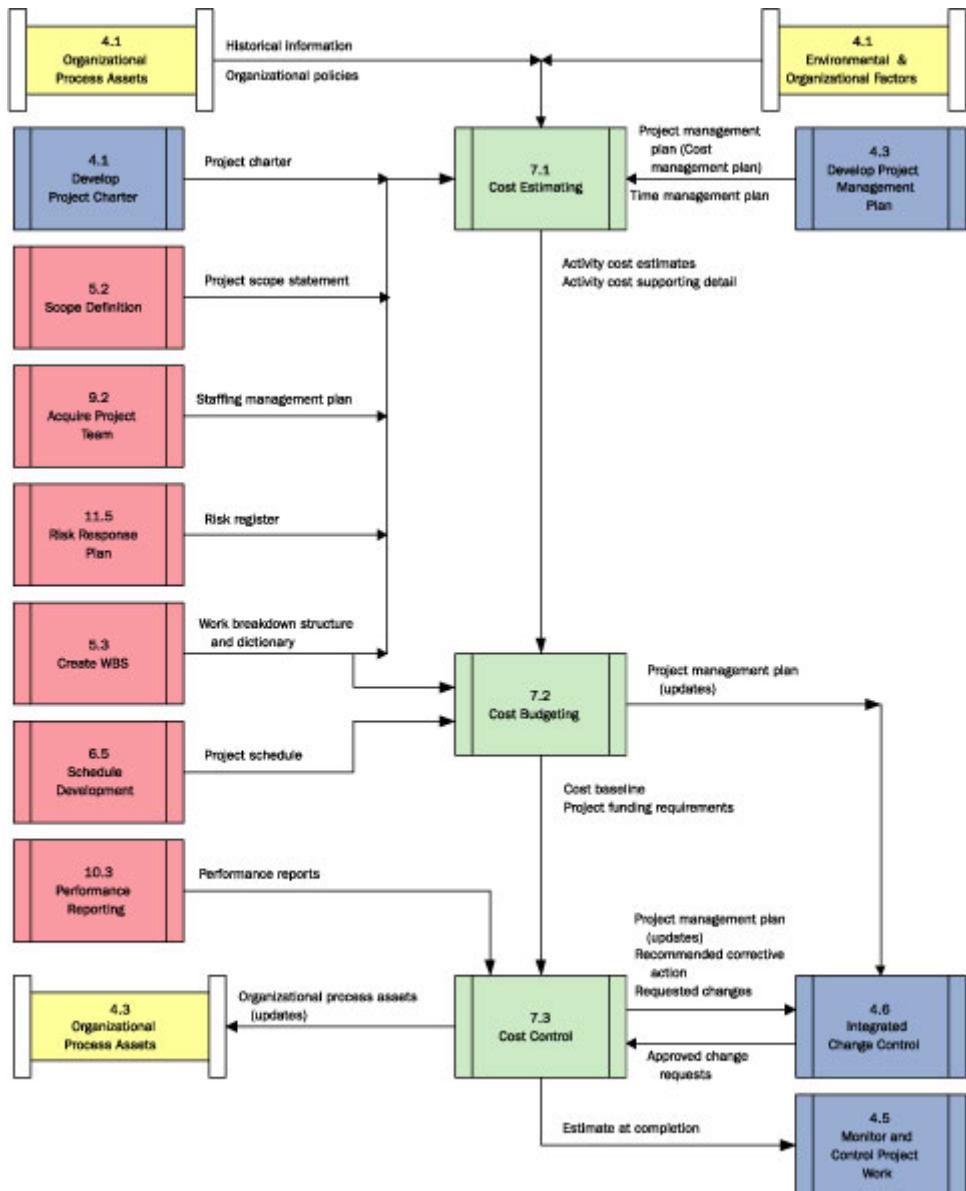


Figure 7-2. Project Cost Management Process Flow Diagram

7.1 COST ESTIMATING

Estimating activity costs involves developing an approximation of the costs of the resources needed to complete project activities. In approximating costs, the estimator considers the possible causes of variation of the cost estimate, including risks.

Cost estimating includes identifying and considering various costing alternatives. For example, in most application areas, additional work during a design phase is widely held to have the potential for reducing the cost of the execution phase. The cost estimating process considers whether the cost of the additional design work can be offset by the expected savings.

Cost estimates are generally expressed in units of currency (dollars, euros, yen, etc.) to facilitate comparisons both within and across projects. In some cases, the estimator can use units of measure to estimate cost, such as staff hours or staff days, along with their cost estimates to facilitate appropriate management control.

Cost estimates can benefit from being refined during the course of the project to reflect the additional detail available. In some application areas, there are guidelines for when such refinements should be made and what degree of accuracy is expected. For example, the Association for the Advancement of Cost Engineering International (AACEI) has identified a progression of five types of cost estimates of construction costs that can be developed during engineering, which are: order of magnitude, conceptual, preliminary, definitive, and control.

The range of the cost estimates:

- Order of Magnitude 50% under to 100% over
- Conceptual 30% under to 50% over
- Preliminary 20% under to 30% over
- Definitive 15% under to 20% over
- Control 10% under to 15% over

The primary inputs to the cost estimating process come from the planning processes discussed in Chapters 3 and 4. Sources of input information come in the form of outputs from Project Management Integration, Scope Management, Time Management, Quality Management, Human Resource Management, and Procurement Management. Once received, all of this information will remain available as inputs to all three of the cost management processes.

Activity costs must be estimated for all resources that will be charged to the project. This includes, but is not limited to; labor, materials, equipment, and supplies, and special categories such as an inflation allowance or a contingency cost. Activity cost estimates is a quantitative assessment of the likely costs of the resources required to complete work package activities.

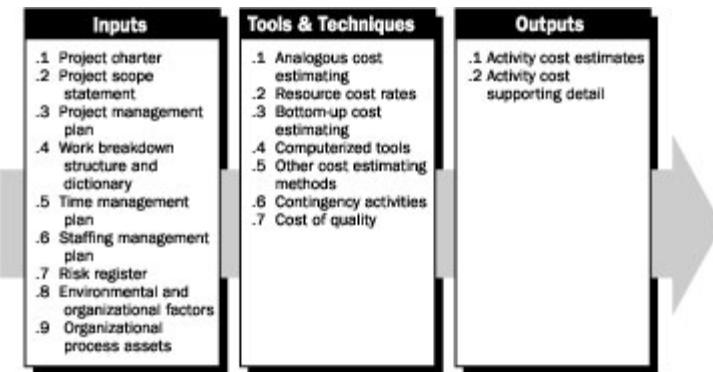


Figure 7-3. Cost Estimating Process Overview

7.1.1 Cost Estimating: Inputs

.1 Project Charter

The project charter (Section 4.1) describes the business needs, cases, and requirements for the project. The project charter can include constraints, assumptions, and requirements. Constraints are specific factors that can limit cost estimating options. One of the most common constraints for many projects is a mandatory milestone deadline. Other constraints can involve required delivery dates, available skilled resources, and organizational policies. Assumptions are factors that, for cost estimating purposes, will be considered to be true, real, or certain. Requirements with contractual and legal implications can include health, safety, security, performance, environmental, insurance, intellectual property rights, equal employment opportunity, licenses, and permits all of which need to be considered when developing the project cost estimate.

.2 Project Scope Statement

The project scope statement (Sections 4.2 and 5.2) describes the current project boundaries. It provides important information about project needs and strategies that must be considered during project cost planning. It also provides constraints and assumptions related to project scope, the list of deliverables, and acceptance criteria for the project and its products and services. All factors should be considered when developing the project cost estimate. The description of the products and services of the project (Section 5.2) provides important information about any technical issues or concerns that need to be considered during project cost planning.

.3 Project Management Plan

The project management plan (Section 4.3) provides the overall plan for managing the project and includes subsidiary plans such as an initial scope statement, change control management plan, and overall contracts management plan, which provide guidance and direction for cost management planning. To the extent that other planning outputs are available, they must be considered during cost planning.

.4 Work Breakdown Structure and Dictionary

The project work breakdown structure (WBS) (Section 5.3) provides the relationship among all the elements of the project and the project deliverables. The WBS dictionary and related detailed statements of work (Section 5.3) provide an identification of the deliverables and a description of the work in each WBS element required to produce each deliverable.

.5 Time Management Plan

The type and quantity of resources and the amount of time those resources will need to be applied to complete the work of the project is a major part of determining the project cost. Activity resources and their respective durations are used as key inputs to this process.

- Estimating activity resources (Section 6.3) involves determining the availability and quantities required of people, equipment and materials needed to perform project activities. It must be closely coordinated with cost estimating
- Activity duration estimates (Section 6.4) will affect cost estimates on any project where the project budget includes an allowance for the cost of financing, including interest charges, and where resources are applied per unit of time for the duration of the activity. Activity duration estimates can also affect cost estimates that have time sensitive costs included in them such as, union labor with regularly expiring collective bargaining agreements; materials with seasonal cost variations; or cost estimates with time related costs such as, time related field overhead costs during construction of a project.

.6 Staffing Management Plan

Project staffing attributes and personnel rates (Section 9.1), which are necessary components for developing the project cost estimate, are used to develop cost estimates.

.7 Risk Register

The cost estimator ought to consider information on risk responses (Section 11.5) when producing cost estimates. Risks, which can be either threats or opportunities, typically have a significant impact on both activity and project costs. As a general rule, when the project experiences a negative risk event, it will nearly always increase cost and delay the schedule.

.8 Environmental and Organizational Factors

The cost estimate planning process must consider the conditions of the marketplace and what materiel, products, goods, and services are available in the marketplace, from whom, and under what terms and conditions (Section 4.1). If the performing organization does not have formally trained project cost estimators, then the project team will have to supply both the resources and the expertise to perform project cost estimating activities.

.9 Organizational Process Assets

The existing formal and informal cost estimating related policies, procedures, and guidelines (Section 4.1) must be considered in developing the cost management plan and selecting the cost estimating tools and tracking and reporting methods to be used.

- **Cost estimating policies.** Some organizations have predefined approaches to cost management. Where these exist, they should be tailored to the project.
- **Cost estimating templates.** Some organizations have developed templates (or a pro-forma standard) for use by the project team. The organization should continuously improve the template, based on its application and usefulness in prior projects.
- **Commercial databases.** Information is often available from commercial databases that track skills and human resource costs, and provide standard costs for material and equipment.

Historical information (Section 4.1) is obtained from various sources within the organization that pertains to the project's product and or service, which can influence the

cost of the project. Information on the cost of many categories of resources is often available from:

- **Project files.** One or more of the organizations involved in the project will maintain records of previous project results that are detailed enough to aid in developing cost estimates. In some application areas, individual team members will maintain such records.
- **Project team knowledge.** The individual members of the project team will remember previous actuals or estimates. While such recollections can be useful, they are generally far less reliable than documented results.
- **Lessons learned.** Cost estimates from previous projects that are similar in scope and size.

7.1.2 Cost Estimating: Tools and Techniques

.1 Analogous Cost Estimating

Analogous cost estimating, means using the actual cost of a previous similar activity as the basis for estimating the cost of the current activity. Analogous cost estimating is frequently used to estimate costs when there is a limited amount of detailed information about the project (e.g., in the early phases). Analogous cost estimating is a form of expert judgment.

Analogous cost estimating is generally less costly than other techniques, but it is also generally less accurate. It is most reliable when the previous projects are similar in fact and not just in appearance, and the individuals or groups preparing the estimates have the needed expertise.

.2 Resource Cost Rates

The individual determining the rates or the group preparing the estimates must know the unit rates, such as staff cost per hour and bulk material cost per cubic yard, for each resource to estimate activity costs. Gathering quotes formally (Section 11.3) or informally (via telephone) is one approach to obtaining rates. In the case of a contract, standard rates to be applied with escalation factors can be included in the contract.

Published price lists are another source. If actual rates are not known, the rates themselves will have to be estimated, but this approach should be used as a last resort.

.3 Bottom-up Cost Estimating

This technique involves estimating the cost of individual work packages or individual activities, also known as Activity Based Costing. The cost and accuracy of bottom-up cost estimating is driven by the size and complexity of the individual activity or work package; generally smaller scope activities increase the accuracy of the activity cost estimates.

.4 Computerized Tools

Computerized tools, such as project management software spreadsheets and simulation and statistical tools are widely used to assist with cost estimating. Such tools can simplify the use of the techniques described above and thereby facilitate rapid consideration of many cost alternatives.

.5 Other Cost Estimating Methods

Other cost estimating methods include vendor bid analysis and an analysis of what the project should cost. In cases where projects are won under competitive processes, additional cost estimating work can be required of the project team to examine the price of individual deliverables and derive a cost that supports the final total project cost.

.6 Contingency Activities

Many cost estimators include contingency allowances for cost and time in many activity estimates. This has the inherent problems of not identifying the original activity estimates and enabling the typical human response of consuming all assigned time and budget.

A solution is to combine the contingency time and resources, including cost for a group of related activities into a single contingency activity or buffer that is intentionally placed directly on the path for that group of activities. As these activities progress through execution, the contingency activity, as measured by the time, cost and resource consumption of the activities can be adjusted. As a result, the activity variances for the related activities are more accurate because they are based on the original estimates, and the contingency used or unused can also be measured in time, cost and resource consumption.

The use of contingency activities will result in clarification of contingency time, cost, and resources. These contingency activities can succeed each activity for which a significant contingency is needed or as a composite contingency for all activities in a work package.

Contingency reserves are budgeted costs to be used at the direction of the Project Manager to deal with anticipated, but not certain, events; these are “known unknowns” and are part of the cost base line. Contingency reserves are usually assigned at the work package level as a zero duration summary activity spanning from the start to the end of the work package sub-network.

.7 Cost of Quality

Cost of quality (Section 8.1) can also be used to prepare the activity cost estimate.

7.1.3 Cost Estimating: Outputs

.1 Activity Cost Estimates

Activity cost estimates are a quantitative assessment of the likely costs of the resources required to complete project activities. They can be presented in summary or in detail. Costs must be estimated for all resources that will be applied to the project. This includes, but is not limited to, labor, materials, supplies, equipment, and special categories such as an inflation allowance or cost reserve.

.2 Activity Cost Supporting Detail

The amount and type of additional details supporting the cost estimate vary by application area. Regardless of the level of detail, the supporting documentation should provide a clear, professional, and complete picture by which the cost estimate was derived.

Supporting detail for the activity cost estimates should include:

- Description of the activity’s scope of work.
- Documentation of the basis for the estimate; i.e., how it was developed.
- Documentation of any assumptions made.
- Indication of the range of possible results; e.g., $\$10,000 \pm \$1,000$ to indicate that the item is expected to cost between \$9,000 and \$11,000.

7.2 COST BUDGETING

Cost budgeting involves aggregating the estimated costs of individual activities or work packages to establish a total cost baseline for measuring project performance. Activity or work package estimates are done after the project charter provides overall budgetary approval, but top-level WBS component estimates should be done prior to the detailed budget requests and work authorization.

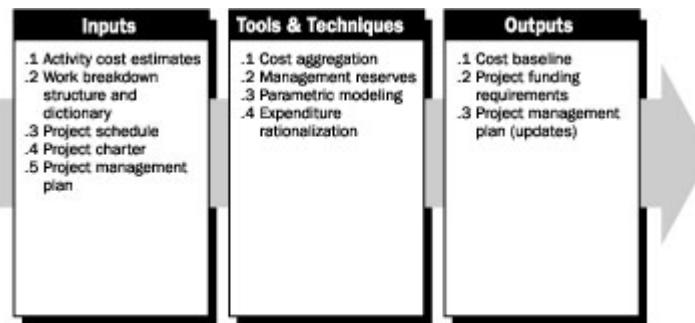


Figure 7-4. Cost budgeting process overview

7.2.1 Cost Budgeting: Inputs

.1 Activity Cost Estimates

Activity cost estimates (Section 7.1) are aggregated to obtain a cost estimate for each work package.

.2 Work Breakdown Structure and Dictionary

The WBS (Section 5.2) identifies the project's WBS components for which costs will be budgeted.

.3 Project Schedule

The project schedule (Section 6.5) includes planned start and expected finish dates for the project's activities, milestones, and work packages. This information is used to aggregate costs to the time periods when the costs are planned to be incurred.

.4 Project Charter

Formal periodic limitations of the expenditure of project funds can be given in the project charter or contract. These funding constraints can be due to annual funding authorizations by the buyer's organization or other entities like government agencies. This constraint would typically be identified in the project charter (Section 4.1).

.5 Project Management Plan

The project management plan and its subsidiary plans should be considered during cost budgeting.

7.2.2 Cost Budgeting: Tools and Techniques

.1 Cost Aggregation

The activity cost estimates are aggregated by work packages in accordance with the work breakdown structure. The work package cost estimates are then progressively aggregated for the higher component levels of the work breakdown structure and ultimately for the entire project.

.2 Management Reserves

Management reserves are budgets reserved for unplanned but potentially required changes to scope and cost; these are "unknown unknowns" and the project manager must

obtain approval before obligating or spending this reserve. Management reserves are not a part of the project cost baseline but are included in the budget for the project. They are not distributed as budget and therefore are not a part of the earned value calculations.

.3 Parametric Modeling

Parametric modeling involves using project characteristics (parameters) in a mathematical model to predict total project costs. Models can be simple (residential home construction will cost a certain amount per square foot of living space) or complex (one model of software development costs uses thirteen separate adjustment factors, each of which has five to seven points within it.)

Both the cost and accuracy of parametric models vary widely. They are most likely to be reliable when:

- The historical information used to develop the model is accurate.
- The parameters used in the model are readily quantifiable.
- The model is scalable such that, it works for a very large project as well as a very small one.

.4 Expenditure Rationalization

Large variations in the periodic expenditure of funds are usually undesirable for organizational operations. Therefore, the disbursement of project funds will need to be adjusted to smooth or regulate those expenditures. This is accomplished by placing date constraints for some work packages or components into the project schedule. As this impacts the allocation of resources, unless funds were used as a limiting resource in the schedule development process, the schedule development process will need to be repeated using these new date constraints. The final product of these iterations is a cost baseline.

7.2.3 Cost Budgeting: Outputs

.1 Cost Baseline

The cost base line is a time-phased budget that will be used to measure and monitor overall cost performance on the project. It is developed by summing estimated costs by period and is usually displayed in the form of an S-curve, as illustrated in Figure 7-4.

Also represented on Figure 7-4 is the expected funding for the project. The project manager can be invaluable, in providing the information necessary to support funding requests to ensure a positive funding flow in advance of expenditures.

Many projects, especially larger ones, have multiple cost baselines to measure different aspects of cost performance. For example, management will require that the project manager track internal costs (employee labor) separately from external costs (subcontractors and construction materials).

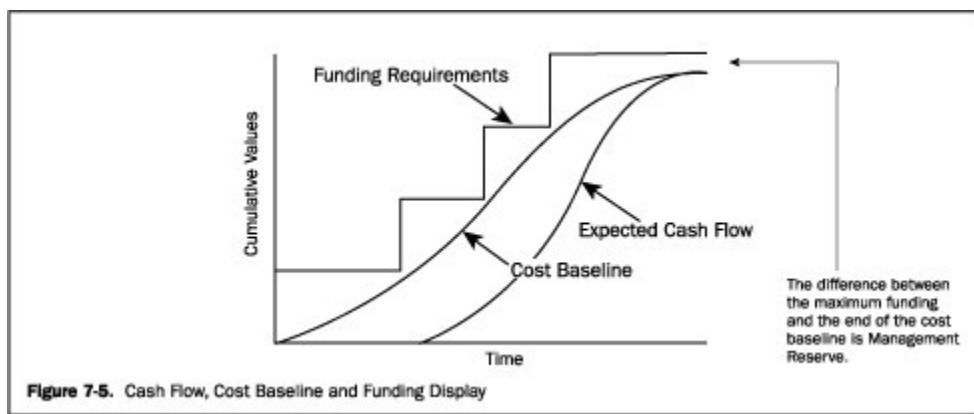
.2 Project Funding Requirements

Funding requirements, both total and periodic (e.g., quarterly or annual), are derived from the cost baseline and can exceed, usually by a margin to allow for either early progress or cost overruns, the expected expenditures during the respective time periods. Funding usually occurs in incremental amounts, which are not continuous, and therefore appears as a step function in Figure 7-5. The total funds required are those included in the cost baseline plus the management reserve amount. Some portion of the management reserve can be included incrementally in each funding step or funded when needed depending on the buyer's policies.

Although figure 7-5 shows the management reserve amount at the end of the project, in reality the cost baseline and the cash flow lines would increase when a portion of the management reserve is authorized and when it is spent. A gap at the end of a project between the funds allocated and the baseline and cash flow amounts shows the amount of the management reserve that was not used.

.3 Project Management Plan (Updates)

The cost budgeting process may require changes to the cost management plan a subsidiary of the project management plan. The cost baseline is also incorporated into the project management plan. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).



7.3 COST CONTROL

Project cost control includes:

- Influencing the factors that create changes to the cost baseline to ensure that the changes are agreed upon.
- Managing the actual changes when and as they occur.
- Assuring that cost overruns do not exceed the authorized funding both periodically and in total for the project.
- Monitoring cost performance to detect and understand variances from the cost plan.
- Recording all appropriate changes accurately against the cost baseline.
- Preventing incorrect, inappropriate, or unauthorized changes from being included in the reported cost or resource usage.
- Informing appropriate stakeholders of authorized changes.
- Acting to bring expected cost overruns within acceptable limits.

Project cost control, searches out the causes of both positive and negative variances and is part of integrated change control (Section 4.6). For example, inappropriate responses to cost variances can cause quality or schedule problems, or produce an unacceptable level of risk later in the project.

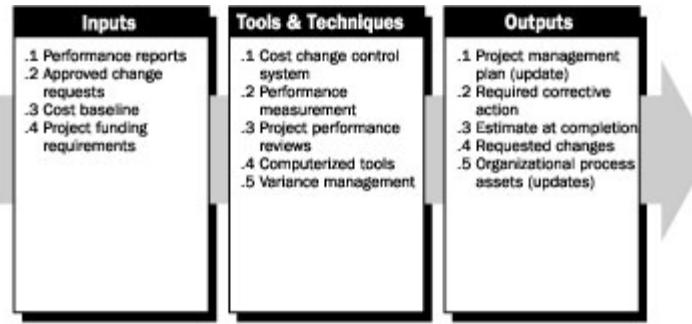


Figure 7-6. Cost Control Process Overview

7.3.1 Cost Control: Inputs

.1 Performance Reports

Performance reports (Section 10.3) provide information on cost and resource performance as a result of actual work progress.

.2 Approved Change Requests

Approved changes from the integrated change control (Section 4.6) include modifications to the cost terms of the contract or to the description of the materiel, products, goods, or services to be provided.

.3 Cost Baseline

Described in Section 7.2.

.4 Project Funding Requirements

Described in Section 7.2.

7.3.2 Cost Control: Tools and Techniques

.1 Cost Change Control System

A cost change control system defines the procedures by which the cost baseline can be changed. It includes the paperwork, tracking systems, and approval levels necessary for authorizing changes. The cost change control system should be integrated with the integrated change control (Section 4.6).

.2 Performance Measurement

Performance measurement techniques help to assess the magnitude of any variances that will invariably occur. The Earned Value Management (EVM) technique compares the value of the work completed at the original allocated budget amount to both the budgeted cost of work planned and to the actual cost for completed work. This technique is especially useful for cost control.

An important part of cost control is to determine what is causing the variance and to decide if the variance requires corrective action. Performance measurement uses the various baselines contained in the project management plan (Section 4.3) to assess project progress, and the magnitude of any variations that occur.

Earned value (EV) analysis involves calculating four key values for each activity:

- Planned Value (PV) is the total budgeted planned amount to be spent on an activity up to a given point in time.
- Actual Cost (AC) is the total cost incurred in accomplishing work on the activity during a given period. This Actual Cost must correspond in definition and

coverage to whatever was budgeted for the PV and the EV (example: direct hours only, direct costs only or all costs including indirect costs).

- Earned Value is the budgeted amount for the work actually completed.
- Estimate to Complete (ETC) is the cost estimate for work remaining and is used in forecasting the project cost at completion.
 - $ETC = (\text{total PV} - \text{EV to date})$
 - $ETC = (\text{remaining PV} \times CPI)$

These four values are used in combination to provide measures of whether or not work is being accomplished as planned. The most commonly used measures are the cost variance (CV) [$CV = EV - AC$], and the schedule variance (SV) [$SV = EV - PV$]. These two values, the CV and SV, can be converted to efficiency indicators to reflect the cost and schedule performance of any project.

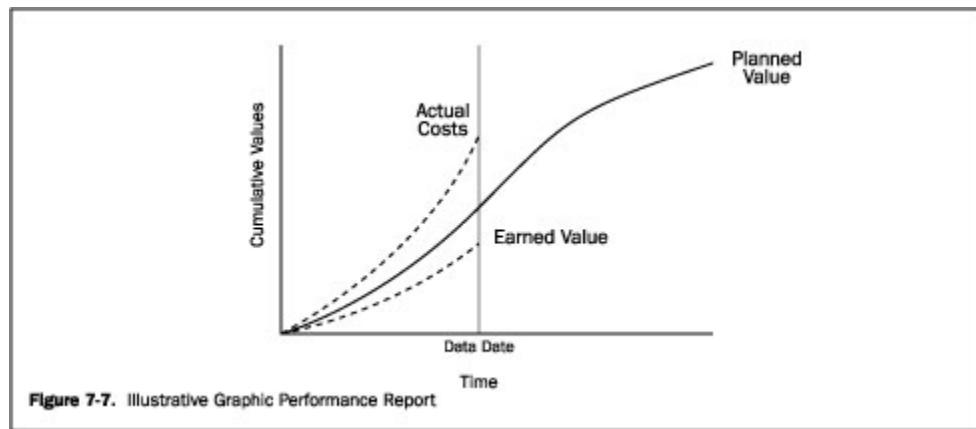
The cost performance index CPI [$CPI = EV/AC$] is the most commonly used cost-efficiency indicator. A CPI value less than 1.0 indicates a cost overrun of the estimates. A CPI value greater than 1.0 indicates a cost under run of the estimates.

The cumulative CPI (the sum of all individual EV budgets divided by the sum of all individual AC's) is widely used to forecast project costs at completion. The accurate and comprehensive completion estimate uses an independent estimate to complete (not calculated) in the formula for estimate at completion (EAC), [$EAC = ETC + AC$] where the ETC represents work remaining and considers the resource(s) performance to date.

The schedule performance index (SPI = EV/PV) is used, in addition to the schedule status (Section 6.6.) to predict the completion date, and is sometimes used in conjunction with the CPI to forecast the project completion estimates.

Earned Value less Planned Value is the Schedule Variance (SV) and Earned Value less Actual Costs is the Cost Variance (CV) for the project. Schedule Variance will ultimately = 0 when the project is completed because all of the planned values will have been earned. The amount of variance of these values tend to decrease as the project reaches completion due to the compensating effect as more work is accomplished. Predetermined acceptable variance values can be established over the duration of the project that will decrease as the project progresses towards completion.

Figure 7-7 uses S-curves to display cumulative EV data for a project that is over budget and behind the work plan, (worst case).



Earned value analysis in its various forms is a commonly used method of performance measurement. It integrates scope, cost (or resource), and schedule measures to help the project management team assess project performance.

.3 Project Performance Reviews

Performance reviews compare activities planned start time versus actual start time; planned completion time versus actual completion time; number of early starts versus late starts; activities over running and under running budget; milestones due and milestones met; etc.

Performance reviews are meetings held to assess activity status and progress and are typically used in conjunction with one or more of the following performance-reporting techniques described below.

- **Variance analysis.** Variance analysis involves comparing actual project results to planned or expected results. Cost and schedule variances are the most frequently analyzed, but variances from plan in the areas of scope, resource, quality, and risk are often of equal or greater importance.
- **Trend analysis.** Trend analysis involves examining project results over time to determine if performance is improving or deteriorating.
- **Earned value analysis.** The Earned value system compares planned results to actual performance results and actual costs.

.4 Computerized Tools

Computerized tools, such as project management software and spreadsheets, are often used to track planned costs versus actual costs, and to forecast the effects of cost changes.

.5 Variance Management

The cost management plan describes how cost variances will be managed such as different responses to major problems versus minor ones (Section 4.3).

7.3.3 Cost Control: Outputs

.1 Project Management Plan (Updates)

Activity cost estimates and project budget documents are components of the project management plan and all approved changes are incorporated as updates into the project management plan.

Revised activity cost estimates are modifications to the cost information used to manage the project. Appropriate stakeholders must be notified as needed. Revised cost estimates will or will not require adjustments to other aspects of the project work plan.

Budget updates are a special category of revised cost estimates. Budget updates are changes to an approved cost baseline. These numbers are generally revised only in response to scope changes. In some cases, cost variances will be so severe that a revised cost baseline is needed to provide a realistic basis for performance measurement.

Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

.2 Recommended Corrective Action

Corrective action is anything done to bring expected future performance in line with the project management plan.

.3 Estimate at Completion

An Estimate at Completion (EAC) is a forecast of most likely total project costs based on project performance and risk quantification (Section 11.4). The most common forecasting techniques are some variation of:

- EAC = Actual costs to date plus a new estimate for all remaining work. This approach is most often used when past performance shows that the original estimating assumptions were fundamentally flawed, or that they are no longer relevant to a change in conditions. Formula: $EAC = AC + ETC$.
- EAC = Actual costs to date plus remaining budget ($BAC - EV$). This approach is most often used when current variances are seen as atypical and the project management team expectations are that similar variances will not occur in the future. Formula: $EAC = AC + BAC - EV$.
- EAC = Actual costs to date plus the remaining project budget ($BAC - EV$) modified by a performance factor, often the cumulative cost performance index (CPI). This approach is most often used when current variances are seen as typical of future variances. Formula: $EAC = AC + ((BAC - EV)/CPI)$ — this CPI is the cumulative CPI.

Each of these approaches can be the correct approach for any given project and will provide the project management team with a signal if the EAC forecasts go beyond acceptable tolerances.

.4 Requested Changes

Analysis of project performance often generates a request for a change to some aspect of the project. Requested changes can occur in many forms: oral or written, direct or indirect, externally or internally initiated, and legally mandated or optional. Changes can require increasing the budget or can allow decreasing it. These requested changes are processed through the project integrated change control (Section 4.6).

.5 Organizational Process Assets (Updates)

Lessons learned documentation includes the root causes of cost variances, the reasoning behind the corrective action chosen, and other types of lessons learned from cost control should be documented so that they become part of the historical databases for both this project and the performing organization.

Chapter 8

Project Quality Management

Project Quality Management processes include all the activities of the performing organization that determine quality policies, objectives and responsibilities so that the project will satisfy the needs for which it was undertaken. It implements the quality management system through the policy, procedures and processes of quality planning, quality assurance, quality control, with continuous process improvement activities conducted throughout, as appropriate. Figure 8-1 provides an overview of the Project Quality Management processes and Figure 8-2 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes. The Project Quality Management processes include the following:

- 8.1 Quality Planning** - identifying which quality standards are relevant to the project and determining how to satisfy them.
- 8.2 Perform Quality Assurance** - applying the planned, systematic quality activities (such as audits or peer reviews) to ensure that the project will employ all processes needed to meet all stakeholder expectations.
- 8.3 Perform Quality Control** - monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.

These processes interact with each other and with the processes in the other knowledge areas as well. Each process may involve effort from one or more individuals or groups of individuals, based on the needs of the project. Each process generally occurs at least once in every project phase.

Although the processes are presented here as discrete elements with well-defined interfaces, in practice they can overlap and interact in ways not detailed here. Process interactions are discussed in Chapters 3 and 4.

The basic approach to quality management described in this section is intended to be compatible with that of the International Organization for Standardization. This generalized approach should also be compatible with proprietary approaches to quality management such as those recommended by Deming, Juran, Crosby and others, and non-proprietary approaches such as Total Quality Management (TQM), Six Sigma, Failure Mode Effects Analysis, Design Reviews, Voice of the Customer, and Continuous Improvement.

Project Quality Management must address both the management of the project and the product of the project. While *Project* Quality Management applies to all projects, regardless of the nature of their product, *product* quality measures and techniques are specific to the particular type of product(s) produced by the project. For example, quality management of software *products* entails different approaches and measures than nuclear power plants, while *Project* Quality Management approaches apply to both. In either

case, failure to meet quality requirements in either dimension can have serious negative consequences for any or all of the project stakeholders. For example:

- Meeting customer requirements by overworking the project team may produce negative consequences in the form of increased employee attrition, unfounded errors, or rework.
- Meeting project schedule objectives by rushing planned quality inspections may produce negative consequences when errors go undetected.

Quality is “the characteristics of a [process], product or service that bear on its ability to satisfy stated or implied needs” (American Society for Quality, 1999). Stated and implied needs are the inputs to developing project requirements. A critical element of quality management in the project context is the necessity to turn implied needs into requirements through project scope management.

Quality and grade are not the same. Grade is a category assigned to products or services having the same functional use but different technical characteristics. Low quality is always a problem; low grade may not be. For example, a software product can be of high quality (no obvious bugs, readable manual) and low grade (a limited number of features), or of low quality (many bugs, poorly organized user documentation) and high grade (numerous features). The project manager and the project management team are responsible for determining and delivering the required levels of both quality and grade.

Precision and accuracy are not equivalent. Precision is consistency that the value of repeated measurements are clustered and have little scatter. Accuracy is correctness that the measured value is very close to the true value. Precise measurements are not necessarily accurate. A very accurate measurement is not necessarily precise. The project management team must determine how much accuracy or precision or both are required.

Modern quality management complements project management. For example, both disciplines recognize the importance of:

- **Customer satisfaction** - understanding, managing and influencing needs so that customer expectations are met. This requires a combination of conformance to requirements (the *project* must produce what it said it would produce) and fitness for use (the *product* or service produced must satisfy real needs).
- **Prevention over inspection** - the cost of preventing mistakes is always much less than the cost of correcting them, as revealed by inspection.
- **Management responsibility** - success requires the participation of all members of the team, but it remains the responsibility of management to provide the resources needed to succeed.
- **Continuous improvement** - the plan-do-check-act cycle described by Shewart and promoted by Deming and others is the basis for quality improvement. In addition, quality improvement initiatives undertaken by the performing organization, such as TQM and Six Sigma, can improve the quality of the project’s management as well as the quality of the project’s product.

The project management team needs to consider the cost of quality, which refers to the total cost of all efforts to achieve product/service quality. This includes all work to ensure conformance to requirements, as well as all work resulting from nonconformance to requirements. The project management team should realize that project decisions can

impact operational costs of quality as a result of product returns, warranty claims, and recall campaigns.

However, there is an important difference of which the project management team must be acutely aware—the temporary nature of the project means that investments in product quality improvement, especially defect prevention and appraisal, can often be borne by the acquiring organization, rather than the project, since the project may not last long enough to reap the rewards.

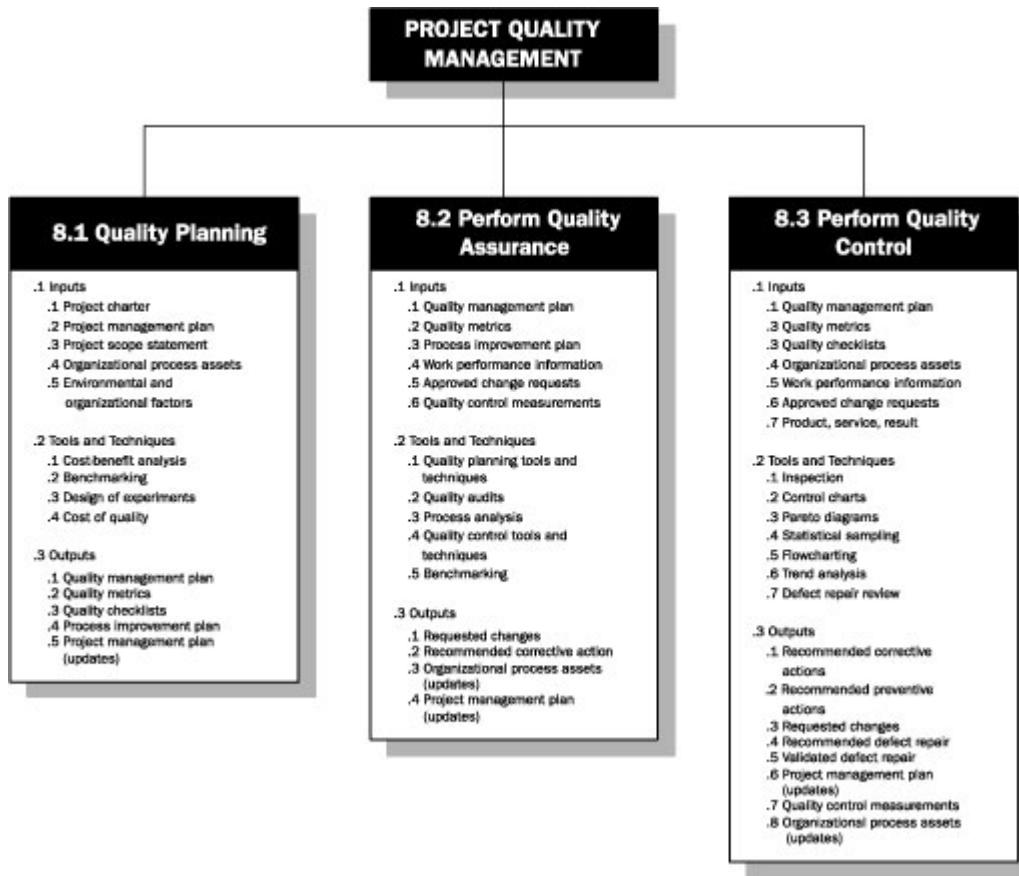


Figure 8.1: Project Quality Management Overview

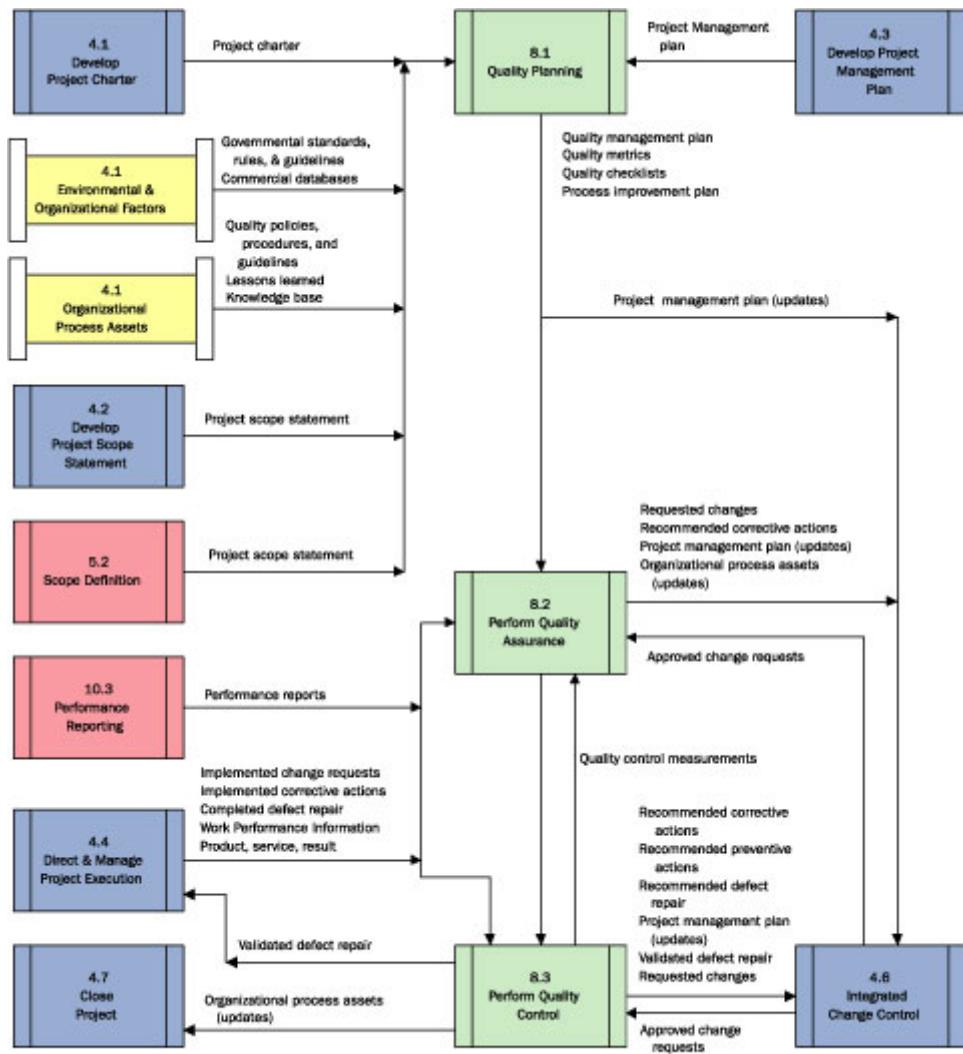


Figure 8-2: Project Quality Management Process Flow Diagram

8.1 QUALITY PLANNING

Quality planning involves identifying which quality standards are relevant to the project and determining how to satisfy them. It is one of the key processes during project planning (Sections 4.2 and 5.2) and should be performed regularly and in parallel with the other project planning processes. For example, the required changes in the product to meet identified quality standards may require cost or schedule adjustments, or the desired product quality may require a detailed risk analysis of an identified problem.

The quality planning techniques discussed here are those techniques most frequently used on projects. There are many others that may be useful on certain projects or in some application areas. The project team members should also be aware of one of the fundamental tenets of modern quality management: quality is planned and designed in, not inspected in.

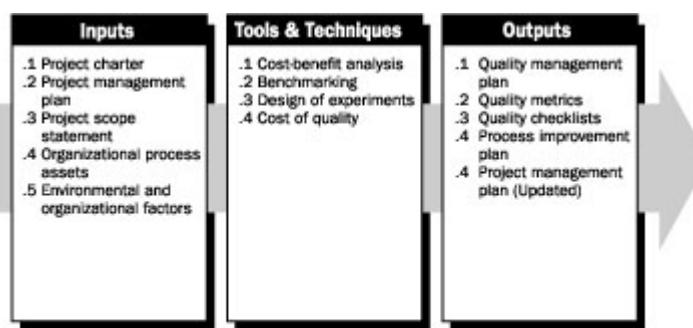


Figure 8-3: Quality Planning Process Overview

8.1.1 Quality Planning: Inputs

.1 Project Charter

Described in Section 4.1.

.2 Project Management Plan

Described in Section 4.2.

.3 Project Scope Statement

The project scope statement (Sections 4.2 and 5.2) is a key input to quality planning since it documents major project deliverables, the project objectives that serve to define important stakeholder requirements, thresholds, and acceptance criteria.

Thresholds, which are defined as cost, time, or resource values used as parameters, can be part of the product specifications. If these threshold values are exceeded, it will require action from the project management team.

Acceptance criteria include performance requirements and essential conditions that must be achieved before project deliverables are accepted. The definition of acceptance criteria can significantly increase or decrease project quality costs. The result of the deliverables satisfying all acceptance criteria implies that the needs of the customer have been met. Acceptance criteria validates formal acceptance cited in Section 5.4. Although elements of the product scope description (Section 5.2) may be embodied in the project scope statement, the product description will often contain details of technical issues and other concerns that can affect quality planning.

.4 Organizational Process Assets

The project management team must consider any organizational quality policies, procedures, and guidelines specific to the application area that may affect the project (Section 4.1).

The quality policy is the intended direction of a performing organization with regard to quality, as endorsed by senior management. The quality policy of the performing organization for their *products* often can be adopted “as is” for use by the *project*. However, if the performing organization lacks a formal quality policy, or if the project involves multiple performing organizations (as with a joint venture), then the project management team will need to develop a quality policy for the project (Section 4.3).

Regardless of the origin of the quality policy, the project management team is responsible for ensuring that the project stakeholders are fully aware of the policy through the appropriate distribution of information (Section 10.2).

.5 Environmental and Organizational Factors

The project management team must consider any governmental agency regulations, rules, standards, and guidelines specific to the application area that may affect the project (Section 4.1).

8.1.2 Quality Planning: Tools and Techniques

.1 Cost-Benefit Analysis

Quality planning must consider cost-benefits tradeoffs. The primary benefit of meeting quality requirements is less rework, which means higher productivity, lower costs and increased stakeholder satisfaction. The primary cost of meeting quality requirements is the expense associated with Project Quality Management activities.

.2 Benchmarking

Benchmarking involves comparing actual or planned project practices to those of other projects to generate ideas for improvement and to provide a standard by which to measure performance. The other projects can be within the performing organization or outside of it, and can be within the same application area or in another.

.3 Design of Experiments

Design of experiments (DOE) is a statistical method that helps identify which factors may influence specific variables of a product or process under development or in production. It also plays a role in the optimization of products or processes. An example is where an organization can use DOE to reduce the sensitivity of product performance to sources of variations caused by the environmental or manufacturing differences. The most important aspect of this technique is that it provides a statistical framework for systematically changing all of the important factors, instead of changing the factors one at a time. The analysis of the experimental data should provide the optimal conditions for the product or process, highlighting the factors that influence the results and revealing the presence of interactions and synergisms among the factors. For example, automotive designers use this technique to determine which combination of suspension and tires will produce the most desirable ride characteristics at a reasonable cost.

.4 Cost of Quality

Cost of quality refers to the total cost of all efforts to achieve product or service quality and includes all work to ensure conformance to requirements, as well as all work resulting from nonconformance to requirements. There are three types of costs that are

incurred: prevention costs, appraisal costs and failure costs, where the latter is broken down into internal and external costs.

8.1.3 Quality Planning: Outputs

.1 Quality Management Plan

The quality management plan describes how the project management team will implement the performing organization's quality policy. The quality management plan is a component or a subsidiary plan of the project management plan (Section 4.3).

The quality management plan provides input to the overall project management plan and must address quality control, quality assurance, quality improvement and continuous process improvement for the project. It also provides for quality assurance (QA) activities including design reviews, quality audits and code inspections.

The quality management plan may be formal or informal, highly detailed, or broadly framed, based on the requirements of the project. The quality management plan should include efforts at the front end of a project to ensure that the earlier decisions on concepts, designs, and tests are correct. These efforts should be performed through an independent peer review and not include members of the project team. The benefits of this review can include reduction of cost and schedule overruns caused by rework.

.2 Quality Metrics

A metric is an operational definition, which describes, in very specific terms, what something is and how the quality control process measures it. For example, it is not enough to say that meeting the planned schedule dates is a measure of management quality. The project management team must also indicate whether every activity must start on time or only finish on time and whether individual activities will be measured, or only certain deliverables and if so, which ones. Quality metrics are used in the quality assurance and quality control processes.

.3 Quality Checklists

A checklist is a structured tool, usually component specific, used to verify that a set of required steps has been performed. Checklists may be simple or complex. They are usually phrased as imperatives ("Do this!") or interrogatories ("Have you done this?"). Many organizations have standardized checklists available to ensure consistency in frequently performed tasks. In some application areas, checklists are also available from professional associations or commercial service providers. Quality checklists are used in the quality control process.

.4 Process Improvement Plan

The process improvement plan is a subsidiary of the project management plan (Section 4.3). The process improvement plan details the steps for analyzing processes that will facilitate the identification of waste and non-value added activity, thus increasing customer value, such as:

- **Process boundaries.** Describes the purpose, start and end of processes, their inputs and outputs, data required, if any and the owner and stakeholders of processes.
- **Process configuration.** A flowchart of processes to facilitate analysis with interfaces identified.
- **Process metrics.** Maintain control over status of processes.

- **Targets for improved performance.** Targets guide the process improvement activities.

.5 Project Management Plan (Updates)

The project management plan will be updated through the inclusion of a subsidiary quality management plan and process improvement plan (Section 4.3). Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

8.2 PERFORM QUALITY ASSURANCE

Quality assurance (QA) is the application of planned, systematic quality activities to ensure that the project will employ all processes needed to meet all stakeholder expectations and provide the confidence that the product of the project will fulfill the requirements for quality.

A quality assurance department or similar organization often oversees quality assurance activities. QA support, regardless of the unit's title, may be provided to the project team, the management of the performing organization, the customer or sponsor, as well as other stakeholders not actively involved in the work of the project. QA also provides an umbrella for another important quality activity, that of continuous process improvement. Continuous process improvement provides an iterative means for improving the quality of all processes.

Continuous process improvement reduces waste and non-value-added activities, which allows processes to operate at increased levels of efficiency and effectiveness. Process improvement is distinguished by its identification and review of organizational business processes. It may be applied to other processes within an organization as well, from micro processes, such as the coding of modules within a software program or macro processes, such as the opening of new markets.

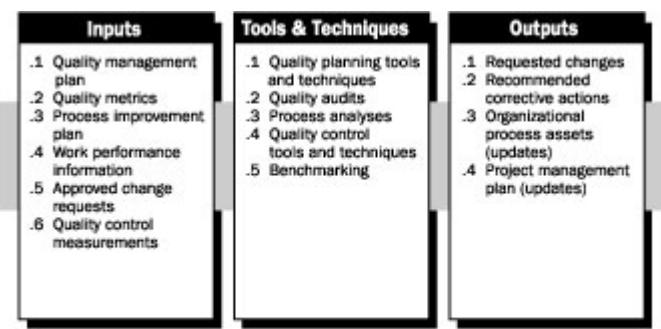


Figure 8-4. Perform Quality Assurance Process Overview

8.2.1 Perform Quality Assurance: Inputs

.1 Quality Management Plan

The quality management plan describes how quality assurance will be performed within the project (Section 8.1).

.2 Quality Metrics

Described in Section 8.1.

.3 Process Improvement Plan

Described in Section 8.1.

.4 Work Performance Information

Work performance information (Section 4.4), including project deliverables status, required corrective actions, and performance reports (Section 10.3) are important inputs to quality assurance and can be used in areas such as, audits, quality reviews, and process analyses.

.5 Change Requests

Approved change requests (Section 4.6) can include modifications such as work methods, product requirements, quality requirements, scope, and schedule. Approved changes need to be analyzed for any effects upon the quality management plan, quality metrics, or quality checklists. Approved changes are important inputs to quality assurance and can be used in areas such as, audits, quality reviews, and process analyses. All changes should be formally documented in writing and any verbally discussed but undocumented changes should not be processed or implemented.

.6 Quality Control Measurements

Quality control measurements (Section 8.3) are the results of quality control activities that are fed back to the quality assurance process for use in re-evaluating and analyzing the quality standards and processes of the performing organization.

8.2.2 Perform Quality Assurance: Tools and Techniques

.1 Quality Planning Tools and Techniques

The quality planning tools and techniques (Section 8.1) also can be used for quality assurance activities as well.

.2 Quality Audits

A quality audit is a structured, independent review to determine if the results of a project's quality activities comply with organizational policies, processes and procedures. The objective of a quality audit is to identify inefficient and ineffective policies, processes and procedures in use on projects. The subsequent effort to correct these deficiencies should result in a reduced cost of quality and an increase in the percentage of acceptance of the product or service by the customer or sponsor within the performing organization. Quality audits may be scheduled or random and they may be carried out by properly trained in-house auditors or by third parties, external to the performing organization.

.3 Process Analysis

Process analysis follows the steps outlined in the process improvement plan to identify needed improvements from an organizational and technical standpoint. This analysis also examines problems experienced, constraints experienced, and non-value-added activities identified during process operation.

.4 Quality Control Tools and Techniques

Described in Section 8.3.

.5 Benchmarking

Described in Section 8.1.

8.2.3 Perform Quality Assurance: Outputs

.1 Requested Changes

Quality improvement includes taking action to increase the effectiveness and efficiency of the policies, processes and procedures of the performing organization, which should provide added benefits to the stakeholders of all projects (Section 4.6).

.2 Recommended Corrective Actions

Quality improvement includes recommending actions to increase the effectiveness and efficiency of the performing organization. Corrective action is an action that is recommended to be taken immediately as a result of quality assurance activities such as audits and process analyses.

.3 Organizational Process Assets (Updates)

Updated quality standards provide validation of the effectiveness and efficiency of the performing organization's quality standards and processes to meet stakeholder expectations and provide confidence that the product meets quality requirements. These quality standards are used to conduct the quality control processes (Section 8.3).

.4 Project Management Plan (Updates)

The project management plan will be updated from changes to the quality management plan that result from changes to the quality assurance process (Section 4.3). These updates can include incorporation of processes that have been through continuous process improvement and are ready to repeat the cycle and improvements to processes that have been identified and measured and are ready to be implemented. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

8.3 PERFORM QUALITY CONTROL

Performing quality control (QC) involves monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory results. It should be performed throughout the project. Project results include both product results, such as deliverables and project management results, such as cost and schedule performance. QC is often performed by a quality control department or similarly titled organizational unit. QC can also include taking action to eliminate causes of unsatisfactory project performance.

The project management team should have a working knowledge of statistical quality control, especially sampling and probability, to help them evaluate quality control outputs. Among other subjects, the team may find it useful to know the differences between the following pairs of terms:

- Prevention (keeping errors out of the process) and inspection (keeping errors out of the hands of the customer).
- Attribute sampling (the result conforms, or it does not) and variables sampling (the result is rated on a continuous scale that measures the degree of conformity).
- Special causes (unusual events) and random causes (normal process variation).
- Tolerances (the result is acceptable if it falls within the range specified by the tolerance) and control limits (the process is in control if the result falls within the control limits).

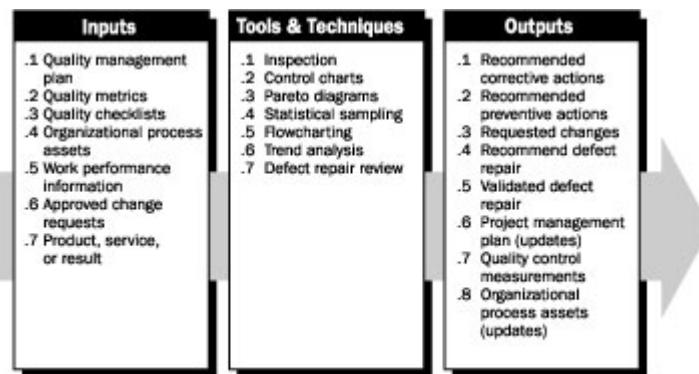


Figure 8-5. Perform Quality Control Overview

8.3.1 Perform Quality Control: Inputs

.1 Quality Management Plan

Described in Sections 8.1 and 8.2.

.2 Quality Metrics

Described in Section 8.1.

.3 Quality Checklists

Described in Section 8.1.

.4 Organizational Process Assets

Described in Section 8.2.

.5 Work Performance Information

Work performance information (Section 4.4), including project deliverables completion status and the implementation of required corrective actions are important inputs to quality control. Information from the project management plan about the planned or expected results should be available along with information about the actual results and implemented change requests.

.6 Approved Change Request

Approved change requests (Section 4.6) can include modifications such as revised work methods and revised schedule. The timely correct implementation of approved changes needs to be verified.

.7 Product, Service, or Result

Described in Sections 4.4 and 4.7.

8.3.2 Perform Quality Control: Tools and Techniques

.1 Inspection

Inspection includes activities such as measuring, examining and testing undertaken to determine whether results conform to requirements. Inspections can be conducted at any level; for example, the results of a single activity can be inspected, or the final product of the project can be inspected. Inspections are also called reviews, product reviews, audits and walkthroughs; in some application areas, these terms have narrow and specific meanings. Inspections are also used to validate defect repairs.

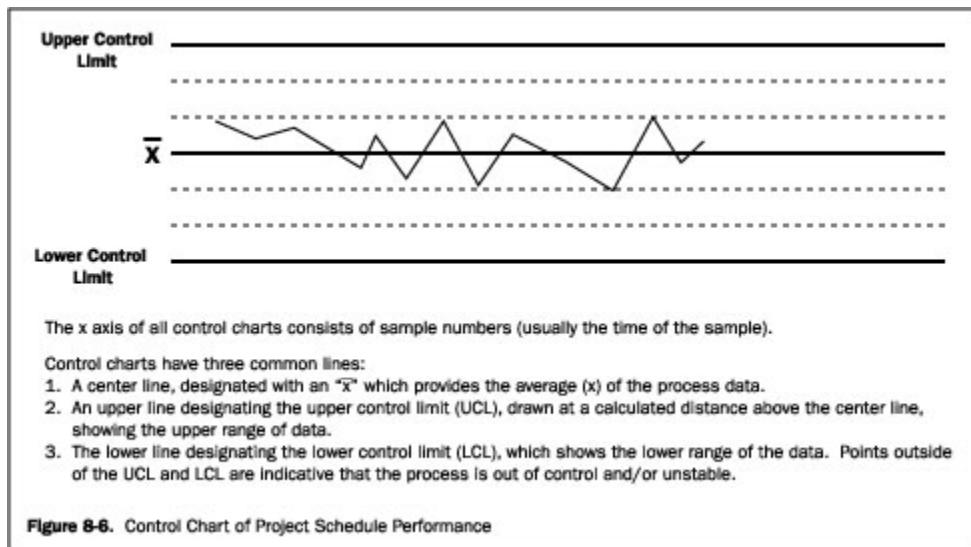
.2 Control Charts

A control chart's purpose is to determine whether or not a process is stable or has predictable performance. Control charts may serve as a data gathering tool to show when a process is subject to special cause variation, which creates an out-of-control condition. Control charts also illustrate how a process behaves over time. They are a graphic display

of the interaction of process variables on a process to answer the question: Are the process variables within acceptable limits? Examination of the non-random pattern of data points on a control chart may reveal wildly fluctuating values, sudden process jumps or shifts, or a gradual trend in increased variation. By monitoring the output of a process over time, a control chart may be employed to assess whether the application of process changes resulted in the desired improvements. When a process is within acceptable limits, the process need not be adjusted. When a process is outside acceptable limits, the process should be adjusted. The upper control limit and lower control limit are usually set at ± 3 sigma (i.e., standard deviation).

Control charts can be used for both *project* and *product* life cycle processes. An example of a *project* use of control chart is determining whether cost variances or schedule variances is outside of acceptable limits (for example, plus or minus 10 percent). An example of *product* use of control charts is evaluating whether the number of defects found during testing are acceptable or unacceptable in relation to the organization's standards for quality.

Control charts can be used to monitor any type of output variable. Although used most frequently to track repetitive activities, such as manufactured lots, control charts also can be used to monitor cost and schedule variances, volume and frequency of scope changes, errors in project documents, or other management results to help determine if the project management process is in control. Figure 8-6 is a control chart of project schedule performance.

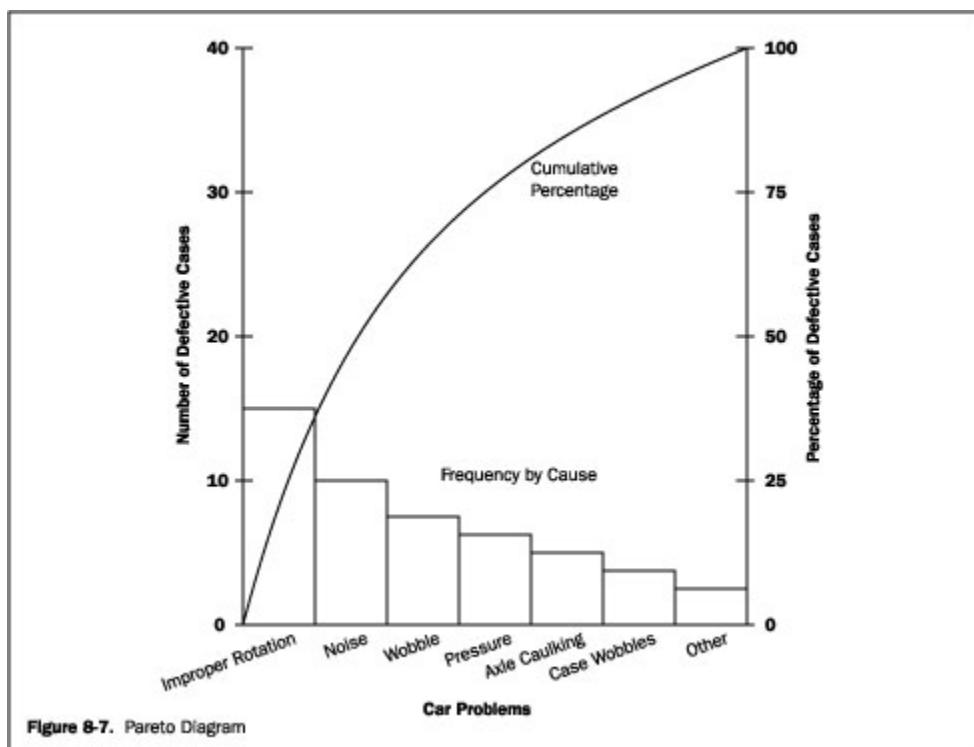


.3 Pareto Diagrams

A Pareto diagram is a histogram, ordered by frequency of occurrence, that shows how many defects were generated by type or category of identified cause (Figure 8-7). It is not considered a control chart. The Pareto technique is used primarily to identify and evaluate nonconformities.

In Pareto Diagrams, rank ordering is used to guide corrective action. The project team should take action to fix the problems that are causing the greatest number of defects first. Pareto diagrams are conceptually related to Pareto's Law, which holds that a relatively small number of causes will typically produce a large majority of the problems

or defects. This is commonly referred to as the 80/20 principle, where 80 percent of the problems are due to 20 percent of the causes. Pareto Diagrams also can be used to summarize all types of data for 80/20 analyses.



.4 Statistical Sampling

Statistical sampling involves choosing part of a population of interest for inspection (for example, selecting ten engineering drawings at random from a list of seventy-five).

Appropriate sampling can often reduce the cost of quality control. There is a substantial body of knowledge on statistical sampling; in some application areas, it may be necessary for the project management team to be familiar with a variety of sampling techniques.

.5 Flowcharting

Flowcharting is used in quality control to help analyze how problems occur. A flowchart is any diagram that shows how various elements of a system relate. Flowcharting techniques commonly used in quality management include:

- Cause-and-effect diagrams, also called Ishikawa diagrams or fishbone diagrams, which illustrate how various factors might be linked to potential problems or effects. Figure 8-8 is an example of a generic cause-and-effect diagram.

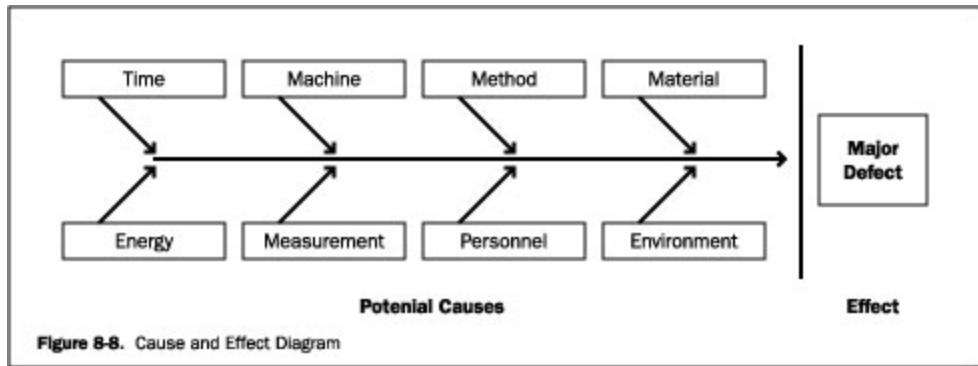


Figure 8-8. Cause and Effect Diagram

- System or process flowcharts show how various elements of a system interrelate. Figure 8-9 is an example of a process flowchart for design reviews. Flowcharting can help the project team anticipate what and where quality problems might occur and thus can help develop approaches for dealing with them.

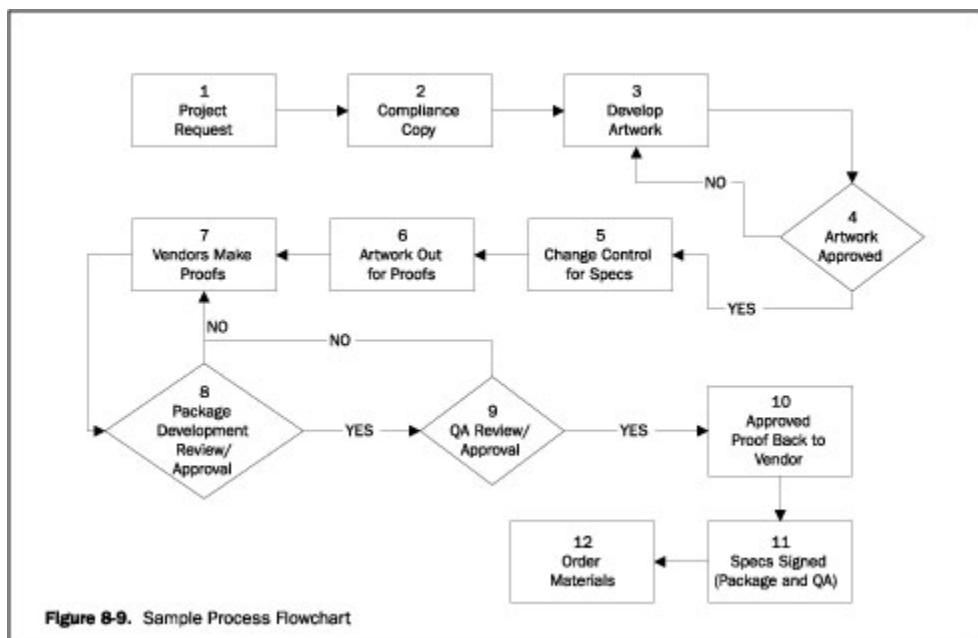


Figure 8-9. Sample Process Flowchart

.6 Trend Analysis

Trend analysis involves using mathematical techniques to forecast future outcomes based on historical results. Trend analysis is often used to monitor:

- Technical performance.** How many errors or defects have been identified, how many remain uncorrected.
- Cost and schedule performance.** How many activities per period were completed with significant variances?

.7 Defect Repair Review

Defect repair review is an action taken by the quality control department or similarly titled organization to ensure that product defects are repaired and brought into compliance with requirements or specifications.

8.3.3 Perform Quality Control: Outputs

.1 Recommended Corrective Actions

Corrective action (Section 4.4) involves immediate action taken as a result of a quality control measurement that indicates that the manufacturing or development process exceeds established parameters.

.2 Recommended Preventive Actions

Preventive action (Section 4.4) involves action taken to forestall a condition that may exceed established parameters in a manufacturing or development process, which may have been indicated through a quality control measurement.

.3 Requested Changes

If the recommended corrective or preventive actions require a change to the project, a change request should be initiated in accordance with the defined change control process (Section 4.6).

.4 Recommended Defect Repair

A defect is where a component does not meet its requirements or specifications and needs to be repaired or replaced. Defects are identified and recommended for repair by the quality control department or similarly titled organization. The project team should make every reasonable effort to minimize the errors that cause the need for defect repair.

.5 Validated Defect Repair

The repaired items are re-inspected and will be either accepted or rejected then notification of the decision provided (Section 4.4). Rejected items may require further defect repair.

.6 Project Management Plan (Updates)

The project management plan is updated to reflect changes to the quality management plan that result from changes in performing the quality control process. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

.7 Quality Control Measurements

Quality control measurements represent the results of quality control activities that are fed back to quality assurance (Section 8.2) to re-evaluate and analyze the quality standards and processes of the performing organization.

.8 Organization Process Assets (Updates)

- **Completed checklists.** When checklists are used, the completed checklists should become part of the project's records (Section 4.7).
- **Lessons learned documentation.** The causes of variances, the reasoning behind the corrective action chosen and other types of lessons learned from quality control should be documented so that they become part of the historical database for both this project and of the performing organization. Lessons learned are documented, at a minimum, during project closure (Section 4.7).

Chapter 9

Project Human Resource Management

Project Human Resource Management includes the processes required to organize and manage the project team. The project team is comprised of the people who have assigned roles and responsibilities for completing the project. While it is common to speak of roles and responsibilities being assigned, team members should be involved in much of the project's planning and decision-making. Early involvement of team members adds expertise during the planning process and strengthens commitment to the project. Project team members can also be referred to as the project's staff.

The project management team is a subset of the project team and is responsible for project management activities such as planning, controlling and closing. This group may be called the core, executive or leadership team. For smaller projects, the project management responsibilities can be shared by the entire team or administered solely by the project manager. The project sponsor works with the project management team, typically assisting with matters such as project funding, clarifying scope questions and influencing others in order to benefit the project.

Figure 9-1 provides an overview of the Human Resource Management processes and Figure 9-2 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes. The Project Human Resource Management processes include the following:

- 9.1 Human Resource Planning** - Identifying and documenting project roles, responsibilities and reporting relationships, as well as create the staffing management plan.
 - 9.2 Acquire Project Team** - Obtaining the human resources needed to complete the project.
 - 9.3 Develop Project Team** - Developing individual and group competencies to enhance project performance.
 - 9.4 Manage Project Team** - Tracking individual and team performance, provide feedback, resolve issues and coordinate changes to enhance project performance.
- These processes interact with each other and with the processes in the other knowledge areas as well. Each process can involve effort from one or more individuals or groups of individuals, based on the needs of the project. Each process generally occurs at least once in every project life cycle phase. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they can overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3 and 4.

For example, a few initial team members can create the detailed project scope statement (Section 5.2) and the work breakdown structure (WBS) (Section 5.3). The newly created WBS can lead to additional planning and acquisition of human resources.

The type and number of project team members can often change as the project progresses.

Human resource administrative activities such as labor contracts; benefits administration and hiring assessments are seldom a direct responsibility of the project management team. However, the team must be sufficiently aware of administrative requirements to ensure compliance. The project manager and the project management team must also apply general management skills and soft skills to manage people effectively (Section 1.4).

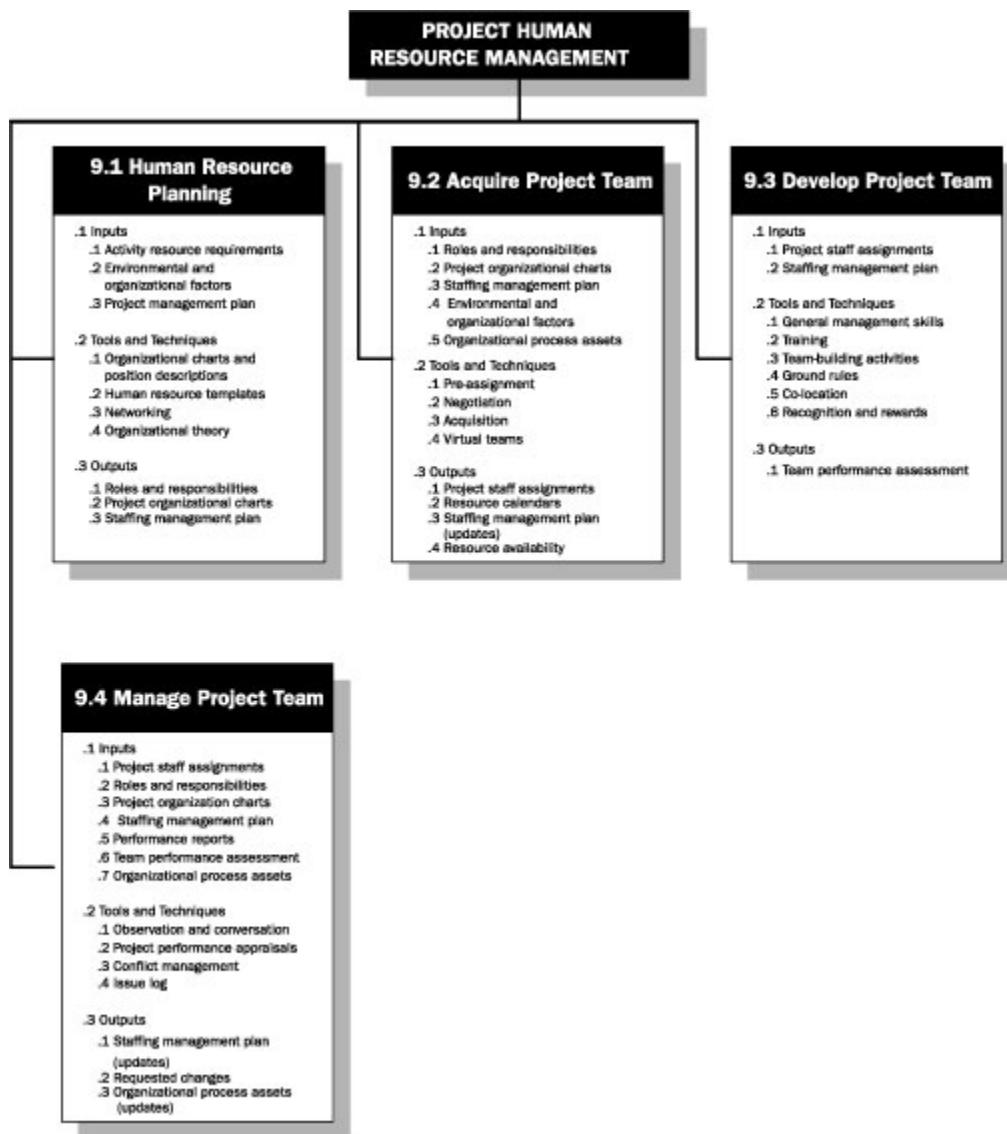


Figure 9-1. Project Human Resource Management Overview

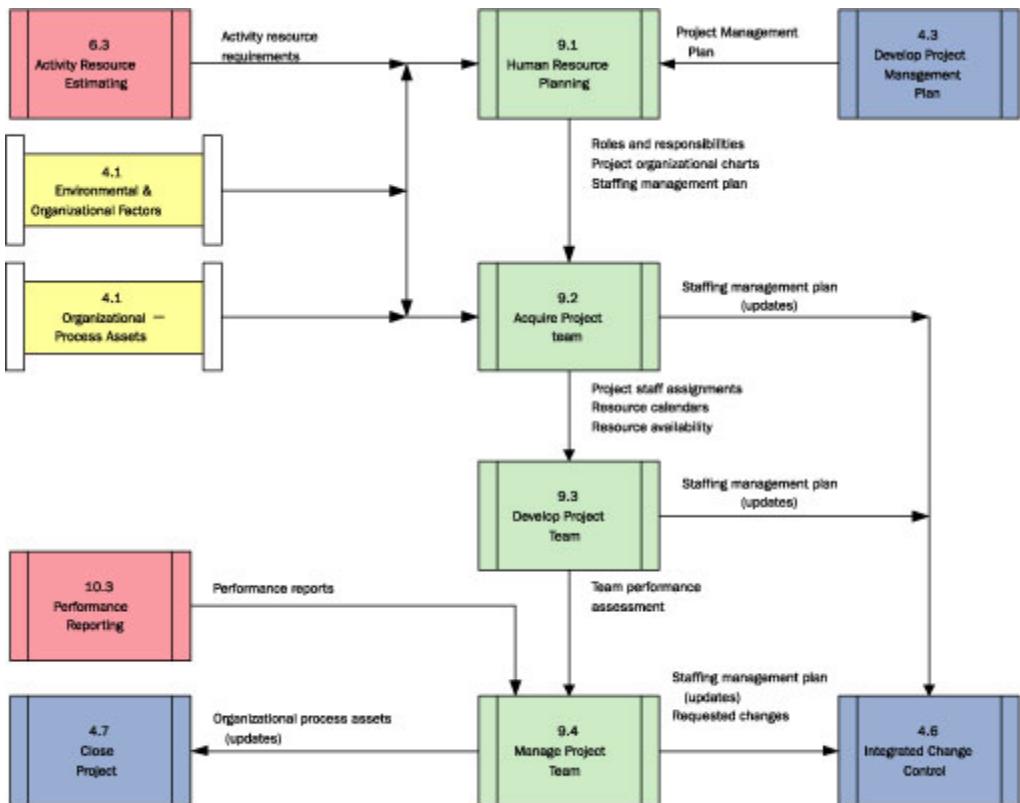


Figure 9-2. Project Human Resource Management Process Flow

9.1 HUMAN RESOURCE PLANNING

Human resource planning determines project roles, responsibilities and reporting relationships. Project roles can be designated for individuals or groups. Those individuals or groups can be part of the organization performing the project, external to it or a combination. Human resource planning also creates a staffing management plan that can include how and when project team members will be acquired, the criteria for releasing them from the project, and identification of training needs, plans for recognition and rewards, compliance considerations, safety issues, and the impact of the staffing management plan on the organization.

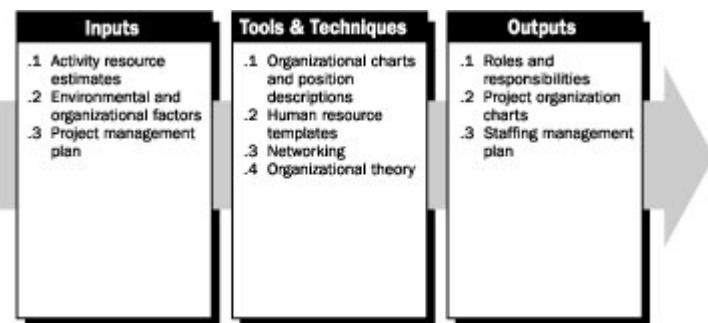


Figure 9-3. Human Resource Planning Overview

9.1.1 Human Resource Planning: Inputs

.1 Activity Resource Estimates

Project organizational planning uses the activity resource estimates (Section 6.3) to determine the human resource needs for the project. The preliminary estimates regarding the required people and competencies for the project team members are refined as part of the human resource planning process.

.2 Environmental and Organizational Factors

The creation of project roles and responsibilities are developed with an understanding of the ways that existing organizations will be involved and how the technical disciplines and people currently interact with one another. Some of the environmental and organizational factors (Section 4.1) important to human resource planning are:

- **Organizational.** Which organizations or departments will be involved in the project? What are the current working arrangements among them? What formal and informal relationships exist among them?
- **Technical.** What are the different disciplines and specialties that will be needed to complete this project? Are there different types of software languages, engineering approaches or kinds of equipment that will need to be coordinated? Do the transitions from one life cycle phase to the next present any unique challenges?
- **Interpersonal.** What types of formal and informal reporting relationships exist among people who are candidates for the project team? What are the candidates' job descriptions? What are their supervisor-subordinate relationships? What are their supplier-customer relationships? What cultural or language differences will affect working relationships among team members? What levels of trust and respect currently exist?
- **Logistical.** How much distance separates the people and units that will be part of the project? Are people in different buildings, time zones or countries?
- **Political.** What are the individual goals and agendas of the potential project stakeholders? Which groups and people have informal power in areas important to the project? What informal alliances exist?

In addition to the factors listed above, constraints limit the project team's options.

Examples of constraints that can limit flexibility specific to the human resource planning area are:

- **Organizational structure.** An organization whose basic structure is a weak matrix means a relatively weaker role for the project manager (Section 2.3).
- **Collective bargaining agreements.** Contractual agreements with unions or other employee groups can require certain roles or reporting relationships.
- **Economic conditions.** Hiring freezes, reduced training funds, or a lack of travel budget are examples of economic conditions that may restrict staffing options.
- **Historical preferences.** If members of the project management team or supporting functional managers have had success with certain structures in the past, they are likely to advocate similar structures in the future.

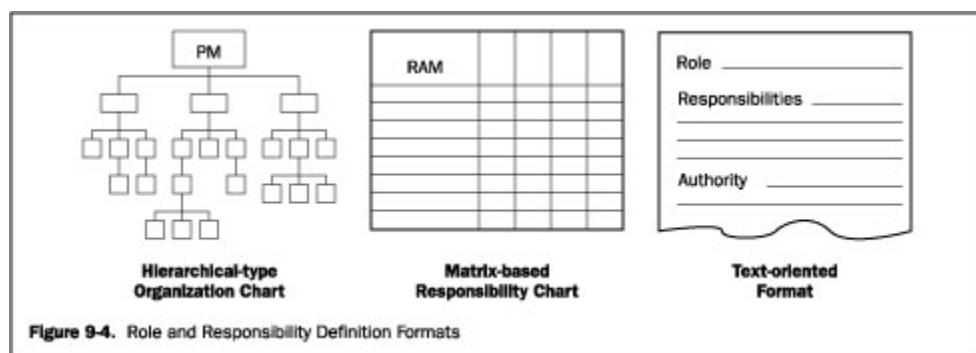
.3 Project Management Plan

The project management plan (Section 4.3) includes descriptions of project management activities such as quality assurance, risk management, and procurement that will help the project management team identify all of the required roles and responsibilities.

9.1.2 Human Resource Planning: Tools and Techniques

.1 Organizational Charts and Position Descriptions

Various formats exist to document team member roles and responsibilities. Most of the formats fall into one of three types (Figure 9-4): hierarchical, matrix, and text-oriented. Additionally, some project assignments are listed in subsidiary project plans, such as the risk, quality, or communication plans. A team directory (Section 9.2) is not included in this section because the directory primarily serves as a communication tool, not as a description of duties. Whichever combination of methods is used, the objective is to ensure that each work package has an unambiguous owner and that all team members have a clear understanding of their roles and responsibilities.



- **Hierarchical-type charts.** The traditional organizational chart structure can be used to show positions and relationships in a graphic, top-down format. Work breakdown structures (WBS), that are primarily designed to show how project deliverables are broken down into work packages, become one way to show high-level areas of responsibility when the name of the person responsible for each element is included. The organizational breakdown structure (OBS) looks similar to the WBS. But instead of being arranged according to a breakdown of project deliverables, it is arranged according to an organization's existing departments, units or teams. The project activities or work packages are listed under each existing department. This way, an operational department such as information technology or purchasing can see all of its project responsibilities by looking at its portion of the OBS. The resource breakdown structure (RBS) is another hierarchical chart, useful for breaking down the project by types of resources. For example, to view a breakdown that depicts the work of all the welders on a shipbuilding project, who are scattered among different branches of the OBS and WBS, an RBS that groups the information by resource type can be appropriate. The RBS is often helpful in tracking project costs and can be aligned with the organization's accounting system. The RBS can contain resource categories other than human resources, such as materials and equipment.
- **Matrix-based charts.** A responsibility assignment matrix (RAM) is used to illustrate the connections between work that needs to be done and project team members. On larger projects, RAMs can be developed at various levels. For example, a high-level RAM can define which project team group or unit is responsible for each component of the work breakdown structure, while lower-level RAMs are used within the group to designate roles, responsibilities and level

of authority for specific activities. The matrix format -- also called a table -- allows a person to see all activities associated with one person or to see all people associated with one activity. A responsibility assignment matrix is sometimes referred to by the letters used in the matrix. For example, the RAM shown in Figure 9-5 may be called a RACI chart (Responsible-Accountable-Consult-Inform) because the names of roles being documented are responsible, accountable, consult, and inform. The sample chart shows the work to be done in the left column as activities, but RAMs may show responsibilities at various levels of detail. The people may be shown as individuals or groups. Another way to illustrate project responsibilities in a matrix is through the use of scheduling software. Most project management scheduling software packages allow users to create standard or customized reports that display the responsibilities of a particular person or department.

RACI Chart		Person				
Activity		Ann	Ben	Carlos	Dina	Ed
Define		A	R	I	I	I
Design		I	A	R	C	C
Develop		I	A	R	C	C
Test		A	I	I	R	I

R = Responsible A = Accountable C = Consult I = Inform

Figure 9-5. Responsibility Assignment Matrix (RAM) Using a RACI Format

- **Text-oriented formats.** Team member responsibilities that require detailed descriptions can be specified in text-oriented formats. Usually in outline form, the documents provide information such as responsibilities, authority, competencies and qualifications. The documents are known by various names, including position descriptions and role-responsibility-authority forms. These descriptions and forms make excellent templates for future projects, especially when the information is updated throughout the current project by applying lessons learned.
- **Other sections of the project plan.** Some responsibilities related to managing the project are listed and explained in other sections of the project management plan. For example, the risk response plan lists risk owners, the communication plan lists team members responsible for various communication activities, and the quality plan designates people responsible for carrying out quality assurance and quality control activities.

.2 Human Resource Templates

As project management methodology matures within an organization, templates are developed based on organization charts and position descriptions from previous projects. These human resource templates reduce the amount of planning time needed at the beginning of a project and reduce the likelihood of missing important responsibilities.

.3 Networking

Informal interaction with others in an organization or industry is a constructive way to understand political and interpersonal factors that will impact the effectiveness of various staffing management options. Human resources networking activities include proactive correspondence, luncheon meetings, informal conversations and trade conferences. While concentrated networking can be a useful technique at the beginning of a project, carrying out networking activities on a regular basis before a project begins is also effective.

.4 Organizational Theory

There is a substantial body of literature describing how organizations can and should be structured. The project management team should be familiar with the subject of organizational theory so the team can apply this knowledge to the creation of project roles and reporting relationships.

9.1.3 Human Resource Planning: Outputs

.1 Roles and Responsibilities

The following items should be addressed when listing the roles and responsibilities needed to complete the project:

- **Role.** The label describing the portion of a project for which a person is accountable. Examples of project roles are civil engineer, court liaison, business analyst, and testing coordinator. Role clarity concerning authority, responsibilities and boundaries is essential for project success.
- **Authority.** The right to apply project resources and make decisions. Examples of decisions needing to be made during a project include the selection of a method for completing a task, quality acceptance and how to respond to project variances. Team members operate best when their level of authority matches their responsibilities.
- **Responsibility.** The work that a project team member is expected to perform in order to complete the project's tasks and activities.
- **Competency.** The skill and capacity required to complete project activities. If project team members do not possess required competencies, performance can be jeopardized. When such mismatches are identified, proactive responses such as training, hiring additional people or scope changes must be initiated.

.2 Project Organization Charts

A project organization chart is a graphic display of project reporting relationships (Section 9.1). It can be formal or informal, highly detailed or broadly framed, based on the needs of the project. For example, the organization chart for an internal five-person project is unlikely to have the rigor and detail of the organization chart for a 3,000-person disaster response team.

.3 Staffing Management Plan

The staffing management plan, a subset of the project management plan (Section 4.3), describes when and how human resource requirements will be met. The staffing management plan can be formal or informal, highly detailed or broadly framed, based on the needs of the project. The plan is updated continually during the project to direct ongoing team member acquisition and development actions. Information in the staffing management plan varies by application area and project size, but items that can be considered include:

- **Staff acquisition.** The project management team must answer a number of questions in order to plan for the acquisition of project team members. Will the human resources come from within the organization or from external, contracted sources? Do adequate numbers of people have the required competencies or will people need to be trained? Will team members need to work in a fixed location or can they work from distant locations? What are the costs associated with each level of expertise needed for the project? How much assistance can the organization's human resource department provide to the project management team?
- **Timetable.** The staffing management plan must describe when project team members, individually or collectively, will be needed and when acquisition activities such as recruiting must start. One tool for charting the human resource needs is a resource histogram (Section 6.5). This bar chart illustrates the number of hours that a person, department or entire project team will be needed each week or month over the course of the project. The chart can include a horizontal line that represents the maximum number of hours available from a particular resource. Bars that extend beyond the maximum available hours identify the need for a resource leveling strategy, such as adding more resources or extending the length of the schedule. A sample resource histogram is illustrated in Figure 9-6.
- **Release criteria.** Determining the method and timing of releasing team members benefits both the project and team members. When team members are released from a project at the optimum time can eliminate payments made for people who are finished with their responsibilities and reduce the costs. Morale is improved when smooth transitions to upcoming projects are already planned.
- **Training needs.** If the team members to be assigned are not expected to have the required competencies, a training plan will need to be developed as part of the project. The plan may also need to include ways to help team members obtain certifications that would benefit the project.
- **Recognition and rewards.** Clear criteria for rewards and a planned system for their use will promote and reinforce desired behaviors. To be effective, recognition and rewards must be based on activities and performance under a person's control. For example, a team member who is to be rewarded for meeting cost objectives should have an appropriate level of control over decisions that affect expenses. Creating a plan with established times for rewards will ensure that recognition takes place and is not forgotten. Recognition and rewards are awarded as part of the team development process (Section 9.3).
- **Compliance.** The project management team must have a plan for complying with applicable government regulations, union contracts and other established human resource policies.
- **Safety.** Projects that involve physical danger will not only want to address these issues in the risk management plan, but include corresponding policies and actions in the staffing management plan.

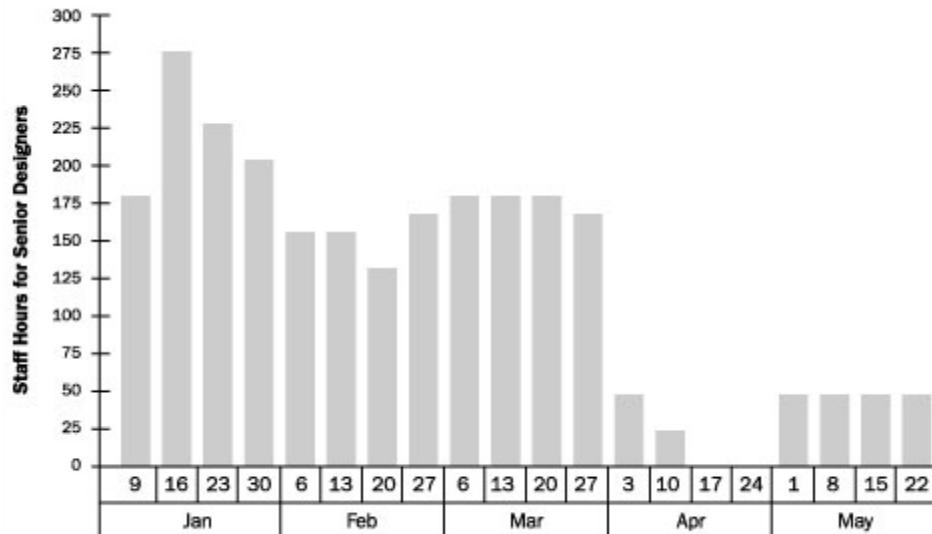


Figure 9-6. Illustrative Resource Histogram

9.2 ACQUIRE PROJECT TEAM

Acquire project team is the process of obtaining the human resources. The project management team is responsible for ensuring that the human resources selected will be able to achieve the project requirements.

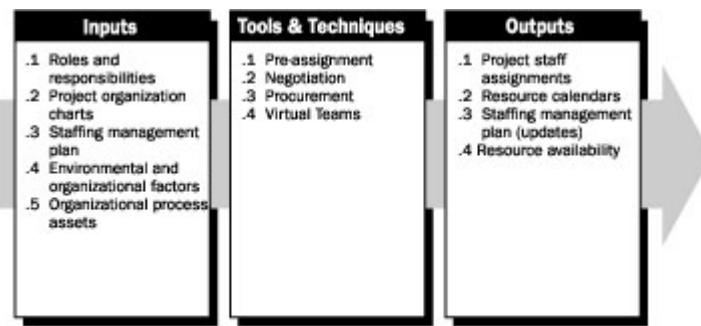


Figure 9-7. Acquire Project Team Overview

9.2.1 Acquire Project Team: Inputs

.1 Roles and Responsibilities

The roles and responsibilities define the skills and competencies needed for the project (Section 9.1).

.2 Project Organization Charts

The project organization charts provide an overview regarding the number of people needed for the project (Section 9.1).

.3 Staffing Management Plan

The staffing management plan, along with the project schedule, identifies the time periods each project team member will be needed and other information important to acquiring the project team (Section 9.1).

.4 Environmental and Organizational Factors

When the project management team is able to influence or direct staff assignments, it must consider the characteristics of potential candidates, such as:

- **Ability.** What competencies do people possess?
- **Experience.** Have the people done similar or related work? Have they done it well?
- **Interests.** Are the people interested in working on this project?
- **Availability.** Will the most desirable people be available during the necessary time frames?
- **Cost.** How much will each team member need to be paid, particularly if they are contracted from outside the organization?

.5 Organizational Process Assets

One or more of the organizations involved in the project may have policies, guidelines, or procedures governing staff assignments (Section 4.2). The human resource department of the performing organizations also can assist with recruitment, hiring and orientation of project team members.

9.2.2 Acquire Project Team: Tools and Techniques

.1 Pre-assignment

In some cases, project team members are known in advance, that is, they are pre-assigned. This can occur if the project is the result of specific people being promised as part of a competitive proposal, if the project is dependent on the expertise of particular individuals, or if some staff assignments are defined within the project charter.

.2 Negotiation

Staff assignments must be negotiated on most projects. For example, the project management team may need to negotiate with:

- Responsible functional managers to ensure that the project receives appropriately competent staff in the required time frame and that project team members will be able to work on the project until their tasks are completed
- Other project management teams within the performing organization to appropriately assign scarce or specialized resources.

The project management team's ability to influence others in the various organizations plays an important role in negotiating staff assignments, as do the politics of the organizations involved (Section 2.4). For example, a functional manager will weigh the benefits and visibility of competing projects when determining where to assign exceptional performers that all project teams desire.

.3 Procurement

When the performing organization lacks the in-house staff needed to complete the project the required services can be acquired from outside sources (Section 12.4). This may involve hiring individual consultants or subcontracting work to another organization.

.4 Virtual Teams

The use of virtual teams creates new possibilities when acquiring project team members. Virtual teams can be defined as groups of people with a shared goal who fulfill their roles

with little or no time spent meeting face to face. The availability of electronic communication, such as email and video conferencing, has made such teams feasible. The virtual team format makes it possible to:

- Form teams of people from the same company who live in widespread geographic areas
- Add special expertise to a project team, even though the expert is not in the same geographic area
- Incorporate employees who work from home offices
- Form teams of people who work different shifts or hours
- Include people with mobility handicaps
- Move forward with projects that would have been ignored due to travel expenses.

When leading a virtual team, project managers must learn to evaluate team member efforts and commitment by observing the patterns of interaction without the benefit of personal contact. Communication planning (Section 10.1) becomes increasingly important. Project managers must put more energy into setting clear expectations, developing protocols for confronting conflict, including people in decision-making, and sharing credit in successes.

9.2.3 Acquire Project Team: Outputs

.1 Project Staff Assignments

The project is staffed when appropriate people have been assigned to work on it. Documentation can include memos to team members, a team directory, and names inserted into other parts of the project management plan, such as organization charts and schedules. A team directory includes all necessary contact information.

.2 Resource Calendars

Resource calendars identify the periods during which each assigned project team member is available (Section 6.4). Creating a reliable final schedule (Section 6.5) depends on having a good understanding of each person's schedule conflicts, including vacation time and commitments to other projects.

.3 Staffing Management Plan (Updates)

As specific individuals fill the roles and responsibilities, changes may need to be made to the staffing management plan, because people seldom fit the exact staffing requirements that are planned (Section 9.1). Other reasons for changing the staffing management plan include promotions, retirements, illnesses, performance issues, and changing workloads.

.4 Resource Availability

Resource availability documents the number and type of each human resource skill, discipline or expertise available for use on the project.

9.3 DEVELOP PROJECT TEAM

Project team development strives to meet two objectives:

- Improve the skills of individual team members in order to increase their ability to complete project activities
- Improve feelings of trust and cohesiveness among team members in order to raise productivity through greater teamwork.

Examples of effective teamwork include assisting one another when workloads are unbalanced, communicating in ways that fit individual preferences and sharing information and resources. Team development efforts have greater benefit when conducted early, but should take place throughout the life cycle of the project.

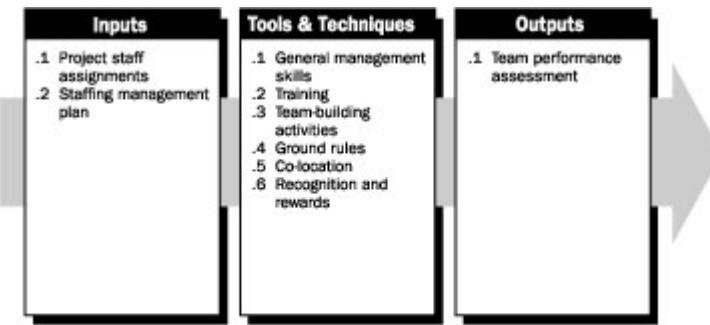


Figure 9-8. Develop Project Team Overview

9.3.1 Develop Project Team: Inputs

.1 Project Staff Assignments

Team development starts with a list of the project team members. Project staffing assignment documents (Section 9.2) identify the people who are on the team.

.2 Staffing Management Plan

The staffing management plan (Section 9.1) identifies training strategies and plans for developing the project team. As the project progresses, items such as rewards, feedback, additional training and disciplinary actions are added to the plan as a result of ongoing team performance assessments (Section 9.3) and other forms of project team management (Section 9.4).

9.3.2 Develop Project Team: Tools and Techniques

.1 General Management Skills

Soft skills (Section 1.5) are particularly important to team development. By understanding the sentiments of project team members, anticipating their actions, acknowledging their concerns, and following up on their issues, the project leaders can greatly reduce the number of problems and increase cooperation. Skills such as empathy, influence, creativity, and group facilitation are valuable assets when managing the project team.

When needed, the project management team must use disciplinary action to maintain order, as well as deter and reprimand actions that are detrimental to the project, the organization, or members of the project team. While discipline can be uncomfortable, project leaders must protect the safety and interests of those associated with the project and assure compliance with the project management plan.

.2 Training

Training includes all activities designed to enhance the competencies of the project team members. Training can be formal or informal. Examples of training methods include classroom, online, computer-based, on-the-job training from another project team member, mentoring, and coaching.

If project team members lack necessary management or technical skills, such skills must be developed as part of the project work, or steps must be taken to appropriately re-staff the project. Scheduled training will take place as stated in the staff management plan. Unplanned training will take place as a result of observation, conversation, and project performance appraisals conducted as part of the controlling process of managing the project team. There is a substantial body of literature regarding successful training methods for adult learners.

.3 Team-Building Activities

Team-building activities can vary from a five-minute agenda item in a status review meeting to an off-site, professionally facilitated experience designed to improve interpersonal relationships. Some group activities, such as developing the work breakdown structure, may not be explicitly designed as team-building activities, but can increase team cohesiveness when that planning activity is well structured and facilitated. It also is important to encourage informal communication and activities because of their role in building trust and establishing good working relationships. Team-building strategies are particularly valuable when team members operate electronically from remote locations without the benefit of face-to-face contact, whether their teammates are stationed at home offices or other countries.

.4 Ground Rules

Ground rules establish clear expectations regarding acceptable behavior by project team members. Early commitment to clear guidelines decreases misunderstandings and increases productivity. The process of discussing ground rules allows team members to discover values that are important to one another. The project management team must help the team enforce the rules once they are established.

.5 Co-Location

Co-location involves placing many or all of the most active project team members in the same physical location to enhance their ability to perform as a team. Co-location can be temporary, such as at strategically important times during the project, or for the entire project. Co-location strategy can include a meeting room, sometimes called a war room, with electronic communication devices, places to post schedules, and other conveniences that enhance communication and a sense of community. While co-location is considered good strategy, the use of virtual teams is reducing the frequency that team members are located together for the entire project.

.6 Recognition and Rewards

Part of the team development process involves recognizing and rewarding desirable behavior. The original plans concerning ways to reward people are developed during human resource planning (Section 9.1). Award decisions are made, formally or informally, during the process of managing the project team through performance appraisals (Section 9.4).

The project management team must be careful to reward only desirable behavior. For example, the willingness to work overtime to meet an aggressive schedule objective should be rewarded or recognized; needing to work overtime as the result of poor planning should not be rewarded. Win-lose (zero sum) rewards that only a limited number of project team members can achieve – such as team member of the month, can hurt team cohesiveness. Rewarding win-win behavior that everyone can achieve, such as turning in progress reports on time – tends to increase support among team members.

Recognition and rewards must also consider cultural differences. For example, developing appropriate team rewards in a culture that prizes individualism can be very difficult.

9.3.3 Develop Project Team: Outputs

.1 Team Performance Assessment

As development efforts such as training, team building and co-location are implemented; the project management team makes informal or formal assessments of the project team's effectiveness. Effective team development strategies and activities are expected to increase the team's performance, which increases the likelihood of meeting project objectives. The evaluation of a team's effectiveness can include indicators such as:

- Improvements in individual skills that allow a specific person to perform assigned activities more effectively
- Improvements in competencies that help the team perform work better together as a group
- Low staff turnover rate.

9.4 MANAGE PROJECT TEAM

When managing the project team, the project management team tracks individual and team performance, provides feedback and coordinates changes to enhance performance and keep the project on course. The project management team must observe team behavior, manage conflict, resolve issues and appraise team member performance. As a result of managing the project team, the staffing management plan is updated, change requests are submitted, issues are resolved, input is given to organizational performance appraisals and lessons learned are added to the organization's database.

Management of the project team is complicated when individual team members are accountable to both a functional manager and the project manager within a matrix organization (Section 2.3). Effective management of this dual reporting relationship is often a critical success factor for the project and is generally the responsibility of the project manager.

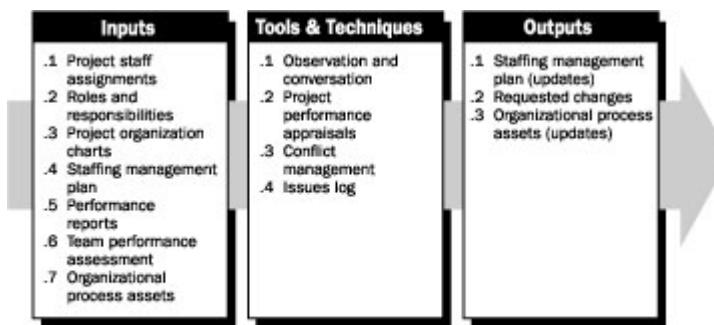


Figure 9-9. Manage Project Team Overview

9.4.1 Manage Project Team: Inputs

.1 Project Staff Assignments

The project staff assignments (Section 9.2) provide a list of the project team members to be evaluated during this monitor and control process.

.2 Roles and Responsibilities

The project manager must have a list of the staff's roles and responsibilities in order to monitor and evaluate their performance (Section 9.1).

.3 Project Organization Charts

The project organization charts provide a picture of the reporting relationships among project team members (Section 9.1).

.4 Staffing Management Plan

The staffing management plan lists the time periods that team members are expected to work on the project, along with training plans, certification requirements, and compliance issues (Section 9.1).

.5 Performance Reports

Performance reports provide feedback to the project team about performance against the project management plan and schedule (Section 10.3). Performance reports should include information from any customers and outside auditors who may be evaluating the project and performance of the project team. Examples of performance areas that can help with project team management include results from schedule control, cost control, quality control, scope verification, and procurement audits.

.6 Team Performance Assessment

The project management team makes ongoing formal or informal assessments of the project team's performance. This information is needed to make decisions regarding recognition, rewards, and corrective action. Decisions and their associated actions become updates to the staffing management plan (Section 9.1), which are acted upon as part of team development (Section 9.3).

.7 Organizational Process Assets

The project management team should utilize an organization's policies, procedures and systems for rewarding employees during the course of a project (Section 4.2).

Organizational recognition dinners, certificates of appreciation, newsletters, bulletin boards, web sites, bonus structures, corporate apparel and other organizational perquisites should be available to the project management team as part of the project management process.

9.4.2 Manage Project Team: Tools and Techniques

.1 Observation and Conversation

The project management team must stay in touch with the work and attitudes of project team members. This requires proactive communication, whether on a face-to-face basis or other methods appropriate in the case of virtual teams (Section 9.2). The project manager needs to be aware of those accomplishments, which make the team members proud, in addition to progress being made on project deliverables. The project manager also needs to identify issues of concern and potential conflicts.

.2 Project Performance Appraisals

The need for formal or informal project performance appraisals depends on the length of the project, complexity of the project, organizational policy, labor contract requirements, and the amount and quality of regular communication. Project team members need to receive feedback from the people who supervise their project work. Evaluation

information also can be gathered from people who interact with project team members by using 360-degree feedback principles. The term 360-degree means that feedback regarding performance is provided to the person being evaluated from many sources, including superiors, peers and subordinates.

Objectives for conducting performance appraisals during the course of a project can include re-clarification of roles and responsibilities, structured time to ensure team members receive positive feedback in what might otherwise be a hectic environment, discovery of unknown or unresolved issues, developing individual training or coaching plans and establishing individual goals for future time periods.

.3 Conflict Management

Successful conflict management results in greater productivity and positive working relationships. Team ground rules, group norms and solid project management practices, like communication planning and role definition, reduce the amount of conflict. When managed properly, differences of opinion are healthy and can lead to increased creativity and better decision-making. When the differences become a negative factor, project team members are initially responsible for resolving their own conflicts. If conflict escalates, the project manager should help facilitate a satisfactory resolution. Conflict should be addressed early and usually in private, using a direct, collaborative approach. If disruptive conflict continues, increasingly formal procedures will need to be used, including the possible use of disciplinary actions.

.4 Issue Log

Issue resolution addresses obstacles that can block the team from achieving its goals. These obstacles can include factors such as differences of opinion, decisions that must be made, situations that must be investigated, and emerging or unanticipated responsibilities that must be assigned to someone on the project team. As issues arise in the course of managing the project team, a written log documents the person responsible for resolving the issues by a target date.

9.4.3 Manage Project Team: Outputs

.1 Staffing Management Plan (Updates)

As the project progresses, the project management team must take corrective action, which is documented in the form of updates to the staffing management plan (Section 9.1). Corrective action for human resource management includes items such as staffing changes, additional training, and disciplinary actions. Staffing changes may require moving people to different assignments, outsourcing some work, and replacing team members who leave. The project management team also must determine how and when to give out rewards and recognition based on the team's performance.

.2 Requested Changes

Staffing changes, whether by choice or by uncontrollable events, can affect the project's ability to meet the original plan. When staffing issues are going to disrupt the project plan, such as causing the schedule to be extended or the budget to be exceeded, a change request needs to be processed in accordance with the integrated change control system (Section 4.6).

.3 Organizational Process Assets (Updates)

- **Resolved issues.** During the course of monitoring and controlling the project team members, not all issues will result in additions to the staffing management plan or

change requests. Those issues that are addressed and resolved can be closed in the issue log (9.4).

- **Input to organizational performance appraisals.** Project staff generally should provide input to the regular organizational performance appraisals of any project team member with whom they interact in a significant way.
- **Lessons learned documentation.** All knowledge learned during the project should be documented so it becomes part of the historical database of the organization. Lessons learned in the area of human resources may include:
 - Organizational charts, position descriptions and staffing management plans that can be saved as templates.
 - Ground rules, conflict management techniques and recognition events that were particularly useful.
 - Procedures for virtual teams, co-location, negotiation, procurement, training and team building that proved to be successful.
 - Special skills or competencies by individual team members that were discovered during the project.

Chapter 10

Project Communications Management

Project Communications Management includes the processes required to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information. The Project Communications Management processes provide the critical links among people, ideas and information that are necessary for successful communications. Project managers can spend an inordinate amount of time communicating with the project team, stakeholders, the customer and sponsor. Everyone involved in the project should understand how communications affects the project as a whole. Figure 10-1 provides an overview of the Project Communications Management processes and Figure 10-2 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes. The Project Communications Management processes include the following:

- 10.1 Communications Planning** - determining the information and communications needs of the stakeholders: who are they, what is their level of interest and influence on the project, who needs what information, when they will need it and how it will be given to them.
- 10.2 Information Distribution** - making needed information available to project stakeholders in a timely manner.
- 10.3 Performance Reporting** - collecting and disseminating performance information. This includes status reporting, progress measurement and forecasting.
- 10.4 Manage Stakeholders** - managing communications to satisfy the needs of and resolve issues with project stakeholders.

The processes listed above interact with each other and with the processes of other knowledge areas. Each process can involve effort from one or more individuals or groups of individuals, based upon the requirements of the project. Each process occurs at least once in every project or phase. Although the processes are presented as discrete elements with well-defined interfaces, in practice they can overlap and interact in ways that are not detailed in this chapter (Section 3.3).

Communications skills are related to but not the same as project management communications. The art of communications is a broad subject and involves a substantial body of knowledge including:

- Sender-receiver models - feedback loops, barriers to communications.
- Choice of media - when to communicate in writing versus when to communicate orally, when to write an informal memo versus when to write a formal report, face-to-face versus e-mail. The media chosen for communication tasks will depend upon the situation.

- Writing style - active versus passive voice, sentence structure, word choice
- Presentation techniques - body language, design of visual aids.
- Meeting management techniques - preparing an agenda, dealing with conflict.

A basic model of communication, shown in Figure 10-3, demonstrates how ideas or information is sent and received between two parties, defined as the sender and the receiver. The key elements of the model include:

- Encode - to translate thoughts or ideas into a language that is understood by others.
- Message - the output of encoding.
- Medium - the method used to convey the message.
- Noise - anything that interferes with the transmission and understanding of the message (e.g., distance).
- Decode - to translate the message back into meaningful thoughts or ideas.

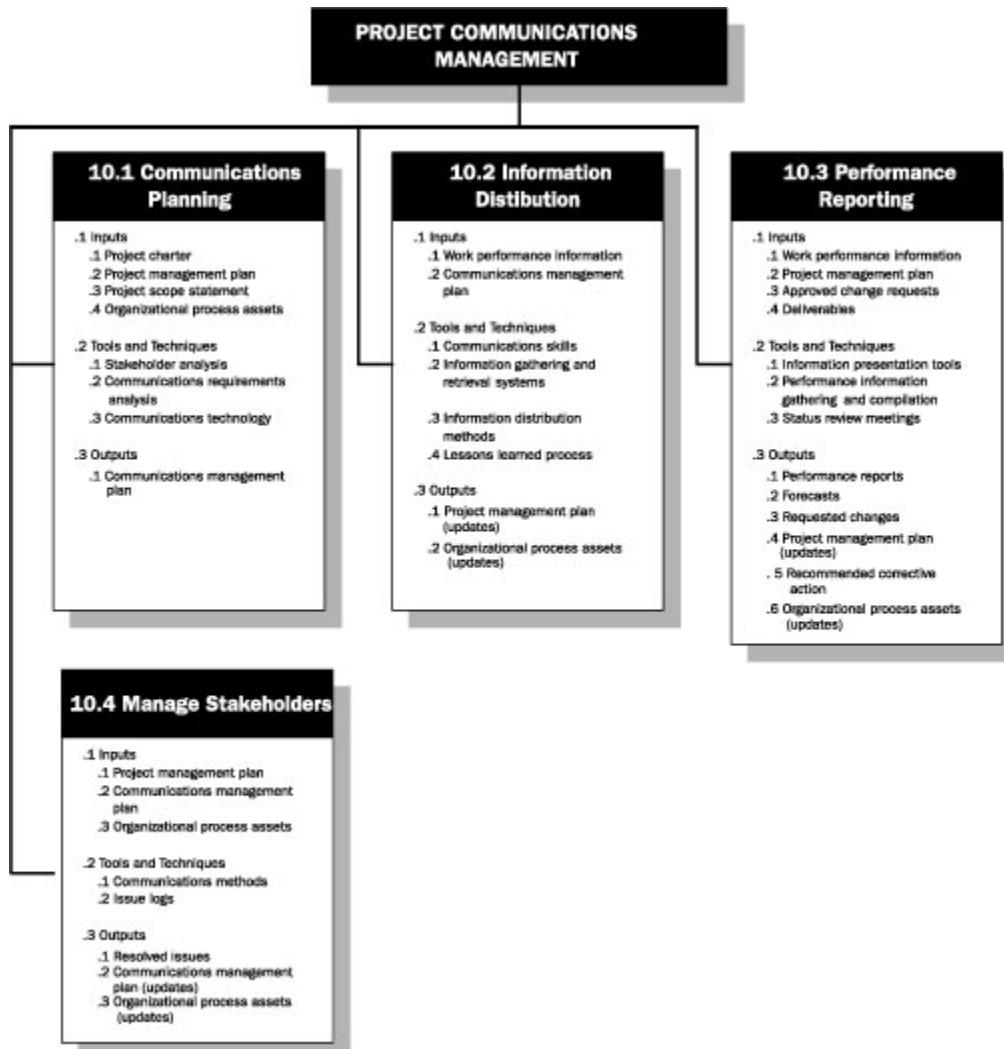


Figure 10-1. Project Communications Management Overview

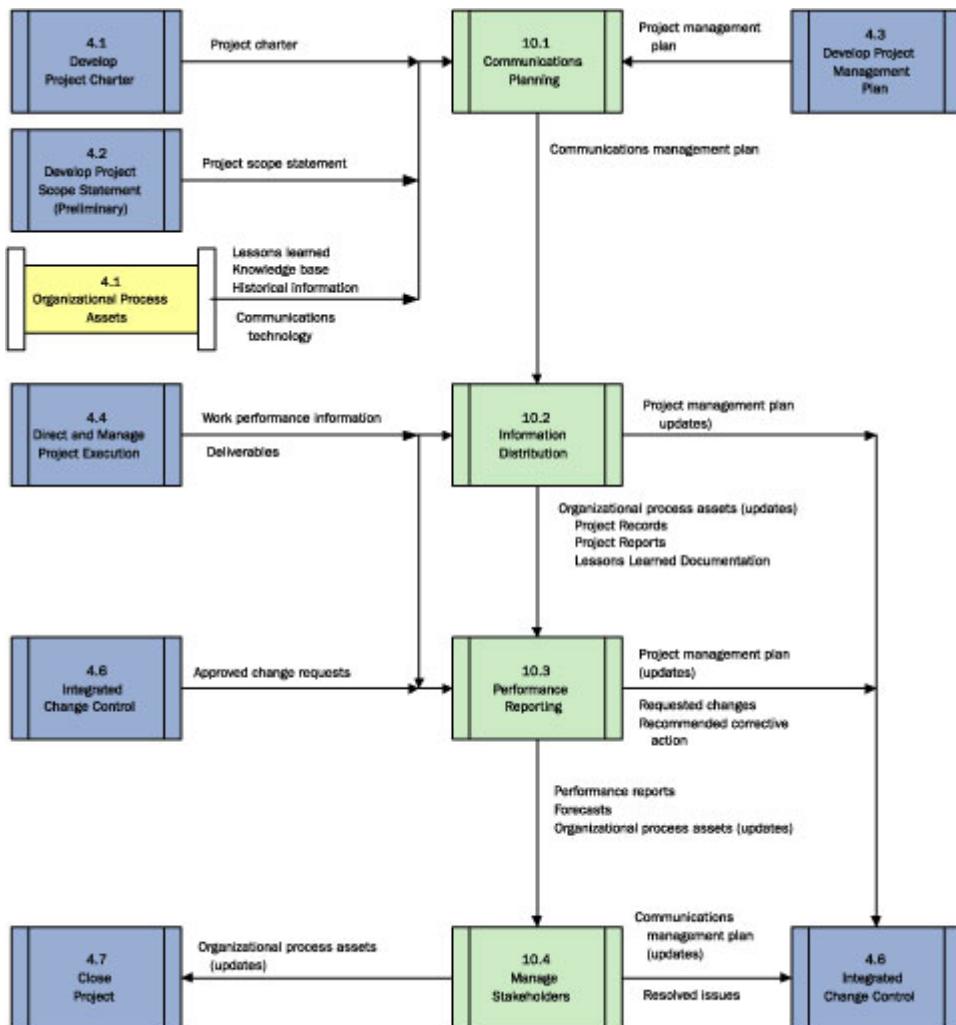


Figure 10-2. Project Communications Management Process Flow

Inherent in the model shown in Figure 10-3 is an action to acknowledge a message. Acknowledgement means that the receiver signals receipt of the message, but not necessarily agreement with the message. Another action is the response to a message, which means that the receiver has decoded, understands and is replying to the message.

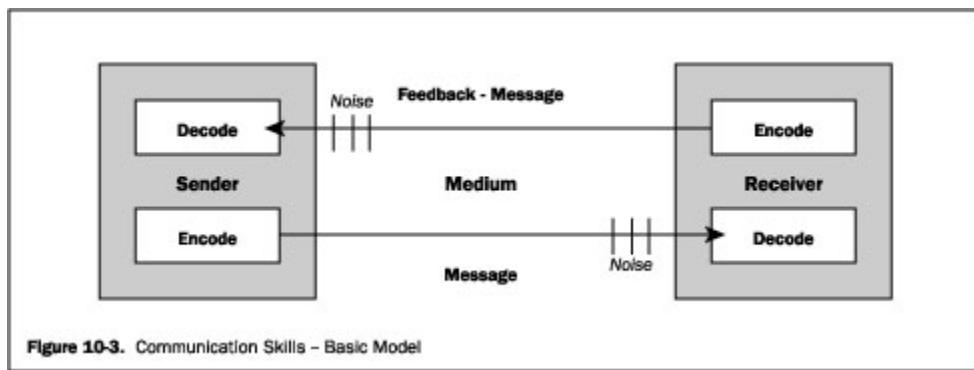


Figure 10-3. Communication Skills – Basic Model

The elements in the communications model need to be taken into account when discussing project communications. There are many challenges in using these elements to effectively communicate with project stakeholders. Consider a highly technical, multi-national project team. For one team member to successfully communicate a technical concept to another team member in a different country can involve encoding the message in the appropriate language, sending the message using a variety of technologies and having the receiver decode compromises the original meaning of the message. A breakdown in communications can negatively affect the project.

10.1 COMMUNICATIONS PLANNING

The communications planning process determines the information and communications needs of the stakeholders: who needs what information, when they will need it, how it will be given to them and by whom. While all projects share the need to communicate project information, the informational needs and the methods of distribution vary widely. Identifying the informational needs of the stakeholders and determining a suitable means of meeting those needs is an important factor for project success.

On most projects, the majority of communications planning is done as part of the earliest project phases. However, the results of this planning process should be reviewed regularly throughout the project and revised as needed to ensure continued applicability.

Communications planning is often tightly linked with organizational structure (Section 2.3) since the project's organizational structure will have a major effect on the project's communications requirements.

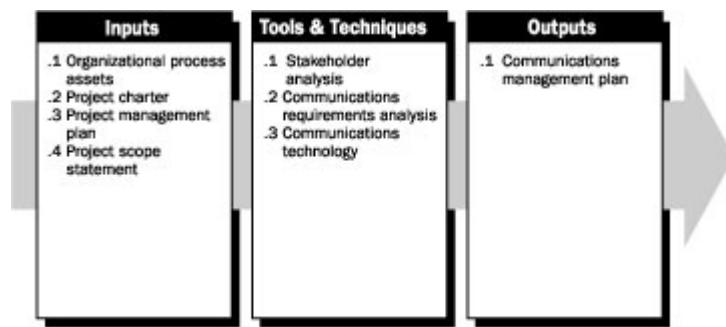


Figure 10-4. Communications Planning Overview

10.1.1 Communications Planning: Inputs

.1 Organizational Process Assets

- The lessons learned knowledge base should provide access to historical information and lessons learned about both the results of previous project selection decisions and previous project performance.
- Historical information concerning previous projects can be located in the performing organization's lessons learned knowledge base or project archives.

.2 Project Charter

Described in Section 4.1.

.3 Project Management Plan

The project management plan provides background information about the project including dates and constraints that may be relevant to communications planning (Section 4.3).

.4 Project Scope Statement

The scope statement is an initial narrative description of the project scope (Sections 4.2 and 5.2) that provides a documented basis for future project decisions and for confirming a common knowledge of project scope among the stakeholders.

- **Constraints.** Constraints are factors that can limit the project management team's options. When a project is performed under contract, there are specific contractual provisions that can affect communications planning. For example, if substantial project resources are to be procured under contract, then consideration will have to be given to the methods of handling resource procurement under the contract.
- **Assumptions.** Specific assumptions that affect communications planning will depend upon the particular project.

10.1.2 Communications Planning: Tools and Techniques

.1 Stakeholder Analysis

A key component of communications planning is stakeholder analysis. Stakeholders are individuals, work groups and organizations that are actively involved in the project, or whose interests can be positively or negatively affected as a result of project execution or project completion. Stakeholders can also exert influence over the project and its results.

Some stakeholders who are not project team members can have project-related responsibilities. For example, employees who are being relocated to a new building may not be project team members for the relocation project but are stakeholders because they are affected by the project. In this case the employees being moved are responsible for giving input during the planning phase, reviewing correspondence pertinent to them and responding as needed. Participation, review, and response are three responsibilities that can apply to non-team stakeholders.

Stakeholder analysis serves two purposes. First, the analysis determines the information needs of the various stakeholders (Section 2.2) and second, it identifies the influence and interests of the stakeholders that will enable the project manager to devise a communication strategy that will best serve the project.

The information needs analysis should consider methods and technologies that will provide the required information and are suited to the project. Care should be taken to avoid wasting resources on unnecessary information or inappropriate technology.

The stakeholder influence and interest analysis should entail a structured, systematic review of the level of stakeholder interest in the project and the level of their ability to influence the project's outcome.

Stakeholder analysis often begins with a brainstorming session to list the stakeholders. Then the brainstorming group will evaluate and list the stakeholders' needs or conduct interviews or surveys to gather input directly from the stakeholders.

.2 Communications Requirements Analysis

The analysis of the communications requirements results in the sum of the information needs of the project stakeholders. Requirements are defined by combining the type and format of information needed with an analysis of the value of that information. Project resources should be expended only on communicating information that contributes to

success or where a lack of communication can lead to failure. This does not mean that “bad news” should not be shared; rather, the intent is to prevent overwhelming stakeholders with minutiae.

The Project Manager should consider the number of potential communication channels or paths as an indicator of the complexity of a project's communications.

The total number of communications channels is $n(n-1)/2$, where n = number of stakeholders. Thus a project with 10 stakeholders has 45 potential communication channels. A key element of planning the project's communications, therefore, is to determine and limit who will communicate with whom and who will receive what information. Information typically required to determine project communications requirements includes:

- Organization charts
- Project organization and stakeholder responsibility relationships
- Disciplines, departments and specialties involved in the project
- Logistics of how many individuals will be involved with the project and at which locations
- Internal information needs, e.g., communicating across organizations
- External information needs, e.g., communicating with the media or contractors
- Stakeholder information.

.3 Communications Technology

The methodologies used to transfer information back and forth among project stakeholders can vary significantly. For example, a project management team may include brief conversations all the way through to extended meetings, or simple written documents to material (i.e., schedules and databases) that are accessible online as methods of communication.

Communications technology factors that can affect the project include:

- The immediacy of the need for information - is project success dependent upon having frequently updated information available on a moment's notice or would regularly issued written reports suffice?
- The availability of technology - are the systems that are already in place appropriate or do project needs warrant change?
- The expected project staffing - are the proposed communications systems compatible with the experience and expertise of the project participants or will extensive training and learning be required?
- The length of the project - is the available technology likely to change before the project is over?
- The project environment - does the team meet and operate on a face-to-face or in a virtual environment?

10.1.3 Communications Planning: Outputs

.1 Communications Management Plan

The communications management plan is contained in or is a subsidiary plan of the project management plan is a document that provides:

- Stakeholder needs and expectations
- The information to be communicated including format, content and level of detail

- The individual responsible for communicating the information
- The individual or groups who will receive the information
- The methods or technologies used to convey the information, such as memorandum, e-mail, press release, etc.
- The frequency of the communication, such as weekly
- An escalation process identifying time frames and the management chain (names) for escalation of issues that cannot be resolved at a lower staff level
- A method for updating and refining the communications management plan as the project progresses and develops
- A glossary of common terminology.

The communications management plan can also include guidelines for project status meetings, project team meetings, e-meetings, and e-mails. The communications management plan can be formal or informal, highly detailed or broadly framed and based on the needs of the project. The communications management plan is contained in or a subsidiary plan of the overall project management plan (Section 4.3). Sample attributes of a communications management plan can include:

- Communications item - the information that will be distributed to stakeholders.
- Purpose - the reason for the distribution of that information.
- Frequency - how often that information will be distributed.
- Start/end dates - the time frame for the distribution of the information.
- Format/medium - the layout of the information and the method of transmission.
- Responsibility - the team member charged with the task of distributing the information.

Communication planning often entails creation of additional deliverables, which in turn require additional time and effort. Thus the project's work breakdown structure, schedule and budget should be updated accordingly.

10.2 INFORMATION DISTRIBUTION

Information distribution involves making information available to project stakeholders in a timely manner. Information distribution includes implementing the communications management plans as well as responding to unexpected requests for information.

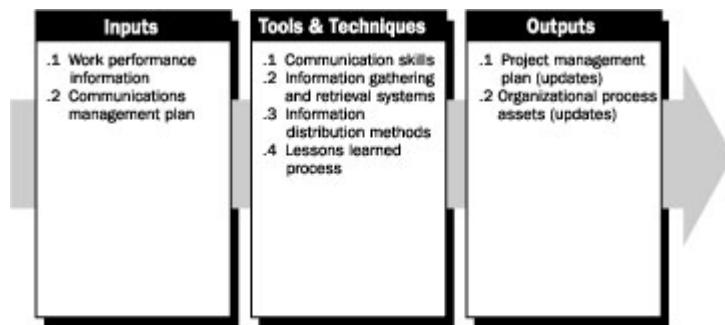


Figure 10-5. Information Distribution Overview

10.2.1 Information Distribution: Inputs

.1 Work Performance Information

Information on the status of project activities being performed to accomplish the project work is routinely collected as part of executing the project management plan (Section 4.4).

.2 Communications Management Plan

Described in Section 10.1.

10.2.2 Information Distribution: Tools and Techniques

.1 Communications Skills

Communications skills are part of general management skills and are used to exchange information. General management skills related to communication include ensuring that the right people get the right information at the right time, as defined in the communications management plan. General management skills also include the art of managing stakeholder expectations.

As part of the communications process, the sender is responsible for making the information clear and complete so that the receiver can receive it correctly and for confirming that it is properly understood. The receiver is responsible for making sure that the information is received in its entirety and understood correctly. Communicating has many dimensions:

- Written and oral, listening and speaking
- Internal (within the project) and external (customer, the media, the public)
- Formal (reports, briefings) and informal (memos, ad hoc conversations)
- Vertical (up and down the organization) and horizontal (with peers).

.2 Information Gathering and Retrieval Systems

Information can be gathered and retrieved through a variety of media including manual filing systems, electronic databases, project management software and systems that allow access to technical documentation such as engineering drawings, design specifications, test plans.

.3 Information Distribution Methods

Information distribution is information collection, sharing, and dissemination to project stakeholders in a timely manner across the project life cycle. Project information can be distributed using a variety of methods, including:

- Project meetings, hard copy document distribution and manual filing systems, and shared-access electronic databases.
- Electronic communication and conferencing tools, such as e-mail, fax and voice mail, telephone, video and web conferencing and web publishing.
- Electronic tools for project management such as web interfaces to scheduling and project management software, meeting and virtual office support software, portals and collaborative work management tools.

.4 Lessons Learned Process

Lessons learned focus on identifying project successes and project failures and include recommendations to improve future performance on projects. During the project life cycle, the project team and key stakeholders identify lessons learned concerning the technical, managerial and process aspects of the project. The lessons learned are compiled, formalized and stored through the project's duration.

The focus of lessons learned meetings can vary. In some cases the focus is on strong technical or product development processes while in other cases, the focus is on the processes that aided or hindered performance of the work. Teams can gather information more frequently if they feel that the increased quantity of data merits the additional investment of time and money. Lessons learned provide future project teams with the information that can increase effectiveness and efficiency of project management. In addition, phase-end lessons learned sessions provide a good team building exercise. Project managers have a professional obligation to conduct lessons learned sessions for all projects with key internal and external stakeholders, particularly if the project yielded less than desirable results. Some specific results from lessons learned include:

- Update of the lessons learned knowledge base
- Input to knowledge management system
- Updated corporate policies, procedures, and processes
- Improved business skills
- Overall product and service improvements
- Updates to the risk management plan.

10.2.3 Information Distribution: Outputs

.1 Project Management Plan (Updates)

Changes to the information distribution process should trigger changes to the project management plan and the communications management plan. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

.2 Organizational Process Assets (Updates)

- **Lessons learned documentation.** Documentation includes the causes of issues, the reasoning behind the corrective action chosen and other types of lessons learned information distribution should be documented so that they become part of the historical database for both this project and of the performing organization.
- **Project records.** Project records can include correspondence, memos and documents describing the project. This information should, to the extent possible and appropriate, be maintained in an organized fashion. Project team members can also maintain records in a project notebook.
- **Project reports.** Formal and informal project reports on project status, including lessons learned, issues logs, project closure reports, and outputs from other knowledge areas (Chapters 4-12).
- **Project presentations.** The project team provides information formally or informally to any or all of the project stakeholders. The information should be relevant to the needs of the audience, and the method of presentation should be appropriate.
- **Feedback from stakeholders.** Information received from a stakeholder concerning project operations can be distributed and used to modify or improve the future performance of that project.
- **Stakeholder notifications.** Information provided to the stakeholder about resolved issues, approved changes, and general project status.

10.3 PERFORMANCE REPORTING

The performance reporting process involves the collection and dissemination of information to stakeholders. Generally this information includes how resources are being used to achieve project objectives. This process includes:

- Progress and status reporting - describing the project team's progress using a variety of measures - for example, status related to schedule and budget metrics, percent work completed to work scheduled, physical percent completed and what tasks are completed versus what tasks are in process.
- Forecasting - predicting future project status and estimated progress.

Performance reporting should generally provide information on scope, schedule, cost and quality. Many projects also require information on risk and procurement. Reports can be prepared in accordance with a schedule or on an exception basis.

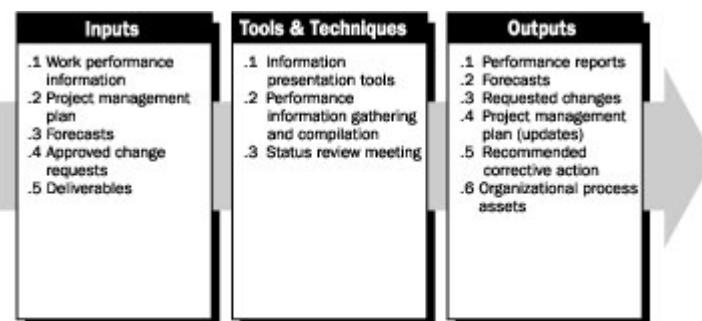


Figure 10-6. Performance Reporting Overview

10.3.1 Performance Reporting: Inputs

.1 Work Performance Information

Described in Section 4.4.

.2 Project Management Plan

The planned performance identified in the project management plan is used to determine variance by comparing planned against actual performance.

.3 Forecasts

Described in Section 4.3.

.4 Approved Change Requests

Approved change requests are requested changes to expand or contract project scope, to modify the estimated cost or to revise activity duration estimates that have been approved and are ready for implementation by the project team.

.5 Deliverables

A deliverable is any measurable, tangible, verifiable work product, document or capability to perform a service that must be produced to complete a project or part of a project.

10.3.2 Performance Reporting: Tools and Techniques

.1 Information Presentation Tools

Software packages that include table reporting, spreadsheet analysis, presentations or graphic capabilities can be used to create presentation quality images of project performance data.

.2 Performance Information Gathering and Compilation

Information can be gathered and compiled from a variety of media including manual filing systems, electronic databases, project management software and systems that allow access to technical documentation such as engineering drawings, design specifications, test plans to produce performance reports.

.3 Status Review Meetings

Status review meetings are regularly scheduled events to exchange information about the project. On most projects status review meetings will be held at various frequencies and on different levels. For example, the project management team can meet weekly by itself and monthly with the customer.

10.3.3 Performance Reporting: Outputs

.1 Performance Reports

Performance reports organize and summarize the information gathered and present the results of any analysis. Reports should provide the kinds of information and the level of detail required by various stakeholders as documented in the communications management plan. Common formats for performance reports include bar charts, Gantt charts, S-curves, histograms and tables.

.2 Forecasts

Described in Section 4.3.

.3 Requested Changes

Analysis of project performance often generates a request for a change to some aspect of the project. These change requests are handled as described in the various change control processes such as scope control, schedule control.

.4 Project Management Plan (Updates)

Changes to the information distribution and performance reporting processes should trigger changes to the project management plan and the communications management plan. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

.5 Recommended Corrective Action

Recommended corrective action includes changes that bring the expected future performance of the project in line with the project management plan.

.6 Organizational Process Assets (Updates)

Lessons learned documentation includes the causes of issues, the reasoning behind the corrective action chosen and other types of lessons learned performance reporting should be documented so that they become part of the historical database for both this project and of the performing organization.

10.4 MANAGE STAKEHOLDERS

Stakeholder management refers to managing communications to satisfy the needs of and resolve issues with project stakeholders. Actively managing stakeholders increases the likelihood that the project will not veer off track due to unresolved stakeholder issues, enhances the ability of people to operate synergistically and limits disruptions during the project. The project manager is usually responsible for stakeholder management.

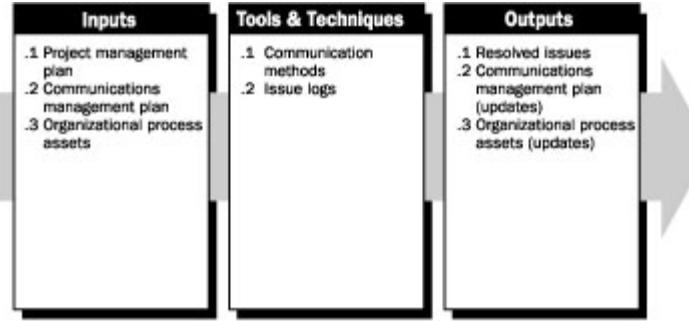


Figure 10-7. Manage Stakeholders Overview

10.4.1 Manage Stakeholders: Inputs

.1 Project Management Plan

Described in Section 4.3.

.2 Communications Management Plan

Stakeholder needs and expectations provide an understanding of stakeholder goals, objectives and level of communication during the project. The needs and expectations are identified, analyzed and documented in the communications management plan (Section 10.1), which is a subsidiary to the project management plan.

.3 Organizational Process Assets

As project issues arise, the Project Manager should address and resolve them with the appropriate project stakeholders.

10.4.2 Manage Stakeholders: Tools and Techniques

.1 Communications Methods

The methods of communications identified for each stakeholder in the communications management plan are utilized during stakeholder management.

Face-to-face meetings are the most effective means for communicating and resolving issues with stakeholders. When face-to-face meetings are not warranted or practical (such as on international projects), telephone calls, electronic mail and other electronic tools are useful for exchanging information and dialoguing.

.2 Issue Logs

An issues log or action-item log is a tool that can be used to document and monitor the resolution of issues. Issues do not usually rise to the importance of becoming a project task or activity, but must usually be addressed in order to maintain good, constructive working relationships among various stakeholders, including team members.

An issue must be clarified and stated in a way that it can be resolved. An owner is assigned and a target date is usually established for closure. Unresolved issues can be a major source of conflict and project delays.

10.4.3 Manage Stakeholders: Outputs

.1 Resolved Issues

As stakeholder expectations are identified and resolved, the issues log will document concerns that have been addressed and closed. Examples include:

- Customers agree to a follow-on contract, which ends protracted discussion of whether requested changes to project scope are within or outside the scope of the current project.
- More staff is added to the project, thus closing the issue that the project is short on required skills.
- Negotiations with functional managers in the organization competing for scarce human resources end in a mutually satisfactory solution before causing the project to be delayed.
- Issues raised by board members about the financial viability of the project have been answered, allowing the project to move forward as planned.

.2 Communications Management Plan (Updates)

As a result of changes in stakeholder issue status, changes in the staffing management plan can be necessary to reflect changes to how communications with stakeholders will occur. For example, it can be necessary to switch from e-mail communication to face-to-face meetings for important issues.

.3 Organizational Process Assets (Updates)

Lessons learned documentation includes the causes of issues, the reasoning behind the corrective action chosen and other types of lessons learned about stakeholder management should be documented so that they become part of the historical database for both this project and of the performing organization.

Chapter 11

Project Risk Management

Project Risk Management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and control on a project. The objectives of Risk Management are to increase the probability and impacts of positive events and decrease the probability and impacts of events adverse to project objectives. Figure 11-1 provides an overview of the Project Risk Management processes and Figure 11-2 provides a process flow diagram of those processes and their inputs, outputs, and other related knowledge area processes. The Project Risk Management processes include the following:

- 11.1 Risk Management Planning** - deciding how to approach, plan and execute the risk management activities for a project.
- 11.2 Risk Identification** - determining which risks might affect the project and documenting their characteristics.
- 11.3 Qualitative Risk Analysis** - prioritizing risks for subsequent further analysis or action by assessing and combining their probability and impacts.
- 11.4 Quantitative Risk Analysis** - analyzing numerically the effect on overall project objectives of identified risks.
- 11.5 Risk Response Planning** - developing options and actions to enhance opportunities and to reduce threats to project objectives.
- 11.6 Risk Monitoring and Control** - tracking identified risks, monitoring residual risks, identifying new risks, executing risk response plans, and evaluating their effectiveness throughout the project life cycle.

These processes interact with each other and with the processes in the other knowledge area processes. Each process occurs at least once in every project. While the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapters 3 and 4.

Project risk is an uncertain event or condition that, if it occurs, has a positive or a negative effect on at least one project objective. A risk may have one or more causes and, if it occurs, one or more impacts. For example, a cause may be requiring an environmental permit to do work or having limited personnel assigned to design the project. The risk event is that the permitting agency may take longer than planned to issue a permit for some reason, or the design personnel available and assigned may not be adequate for the task. If either of these uncertain events occurs, there may be an impact on the project cost, schedule, or performance. Risk conditions could include aspects of the project's or organization's environment that may contribute to project risk, such as poor project management practices, lack of integrated management systems, concurrent multiple projects, or dependency on external participants who cannot be controlled.

Project risk has its origins in the uncertainty that is present in all projects. Known risks are those that have been identified and analyzed, and it may be possible to plan for those risks using the processes described in this chapter. Unknown risks cannot be managed proactively, and a prudent response by the project team can be to allocate general contingency against such risks, as well as against any known risks for which it may not be cost-effective or possible to develop a proactive response.

Organizations perceive risk as it relates to threats to project success or to opportunities to enhance chances of project success. Risks that are threats to the project may be accepted if the risk is in balance with the reward that may be gained by taking the risk. For example, adopting a fast track schedule (Section 6.4) that may be overrun is a risk taken to achieve an earlier completion date. Risks that are opportunities, such as work acceleration that may be gained by assigning more expert staff, may be pursued to benefit the project's objectives.

Individuals, and by extension organizations, have attitudes toward risk that affect both the accuracy of the perception of risk and the way they respond. Attitudes about risk should be made explicit wherever possible. A consistent approach to risk that meets the organization's requirements should be developed for each project, and communication about risk and its handling should be open and honest. Risk responses reflect an organization's balance between risk-taking and risk-avoidance.

To be successful, the organization must be committed to addressing the management of risk proactively and consistently throughout the project.

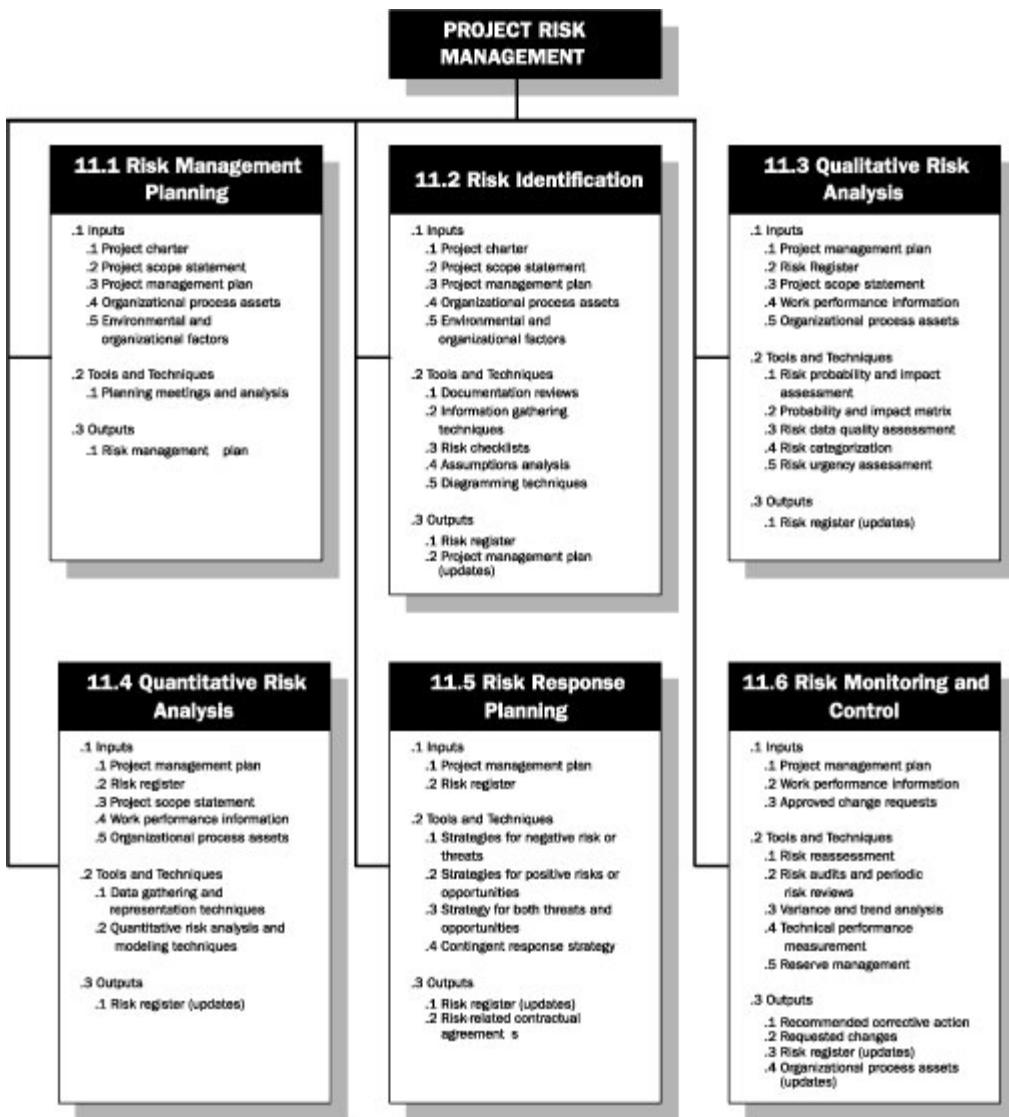


Figure 11-1 Project Risk Management Overview

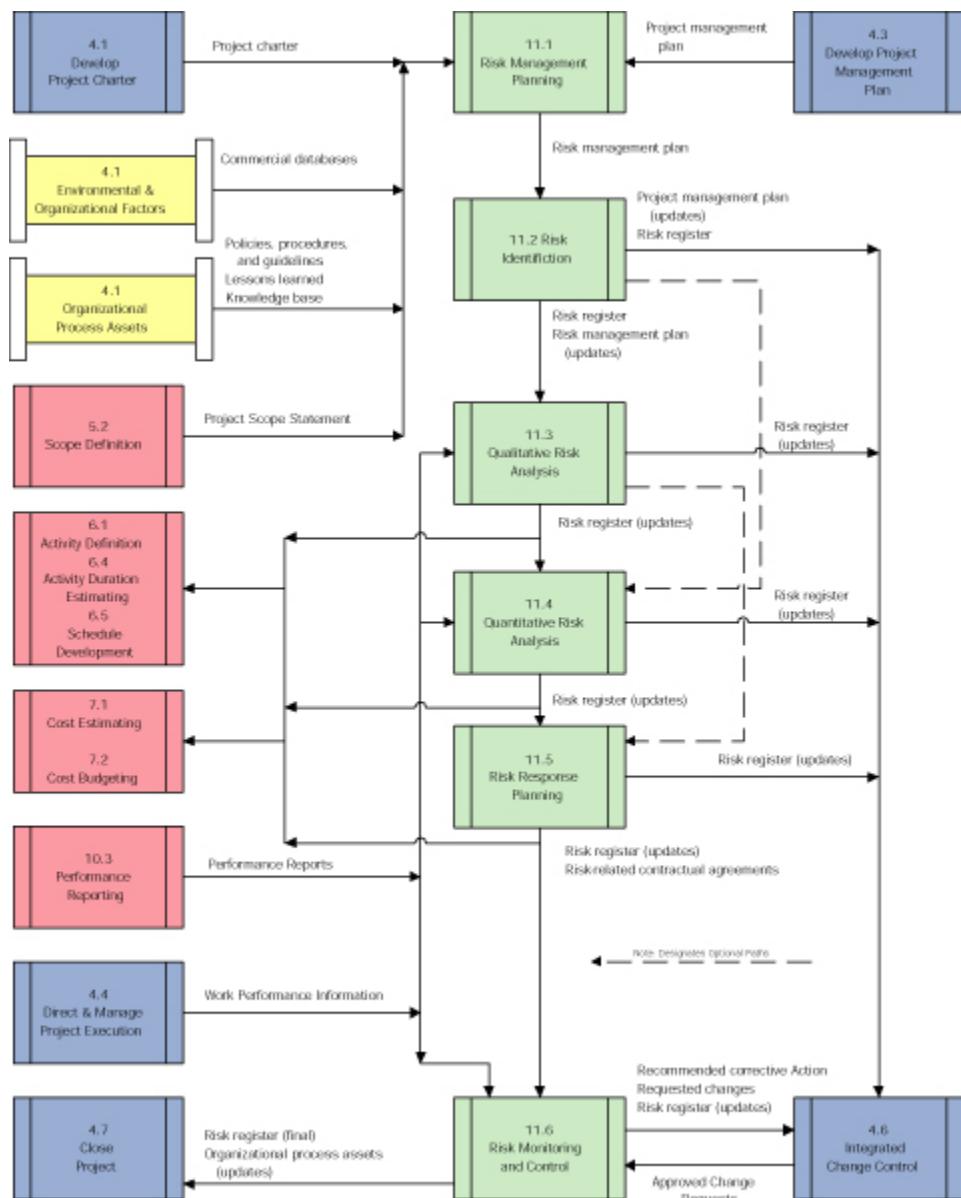


Figure 11-2: Project Risk Management Process Flow

11.1 RISK MANAGEMENT PLANNING

Careful and explicit planning enhances the possibility of success of the risk management processes described in later sections. Risk Management Planning is the process of deciding how to approach and conduct the risk management activities for a project. It is important to The planning of the risk management processes is important to ensure that the level, type and visibility of risk management are commensurate with both the risk and importance of the project to the organization, to provide for sufficient resources and time for risk management activities, and to establish an agreed basis for evaluating risks. The Risk Management Planning process should be completed early during project planning, since it is crucial to successfully performing the other processes described in this chapter. This completion of this process typically leads to the Risk Identification process.

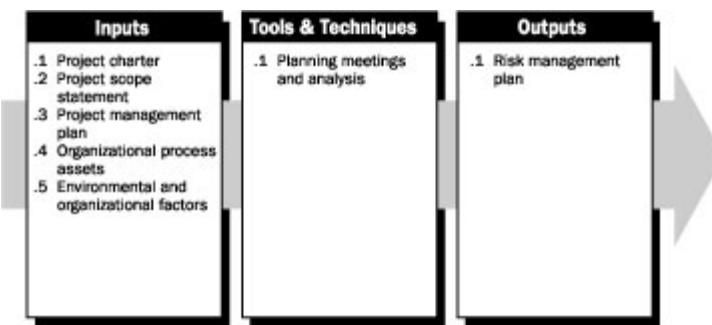


Figure 11-3. Risk Management Planning Overview

11.1.1 Risk Management Planning: Inputs

.1 Project Charter

Described in Section 4.1.

.2 Project Scope Statement

Described in Sections 4.2 and 5.2.

.3 Project Management Plan

Described in Section 4.3.

.4 Organizational Process Assets

Organizations may have predefined approaches to risk management such as risk categories, common definition of concepts and terms, standard templates, roles and responsibilities and authority levels for decision-making. The organization can use and continuously improve these based on their application and usefulness in projects (Section 4.1).

.5 Environmental and Organizational Factors

The attitudes toward risk and the risk tolerance of organizations and individuals involved in the project will influence the project management plan (Section 4.3). Risk attitudes and tolerances may be expressed in policy statements or revealed in actions (Section 4.1)

11.1.2 Risk Management Planning: Tools and Techniques

.1 Planning Meetings and Analysis

Project teams hold planning meetings to develop the Risk Management Plan. Attendees at these meetings can include the project manager, the project team leaders, anyone in the

organization with responsibility to manage the risk planning and execution activities, key stakeholders, and others, as needed.

Basic plans for conducting the risk management activities are defined in these meetings. Risk cost elements and schedule activities will be developed for inclusion in the project budget and schedule respectively. Risk responsibilities will be assigned. General organizational templates for risk categories and definition of terms such as levels of risk probability by type of risk, impact by type of objectives, and the probability and impact matrix will be tailored to the specific project. The outputs of these activities will be summarized in the Risk Management Plan.

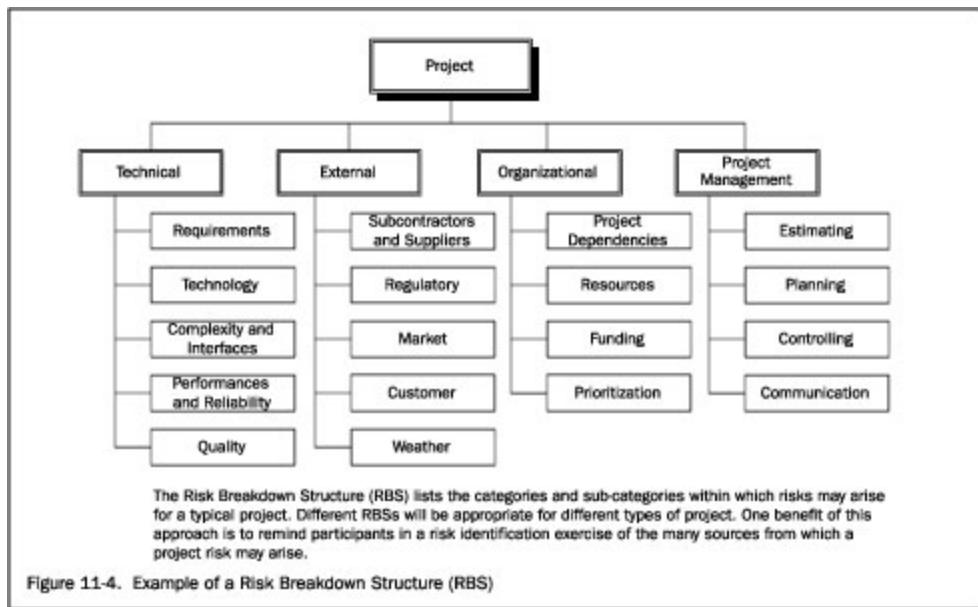
11.1.3 Risk Management Planning: Outputs

.1 Risk Management Plan

The Risk Management Plan describes how risk management will be structured and performed on the project. It becomes a subset of the Project Management Plan (Section 4.3). The Risk Management Plan includes the following:

- **Methodology.** Defines the approaches, tools, and data sources that may be used to perform risk management on the project.
- **Roles and responsibilities.** Defines the lead, support, and risk management team membership for each type of activity in the Risk Management Plan and assigns individuals to these roles.
- **Budgeting.** Assigns resources and estimates costs needed for risk management for inclusion in the project cost baseline (Section 7.3).
- **Timing.** Defines how often the risk management process will be performed throughout the project life cycle and establishes risk management activities to be included in the project schedule (Section 6.5).
- **Risk categories.** Provides a structure that ensures a comprehensive process of systematically identifying risk to a consistent level of detail contributes to the effectiveness and quality of risk identification. An organization can use a previously prepared categorization of typical risks. A Risk Breakdown Structure (RBS) (Figure 11-4) is one approach to providing such a structure, but it can also be addressed by simply listing the various aspects of the project. The risk categories may be revisited during the risk identification process.

A good practice is to review the risk categories during the Risk Management Planning process prior to their use in the Risk Identification process. Risk categories based on prior projects may need to be tailored, adjusted, or extended to new situations, before those categories can be used on the current project.



- **Definitions of risk probability and impact.** General definitions of probability and impact are often developed by the organization. The quality and credibility of the qualitative risk analysis requires that different levels of the risks' probability and impact should be defined. Below are examples of impact definitions used on many projects (Figure 11-5). These definitions are tailored to the individual project during the Risk Management Planning process and included in the Risk Management Plan for use in the Qualitative Risk Analysis process (Section 11.3).

A relative scale representing probability values from very unlikely to almost certain could be used. Alternatively, numerical probabilities assigned or a general scale (e.g., .1, .3, .5, .7, .9) can be used. Definitions can be developed that provide more objective criteria for probability for the type of risk under consideration.

The impact scale reflects the significance of impact, either negative for threats or positive for opportunities, on each project objective () if a risk occurs. Impact scales are specific to the objective potentially impacted, the type and size of the project, the organization's strategies and financial state and its degree of sensitivity to particular impacts. Relative scales for impact are simply rank-ordered descriptors such as "very low", "low", "moderate", "high", and "very high" reflecting increasingly extreme impacts as defined by the organization. Alternatively, numeric scales assign values to these impacts. These values may be linear (e.g., .1, .3, .5, .7, .9), or nonlinear (e.g., .05, .1, .2, .4, .8). Nonlinear scales may represent the organization's desire to avoid high-impact threats or exploit high-impact opportunities even if they have relatively low probability.

Figure 11-5 is an example for negative impacts of definitions that might be used in evaluating risk impacts related to four project objectives. That figure illustrates both relative and numeric (in this case, nonlinear) approaches.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives (Examples are Shown for Negative Impacts Only) Relative or Numerical (Non-Linear) Scales are Shown					
Project Objective	Very Low .05	Low .10	Moderate .20	High .40	Very High .80
Cost	Insignificant Cost Increase	<10% Cost Increase	10-20% Cost Increase	20-40% Cost Increase	>40% Cost Increase
Time	Insignificant Time Increase	<5% Time Increase	5-10% Time Increase	10-20% Time Increase	>20% Time Increase
Scope	Scope Decrease Barely Noticeable	Minor Areas of Scope Affected	Major Areas of Scope Affected	Scope Reduction Unacceptable to Sponsor	Project End Item is Effectively Useless
Quality	Quality Degradation Barely Noticeable	Only Very Demanding Application are Affected	Quality Reduction Requires Sponsor Approval	Quality Reduction Unacceptable to Sponsor	Project End Item is Effectively Useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Figure 11-5. Definition of Impact Scaled for Four Project Objectives

- **Probability and impact matrix.** Risks are prioritized according to their potential implications for meeting the project's objectives. The typical approach to prioritizing risks is to use a look-up table or a Probability and Impact Matrix (Figure 11-8 and Section 11.3.). The specific combinations of probability and impact that lead to a risk being rated as "high," "moderate," or "low" importance – with the corresponding importance for planning responses to the risk (Section 11.5) – are usually set by the organization. They are reviewed and can be tailored to the specific project during the Risk Management Planning process.
- **Revised stakeholders' tolerances.** Stakeholders' tolerances may be revised in the Risk Management Planning process as they apply to the specific project.
- **Reporting formats.** Describes the content and format of the Risk Register (Sections 11.2, 11.3, 11.4 and 11.5) as well as any other risk reports required. Defines how the results of the risk management processes will be documented, analyzed, and communicated.
- **Tracking.** Documents how all facets of risk activities will be recorded for the benefit of the current project, future needs, and lessons learned. Documents if and how risk processes will be audited.

11.2 RISK IDENTIFICATION

Risk Identification involves identifying risks that may occur on a particular project and determining which risks might affect the project and documenting their characteristics. Participants in risk identification activities can include the following, where appropriate: project manager, project team leaders, project team, risk management team if assigned, subject matter experts from outside the project team, customers, end users, other project managers, stakeholders, and outside risk management experts.

Risk Identification is an iterative process because new risks may become known as the project progresses through its life cycle (Section 2.1). The frequency of iteration and who participates in each cycle will vary from case to case. The project team should be

involved in the process so that they can develop and maintain a sense of ownership of and responsibility for the risks and associated risk response actions. Persons outside the team may provide additional objective information. The Risk Identification process usually leads to the Qualitative Risk Analysis process (Section 11.3). Alternatively, it can lead directly to the Quantitative Risk Analysis process (Section 11.4) when conducted by an experienced risk manager. On some occasions simply the identification of a risk may suggest its response, and these should be recorded for further analysis and implementation in the Risk Response Planning process (Section 11.5).

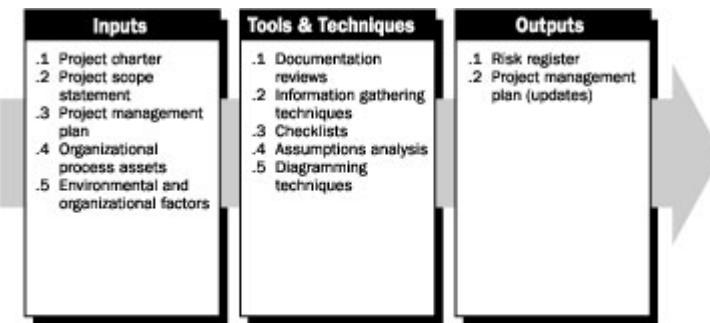


Figure 11-6. Risk Identification Overview

11.2.1 Risk Identification: Inputs

.1 Project Charter

The Project Charter contains descriptions of the purpose of the project, objectives of the owner, sponsor, or stakeholders, expectations for the project, and project assumptions (Section 4.1).

.2 Project Scope Statement

Project assumptions are found in the project scope statement (Sections 4.4). Uncertainty in project assumptions should be evaluated as potential project risks.

.3 Project Management Plan

Each risk management process requires use of the Risk Management Plan. Key inputs from the risk management plan to the risk identification process are the assignments of roles and responsibilities, provision for risk management tasks in the budget and schedule, and categories of risk (Section 11.1), which are sometimes expressed in the Risk Breakdown Structure (RBS) (Figure 11-4). The risk identification process also requires an understanding of the project's mission, scope, schedule, cost and quality management plans found in the project management plan (Section 4.3). Outputs of other processes should be reviewed to identify possible risks across the entire project. These may include, but are not limited to the project charter, WBS, project scope statement, cost estimates, schedule, resource plan, dependencies on actions of those outside the project, measures of project success, procurement plan, assumptions underlying the project plan, and constraints list.

.4 Organizational Process Assets

Information on prior projects may be available from previous project files including actual data and lessons learned (Section 4.1).

5. Environmental and Organizational Factors

Published information, including commercial databases, academic studies, benchmarking or other industry studies, may also be useful in identifying risks (Section 4.1).

11.2.2 Risk Identification: Tools and Techniques

.1 Documentation Reviews

A structured review may be performed of project documentation, including plans, assumptions, prior project files, and other information. The quality of the plans, the consistency between those plans and with the project requirements and assumptions can be indicators of risk in the project.

.2 Information Gathering Techniques

Examples of information-gathering techniques used in identifying risk can include:

- **Brainstorming.** The goal of brainstorming is to obtain a comprehensive list of project risks. The project team usually performs brainstorming, often with a multidisciplinary set of experts not on the team. Ideas about project risk are generated under the leadership of a facilitator. Risk Breakdown Structure elements or categories of risk (Section 11.1) can be used as a framework. Risks are then identified and categorized by type of risk, and their definitions are sharpened.
- **Delphi technique.** The Delphi technique is a way to reach a consensus of experts. Project risk experts participate in this technique anonymously. A facilitator uses a questionnaire to solicit ideas about the important project risks. The responses are summarized and are then re-circulated to the experts for further comment. Consensus may be reached in a few rounds of this process. The Delphi technique helps reduce bias in the data and keeps any one person from having undue influence on the outcome.
- **Interviewing.** Interviewing experienced project participants, stakeholders, and subject-matter experts can identify risks. This is one of the main sources of risk identification data gathering.
- **Root cause identification.** This is an inquiry into the essential causes of a project's risks. It sharpens the definition of the risk and allows grouping risks by causes. Effective risk responses can be developed if the root cause of the risk is addressed.
- **Strengths, weaknesses, opportunities, and threats (SWOT) analysis.** This technique ensures examination of the project from each of the SWOT perspectives to increase the breadth of the risks considered.

.3 Checklists

Risk identification checklists can be developed based on historical information and knowledge that has been accumulated from previous similar projects and from other sources of information. The lowest level of the RBS can also be used as a risk checklist. While a checklist can be quick and simple, it is impossible to build an exhaustive one. Care should be taken to explore items that do not appear on the checklist. The checklist should be reviewed during project closure to improve it for use on future projects.

.4 Assumptions Analysis

Every project is conceived and developed based on a set of hypotheses, scenarios, or assumptions. Assumptions analysis is a tool that explores the validity of assumptions as

they apply to the project. It identifies risks to the project from inaccuracy, inconsistency, or incompleteness of assumptions.

.5 Diagramming Techniques

Risk diagramming techniques may include:

- **Cause-and-effect diagrams** (also known as Ishikawa or fishbone diagrams). These are useful for identifying causes of risks (Section 8.3).
- **System or process flow charts.** These show how various elements of a system interrelate and the mechanism of causation (Section 8.3).
- **Influence diagrams.** These are graphical representations of situations showing causal influences, time ordering of events, and other relationships among variables and outcomes.

11.2.3 Risk Identification: Outputs

The outputs from Risk Identification are typically contained in a document that can be called a Risk Register.

.1 Risk Register

The primary outputs from risk identification are the initial entries into the Risk Register, which becomes a component of the Project Management Plan (Section 4.3). The Risk Register ultimately contains the results of risk analyses, prioritization, and responses after other risk management processes are conducted. The preparation of the risk register begins in the risk identification process with the following information, which becomes available to other project management and Project Risk Management processes.

- **List of identified risks.** The identified risks, including their root causes and uncertain project assumptions, are described, their impacts are identified and persons (the “risk owners”) are assigned to take responsibility for further analysis, responses, and monitoring.
- **Symptoms or warning signs.** These are indications that a risk requires increased attention or is about to occur. An event that is known to have occurred is no longer a risk but may be a problem or an issue.
- **List of potential responses.** Potential responses to a risk may be identified during the risk identification process. These responses will be useful as inputs to the risk response planning process (Section 11.5).
- **Root causes of risk.** These are the fundamental conditions or events that may give rise to the identified risk. Root causes may give rise to more than one risk, a fact that can lead to very effective risk responses.
- **Updated risk categories.** The process of identifying risks can lead to new risks categories being added to the list of risk categories. The risk breakdown structure developed in the risk management planning process may have to be enhanced or amended based on the results of the risk identification process.

.2 Project Management Plan (Update)

The Risk Identification process can establish a need for further action including updates to other process plans contained in the Project Management Plan. For example, the work breakdown structure (WBS) may not have sufficient detail to allow adequate identification of risks, or the schedule may not include the activities that may be affected by the important risks. Requested changes (additions, modification, revisions) to the

project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

11.3 QUALITATIVE RISK ANALYSIS

Qualitative risk analysis includes methods for prioritizing the identified risks (Section 11.2) for further action such as quantitative risk analysis or risk response planning. Organizations can improve the project's performance effectively by focusing on high-priority risks. Qualitative risk analysis assesses the priority of identified risks using their probability of occurring and the corresponding impact on project objectives if the risks do occur.

Definitions of the levels of probability and impact and expert interviewing can help to correct biases that are often present in the data used in this process. The time criticality of risk-related actions may magnify the importance of a risk. An evaluation of the quality of the available information on project risks also helps understand the assessment of the risk's importance to the project.

Qualitative risk analysis is usually a rapid and cost-effective means of establishing priorities for risk response planning, and lays the foundation for quantitative risk analysis if this is required. Qualitative risk analysis should be revisited during the project's life cycle to stay current with changes in the project risks. Qualitative analysis of risk requires the outputs of risk management planning and risk identification processes (Sections 11.1 and 11.2). This process can lead into quantitative risk analysis (Section 11.4) or directly into risk response planning (Section 11.5).

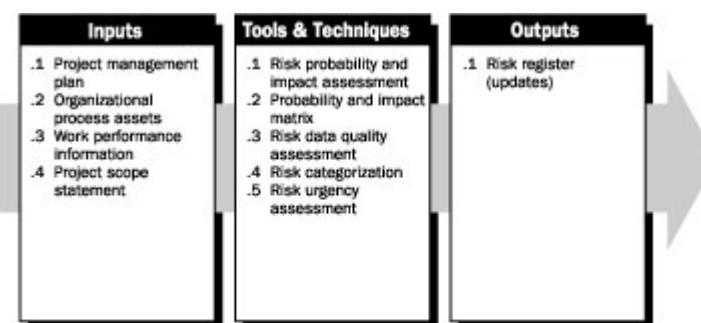


Figure 11-7. Qualitative Risk Analysis Overview

11.3.1 Qualitative Risk Analysis Process: Inputs

.1 Project Management Plan

The Project Management Plan (Section 4.3) includes:

- **Risk management plan** (Section 11.1.). Key elements of that plan for qualitative risk analysis include: roles and responsibility for risk management, budgets and schedule activities for risk management, risk categories, definition of probability and impact, the probability and impact matrix and revised stakeholders' risk tolerances (also environmental and organizational factors in Section 4.1). These inputs are usually tailored to the project during the risk management planning process. If they are not available they can be developed during the qualitative risk analysis process.

- **Risk register** (Section 11.2.). This document contains the risks identified during the Risk Identification process, including root causes of risk, important assumptions, and symptoms or warning signs that a risk is likely to occur.

.2 Organizational Process Assets

Data about risks on past projects and the lessons learned knowledge base can be used in the qualitative risk analysis (Section 4.3.1.8).

.3 Work Performance Information

The characteristics of a risk often depend on the project's progress through its life cycle. Early in the project many risks have not surfaced, making it likely that more risks will be identified as the project progresses. If qualitative risk analysis is conducted during the intermediate project life cycle phases (Section 2.1) then the reported work performance information from the direct and manage project execution processes (Section 4.4) and the performance reports (Section 10.3) may provide measures of project status.

.4 Project Scope Statement

Projects of a common or recurrent type tend to have more well-understood risks. Projects using state-of-the-art or first-of-its-kind technology or highly complex projects tend to have more uncertainty. This can be evaluated by examining the project scope statement (Section 4.2).

.5 Risk Register

Described in Section 11.2.

11.3.2 Qualitative Risk Analysis: Tools and Techniques

.1 Risk Probability and Impact Assessment

Risk probability describes the likelihood that a risk will occur. Risk impact describes the effect if the risk occurs on a project objective such as time, cost, scope or quality, including both negative effects for threats and positive effects for opportunities.

Probability and impact are assessed for each identified risk. Risks can be assessed in interviews or meetings with participants selected for their familiarity with the risk categories on the agenda. Project team members and, possibly, knowledgeable people from outside the project are included. Expert judgment is required since there is usually little information on risks from the organization's database of past projects. An experienced facilitator may lead the discussion since the participants may have little experience with risk assessment.

The level of probability for each risk and its impact on each objective is evaluated during the interview or meeting. Explanatory detail, including assumptions, justifying the levels assigned is also recorded. Risk probability and impacts can be assigned descriptive relative terms such as "very low", "low", "moderate", "high", and "very high", although some risk analysts use "catastrophic" for the highest impact category. Alternatively, numeric terms, e.g., .1, .3, .5, .7, .9 can be used. Sometimes risks with obviously low ratings of probability and impact will not be rated but will be included on a watch list for future monitoring.

.2 Probability and Impact Matrix

Risks can be prioritized for further quantitative analysis (Section 11.4) and response (Section 11.5) based on their risk rating. Ratings are assigned to risks based on their assessed probability and impact (Section 11.3). Evaluation of each risks' importance, and hence priority for attention, is typically conducted using a look-up table or a probability

and impact matrix (Figure 11-8) that specifies combinations of probability and impact that lead to rating the risks as low, moderate or high priority. Descriptive terms or numeric values can be used, depending on organizational preference.

The organization must determine which combinations of probability and impact result in a classification of high risk (red condition), moderate risk (yellow condition), and low risk (green condition). Usually these risk rating rules are specified by the organization in advance of the project and included in organizational process assets (Section 4.1). Risk rating rules can be tailored in risk management planning (Section 11.1) to the specific project.

A probability and impact matrix, such as the one shown in Figure 11-8, is often used.

Probability and Impact Matrix						
Probability	Risk Score = Probability x Impact					
	0.9	0.05	0.09	0.18	0.36	0.72
	0.7	0.04	0.07	0.14	0.28	0.56
	0.5	0.03	0.05	0.10	0.20	0.40
	0.3	0.02	0.03	0.06	0.12	0.24
	0.1	0.01	0.01	0.02	0.04	0.08
		0.05	0.10	0.20	0.40	0.80

Impact (ratio scale) on an Objective (e.g., cost, time, scope or quality)

Each risk is rated on its probability of occurring and impact on an objective if it does occur. The organization's thresholds for low, moderate or high risks are shown in the matrix and determine whether the risk is scored as high, moderate or low for that objective.

Figure 11-8. Probability and Impact Matrix

An organization can rate a risk separately for each objective (e.g., cost, time, and scope). In addition it can develop ways to determine one overall rating for each risk, for example by using a weighted average of the objective-specific scores to derive a blended risk score for each risk.

The risk score helps guide risk responses. For example, risks that have a negative impact on the objectives if they occur (threats) that are in the high-risk (red) zone of the matrix may require priority action and aggressive response strategies. Threats in the low-risk (green) zone may not require proactive management action beyond being placed on a watch list or adding a contingency reserve.

Similarly for opportunities, those in the high-risk (red) zone that can be obtained most easily and offer the greatest benefit should therefore be targeted first. Opportunities in the low-risk (green) zone should be monitored. While the same probability and impact matrix can be used for both threats and opportunities, a mirror double matrix can clarify which threats and opportunities require priority attention.

.3 Risk Data Quality Assessment

A qualitative risk analysis requires accurate and unbiased data if it is to be credible. Analysis of the quality of risk data is a technique to evaluate the degree to which the data about risks is useful for risk management. It involves examining the degree to which the

risk is understood and the accuracy, quality, reliability, and integrity of the data about the risk.

The use of low quality risk data may lead to a qualitative risk analysis of little use to the project. If data quality is unacceptable, it may be necessary to gather better data.

Often collection of information about risks is difficult and consumes time and resources beyond that originally planned.

.4 Risk Categorization

Risks to the project can be categorized by sources of risk (e.g., using the RBS), the area of the project affected (e.g., using the WBS) or other useful category (e.g., project phase) to determine areas of the project most exposed to the effects of uncertainty. Grouping risks by common root causes can lead to developing effective risk responses.

.5 Risk Urgency Assessment

Risks requiring near term responses may be considered more urgent to address. Indicators of priority can include time to affect a risk response, symptoms and warning signs, and the risk rating.

11.3.3 Qualitative Risk Analysis: Outputs

.1 Risk Register (Updates)

The risk register is initiated during the risk identification process (Section 11.2). The risk register is updated with information from qualitative risk analysis and the updated risk register is included in the project management plan (Section 4.1). The risk register updates from qualitative risk analysis include:

- **Relative rating or priority list of project risks.** The probability and impact matrix can be used to classify risks according to their individual significance. The project manager can then use the results to focus attention on those items of high significance to the project where responses can lead to better project outcomes. Risks may be listed in priority separately for cost, time, scope and quality since organizations may value one objective over another. A description of the basis for the assessed probability and impact should be included for risks assessed as important to the project.
- **Risks grouped by categories.** Risk categorization can reveal common causes of risk or project areas requiring particular attention. Discovering concentrations of risk may improve the effectiveness of risk responses.
- **List of risks requiring response in the near term.** Those risks that require an urgent response and those that can be handled at a later date may put into a group.
- **List of risks for additional analysis and response.** Some risks might warrant more analysis, including quantitative risk analysis, as well as response action.
- **Watch lists of low priority risks.** Risks that are not assessed as important in the qualitative risk analysis process can be placed on a watch list for continued monitoring.
- **Trends in qualitative risk analysis results.** As the analysis is repeated, a trend of results for particular risks may become apparent, and can make risk response or further analysis more or less urgent and important.

11.4 QUANTITATIVE RISK ANALYSIS

The Quantitative Risk Analysis process numerically analyzes the effect of all identified risks on project objectives. It also presents a quantitative approach to making decisions in the presence of uncertainty. This process uses techniques such as Monte Carlo simulation and decision tree analysis to:

- Quantify the possible outcomes for the project and their probability
- Assess the probability of achieving specific project objectives
- Identify risks requiring the most attention by quantifying their relative contribution to overall project risk
- Identify realistic and achievable cost, schedule, or scope targets, given the project risks
- Determine the best project management decision when some conditions or outcomes are uncertain.

Quantitative risk analysis generally follows the qualitative risk analysis process, although experienced risk managers sometimes perform it directly after risk identification. In some cases quantitative risk analysis may not be required to develop effective risk responses. Availability of time and budget and the need for qualitative or quantitative statements about risk and impacts will determine which method(s) to use on any particular project. Trends in the results, when quantitative risk analysis is repeated, can indicate the need for more or less risk management action. It is an input to the risk response planning process.

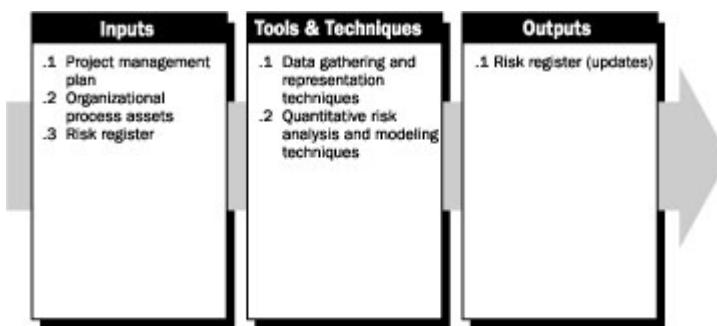


Figure 11-9. Quantitative Risk Analysis Overview

11.4.1 Quantitative Risk Analysis: Inputs

.1 Project Management Plan

The Project Management Plan (Section 4.5.2.1) includes:

- The risk management plan (Section 11.1) with key elements for quantitative risk analysis that include: roles and responsibilities for conducting risk management, budgets and activities in the schedule that provide for risk management and risk categories, e.g., the risk breakdown structure and revised stakeholders' risk tolerances, and identified environmental and organizational factors (Section 4.1).
- The risk register (Sections 11.2 and 11.3) with its updates. Key items from the Risk Register for quantitative risk analysis from this report include the list of

identified risks and the relative rating or priority list of project risks, and the risks grouped by categories.

- The project schedule management plan including logic and duration estimates used in determining schedules developed in the time management processes (Section 6.5).
- The project cost management plan including cost estimates developed in the cost management processes (Section 7.2.3.1).
- The project scope statement (Section 5.2) and scope management plan (Section 5.1).
- The work breakdown structure (Section 5.3).

.2 Organizational Process Assets

Information on prior, similar completed projects, studies of similar projects by risk specialists, and risk databases that may be available from industry or proprietary sources (Section 4.1).

.3 Risk Register

Described in Section 11.2.

11.4.2 Quantitative Risk Analysis: Tools and Techniques

.1 Data Gathering and Representation Techniques

- **Interviewing.** Interviewing techniques are used to quantify the probability and impacts of risks on project objectives. The information needed depends upon the type of probability distributions that will be used. For instance, information would be gathered on the optimistic (low), pessimistic (high), and the most likely scenarios if triangular distributions are used, or on mean and standard deviation for the normal and lognormal distributions. Examples of three-point estimates for a cost estimate are shown in Figure 11-10. Documenting the rationale of the risk ranges is an important component of the risk interview, because it can provide information on reliability of the results and credibility of the analysis.

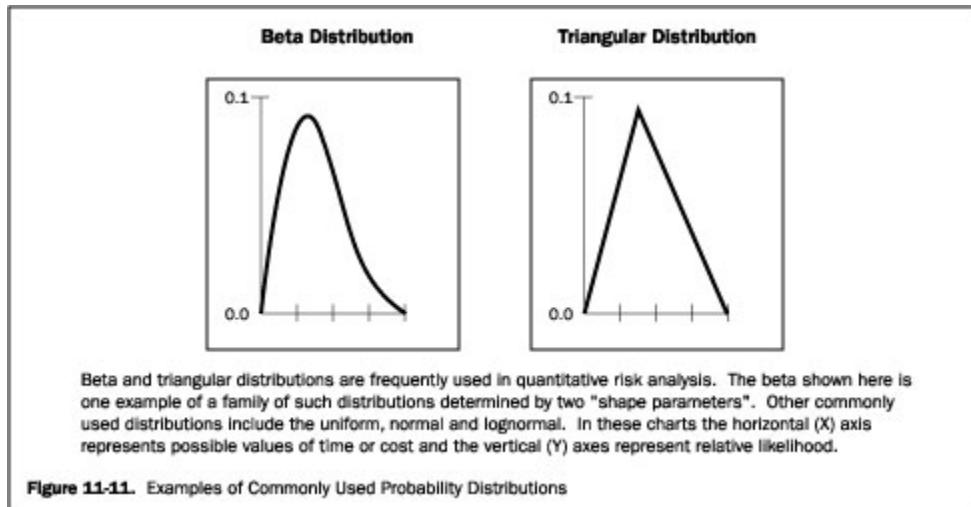
Project Cost Estimates and Ranges			
WBS Element	Low	Most Likely	High
Design	4	6	10
Build	16	20	35
Test	11	15	23
Total Project		41	

The risk interview determines the three-point estimates for each WBS element for triangular or other asymmetrical distributions. In this example, the likelihood of completing the project at or below the traditional estimate of \$41 is relatively small as shown in the simulation results (Figure 11-13).

Figure 11-10. Cost Estimates and Ranges Collected During the Risk Interview

- **Probability distributions.** Continuous probability distributions are often used to represent the uncertainty in values such as durations of schedule activities and costs of project elements. Discrete distributions can be used to represent uncertain

events such as the outcome of a test or a possible scenario in a decision tree. Two examples of widely-used continuous distributions are shown in Figure 11-11. It is important that the distributions can be asymmetrical, such as those shown in Figure 11-11, so their shapes can be compatible with the data typically developed during the project risk analysis. Uniform distributions can be used if there is no obvious value that is more likely than any other, such as in the early concept stage of design.



- **Expert judgment.** Input may come from the project team (Section 5.1), subject matter experts in the organization and from others outside the organization such as engineering or statistical experts.

.2 Quantitative Risk Analysis and Modeling Techniques

Commonly used techniques in quantitative risk analysis include:

- **Sensitivity analysis.** Sensitivity analysis helps to determine which risks have the most potential impact on the project. It examines the extent to which the uncertainty of each project element affects the objective being examined when all other uncertain elements are held at their baseline values. The typical display of results is the tornado diagram.
- **Expected monetary value analysis.** Expected monetary value (EMV) is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen (i.e., analysis under uncertainty). The EMV is calculated by multiplying the value of each possible outcome by its probability of occurring and adding the results together. A common use of this analysis is in decision tree analysis (Figure 11-12). Modeling and simulation is recommended for use in cost and schedule risk analysis because it is more powerful and less subject to misuse than EMV.
- **Decision tree analysis.** A decision tree analysis is usually structured using a decision tree diagram that describes a situation under consideration and the implications of each of the available choices and possible scenarios. It incorporates the cost of each available choice, the probabilities of each possible scenario and the rewards of each alternative logical path. Solving the decision tree

provides the expected monetary value (or utility to the organization) of each alternative when all the uncertain implications, costs, rewards and subsequent decisions are quantified. A simple decision tree is shown in Figure 11-12.

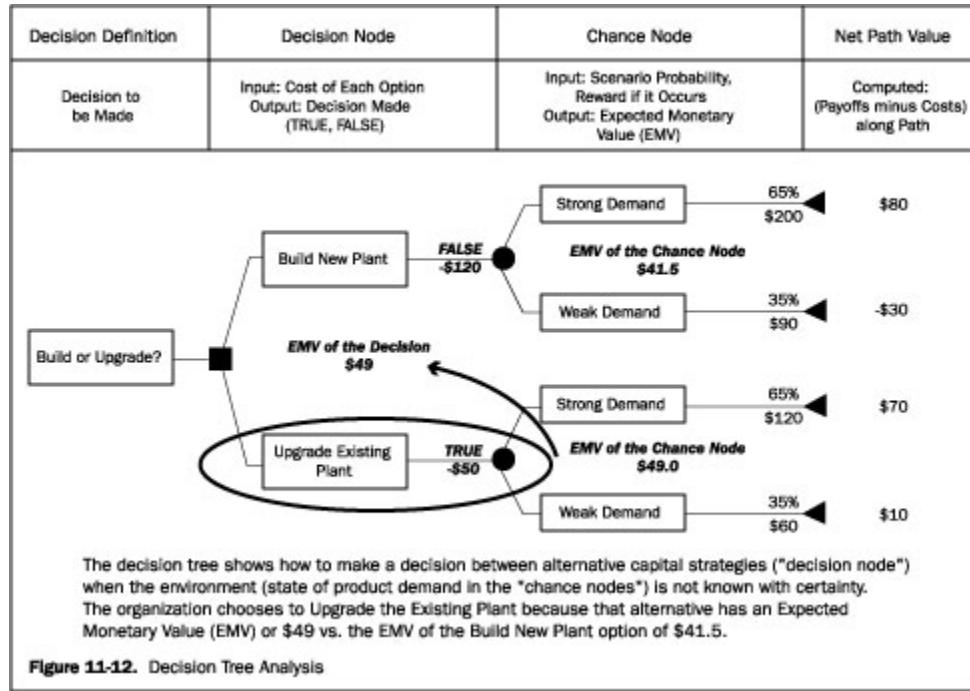
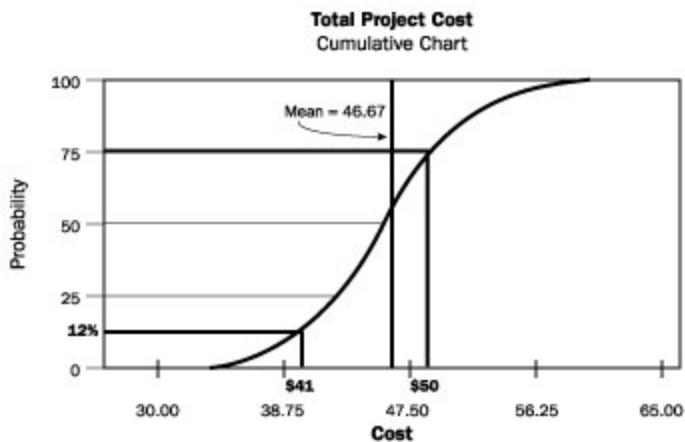


Figure 11-12. Decision Tree Analysis

- **Modeling and simulation.** A project simulation uses a model that translates the uncertainties specified at a detailed level of the project into their potential impact on project objectives. Simulations are typically performed using the Monte Carlo technique. In a simulation the project model is solved many times (iterated) with the input values (e.g., cost of project elements or duration of schedule tasks) chosen for each iteration at random from the probability distributions of each variable. A probability distribution of project results (e.g., total cost or completion date) is calculated.

For a cost risk analysis, a simulation can use the traditional project WBS (Section 5.3.) or a cost breakdown structure as its model. For a schedule risk analysis, the precedence diagramming method (PDM) schedule is used (Section 6.2). A cost risk simulation result is shown in Figure 11-13.



This cumulative likelihood distribution reflects the risk of overrunning the cost estimate assuming the data ranges contained in Figure 11-11 and triangular distributions. It shows that the project is only 12 percent likely to meet the \$41 estimate. If a conservative organization wants a 75% likelihood of success, a budget of \$50 (a contingency of nearly 22%) is required.

Figure 11-13. Cost Risk Simulation Results

11.4.3 Quantitative Risk Analysis: Outputs

.1 Risk Register (Update)

The risk register is initiated in risk identification (Section 11.2) and updated in qualitative risk analysis (Section 11.3). It is further updated in quantitative risk analysis. The risk register is a component of the Project Management Plan (Section 4.5.2.1). Updates include the following main components:

- **Probabilistic analysis of the project.** Estimates are made of potential project schedule and cost outcomes, listing the possible completion dates and costs with their associated confidence levels. This output, typically expressed as a cumulative distribution is used along with stakeholder risk tolerances to permit quantification of the cost and time contingency reserves needed to bring the risk of overrunning stated project objectives to a level acceptable to the organization (Section 11.5). For instance, in Figure 11-13, the cost contingency to the 75th percentile is \$9 or about 22%.
- **Probability of achieving the cost and time objectives.** The probability of achieving the project objectives under the current plan and with the risks facing the project can be estimated using quantitative risk analysis results. For instance, in Figure 11-13 the likelihood of achieving the cost estimate of \$41 (Figure 11-9) is about 12%.
- **Prioritized list of quantified risks.** This list of risks includes those that pose the greatest threat or present the greatest opportunity to the project. These include the risks that require the greatest cost contingency and those that are most likely to influence the critical path.
- **Trends in quantitative risk analysis results.** As the analysis is repeated, a trend of results may become apparent that leads to conclusions affecting risk responses (Section 11.5).

11.5 RISK RESPONSE PLANNING

Risk Response Planning is the process of developing options and determining actions to enhance opportunities and reduce threats to the project's objectives. It follows the qualitative risk analysis and quantitative risk analysis processes. It includes the identification and assignment of individuals or parties (the "risk response owner") to take responsibility for each agreed and funded risk response. Risk Response Planning addresses the risks by their priority, inserting resources and tasks into the budget, schedule and project management plan as needed.

Planned risk responses must be appropriate to the significance of the risk, cost effective in meeting the challenge, timely, realistic within the project context, agreed upon by all parties involved, and owned by a responsible person. Selecting the best risk response from several options is often required.

The risk response planning section presents commonly used approaches to planning responses to the risks. Risks include threats and opportunities that can affect project success, and responses are discussed for each.

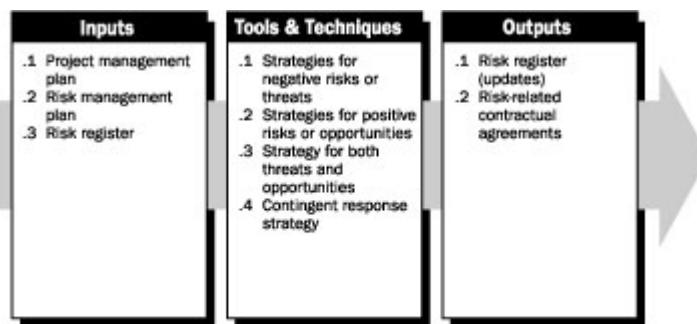


Figure 11-14. Risk Response Planning Overview

11.5.1 Risk Response Planning: Inputs

.1 Project Management Plan

The project management plan (Section 4.5) contains:

- **Risk management plan** (Section 11.1). Important components of the Risk Management Plan for the Risk Response Planning process include the assignment of personnel, risk analysis definitions, risk thresholds for low, moderate, and high risks, time and budget to the conduct of Project Risk Management.
- **Risk register**. The Risk Register is first developed in the risk identification process (Section 11.2) and is updated during Qualitative risk analysis process (Sections 11.3). The risk response planning process may have to refer back to identified risks, root causes of risks, list of potential responses, the risk owners, symptoms and warning signs in developing risk responses. Important inputs to risk response planning from that process include the relative rating or priority list of project risks, list of risks requiring response in the near term, the list of risks for additional analysis and response, the trends in qualitative risk analysis results, root causes, the risks grouped by categories and the watch list of low priority risks. The risk register is further updated during the quantitative risk analysis process (Section 11.4). Outputs from that process that are important inputs to risk

response planning can include the probabilistic analysis of the project, the probability of achieving the cost and time objectives, the prioritized list of quantified risks, and the trends in quantitative risk analysis results.

11.5.2 Risk Response Planning: Tools and Techniques

Several risk response strategies are available. The strategy or mix of strategies most likely to be effective should be selected for each risk. Decision tools such as the decision tree analysis (Section 11.4) can be used to choose the most appropriate responses. Then specific actions should be developed to implement that strategy. Primary and backup strategies may be selected. A fallback plan can be developed to be implemented if the selected strategy turns out not to be fully effective or if an accepted risk occurs. Often a contingency reserve is allocated for time or cost. Finally, contingency plans can be developed along with identification of the conditions that trigger their execution.

.1 Strategies for Negative Risks (Threats)

Three strategies typically deal with threats or risks that may have negative impacts on project objectives if they occur. These strategies are to avoid, transfer, and mitigate.

- **Avoid.** Risk avoidance is changing the project plan to eliminate the threat posed by an adverse risk, to isolate the project objectives from its impact or to relax the objective that is in jeopardy such as by getting more time or reducing scope. Some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise.
- **Transfer.** Risk transference is seeking to shift the negative impact of a threat to a third party together with ownership of the response. Transferring the risk simply gives another party responsibility for its management; it does not eliminate it. Transferring liability for risk is most effective in dealing with financial risk exposure. Risk transference nearly always involves payment of a risk premium to the party taking on the risk. Transference tools include the use of insurance, performance bonds, warranties, and guarantees. Contracts may be used to transfer liability for specified risks to another party. Use of a cost-type contract may transfer the cost risk to the buyer, while a fixed-price contract may transfer risk to the seller if the project's design is stable.
- **Mitigate.** Mitigation seeks to reduce the probability and impacts of an adverse risk event to an acceptable threshold. Taking early action to reduce the probability of a risk occurring or its impact on the project is often more effective than trying to repair the impacts after it has occurred. Adopting less complex processes, conducting more tests, or choosing a more stable supplier are examples of mitigation actions. Mitigation may require prototype development to reduce the risk of scaling up from a bench-scale model or a process or product. Where it is not possible to reduce probability, a mitigation response might address the risk impact by targeting linkages that determine the severity. For example, designing redundancy into a subsystem may reduce the impact that results from a failure of the original component.

.2 Strategies for Positive Risks (Opportunities)

Three responses are suggested to deal with risks with potentially positive impacts on project objectives. These strategies are to exploit, share and enhance.

- **Exploit.** This strategy may be selected for risks with positive impacts where the organization wishes to ensure that the opportunity is realized. The aim of this strategy is to eliminate the uncertainty associated with a particular upside risk by making the opportunity definitely happen. Direct exploiting responses include assigning more talented resources to the project to reduce the time to completion or to provide better quality than originally planned.
- **Share.** Sharing a positive risk involves allocating ownership to a third party who is best able to capture the opportunity for the benefit of the project. Examples of sharing actions include forming risk-sharing partnerships, teams, special-purpose companies or joint ventures, which can be established with the express purpose of managing opportunities.
- **Enhance.** This strategy aims to modify the “size” of an opportunity by increasing probability and positive impacts, and by identifying and maximizing key drivers of these positive-impact risks. Seeking to facilitate or strengthen the cause of the opportunity, proactively targeting and reinforcing its trigger conditions might increase probability. Impact drivers can also be targeted, seeking to increase the project’s susceptibility to the opportunity.

.3 Strategy for Both Threats and Opportunities

Typically, a further strategy of acceptance can be adopted because it is usually impossible to eliminate all risk from the project. This strategy indicates that the project team has decided not to change the project plan to deal with a risk or is unable to identify any other suitable response strategy. It may be adopted for either threats or opportunities. The most common risk acceptance response is to establish a contingency reserve, including amounts of time, money, or resources to handle known or even sometimes potential unknown risks.

.4 Contingent Response Strategy

Some responses are designed for use only if certain events occur. It is appropriate for some risks to make a response plan, but put it on the shelf for later use, if it is believed that there will be sufficient warning to implement the plan. Events that trigger the contingency plan, such as missing intermediate milestones or gaining higher priority with a supplier, should be defined and tracked.

11.5.3 Risk Response Planning: Outputs

.1 Risk Register (Updates)

The risk register has been developed in risk identification and updated during qualitative risk analysis and quantitative risk analysis (Sections 11.2, 11.3 and 11.4). Risk response strategies, once agreed to, must be fed back into the appropriate processes in other knowledge areas including the project’s budget and schedule. The risk register updates become updates to the Project Management Plan (Section 4.3), which is applied in the direct and manage project execution processes (Section 4.5) to ensure that agreed actions are implemented and monitored as part of the ongoing project. In the risk response planning process appropriate responses are chosen, agreed upon, and included in the risk register. The risk register should be written to the level of detail at which the actions will be taken. Often the high and moderate risks are included in detail. Risks judged to be of low priority are included in a “watch list” for periodic monitoring. Components of the risk register at this point can include:

- Identified risks, their descriptions, the area(s) of the project (e.g., WBS element) affected, their causes (e.g., RBS element), and how they may affect project objectives.
- Risk owners and assigned responsibilities.
- Results from the qualitative and quantitative risk analysis processes, including prioritized lists of project risks and probabilistic analysis of the project
- Agreed response strategies.
- Specific actions to implement the chosen response strategy.
- The level of risk expected to be remaining after the actions are implemented.
- Symptoms and warning signs of risks' occurrence.
- Budget and schedule activities required to implement the chosen responses.
- Contingency reserves of time and cost designed to provide for stakeholders' risk tolerances.
- Contingency plans and triggers that call for their execution.
- Fallback plans for use as a reaction to a risk that has occurred.
- Residual risks that are expected to remain after planned responses have been taken, as well as those that have been deliberately accepted.
- Secondary risks that arise as a direct result of implementing a risk response.
- Contingency reserves are calculated based on the quantitative analysis of the project (Section 11.4) and the organization's risk thresholds (Section 11.1).

.2 Risk-Related Contractual Agreements

Contractual agreements, such as agreements for insurance, services, and other items as appropriate, that may be entered into can be prepared to specify each party's responsibility for specific risks, should they occur.

11.6 RISK MONITORING AND CONTROL

Planned risk responses (Section 11.5) that are included in the project management plan are executed (Section 4.4) and the project work can be continuously monitored for new and changing risks.

Risk Monitoring and Control is the process of identifying, analyzing and planning for newly-arising risks, keeping track of the identified risks and those on the watch list, monitoring trigger conditions for contingency plans, monitoring residual risks, and reviewing the execution of risk responses while evaluating their effectiveness. The Risk monitoring and control applies new tools, such as variance and trend analysis, which require the use of performance data generated during project execution (Section 4.4).

Risk monitoring and control is an ongoing process for the life of the project. Other purposes of risk monitoring and control are to determine if:

- Project assumptions are still valid
- Risk, as assessed, has changed from its prior state, with analysis of trends
- Proper risk management policies and procedures are being followed
- Contingency reserves of time, cost and scope should be modified in line with the risks of the project.

Risk monitoring and control can involve choosing alternative strategies, executing a contingency or fallback plan, taking corrective action, and modifying the project management plan. The risk response owner reports periodically to the project manager on

the effectiveness of the plan, any unanticipated effects, and any mid-course correction needed to handle the risk appropriately. Risk monitoring and control also includes updating the organizational process assets (Section 4.1) including project lessons learned databases and risk management templates for the benefit of future projects.

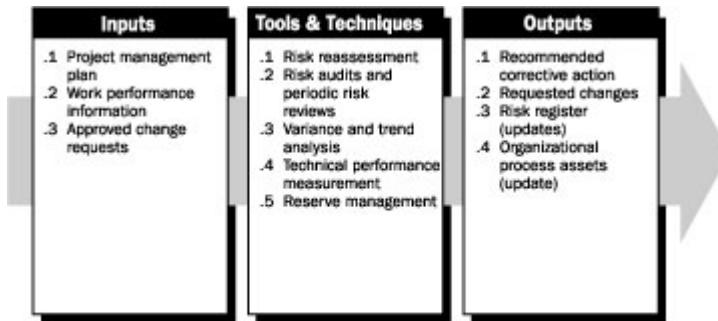


Figure 11-15. Risk Monitoring and Control Overview

11.6.1 Risk Monitoring and Control: Inputs

.1 Project Management Plan

The Project Management Plan (Section 4.3) includes:

- **Risk management plan** (Section 11.1). This plan has key inputs that include the assignment of people, including the risk owners, time and other resources to Project Risk Management.
- **Risk register** (Sections 11.2, 11.3 and 11.4). The risk register has key inputs that include identified risks and risk owners, agreed upon risk responses and specific implementation actions, symptoms and warning signs of risk, residual and secondary risks, watch list of low priority risks and the time and cost contingency reserves.

.2 Work Performance Information

Work performance information (Section 4.4), including project deliverables status, corrective actions, and performance reports (Section 10.3) are important inputs to risk monitoring and control.

.3 Approved Change Requests

Approved change requests (Section 4.6) can include modifications such as work methods, contract terms, scope, and schedule. Approved changes can generate risks or changes in identified risks and those changes need to be analyzed for any effects upon the risk register, risk response plan, or risk management plan. All changes should be formally documented in writing and any verbally discussed but undocumented changes should not be processed or implemented.

11.6.2 Risk Monitoring and Control: Tools and Techniques

.1 Risk Reassessment

Risk monitoring and control often requires identification of new risks and reassessment of risks, using the processes of this chapter as appropriate. The amount and detail of repetition that is appropriate depends on how the project progresses relative to its objectives. For instance, if a risk emerges that was not anticipated in the risk register or

included on the watch list, or if its impact on objectives is different from what was expected, the planned response may not be adequate. It will then be necessary to perform additional response planning to control the risk.

.2 Risk Audits and Periodic Risk Reviews

Risk audits examine and document the effectiveness of risk responses in dealing with identified risks and their root causes, as well as the effectiveness of the risk management process. Project risk reviews should be regularly scheduled. Project Risk Management should be an agenda item at project team progress status meetings.

.3 Variance and Trend Analysis

Trends in the project's execution should be reviewed using performance data. Earned value analysis and other methods of project variance and trend analysis may be used for monitoring overall project performance. Results from these analyses may forecast potential deviation of the project at completion from cost and schedule targets. Deviation from the baseline plan may indicate the potential impact of threats or of opportunities. Earned value analysis is described in Section 7.3.

.4 Technical Performance Measurement

Technical performance measurement compares technical accomplishments during project execution to the project management plan's schedule of technical achievement. Deviation, such as demonstrating more or less functionality than planned at a milestone, can help to forecast the degree of success in achieving the project's scope.

.5 Reserve Management

Throughout execution of the project some risks may occur, with positive or negative impacts on budget or schedule contingency reserves (Section 11.5). Reserve management compares the amount of the contingency reserves remaining to the amount of risk remaining at any time in the project in order to determine if the remaining reserve is adequate or not.

11.6.3 Risk Monitoring and Control: Outputs

.1 Recommended Corrective Actions

Included are contingency plans and workaround plans. The latter are responses which were not initially planned but are required to deal with emerging risks that were previously unidentified or accepted passively. Workarounds must be properly documented and included in the project execution processes. Recommended corrective actions (Section 4.4) are inputs to direct and manage project execution (Section 4.4).

.2 Requested Changes

Implementing contingency plans or workarounds frequently results in a requirement to change the project plan to respond to risks. Requested changes are prepared and submitted as a result of risk monitoring and control activities. Approved change requests (Section 4.6) are issued and become inputs to the direct and manage project execution processes (Section 4.4) and risk monitoring and control.

.3 Risk Register (Updates)

An updated risk register that contains the actual results of the project's risks and of risk responses can help project managers plan for risk throughout the organization and on future projects. This completes the record of risk management on the project and is an input to close project process (Section 4.7) and becomes part of the project closure document (Section 4.7).

.4 Organizational Process Assets (Updates)

The risk management processes produce information that can be used for future projects and should be captured in the organizational process assets (Section 4.1). The templates for the risk management plan, including the probability and impact matrix, and risk register, can be updated at project closure. Risks can be documented and the risk breakdown structure updated. Lessons learned from the Project Risk Management activities can contribute to the lessons learned knowledge database of the organization. Data on the actual costs and durations of project activities can be added to the organization's databases. The final versions of the risk register and the risk management plan templates, checklists, and risk breakdown structures are included.

Chapter 12

Project Procurement Management

Project Procurement Management includes the processes to purchase or acquire the materiel, products, goods, or services needed to perform the work from outside the project team. The project team can be either the buyer of the project or the seller of the project under a contract.

Project Procurement Management includes the contract management and change control processes required to administer contracts or purchase orders issued by the project team.

Project Procurement Management also includes administering any contract issued by an outside organization that is acquiring the project from the project team.

Figure 12-1 provides an overview of the Project Procurement Management processes and Figure 12-2 provides a process flow view of the processes and their inputs, outputs, and related processes from other knowledge areas.

The Project Procurement Management processes include the following:

12.1 Plan Purchases and Acquisitions - determining what to purchase or acquire and when.

12.2 Plan Contracting - documenting materiel, products, goods and services requirements and identifying potential sellers.

12.3 Request Seller Responses - obtaining information, quotations, bids, offers, or proposals, as appropriate.

12.4 Select Sellers - reviewing offers, choosing from among potential sellers, and negotiating a written contract with seller.

12.5 Contract Administration - managing the contract and the relationship between the buyer and the seller, reviewing and documenting how a seller is performing or has performed to establish required corrective actions and provide a basis for future use of the seller, managing contract related changes and, when appropriate, managing the contractual relationship with the outside buyer of the project.

12.6 Contract Closure - completing and settling each contract, including the resolution of any open items.

These processes interact with each other and with the processes in the other knowledge areas as well. Each process involves effort from one or more individuals or groups of individuals, based on the requirements of the project. Although the processes are presented here as discrete elements with well defined interfaces, in practice they overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapters 3 and 4.

The procurement management processes involve contracts that are legal documents between a buyer and a seller. A contract is a mutually binding agreement that obligates the seller to provide the specified materiel, products, goods, or services and obligates the buyer to pay. A contract is a legal relationship subject to remedy in the courts. The agreement can be simple or complex and can reflect the simplicity or complexity of the deliverables. Contracts can also be called, depending upon the application area, an agreement, a subcontract, or a purchase order. Most organizations have documented policies and procedures specifically defining who can sign and administer such agreements on behalf of the organization.

Although all project documents are subject to some form of review and approval, the legally binding nature of a contract usually means that it will be subjected to a more extensive approval process. In all cases, the primary focus of the review and approval process should be to ensure that the contract language describes materiel, products, goods, or services that will satisfy the identified project need. In the case of major projects undertaken by public agencies, the review process can include public review of the agreement.

The project management team may seek support early from specialists in the disciplines of contracting, purchasing and law. Such involvement can be mandated by an organization's policy.

The various activities involved in the Project Procurement Management processes form the life cycle of a contract. By actively managing the contract life cycle some identifiable project risks can be avoided or mitigated. In fact, entering into a contract for products or services is one method of choice to respond to potential risks. A complex project can involve managing multiple contracts or subcontracts simultaneously or in sequence. In such cases, each contract life cycle (see Chapter 2) can end during any phase of the project life cycle.

Project Procurement Management is discussed within the perspective of the buyer-seller relationship. The buyer-seller relationship can exist at many levels on any one project, and between organizations internal to and external to the acquiring organization. Depending on the application area, the seller can be called a contractor, a subcontractor, a vendor, an agency, or a supplier. Depending on the buyer's position in the project acquisition cycle, the buyer can be called the client, the customer, a prime-contractor, a contractor, an acquiring organization, or just a purchaser. The seller can be viewed during the contract life cycle first as a bidder, then as the selected source, and then as the contracted supplier or vendor.

The seller will typically manage the work as a project if the acquisition is not just for materiel, goods, or common products. In such cases:

The buyer becomes the customer, and is thus a key project stakeholder for the seller.

The seller's project management team must be concerned with all the processes of project management, not just with those of this knowledge area.

The terms and conditions of the contract become key inputs to many of the seller's management processes. The contract can actually contain the inputs (e.g., major deliverables, key milestones, cost objectives), or it can limit the project team's options (e.g., buyer approval of staffing decisions is often required on design projects).

This chapter assumes that the buyer of items for the project is within the project team and that the seller is external to the project team. This relationship is true if the project team is either the seller of a project to a customer, or if the project team is the buyer from other vendors or suppliers of materiel, products, goods, services, or subproject components used on a project.

This chapter assumes that a formal contractual relationship is developed and exists between the buyer and the seller. However, most of the discussion in this chapter is equally applicable to non-contractual formal agreements entered into with other units of the project team's organization.

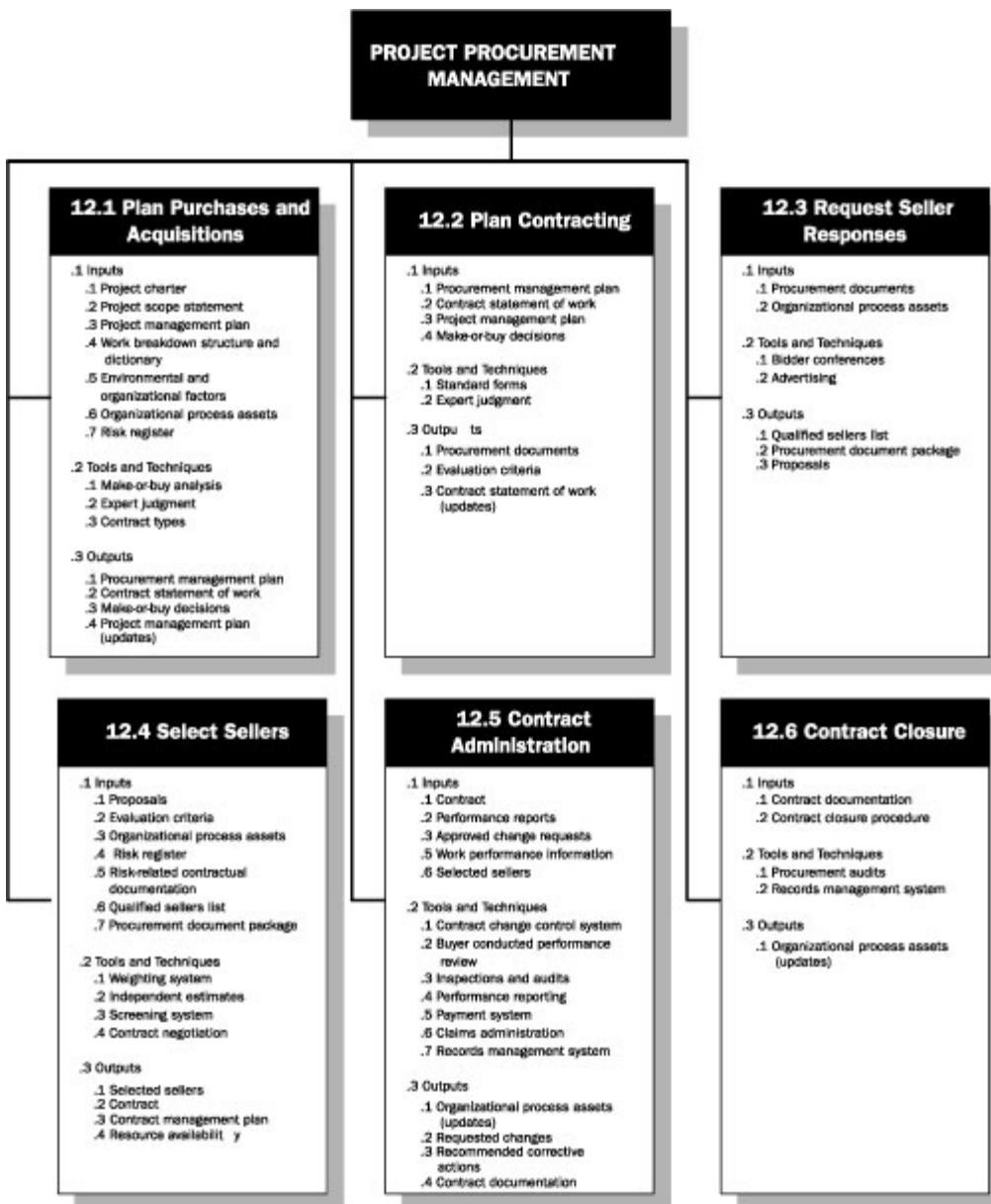


Figure 12.1. Project Procurement Management Overview

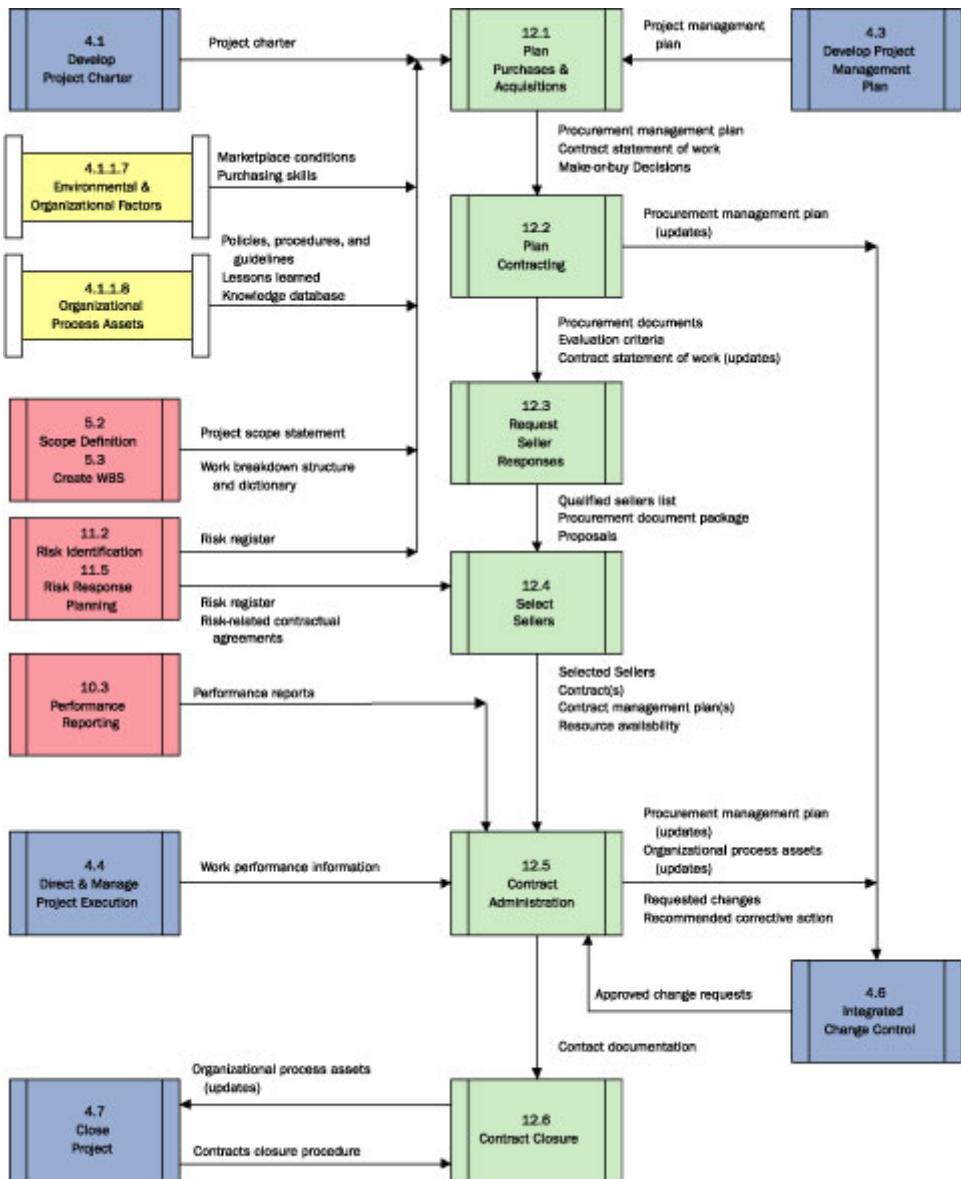


Figure 12-2. Project Procurement Management Process Flow

12.1 PLAN PURCHASES AND ACQUISITIONS

The plan purchases and acquisitions process identifies which project needs can be best met by purchasing or acquiring materiel, products, goods, or services outside the project organization and which should be accomplished by the project team during project execution. This process involves consideration of whether to acquire, how to acquire, what to acquire, how much to acquire, and when to acquire.

When the project obtains materiel, products, goods, and services required for project performance from outside the performing organization, the processes from develop procurement documentation (Section 12.2) through contract closure (Section 12.7) should be performed for each purchased or acquired item.

Procurement planning should also include consideration of potential sellers (Section 12.3), particularly if the buyer wishes to exercise some degree of influence or control over contracting decisions.

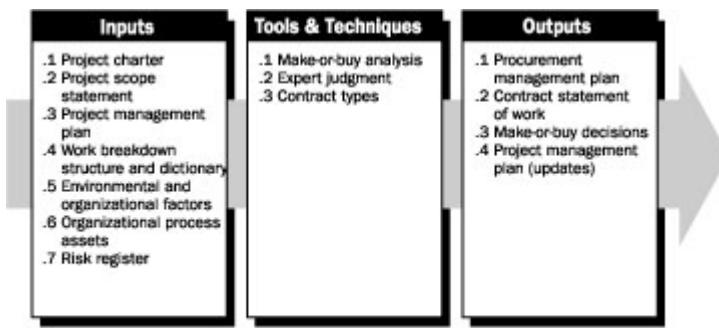


Figure 12-3. Plan Purchases and Acquisitions Overview

12.1.1 Plan Purchases and Acquisitions: Inputs

.1 Project Charter

The project charter (Section 4.1) describes the business needs and can include constraints, assumptions, and requirements for the project. Constraints are specific factors that can limit both the buyer's and seller's options. One of the most common constraints for many projects is funds availability. Other constraints can involve required delivery dates, available skilled resources, and organizational policies. Assumptions are factors that, for procurement planning purposes, will be considered to be true and which can include items such as the assumed availability of multiple suppliers. Requirements with contractual and legal implications can include health, safety, security, performance, environmental, insurance, intellectual property rights, equal employment opportunity, licenses, and permits.

.2 Project Scope Statement

The project scope statement (Sections 4.2 and 5.2) describes the project boundaries. The project scope description provides important information about project needs and strategies that must be considered during procurement planning. The project scope description also provides constraints and assumptions related to project scope, the list of deliverables, and acceptance criteria for the project and its products and services. Consideration is given to all such factors that need to be included in the procurement documentation and flowed down to sellers.

The product scope description (Section 5.2) provides important information about any technical issues or concerns related to the products and services of the project that need to be considered during procurement planning.

.3 Project Management Plan

The project management plan (Section 4.3) provides the overall plan for managing the project and includes subsidiary plans such as a procurement management plan, change control management plan, and overall contracts management plan, which provide guidance and direction for procurement management planning. To the extent that other planning outputs are available, those other planning outputs must be considered during procurement planning. Other planning outputs that are often considered include cost estimates (Section 7.1), schedule (Section 6.5), quality management plans (Section 8.1), cash flow projections, identified risks (Section 11.5), and planned staffing (Section 9.1).

.4 Work Breakdown Structure and Dictionary

The project Work Breakdown Structure (WBS) provides the relationship among all the elements of the project and the project deliverables (Section 5.3).

The WBS dictionary and related detailed statements of work (Section 5.3) provide an identification of the deliverables and a description of the work in each WBS element required to produce each deliverable.

.5 Environmental and Organizational Factors

The procurement planning process must consider the conditions of the marketplace and what materiel, products, goods, and services are available in the marketplace, from whom, and under what terms and conditions. If the performing organization does not have formal purchasing or contracting groups, then the project team will have to supply both the resources and the expertise to perform project procurement activities (Section 4.1).

.6 Organizational Process Assets

The existing formal and informal procurement related policies, procedures, guidelines, and management systems must be considered in developing the procurement management plan and selecting the contract types to be used (Section 4.1).

.7 Risk Register

The risk register contains risk related information such as, the identified risks, root causes of risks, risk owners, risk analyses results, risk prioritization, risk categorization, and risk responses generated by the risk management processes (Sections 11.2, 11.3, 11.4, and 11.5). Risks must be addressed in procurement planning.

12.1.2 Plan Purchases and Acquisitions: Tools and Techniques

.1 Make-or-Buy Analysis

The make-or-buy analysis is a general management technique and a part of the scope definition process that can be used to determine whether a particular product can be produced by the project team or should be purchased. If a buy decision is to be made then a further decision of whether to purchase or rent must also be made. Analysis should include both indirect as well as direct costs. For example, the buy-side of the analysis should include both the actual out-of-pocket costs to purchase the product as well as the indirect costs of managing the purchasing process.

In a make-or-buy analysis, if a buy decision is to be made it must also reflect the perspective of the project team's organization as well as the immediate needs of the project. For example, purchasing an item (anything from a construction crane to a personal computer) rather than renting or leasing it may or may not be cost effective from the perspective of the project. However, if the

project team's organization has an ongoing need for the item, the portion of the purchase cost allocated to the project can be less than the cost of the rental. The cost allocation could be based upon a margin analysis.

The long-range strategy of the project team's organization is also an element in the make-or-buy analysis. Items needed for the performance of the project may not be available within the organization, however, the organization anticipates future requirements for those items and the organization's plans are based on making the items in the future. Such considerations can lead to a make decision in spite of the current project constraints and requirements. When this occurs the costs charged to the project can be less than the actual costs with the difference representing the organization's investment for the future.

.2 Expert Judgment

Expert technical judgment will often be required to assess the inputs to and outputs from this process. Expert purchasing judgment can also be used to develop or modify the criteria that will be used to evaluate offers or proposals made by sellers. Expert legal judgment may involve the services of a lawyer to assist with non-standard procurement terms and conditions. Such judgment and expertise can be applied to both the technical details of the procured products or services and to various aspects of the procurement management processes.

.3 Contract Types

Different types of contracts are more or less appropriate for different types of purchases. Contracts generally fall into one of three broad categories:

- **Fixed-price or lump-sum contracts.** This category of contract involves a fixed total price for a well-defined product. Fixed-price contracts can also include incentives for meeting or exceeding selected project objectives, such as schedule targets. The simplest form of a fixed-price contract is a purchase order.
- **Cost-reimbursable contracts.** This category of contract involves payment (reimbursement) to the seller for seller's actual costs, plus a fee typically representing seller profit. Costs are usually classified as direct costs or indirect costs. Direct costs are costs incurred for the exclusive benefit of the project (e.g., salaries of full-time project staff). Indirect costs, also called overhead and general and administrative costs, are costs allocated to the project by the project team as a cost of doing business (e.g., salaries of management indirectly involved in the project, cost of electric utilities for the office). Indirect costs are usually calculated as a percentage of direct costs. Cost-reimbursable contracts often include incentive clauses where if the seller meets or exceeds selected project objectives, such as schedule targets or total cost, then the seller is receives an incentive or bonus payment.
- **Time and Material (T&M) contracts.** T&M contracts are a hybrid type of contractual arrangement that contains aspects of both cost-reimbursable and fixed-price type arrangements. T&M contracts resemble cost-reimbursable type arrangements in that they are open ended, because the full value of the arrangement is not defined at the time of the award. Thus, T&M contracts can grow in contract value as if they were cost-reimbursable type arrangements. Conversely, T&M arrangements can also resemble fixed-price arrangements. For example, unit rates are preset by the buyer and seller, when both parties agree on the rates for the senior engineer category, or when the contract contains a not-to-exceed cost clause.

The requirements (e.g., standard or custom product version, performance reporting, cost data submittals) that a buyer imposes on a seller along with other considerations such as the degree of market competition will also determine which type of contract will be used. In addition, the seller

can consider some of those specific requirements as items that have additional costs. Another consideration relates to the future potential sale of the product or service being acquired by the project team. Where such potential can be significant, sellers may be inclined or induced to charge prices that are less than would be the case without such future sale potential. While this can reduce the costs to the project, there are legal ramifications if the buyer promises such potential and it is not, in fact, realized.

12.1.3 Plan Purchases and Acquisitions: Outputs

.1 Procurement Management Plan

The procurement management plan should describe how the procurement processes (from developing procurement documentation through contract closure) will be managed. For example:

- Which types of contracts will be used?
- If independent estimates will be needed as evaluation criteria, who will prepare them and when?
- If the performing organization has a procurement, contracting, or purchasing department, what actions can the project management team take on its own?
- If standardized procurement documents are needed, where can they be found?
- How will multiple providers be managed?
- How will procurement be coordinated with other project aspects, such as scheduling and performance reporting?
- What constraints and assumptions could affect planned purchases and acquisitions?
- A procurement management plan can be formal or informal, can be highly detailed or broadly framed, and is based upon the needs of the project. The procurement management plan is a subsidiary element of the project management plan (Section 4.3).

.2 Contract Statements of Work

The statement of work (SOW) for the contract is developed from the project scope statement, the project work breakdown structure (WBS), and WBS dictionary. The SOW describes the procurement item in sufficient detail to allow prospective sellers to determine if they are capable of providing the item. Sufficient detail can vary, based on the nature of the item, the needs of the buyer, or the expected contract form. A SOW describes the materiel, products, goods or services to be supplied by the seller. Information included in a SOW can include specifications, quantity desired, quality levels, performance data, period of performance, work location, and other requirements.

The SOW should be clear, complete, and concise. It should include a description of any collateral services required, such as performance reporting or post project operational support for the procured item. In some application areas, there are specific content and format requirements for a SOW. Each individual procurement item requires a SOW. However, multiple products or services can be grouped as one procurement item within a single SOW.

The SOW can be revised and refined as required as it moves through the procurement process until incorporated into a signed contract. For example, a prospective seller can suggest a more efficient approach or a less costly product than that originally specified.

.3 Make-or-Buy Decisions

The documented decisions of what project materiel, products or services will be either be acquired or will be developed by the project team. The make-or-buy decisions document can be as simple as a listing that includes a short justification for the decision. These decisions can be iterative as subsequent procurement activities indicate a need for a different approach.

.4 Project Management Plan (Updates)

The project management plan is updated to reflect changes and additions resulting from the procurement planning. Requested changes (additions, modification, revisions) to the project management plan and its subsidiary plans are processed through integrated change control (Section 4.6).

12.2 PLAN CONTRACTING

The plan contracting process prepares the documents needed to support the request seller responses process and select sellers process (Sections 12.3 and 12.4).

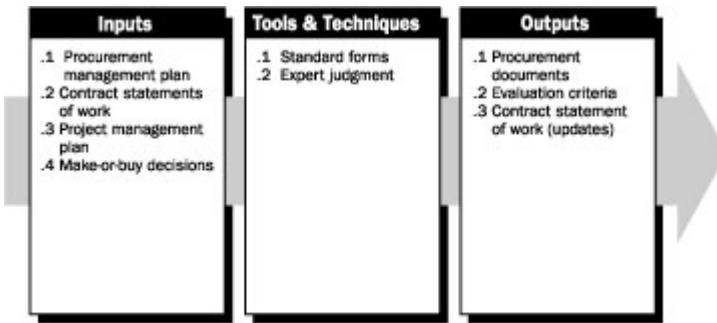


Figure 12-4. Plan Contracting Overview

12.2.1 Plan Contracting: Inputs

.1 Procurement Management Plan

Described in Section 12.1.

.2 Contract Statements of Work

Described in Section 12.1.

.3 Project Management Plan

Other planning output documents (Section 4.3), which have been modified, should be reviewed again as part of the procurement documentation development. In particular, development of procurement documentation should be closely aligned with the project schedule.

.4 Make-or-Buy Decisions

The issued list of items to purchased or acquired and those items to be produced by the project team (Section 12.1).

12.2.2 Plan Contracting: Tools and Techniques

.1 Standard Forms

Standard forms include standard contracts, standard descriptions of procurement items, proposal evaluation criteria checklists, or standardized versions of all or part of the needed bid documents (Section 12.2). Organizations that perform substantial amounts of procurement can have many of these documents standardized.

.2 Expert Judgment

Described in Section 12.1.

12.2.3 Plan Contracting: Outputs

.1 Procurement Documents

Procurement documents are used to seek proposals from prospective sellers. A term such as bid, tender, or quotation is generally used when the source selection decision will be based on price (as when buying commercial or standard items), while a term such as proposal is generally used when other considerations, such as technical skills or technical approach, are paramount. However, the terms are often used interchangeably, and care should be taken not to make unwarranted assumptions about the implications of the term used. Common names for different types of procurement documents include: Invitation for Bid (IFB), Request for Proposal (RFP), Request for Quotation (RFQ), Tender Notice, Invitation for Negotiation, and Contractor Initial Response.

The buyer should structure procurement documents to facilitate an accurate and complete response from each prospective seller and to facilitate easy evaluation of the bids. These documents should always include the relevant SOW, a description of the desired form of the response, and any required contractual provisions (e.g., a copy of a model contract, nondisclosure provisions). With government contracting, some or all of the content and structure of procurement documents can be defined by regulation.

Procurement documents should be rigorous enough to ensure consistent, comparable responses, but flexible enough to allow consideration of seller suggestions for better ways to satisfy the requirements. Inviting the sellers to submit a proposal that is wholly responsive to the request for bid, and to provide a proposed alternative solution in a separate proposal can do this.

Issuing a request to potential sellers to submit a proposal or bid should be done formally in accordance with the project team's organization's policies, which can include publication of the request in public newspapers, in magazines, in public registries, or on the Internet.

.2 Evaluation Criteria

Evaluation criteria are used to rate or score proposals. They can be objective (e.g., "The proposed project manager must be a certified Project Management Professional, PMP®.") or subjective (e.g., "The proposed project manager must have documented previous experience with similar projects."). Evaluation criteria are often included as part of the procurement documents.

Evaluation criteria can be limited to purchase price if the procurement item is readily available from a number of acceptable sources. Purchase price in this context includes both the cost of the item and ancillary expenses such as delivery.

Other selection criteria can be identified and documented to support an assessment for a more complex product or service. For example:

- Understanding of need - is demonstrated by how well the seller's proposal addresses the contract statement of work.
- Overall or life-cycle cost - will the selected seller produce the lowest total cost (purchase cost plus operating cost)?
- Technical capability - does the seller have, or can the seller be reasonably expected to acquire, the technical skills and knowledge needed?
- Management approach - does the seller have, or can the seller be reasonably expected to develop, management processes and procedures to ensure a successful project?
- Technical approach – does the seller's proposed technical methodologies, techniques, solutions, and services meet the procurement documentation requirements or are they likely to provide more than the expected results?
- Financial capacity - does the seller have, or can the seller reasonably be expected to obtain, the necessary financial resources?
- Production capacity and interest – does the seller have the capacity and interest to meet potential future requirements?

- Proprietary rights – does the seller assert proprietary rights in the work processes or services they will use or in the products they will produce for the project.

These types of evaluation criteria, when used in a formalized source selection, are assigned predefined weightings with respect to each other. These types of evaluation criteria can also involve both objective and subjective elements. The proposal evaluation inputs from multiple reviewers should be obtained during the proposal evaluation process and any significant differences in scoring resolved. Overall assessment of an offer can then be based upon the total weighted score for the proposal.

.3 Contract Statement of Work (Updates)

The contract statement of work is described in Section 12.1. Modifications to one or more contract statements of work can be identified during procurement documentation development.

12.3 REQUEST SELLER RESPONSES

The request seller responses process obtains responses, such as bids and proposals, from prospective sellers on how project needs can be met. The prospective sellers, normally at no direct cost to the project or buyer, expend most of the actual effort in this process.

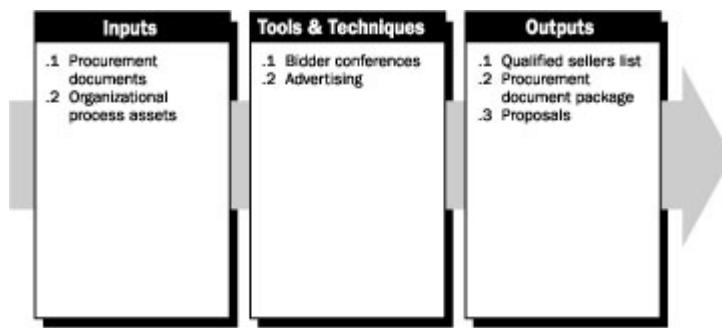


Figure 12-5. Request Seller Responses Overview

12.3.1 Request Seller Responses: Inputs

.1 Procurement Documents

Described in Section 12.2.

.2 Organizational Process Assets

Some organizations maintain lists or files with information on prospective and previously qualified sellers (Section 4.1), sometimes called bidders, who can be asked to bid, propose, or quote on work. These lists will generally have information on relevant past experience and other characteristics of the prospective sellers. Some organizations maintain preferred sellers list that include only sellers already selected through some qualification methodology.

If such lists are not readily available, then the project team will develop its own sources. General information is widely available through the Internet, library directories, relevant local associations, trade catalogs, and similar sources. Detailed information on specific sources can require more extensive effort, such as site visits or contact with previous customers. Procurement documents can also be sent to determine if some or all of the prospective sellers have an interest in becoming a qualified potential seller (Section 4.1).

12.3.2 Request Seller Responses: Tools and Techniques

.1 Bidder Conferences

Bidder conferences (also called contractor conferences, vendor conferences, and pre-bid conferences) are meetings with prospective sellers prior to preparation of a proposal. They are used to ensure that all prospective sellers have a clear, common understanding of the procurement (e.g., technical requirements, and contract requirements). Responses to questions can be incorporated into the procurement documents as amendments. All potential sellers should be given equal standing during this initial buyer and seller interaction.

.2 Advertising

Existing lists of potential sellers can often be expanded by placing advertisements in general circulation publications such as newspapers or in specialty publications such as professional journals. Some government jurisdictions require public advertising of certain types of procurement items; most government jurisdictions require public advertising of pending government contracts.

12.3.3 Request Seller Responses: Outputs

.1 Qualified Sellers List

Qualified sellers who are asked to submit a proposal or quotation.

.2 Procurement Document Package

The procurement document package is a buyer prepared formal request sent to each seller and is the basis upon which a seller prepares a bid for the requested materiel, products, goods, or services that are defined and described in the procurement documentation.

.3 Proposals

Proposals (Section 12.2) are seller-prepared documents that describe the seller's ability and willingness to provide the requested materiel, products, goods, or services described in the procurement documentation. Proposals are prepared in accordance with the requirements of the relevant procurement documents and should reflect the application of applicable contract principles. The seller's proposal should constitute a formal and legal offer to buyer's request. The seller is sometimes requested by the buyer to supplement their proposals with an oral presentation to provide additional evaluation input with respect to the seller's proposed staff and technical proposal.

12.4 SELECT SELLERS

The select seller process receives bids or proposals and applies evaluation criteria to select a successful seller. Aside from cost or price, many factors such as the following can be evaluated in the source selection decision process:

Price can be the primary determinant for an off-the-shelf item, but the lowest proposed price may not be the lowest cost if the seller proves unable to deliver the materiel, products, goods, or services in a timely manner.

Proposals are often separated into technical (approach) and commercial (price) sections with each evaluated separately. Sometimes management sections are required as part of the proposal and also have to be evaluated.

Multiple sources could be required for critical materiel, products, goods, and services to mitigate risks associated with that can be associated with issues such as delivery schedules and quality requirements. The potentially higher cost associated with such multiple sources, including any loss of possible quantity discounts should be considered.

The tools and techniques described here can be used singly or in combination. For example, a weighting system can be used to:

- Select a single source that will be asked to sign a standard contract

- Establish a negotiating sequence by ranking all proposals by the weighed evaluation scores assigned to each proposal.

On major procurement items, the overall process or requesting responses from sellers and evaluating seller's responses can be repeated. A short list of qualified sellers can be established based on a preliminary proposal. A more detailed evaluation can then be conducted based on a more detailed and comprehensive proposal that is requested from the sellers on the short list.

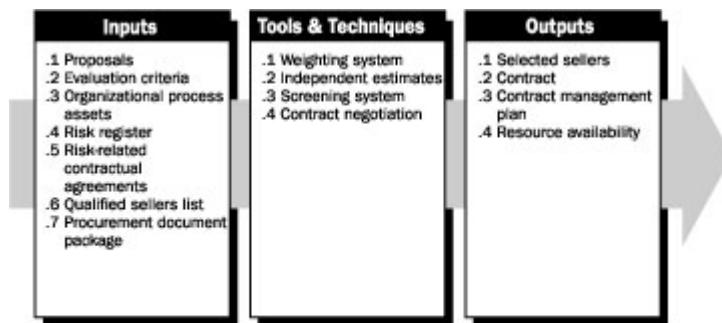


Figure 12-6. Select Sellers Overview

12.4.1 Select Sellers: Inputs

.1 Proposals

Described in Section 12.3.

.2 Evaluation Criteria

Evaluation criteria (Section 12.2) can include samples of the suppliers previously produced materiel, products, goods, or services for the purpose of providing a way to evaluate their capabilities and quality of products. They also can include a review of the supplier's history with the contracting organization.

.3 Organizational Process Assets

Organizations involved in project procurement typically have formal policies that affect the evaluation of proposals (Section 4.1).

.4 Risk Register

The risk register contains risk related information such as, the identified risks, root causes of risks, risk owners, risk analyses results, risk prioritization, risk categorization, and risk responses generated by the risk management processes (Section 11.5). Identified risks and planned responses need to be addressed in preparing and issuing contracts.

.5 Risk-Related Contractual Agreements

Contractual agreements, such as agreements for insurance, services, and other items as appropriate, are prepared to specify each party's responsibility for specific risks, should they occur (Section 11.5).

.6 Qualified Sellers List

Described in Section 12.3.

.7 Procurement Document Package

Described in Section 12.3.

12.4.2 Select Sellers: Tools and Techniques

.1 Weighting System

A weighting system is a method for quantifying qualitative data to minimize the effect of personal prejudice on source selection. Most such systems involve: a) assigning a numerical weight to each of the evaluation criteria, b) rating the prospective sellers on each criterion, c) multiplying the weight by the rating, and d) totaling the resultant products to compute an overall score.

.2 Independent Estimates

For many procurement items, the procuring organization can prepare its own independent estimates of the costs as a check on proposed pricing. Significant differences from these cost estimates can be an indication that the contract statement of work was not adequate, or that the prospective seller either misunderstood or failed to respond fully to the contract statement of work.

.3 Screening System

A screening system involves establishing minimum requirements of performance for one or more of the evaluation criteria and can employ a weighting system and independent estimates. For example, a prospective seller might be required to propose a project manager, who has specific qualifications before the remainder of the proposal would be considered.

.4 Contract Negotiation

Contract negotiation clarifies the structure and requirements of the contract so that mutual agreement can be reached prior to signing the contract. Final contract language should reflect all agreements reached. Subjects covered include responsibilities and authorities, applicable terms and law, technical and business management approaches, proprietary rights, contract financing, technical solution, overall schedule, and price. Contract negotiations conclude with a document that can be signed by both buyer and seller, i.e., the contract. The final contract can be a revised offer by the seller or a counter offer by the buyer.

For complex procurement items, contract negotiation can be an independent process with inputs (e.g., an issues or open items list) and outputs (e.g., memorandum of understanding) of its own. For simple procurement items the terms and conditions of the contract can be fixed and non-negotiable and only need to be accepted by the seller.

12.4.3 Select Sellers: Outputs

.1 Selected Sellers

The sellers selected are those sellers who have been judged to be in a competitive range based upon the outcome of the screening system process, and who have negotiated a draft contract, which will be the actual contract when an award is made.

.2 Contract

A contract awarded to each successful seller. The contract can be in the form of a complex document or a simple purchase order. Regardless of the documents complexity a contract is a mutually binding legal agreement that obligates the seller to provide the specified materiel, products, goods, or services and obligates the buyer to pay for it. A contract is a legal relationship subject to remedy in the courts. The major elements in a contract document generally include, but are not limited to: section headings, statement of work, schedule, period of performance, roles and responsibilities, pricing and payment, inflation adjustments, acceptance criteria, warranty, product support, limitation of liability, fees, penalties, incentives, insurance, performance bonds, subcontractor approval, change request handling, termination, and disputes resolution mechanism.

.3 Contract Management Plan

For significant purchases or acquisitions, a plan to administer the contract is prepared based upon the specific buyer-specified items within the contract such as documentation, delivery, and performance

requirements that the seller must meet. Each contract management plan is a subset of the project management plan.

.4 Resource Availability

The quantity and availability of resources obtained through purchasing and acquisition are documented.

12.5 CONTRACT ADMINISTRATION

Both the buyer and the seller administer the contract for similar purposes. Each party needs to ensure that the other party meets their contractual obligations and that their own legal rights are protected. The contract administration process ensures that the seller's performance meets contractual requirements and that the buyer performs according to the terms of the contract. On larger projects with multiple materiel, products, goods, and services providers, a key aspect of contract administration is managing the interfaces among the various providers. The legal nature of the contractual relationship makes it imperative that the project team is acutely aware of the legal implications of actions taken when administering any contract. Because of the legal considerations, many organizations treat contract administration as an administrative function separate from the project organization. While a contract administrator may be on the project team, they usually report to a function in the performing organization different from the project organization. This is usually true if the performing organization is also the seller of the project to an external customer.

Contract administration includes application of the appropriate project management processes to the contractual relationship(s) and integration of the outputs from these processes into the overall management of the project. This integration and coordination will often occur at multiple levels when there are multiple sellers and multiple products or services involved. The project management processes that must be applied include, but are not limited to:

- Project management plan execution (Section 4.4), to authorize the contractor's work at the appropriate time
- Performance reporting (Section 10.3), to monitor contractor cost, schedule, and technical performance
- Quality control (Section 8.3), to inspect and verify the adequacy of the contractor's product
- Change control (Section 4.6), to assure that changes are properly approved and that all those with a need to know are aware of such changes
- Risk monitoring and control (Section 11.6), to ensure that risks are mitigated.

Contract administration also has a financial management component. Payment terms should be defined within the contract and should involve a specific linkage between seller progress and seller compensation.

The contract administration process reviews and documents how well a seller is performing or has performed to the contract and established required corrective actions. Also, the performance is documented as a basis for future use of the seller. Seller performance evaluation by the buyer is primarily carried out to confirm the competency or lack of competency of the seller relative to performing similar work on the project or other projects. Similar evaluations are also carried out when it is necessary to confirm that a seller is not meeting the seller's contractual obligations and when the buyer contemplates corrective actions.

Contracts can be amended any time prior to contract closure by mutual consent in accordance with the change control terms of the contract. Such amendments may not always be equally beneficial to both the seller and the buyer.

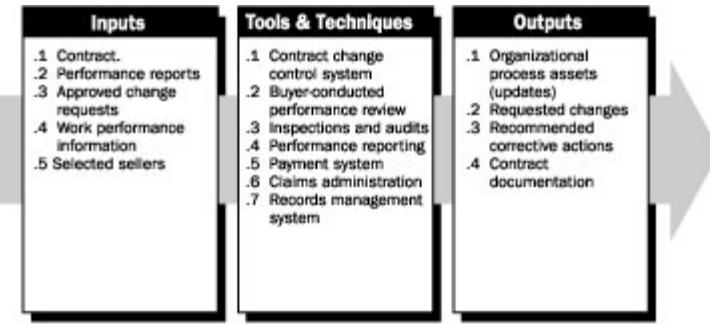


Figure 12-7. Contract Administration Overview

12.5.1 Contract Administration: Inputs

.1 Contract

Described in Section 12.4.

.2 Performance Reports

Seller performance-related documentation includes:

- Seller-developed technical documentation and other deliverables information provided in accordance with the terms of the contract
- Reports on seller performance (Section 10.3).

.3 Approved Change Requests

Requested changes (Section 4.4) and approved changes (Section 4.6.) can include modifications to the terms of the contract or to the description of the materiel, products, goods, or services to be provided. If the seller's work were unsatisfactory, then a decision to terminate the contract would also be handled as a change request. All changes should be formally documented in writing and any verbally discussed but undocumented changes should not be processed or implemented.

Direction may be provided by the buyer or actions may be taken by the seller that the other party considers a constructive change to the contract and that change may be disputed by one party and lead to a claim against the other party and these changes need to be uniquely identified and documented by project correspondence.

.4 Work Performance Information

Work performance information (Section 4.4), including the extent to which quality standards are being met, what costs have been incurred or committed, seller invoices, etc., is collected as part of project execution. The seller must also submit invoices (sometimes called bills or requests for payment) on a timely basis to request payment for work performed. Invoicing requirements, including necessary supporting documentation, are defined within the contract.

The seller's work results, indicating which deliverables have been completed and which have not (Section 4.4).

.5 Selected Sellers

Described in Section 12.4.

12.5.2 Contract Administration: Tools and Techniques

.1 Contract Change Control System

A contract change control system defines the process by which the contract can be modified. It includes the paperwork, tracking systems, dispute resolution procedures, and approval levels necessary for authorizing changes. The contract change control system should be integrated with the integrated change control system (Section 4.6).

.2 Buyer-Conducted Performance Review

A procurement performance review is a structured review of the seller's delivery of the contracted scope to the contracted schedule and quality and for the contracted cost. It can include review of seller prepared documentation and buyer inspections and quality audits conducted during seller's execution of the work. The objective of a performance review is to identify performance successes or failures, progress with respect to the contract statement of work, and contract non-compliances that allow the buyer to quantify the seller's demonstrated ability or inability to perform work.

.3 Inspections and Audits

Inspections and audits (Section 8.2) required to be conducted by the buyer and supported by the seller as specified in the contract documentation can be conducted during execution of the project to identify any weaknesses in the seller's work processes, products, or services. If authorized by contract, some inspection and audit teams can include buyer procurement personnel.

.4 Performance Reporting

Performance reporting provides management with information about how effectively the seller is achieving the contractual objectives. Contract performance reporting should be integrated with the integrated project performance reporting (Section 10.3).

.5 Payment System

Payments to the seller are usually handled by the accounts payable system of the buyer. On larger projects with many or complex procurement requirements, the project can develop its own payment system. In either case, the payment system must include appropriate reviews and approvals by the project management team and payments should be made in accordance with the terms of the contract (Section 4.1).

.6 Claims Administration

Contested changes, those where either the project buyer, or the seller to the performing organization, and the project management team cannot agree on compensation for the change or that a change has even occurred, are variously called claims, disputes, or appeals. These claims are documented, processed, monitored, and managed throughout the contract life cycle, usually in accordance with the terms of the contract. If the parties themselves do not resolve a claim, it may have to be handled in accordance with the dispute resolution procedures established in the contract. These contract clauses can involve arbitration or litigation and can be invoked prior to or after contract closure.

.7 Records Management System

A specific set of processes, related control functions, and automation tools that are consolidated and combined into a whole and used by the project manager to manage contract documentation and records (Section 4.1). The system is used to maintain an index of contract documents and correspondence and assist with retrieving and archiving that documentation.

12.5.3 Contract Administration: Outputs

.1 Organizational Process Assets (Updates)

- **Correspondence.** Contract terms and conditions often require written documentation of certain aspects of buyer/seller communications, such as warnings of unsatisfactory performance and requests for contract changes or clarifications. This can include the reported results of buyer audits and inspections that indicate weaknesses the seller should correct. In addition to specific contract requirements for documentation, a complete and accurate written record of all contract communications, both written and oral, actions taken and decisions made, should be maintained by both parties.

- **Payment schedules and requests.** This assumes that the project is using an external payment system. If the project has its own internal system, the output here would simply be payments.
- **Seller performance evaluation documentation.** Seller performance evaluation documentation is the seller performance evaluation documents prepared by the buyer. The performance evaluations document the seller's ability to continue to perform work on the current contract, indicate if the seller should be allowed to perform work on future projects, or rate how well the seller is performing the project work. These documents can form the basis for early termination of the seller's contract or determining how contract penalties, fees, or incentives are administered. These results of these performance evaluations should also be included in the appropriate qualified seller lists (Section 12.3).

.2 Requested Changes

Requested changes and formally approved changes are fed back through the appropriate project planning and project procurement processes, and the project management plan and relevant contract and project documentation are updated as appropriate. Some approved changes will modify the contract terms and conditions, including the contract statement of work and pricing (Section 4.6).

.3 Recommended Corrective Actions

A recommended corrective action is anything that must be done to bring the seller in compliance with the terms of the contract.

.4 Contract Documentation

Contract documentation includes, but is not limited to, the contract (Section 12.4) itself, along with all supporting schedules, requested unapproved contract changes and approved contract changes (Section 4.6), any seller-developed technical documentation, and other work performance information (Section 4.4), such as deliverables, seller performance reports, warranties, financial documents including invoices and payment records, and the results of contract-related inspections.

12.6 CONTRACT CLOSURE

The contract closure process is similar to administrative closure (described in Section 4.7), in that it involves both project verification (was all work completed correctly and satisfactorily?) and administrative activities (updating of records to reflect final results and archiving of such information for future use). Unresolved claims may be subject to litigation after contract closure (Section 12.5). The contract terms and conditions can prescribe specific procedures for contract closure. Early termination of a contract is a special case of contract closure.

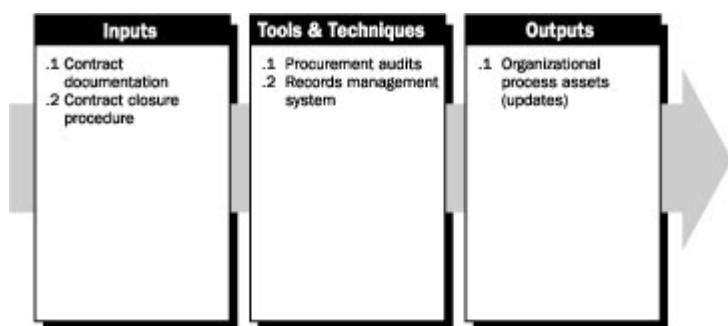


Figure 12-8. Contract Closure Overview

12.6.1 Contract Closure: Inputs

.1 Contract Documentation

Described in Section 12.5.

.2 Contracts Closure Procedure

Described in Section 4.7.

12.6.2 Contract Closure: Tools and Techniques

.1 Procurement Audits

A procurement audit is a structured review of the procurement process from procurement planning through contract administration. The objective of a procurement audit is to identify successes and failures that warrant recognition in the preparation or administration of other procurement contracts on the project or on other projects within the performing organization.

.2 Records Management System

A specific set of processes, related control functions, and automation tools that are consolidated and combined into a whole and used by the project manager to manage contract documentation and records (Section 4.1). Used to maintain an index of contract documents and correspondence and assist with retrieving and archiving that documentation.

12.6.3 Contract Closure: Outputs

.1 Organizational Process Assets (Updates)

- **Contract file.** A complete set of indexed contract documentation should be prepared for inclusion with the final project records (Section 4.7).
- **Deliverable acceptance and closed contracts.** The buyer, usually through its authorized contract administrator, should provide the seller with formal written notice that the contract has been completed and the deliverables have been accepted or rejected (Section 4.7). Requirements for formal deliverable acceptance and contract closure and how to address non-conforming deliverables are usually defined in the contract.
- **Lessons learned documentation.** Lessons learned analysis and process improvement recommendations for future purchasing and acquisition planning and implementation (Section 4.7).

Glossary

1. INCLUSIONS AND EXCLUSIONS

This glossary includes terms that are:

- Unique or nearly unique to project management (e.g., project scope statement, work package, work breakdown structure, critical path method).
- Not unique to project management, but used differently or with a narrower meaning in project management than in general everyday usage (e.g., early start date, schedule activity).

This glossary generally does not include:

- Application area-specific terms (e.g., project prospectus as a legal document—unique to real estate development).
- Terms whose use in project management do not differ in any material way from everyday use (e.g., calendar day, delay).
- Compound terms whose meaning is clear from the combined meanings of the component parts.
- Variants when the meaning of the variant is clear from the base term (e.g., exception report is included, exception reporting is not).

As a result of the above inclusions and exclusions, this glossary includes:

- A preponderance of terms related to Project Scope Management, Project Time Management, and Project Risk Management, since many of the terms used in these knowledge areas are unique or nearly unique to project management.
- Many terms from Project Quality Management, since these terms are used more narrowly than in their everyday usage.
- Relatively few terms related to Project Human Resource Management and Project Communications Management, since most of the terms used in these knowledge areas do not differ significantly from everyday usage.
- Relatively few terms related to Project Cost Management and Project Procurement Management, since many of the terms used in these knowledge areas have narrow meanings that are unique to a particular application area.

2. COMMON ACRONYMS

AC	Actual Cost
ACWP	Actual Cost of Work Performed
AD	Activity Description
ADM	Arrow Diagramming Method
AF	Actual Finish date
AOA	Activity-on-Arrow
AON	Activity-on-Node
AS	Actual Start date
BAC	Budget at Completion
BCWP	Budgeted Cost of Work Performed

BCWS	Budgeted Cost of Work Scheduled
BOM	Bill Of Materials
CAP	Control Account Plan (previously called Cost Account Plan)
CCB	Change Control Board
CPFF	Cost-Plus-Fixed-Fee
CPI	Cost Performance Index
CPIF	Cost-Plus-Incentive-Fee
CPM	Critical Path Method
CV	Cost Variance
DD	Data Date
DU	Duration
DUR	Duration
EAC	Estimate at Completion
EF	Early Finish date
EMV	Expected Monetary Value
ES	Early Start date
ETC	Estimate to Complete
EV	Earned Value
EVM	Earned Value Management
FF	Free Float (or Finish-to-Finish, if used in the context of a lead or a lag)
FFP	Firm Fixed-Price
FPIF	Fixed-Price-Incentive-Fee
FS	Finish-to-Start
IFB	Invitation for Bid
LF	Late Finish date
LOE	Level of Effort
LS	Late Start date
OBS	Organization(al) Breakdown Structure
PC	Percent Complete
PCT	Percent Complete
PDM	Precedence Diagramming Method
PERT	Program Evaluation and Review Technique
PF	Planned Finish date
PM	Project Management or Project Manager
PMBOK®	Project Management Body of Knowledge
PMO	Project Management Office or Program Management Office
PMP®	Project Management Professional
PS	Planned Start date
PV	Planned Value
QA	Quality Assurance
QC	Quality Control
OD	Original Duration
RAM	Responsibility Assignment Matrix
RBS	Risk Breakdown Structure or Resource Breakdown Structure
RFP	Request for Proposal
RD	Remaining Duration

RFQ	Request for Quotation
SF	Scheduled Finish date or Start-to-Finish, if used in the context of a lead or a lag
SOW	Statement of Work
SPI	Schedule Performance Index
SS	Scheduled Start date or Start-to-Start
SV	Schedule Variance
TC	Target Completion date
TF	Total Float or Target Finish date
TQM	Total Quality Management
TS	Target Start date
VE	Value Engineering
WBS	Work Breakdown Structure

3. DEFINITIONS

Many of the words defined here have broader, and in some cases different, dictionary definitions.

The definitions use the following conventions:

- Terms used as part of the definitions and that are defined in the glossary are shown in *italics*.
- When synonyms are included, no definition is given and the reader is directed to the preferred term (i.e., see *preferred term*).
- Related terms that are not synonyms are cross-referenced at the end of the definition (i.e., see also *related term*).

Acceptance Criteria. Those criteria, including performance *requirements* and essential conditions, which must be met before project *deliverables* are accepted.

Accountability Matrix. See *responsibility assignment matrix*.

Acquire Project Team [Process]. The process of obtaining the human resources needed to complete the *project*.

Activity. A component of *work* performed during the course of a *project*. See also *schedule activity*.

Activity Code. One or more numerical or text values that identify characteristics of the work or in some way categorize the *schedule activity* that allows filtering and ordering of activities within reports.

Activity Definition [Process]. The *process* of identifying the specific *schedule activities* that must be performed to produce the various project *deliverables*.

Activity Description (AD). A short phrase or label for each *schedule activity* used in conjunction with an *activity identifier* to differentiate that project activity from other activities. The activity description normally describes the *scope* of work of the activity.

Activity Duration. The time in *calendar* units between the start and finish of a *schedule activity*. See *actual duration*, *original duration*, and *remaining duration*.

Activity Duration Estimating [Process]. The *process* of estimating the number of work periods that will be needed to complete individual *schedule activities*.

Activity Identifier. A short unique numeric or text identification assigned to each *schedule activity* to differentiate that project activity from other activities. Typically unique within any one project schedule network diagram.

Activity List [Output/Input]. A documented tabulation of *schedule activities* that shows the *activity description*, *activity identifier*, and a sufficiently detailed scope of work description so *project team members* understand what *work* is to be performed.

Activity List Attributes [Output/Input]. An extension of the *activity list* that shows the multiple attributes associated with each *schedule activity*. Activity attributes include *activity codes*, *predecessor activities*, *successor activities*, *logical relationships*, *resource requirements*, *imposed dates*, *constraints*, and *assumptions*.

Activity Resource Estimating [Process]. The *process* of estimating the *resources* required for each *schedule activity*.

Activity Sequencing [Process]. The *process* of identifying and documenting inter *schedule activity dependencies*.

Activity-on-Arrow (AOA). See *arrow diagramming method*.

Activity-on-Node (AON). See *precedence diagramming method*.

Actual Cost (AC). Total costs incurred in accomplishing work during a given time period, which can sometimes be direct labor hours alone, direct costs alone, or all costs including indirect costs. More specifically called the actual cost of work performed (ACWP) for an *activity* or *work breakdown structure component*. See also *earned value management*.

Actual Cost of Work Performed (ACWP). See *actual cost (AC)*.

Actual Duration. The time in *calendar* units between the *actual start date* of the *schedule activity* and the *data date* of the *project schedule*.

Actual Finish Date (AF). The point in time that *work* actually ended on a *schedule activity*. (Note: In some application areas, the schedule activity is considered “finished” when work is “substantially complete.”)

Actual Start Date (AS). The point in time that work actually started on a *schedule activity*.

Application Area. A category of *projects* that have common components significant in such projects, but are not needed or present in all projects. Application areas are usually defined in terms of either the product (i.e., by similar technologies or industry sector) or the type of customer or industry sector (i.e., internal versus external, government versus commercial). Application areas can overlap.

Arrow Diagramming Method (ADM) [Technique]. A schedule network diagramming technique in which *schedule activities* are represented by arrows. The tail of the arrow represents the start, and the head represents the finish of the schedule activity (the length of the arrow does not represent the expected duration of the schedule activity). Activities are connected at points called nodes (usually drawn as small circles) to illustrate the sequence in which the activities are expected to be performed. See also *precedence diagramming method*.

Arrow. The graphic presentation of a *schedule activity* also in the *arrow diagramming method* or a *logical relationship* between *schedule activities* in the *precedence diagramming method*.

As-of Date. See *data date*.

Assumptions [Input/Output]. Assumptions are factors that, for planning purposes, are considered to be true, real, or certain without proof or demonstration. Assumptions affect all aspects of *project* planning, and are part of the *progressive elaboration of the project*. *Project teams* frequently identify, document, and validate assumptions as part of their planning process. Assumptions generally involve a degree of *risk*.

Assumptions Analysis [Technique]. A *technique* that explores the accuracy of assumptions and identifies risks to the project from inaccuracy, inconsistency, or incompleteness of assumptions.

Backward Pass. The calculation of *late finish dates* and *late start dates* for the uncompleted portions of all schedule network activities. Determined by working backwards through the schedule *network logic* from the project's *end date*. The end date may be calculated in a *forward pass* or set by the *customer* or *sponsor*. See also *schedule network analysis*.

Bar Chart [Tool]. A graphic display of schedule-related information. In the typical bar chart, schedule *activities* or other *work breakdown structure components* are listed down the left side of the chart, dates are shown across the top, and *activity durations* are shown as date-placed horizontal bars. Also called a Gantt chart.

Baseline Finish Date. The finish date of a schedule activity in the approved project management plan. See also *scheduled finish date*.

Baseline Start Date. The start date of a schedule activity in the approved project management plan. See also *scheduled start date*.

Baseline. The approved time phased plan (for a *project*, a work breakdown structure component, a *work package*, or an *activity*), plus or minus approved scope, cost, schedule, and technical changes. Generally refers to the current baseline, but may refer to the original or some other baseline. Usually used with a modifier (e.g., cost baseline, schedule baseline, performance measurement baseline, technical baseline).

Bill of Materials (BOM). A documented formal hierarchical tabulation of the physical assemblies, subassemblies, and components needed to fabricate a *product*.

Brainstorming [Technique]. A general data gathering and creativity *technique* that can be used to identify *risks* using a group of team members or subject-matter experts. Typically, a brainstorming session is structured so that each participant's ideas are recorded for later analysis. A tool of the *risk identification process*.

Budget. The approved cost estimate for the project or any work breakdown component or any schedule activity. See also *estimate*.

Budget at Completion (BAC). The sum of all the time-phased periodic budget values for a *project* or a *work breakdown structure component* or a *schedule activity*.

Budget Estimate. The approved estimate of the project or any work breakdown component or schedule activity. See also *budget* and *estimate*.

Budgeted Cost of Work Performed (BCWP). See *earned value (EV)*.

Budgeted Cost of Work Scheduled (BCWS). See *planned value (PV)*.

Buffer. See *reserve*.

Buyer. The acquirer of *products*, *materiel*, *goods*, or *services* for an organization.

Calendar. A specific definition of working periods to be applied to the whole project, to some schedule activities, or to some resources.

Calendar Unit. The smallest unit of time used in scheduling the *project*. Calendar units are generally in hours, days, or weeks, but can also be in shifts or even in minutes.

Change Control Board (CCB). A formally constituted group of *stakeholders* responsible for reviewing, evaluating, approving, delaying, or rejecting changes to the *project*, with all decisions and recommendations being recorded.

Change Control System [Tool]. A collection of formal documented *procedures* that define how project *deliverables* and documentation will be controlled, changed, and approved. In most *application areas* the change control system is a subset of the *configuration management system*.

Change Control. Identifying, documenting, approving or rejecting, and controlling changes to the *project baselines*.

Change Request. Requests to expand or reduce the *project scope*, modify policies, *processes*, plans, or *procedures*, modify costs or budgets, or revise schedules. Requests for a change can be direct or indirect, externally or internally initiated, and legally or contractually mandated or optional. Only formally documented change requests are processed and only approved change requests are implemented.

Chart of Accounts [Tool]. Any numbering *system* used to monitor *project costs* by category (e.g., labor, supplies, materials, and equipment). The project chart of accounts is usually based upon the corporate chart of accounts of the primary *performing organization*. See also *code of accounts*.

Charter. See *project charter*.

Checklist [Tool]. Items listed together for convenience of comparison, or to ensure the actions associated with them are managed appropriately and not forgotten.

Close Project [Process]. The *process* of finalizing all *activities* across all of the project process groups to formally close the *project* or *phase*.

Closing Process Group. Those *processes* performed to formally terminate all *activities* of a *project* or *phase*, and transfer the completed *product* to others or close a cancelled *project*.

Code of Accounts [Tool]. Any numbering *system* used to uniquely identify each *component* of the *work breakdown structure*. See also *chart of accounts*.

Co-Location. A location where the *project team members* are physically located in proximity, often in the same room.

Common Cause. A source of variation that is inherent in the *system* and predictable. On a *control chart*, it appears as part of the random process variation i.e., variation from a *process* that would be considered normal or not unusual, and is indicated by a random pattern of points within the *control limits*. Also referred to as Random cause. See also *special cause*.

Communication Management Plan [Output/Input]. The *document* that describes: the communications needs and expectations for the *project*; how and in what format information will be communicated; when and where each communication will be made; and who is responsible for providing each type of communication. A communication management plan can be formal or informal, highly detailed or broadly framed, based on the needs of the project *stakeholders*. The communication management plan is contained in or is a subsidiary plan of the *project management plan*.

Communications Planning [Process]. The *process* of determining the information and communications needs of the project *stakeholders*: who they are, what is their level of

interest and influence on the *project*, who needs what information, when will they need it, and how it will be given to them.

Component. A constituent part, an element, a piece of a complex whole.

Configuration Management System [Tool]. A subsystem of the overall *project management system*. It is a collection of formal documented *procedures* used to apply technical and administrative direction and surveillance to: identify and document the functional and physical characteristics of a *product, result, service, or component*; control any changes to such characteristics; record and report each change and its implementation status; and support the audit of the products, results, or components to verify conformance to *requirements*. It includes the documentation, tracking *systems*, and defined approval levels necessary for authorizing and controlling changes. In most *application areas*, the configuration management system includes the *change control system*.

Constraint [Input]. The state, quality, or sense of being restricted to a given course of action or inaction. An applicable restriction or limitation, either internal or external to the project that will affect the performance of the *project* or a *process*. For example: A schedule constraint is any limitation or restraint placed on the *project schedule* that affects when an *activity* can be scheduled and is usually in the form of fixed *imposed dates*. A cost constraint is any limitation or restraint placed on the *project budget* such as funds available over time. A project *resource* constraint is any limitation or restraint placed on resource usage such as what resource skills or disciplines are available and the amount of a given resource available during a specified time frame.

Contingency. See *reserve* and see also *risk contingency planning*.

Contingency Allowance. See *reserve*.

Contingency Reserve [Output/Input]. The amount of funds or time needed above the *estimate* to reduce the *risk* of overruns of project *objectives* to a level acceptable to the organization.

Contract [Output/Input]. A contract is a mutually binding agreement that obligates the *seller* to provide the specified *product* or *service* and obligates the *buyer* to pay for it.

Contract Administration [Process]. The process of managing the *contract* and the relationship between the *buyer* and the *seller*, reviewing and documenting how a seller is performing or has performed to establish required *corrective actions* and provide a basis for future use of the seller, managing contract related changes and, when appropriate, managing the contractual relationship with the outside buyer of the *project*.

Contract Management Plan [Output/Input]. The *document* that describes how a specific *contract* will be administered and can include items such as required documentation delivery and performance requirements. A contract management plan can be formal or informal, highly detailed or broadly framed, based on the requirements in the contract. Each contract management plan is a subsidiary plan of the *project management plan*.

Contract Closure [Process]. The process of completing and settling the *contract*, including resolution of any open items.

Contract Work Breakdown Structure (CWBS) [Output/Input]. A portion of the *work breakdown structure* for the *project* developed and maintained by a *seller* contracting to provide a *subproject*.

Control Account (CA) [Tool]. Previously called a Cost Account. The CA is a management control point where the integration of *scope* and *budget* and *schedule* takes place, and where the measurement of performance will occur. CAs are placed at selected management points of the *work breakdown structure*. See also *work package*.

Control Account Plan (CAP) [Tool]. Previously called a Cost Account Plan. A plan for all the work and effort to be performed in a control account. Each CAP has a definitive *statement of work*, *schedule*, and time-phased *budget*.

Control Chart [Tool]. A graphic display of process data over time and against established *control limits* and that has a centerline that assists in detecting a trend of plotted values toward either *control limit*.

Control Limits. The area three standard deviations on either side of the centerline, or mean, of a normal distribution of data plotted on a *control chart* that reflects the expected variation in the data. See also *specification limits*.

Control [Technique]. Comparing actual performance with planned performance, analyzing variances, assessing trends to effect process improvements, evaluating possible alternatives, and recommending appropriate *corrective action* as needed.

Controlling. See *control*.

Corrective Action. Documented direction for executing the *project work* to bring expected future performance of the project work in line with the *project management plan*.

Cost. The monetary value or price of a project *activity* or *component* that includes the monetary worth of the *resources* required to perform the activity or produce the component. A specific cost can be composed of a combination of cost components including direct labor hours, other direct costs, indirect labor hours, other indirect costs, and purchased price. (However, in the *earned value management* methodology, in some instances, the term cost can represent only labor hours without conversion to monetary worth.) See also *actual cost* and *estimate*.

Cost Budgeting [Process]. The *process* of aggregating the estimated costs of individual activities or *work packages* to establish a *cost baseline*.

Cost Control [Process]. The *process* of influencing the factors, which create additional costs, and controlling changes to the project budget.

Cost Estimating [Process]. The *process* of developing an approximation of the cost of the *resources* needed to complete *project activities*.

Cost of Quality (COQ). The costs incurred to ensure quality. The cost of quality includes quality planning, quality control, quality assurance, and *rework*. This includes all Price Of Conformance (POC) costs to ensure compliance to requirements (i.e., training, QC systems, etc.) and all Price of Non-Conformance (PONC) costs to fix *products*, *components*, or *processes* that are non-compliant.

Cost Management Plan [Output/Input]. The document that sets out the format and establishes the activities and criteria for planning, structuring, and controlling the *project costs*. A cost management plan can be formal or informal, highly detailed or broadly framed, based on the needs of the project stakeholders. The cost management plan is contained in or is a subsidiary plan of the *project management plan*.

Cost Performance Index (CPI) [Tool]. The cost efficiency ratio of *earned value* to *actual costs*. CPI = EV divided by AC.

Cost Variance (CV) [Tool]. Any difference between the budgeted cost of an *activity*, or the completed portion of an activity, and the actual cost of that activity or its completed portion. CV = EV minus AC.

Cost-Plus-Fixed-Fee (CPFF) Contract. A type of cost-reimbursable *contract* where the *buyer* reimburses the *seller* for the seller's allowable costs (allowable costs are defined by the contract) plus a fixed amount of profit (fee).

Cost-Plus-Incentive-Fee (CPIF) Contract. A type of cost-reimbursable *contract* where the *buyer* reimburses the *seller* for the seller's allowable costs (allowable costs are defined by the contract), and the seller earns its profit if it meets defined performance criteria.

Cost-Reimbursable Contract. A type of *contract* involving payment (reimbursement) by the *buyer* to the *seller* for the seller's actual costs, plus a fee typically representing seller's profit. Costs are usually classified as direct costs or indirect costs. Direct costs are costs incurred for the exclusive benefit of the project, such as salaries of full-time project staff. Indirect costs, also called overhead and genera and administrative cost, are costs allocated to the project by the performing organization as a cost of doing business, such as salaries of management indirectly involved in the project, cost of electric utilities for the office. Indirect costs are usually calculated as a percentage of direct costs. Cost-reimbursable contracts often include incentive clauses where, if the seller meets or exceeds selected project objectives, such as schedule targets or total cost, then the seller receives from the buyer an incentive or bonus payment.

Crashing [Technique]. A specific type of project *schedule compression technique* performed by taking action to decrease the total *project schedule duration* after analyzing a number of alternatives to determine how to get the maximum schedule duration compression for the least additional cost. See *schedule compression* and see also *fast tracking*.

Create WBS (Work Breakdown Structure) [Process]. The *process* of subdividing the major project *deliverables* and project *work* into smaller more manageable *components*.

Criteria. Standards, rules, or tests on which a judgment or decision can be based or by which a *product, service, result, or process* can be evaluated.

Critical Activity. Any *schedule activity* on a *critical path* in a *project schedule*. Most commonly determined by using the *critical path method*. Although some activities are "critical," in the dictionary sense, without being on the critical path, this meaning is seldom used in the project context.

Critical Path [Output/Input]. Generally, but not always, the sequence of *schedule activities* that determines the duration of the *project*. Generally, it is the longest path through the project. However, a critical path can end, as an example, on a *schedule milestone* that is in the middle of the project schedule and that has a finish-no-later-than *imposed date* *schedule constraint*. See also *critical path method*.

Critical Path Method (CPM) [Technique]. A *schedule network analysis technique* used to determine the amount of scheduling flexibility (the amount of *float*) on various logical *network paths* in the *project schedule* network, and to determine the minimum total project *duration*. *Early dates* are calculated by means of a *forward pass*, using a specified *start date*. *Late dates* are calculated by means of a *backward pass*, starting

from a specified completion date, which sometimes is the project *early finish date calculated during the forward pass calculation*.

Current Finish Date. The current *estimate* of the point in time when a *schedule activity* will be completed, where the estimate reflects any reported work progress. See also *scheduled finish date* and *baseline finish date*.

Current Start Date. The current *estimate* of the point in time when a *schedule activity* will begin, where the estimate reflects any reported work progress. See also *scheduled start date* and *baseline start date*.

Customer. The individual or organization that will use the project's *product or service* (See also User).

Data Date (DD). The date at which, or up to which, the project's reporting *system* has provided actual status and accomplishments. Also called *as-of date*.

Decision Tree Analysis [Technique]. The decision tree is a diagram that describes a decision under consideration and the implications of choosing one or another of the available alternatives. It is used when some future scenarios or outcomes of actions are uncertain. It incorporates probabilities and the costs or rewards of each logical path of *events* and future decisions and uses expected monetary value analysis to help the organization identify the relative values of alternate actions. See also *expected monetary value analysis*.

Defect. An imperfection or deficiency in a project *component* where that component does not meet its *requirements* or *specifications* and needs to be either repaired or replaced.

Defect Repair. Formally documented identification of a *defect* in a project *component* with a recommendation to either repair the defect or completely replace the component.

Definitive Estimate. See *estimate*.

Deliverable. Any unique and verifiable *product, result, or capability* to perform a *service* that must be produced to complete a process, phase, or project. Often used more narrowly in reference to an external deliverable, which is a deliverable that is subject to approval by the project sponsor or customer. See also *product, service, and result*.

Dependency. See *logical relationship*.

Design Review [Technique]. A management *technique* used for evaluating a proposed design to ensure that the design of the *system or product* meets the *customer requirements* or to assure that the design will perform successfully, can be produced, and can be maintained.

Develop Project Charter [Process]. The *process* of developing the *project charter* that formal authorizes a project.

Develop Project Management Plan [Process]. The *process* of defining the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans into a *project management plan*.

Develop Project Team [Process]. The *process* of developing the individual and group competencies to enhance *project performance*.

Develop Scope Statement (Preliminary) [Process]. The *process* of developing the preliminary *project scope statement* that provides a high level *scope narrative*.

Direct and Manage Project Execution [Process]. The *process* of executing the *work* defined in the *project management plan* to achieve the project's *objectives* defined in the *project scope statement*.

Discipline. A field of work requiring specific knowledge and that has a set of rules governing work conduct, e.g.; mechanical engineering, computer programming, cost estimating, etc.

Document. A medium and the information recorded thereon, that generally has permanence and can be read by a person or a machine. Examples include *project management plans, specifications, procedures*, studies, and manuals.

Documented Procedure. A formalized written description of how to carry out an *activity, process, technique, or methodology*.

Dummy Activity. A *schedule activity* of zero *duration* used to show a *logical relationship* in the *arrow diagramming method*. Dummy schedule activities are used when logical relationships cannot be completely or correctly described with regular activity *arrows*. Dummies are generally shown graphically as a dashed line headed by an arrow.

Duration Compression [Technique]. See *schedule compression*.

Duration. The number of *work periods* (not including holidays or other nonworking periods) required to complete an *activity* or other *work breakdown structure component*. Usually expressed as workdays or workweeks. Sometimes incorrectly equated with elapsed time. See also *effort*.

Early Finish Date (EF). In the *critical path method*, the earliest possible point in time on which the uncompleted portions of a *schedule activity* (or the *project*) can finish, based on the schedule *network logic*, the *data date*, and any schedule *constraints*. Early finish dates can change as the project progresses and as changes are made to the *project management plan*.

Early Start Date (ES). In the *critical path method*, the earliest possible point in time on which the uncompleted portions of a *schedule activity* (or the *project*) can start, based on the schedule *network logic*, the *data date*, and any schedule *constraints*. Early start dates can change as the project progresses and as changes are made to the *project management plan*.

Earned Value (EV). The value of completed physical work expressed in terms of the approved *budget* assigned to that work. The sum of the approved budgets (may include overhead allocation) for *activities* (or portions of activities) completed during a given period (usually project-to-date). More specifically called the budgeted cost of work performed (BCWP) for an *activity* or *work breakdown structure component*.

Earned Value Management (EVM) [Technique]. A methodology for integrating *scope, schedule, and resources*, and for objectively measuring project performance and progress. Performance is measured by determining the budgeted cost of work performed (i.e., *earned value*) and comparing it the actual cost of work performed (i.e., *actual cost*). Progress is measured by comparing the *earned value* to the budgeted cost of work scheduled (i.e., *planned value*).

Effort. The number of labor units required to complete an *activity* or other *work breakdown structure component*. Usually expressed as staff hours, staff days, or staff weeks. Should not be confused with *duration*.

Environmental and Organizational Factors. Any or all external environmental factors and internal organizational environment factors, from any or all of the organizations involved in the project that surround or influence the project's success. These factors

include organizational culture and structure, infrastructure, existing resources, industry databases, market conditions, available *project management software*.

Estimate [Output/Input]. A quantitative assessment of the likely amount or outcome.

Usually applied to project costs, resources, effort, and durations and is usually preceded by a modifier (i.e. preliminary, conceptual, feasibility, order-of-magnitude, definitive). It should always include some indication of accuracy (e.g., $\pm x$ percent).

Estimate at Completion (EAC) [Output/Input]. The expected total cost of an *activity*, a work breakdown structure component, or the project when the defined *scope of work* is completed. See also *earned value management* and *estimate at completion*.

Estimate to Complete (ETC) [Output/Input]. The expected additional cost needed to complete an *activity*, a group of activities, or the *project*. See also *earned value management* and *estimate at completion*.

Event. Something that happens, an occurrence, an outcome.

Exception Report. Document that includes only major variations from plan (rather than all variations).

Executing Process Group. Those *processes* performed to complete the *work* defined in the *project management plan* to accomplish the project's objectives defined in the project scope statement.

Expected Monetary Values (EMV) Analysis [Technique]. A statistical *technique* that calculates the average outcome when the future includes scenarios that may or may not happen. A common use of this technique is within *decision tree analysis*.

Modeling and simulation is recommended for cost and schedule risk analysis because it is more powerful and less subject to misapplication than EMV.

Expert Judgment [Technique]. Judgment provided based upon expertise in an *application area*, *knowledge area*, *discipline*, industry, etc. as appropriate for the activity being performed. Such expertise may be provided by any group or individual with specialized education, *knowledge*, *skill*, or training, and is available from many sources, including: other units within the performing organization; consultants; *stakeholders*, including *customers*; professional and technical associations; and industry groups.

Failure Mode Effects Analysis (FMEA) [Technique]. An analytical *procedure* in which each potential failure mode in every *component* of a *product* is analyzed to determine its effect on the other components and on the required function of the component; or the examination of a *product* (at the *system* and/or lower levels) for all ways that a failure may occur. For each potential failure, an estimate is made of its effect on the total *system* and of its impact. In addition, a review is undertaken of the action planned to minimize the probability of failure and to minimize its effects.

Fast Tracking [Technique]. A specific project *schedule compression technique* that overlaps phases that would normally be done in sequence, such as design and construction. See *schedule compression* and see also *crashing*.

Finish Date. A point in time associated with a *schedule activity*'s completion. Usually qualified by one of the following: actual, planned, estimated, scheduled, early, late, baseline, target, or current.

Finish-to-Finish. The logical relationship where completion of the work of the *successor schedule activity* cannot finish until the completion of work of the *predecessor schedule activity*. See also *logical relationship*.

Finish-to-Start. The logical relationship where initiation of work of the *successor schedule activity* depends upon the completion of work of the *predecessor schedule activity*. See also *logical relationship*.

Firm Fixed-Price (FFP) Contract. A type of *fixed price contract* where the *buyer* pays the *seller* a set amount (as defined by the *contract*), regardless of the seller's costs.

Fixed-Price or Lump-Sum Contract. A type of *contract* involving a fixed total price for a well-defined *product*. Fixed-price contracts may also include incentives for meeting or exceeding selected *project objectives*, such as schedule targets. The simplest form of a fixed price contact is a purchase order.

Fixed-Price-Incentive-Fee (FPIF) Contract. A type of *contract* where the *buyer* pays the *seller* a set amount (as defined by the *contract*), and the seller can earn an additional amount if the seller meets defined performance *criteria*.

Float. Also called *slack* and *path float*. See *total float* and see also *free float*.

Forecasts. Estimates or predictions of conditions and events in the project's future based on information and knowledge available at the time of the forecast. Forecasts are updated and re-issued based on *work performance information* provided as the project is executed. The information is based on the projects past performance and expected future performance and includes information that could impact the project in the future, such as *estimate at completion* and *estimate to complete*.

Forecast Final Cost. See *estimate at completion*.

Forward Pass. The calculation of the *early start* and *early finish dates* for the uncompleted portions of all network activities. See also *schedule network analysis* and *backward pass*.

Fragnet. Fragment of a project schedule network. See *subnetwork*.

Free Float (FF). The amount of time that a *schedule activity* can be delayed without delaying the early start of any immediately following activities. See also *float* and *total float*.

Functional Manager. Someone with management authority over an organizational unit within a *functional organization*.

Functional Organization. A hierarchical organization where each employee has one clear superior, staff are grouped by areas of specialization, and managed by someone with expertise in that area.

Gantt Chart. See *bar chart*.

Goods. Commodities, wares, merchandise.

Grade. A category or rank used to distinguish items that have the same functional use (e.g., "hammer"), but do not share the same requirements for quality (e.g., different hammers may need to withstand different amounts of force).

Hammock Activity. See *summary activity*.

Hanger. See open end.

Historical Information. Documents and data on prior projects including project files, records, correspondence, closed contracts, and closed projects.

Human Resource Planning [Process]. The *process* of identifying and documenting *project roles*, responsibilities and reporting relationships, as well as creating the *staff management plan*.

Influencer. Individuals or groups that are not directly related to the acquisition or the use of the project's *product*, but due to their position in the *customer* organization can influence, positively or negatively, the course of the *project*.

Influence Diagram [Tool]. Graphical representation of situations showing causal influences, time ordering of *events*, and other relationships among variables and outcomes.

Information Distribution [Process]. The *process* of making needed information available to *project stakeholders* in a timely manner.

Imposed Date. A fixed date imposed on a schedule activity or schedule milestone, usually in the form of a "start no earlier than" and "finish no later than" date.

Initiating Process Group. Those *processes* performed to authorize and define the *scope* of a new *phase* or *project* or that can result in the continuation of halted project *work*. A large number of the initiating processes are typically done outside the project's scope of control by the organization, *program*, or portfolio processes and those processes provide input to the project's initiating processes group.

Initiator. An individual or organization that has both the ability and authority to start a *project*.

Input [Process Input]. Any item, whether internal or external to the project that is required by a *process* before that process proceeds. May be an output from a predecessor process.

Inspection [Technique]. Examining or measuring to verify whether an *activity*, *component*, *product*, *result* or *service* conforms to specified *requirements*.

Integral. Essential to completeness; requisite; constituent with; formed as a unit with another component.

Integrated. Interrelated, interconnected, interlocked, or meshed components blended and unified into a functioning or unified whole.

Integrated Change Control [Process]. The *process* of reviewing all *change requests*, approving changes and controlling changes to *deliverables* and *organizational process assets*.

Integrated Cost/Schedule Reporting. See *earned value management*.

Invitation for Bid (IFB). Generally, this term is equivalent to *request for proposal*. However, in some *application areas*, it may have a narrower or more specific meaning.

Key Event Schedule. See *master schedule*.

Knowledge. Knowing something with the familiarity gained through experience, education, observation, or investigation an understanding a *process*, *practice*, or *technique*, or how to use a *tool*.

Knowledge Area Process. An identifiable project management *process* within a *knowledge area*.

Knowledge Area, Project Management. An identified area of *project management* defined by its *knowledge requirements* and described in terms of its *component processes*, *practices*, *inputs*, *outputs*, *tools*, and *techniques*.

Lag [Technique]. A modification of a *logical relationship* that directs a delay in the *successor schedule activity*. For example, in a *finish-to-start* dependency with a ten-day lag, the successor schedule activity cannot start until ten days after the *predecessor* schedule activity has finished. See also *lead*.

Late Finish Date (LF). In the *critical path method*, the latest possible point in time that a *schedule activity* may be completed based upon the schedule network logic, the project completion date, and any constraints assigned to the schedule activities without violating a schedule constraint or delaying the project completion date. The late finish dates are determined during the *backward pass* calculation of the project schedule network.

Late Start Date (LS). In the critical path method, the latest possible point in time that a *schedule activity* may begin based upon the schedule network logic, the project completion date, and any constraints assigned to the schedule activities without violating a schedule constraint or delaying the project completion date). The late start dates are determined during the *backward pass* calculation of the project schedule network.

Lead [Technique]. A modification of a *logical relationship* that allows an acceleration of the *successor schedule activity*. For example, in a *finish-to-start* dependency with a ten-day lead, the successor *schedule activity* can start ten days before the *predecessor* schedule activity has finished. See also *lag*. A negative lead is equivalent to a positive lag.

Lessons Learned [Input/Output]. The learning gained from the process of performing the project. Lessons learned may be identified at any point. Also considered a project record, to be included in the *lessons learned knowledge base*.

Lessons Learned Knowledge Base. Historical information and *lessons learned* about both the results of previous *project selection* decisions and previous project performance.

Level of Effort (LOE). Support-type *activity* (e.g., *seller* or *customer liaison*, project cost accounting, project management, etc.) that does not readily lend itself to measurement of discrete accomplishment. It is generally characterized by a uniform rate of *work* performance over a period of time determined by the activities supported.

Leveling. See *resource leveling*.

Life Cycle. See *project life cycle*.

Life-Cycle Costing [Technique]. The concept of including acquisition, operating, and disposal costs when evaluating various alternatives.

Line Manager. 1) The manager of any group that actually makes a product or performs a service. 2) A *functional manager*.

Link. See *logical relationship*.

Logic Diagram. See *project schedule network diagram*.

Logic. See *network logic*.

Logical Relationship. A *dependency* between two project *schedule activities*, or between a project *schedule activity* and a *schedule milestone*. See also *precedence relationship*. The four possible types of logical relationships are: *Finish-to Start*; *Finish-to-Finish*; *Start-to-Start*; and *Start-to-Finish*.

Loop. A *schedule network path* that passes the same *node* twice. Loops cannot be analyzed using traditional *schedule network analysis* techniques such as *critical path method*.

Manage Project Team [Process]. The *process* of tracking individual and team performance, providing feedback, resolving issues, and coordinating changes to enhance project performance.

Manage Stakeholders [Process]. The *process* of managing communications to satisfy the needs of and resolve issues with project *stakeholders*.

Master Schedule [Tool]. A summary-level *project schedule* that identifies the major *deliverables* and *work breakdown structure components* and key *schedule milestones*. See also *milestone schedule*.

Materiel. Equipment, apparatus, and supplies used by an organization.

Matrix Organization. Any organizational structure in which the *project manager* shares responsibility with the *functional managers* for assigning priorities and for directing the work of individuals assigned to the *project*.

Methodology. A *system of practices, techniques, procedures, and rules* used by those who work in a *discipline*.

Milestone Schedule. A summary-level *schedule* that identifies the major *schedule milestones*. See also *master schedule*.

Milestone. A significant point or *event* in the *project*, usually completion of a major *deliverable*. See also *schedule milestone*.

Monitor and Control Project Work [Process]. The process of *monitoring* and *controlling* the processes required to initiate, plan, execute, and close a *project* to meet the performance *objectives* defined in the *project management plan* and *project scope statement*.

Monitor [Technique]. Collecting *project* performance data with respect to a plan, producing performance measures, and reporting and disseminating performance information.

Monitoring. See monitor.

Monitoring and Controlling Process Group. Those *processes* performed to measure and *monitor* project execution so that corrective action can be taken when necessary to *control* the execution of the phase or project.

Monte Carlo Analysis [Technique]. A *technique* that computes, or iterates, the *project cost* or *project schedule* many times using input values selected at random from probability distributions of possible costs or durations, to calculate a distribution of possible total project cost or completion dates.

Near-Critical Activity. A *schedule activity* that has low *total float*. The concept of near-critical is equally applicable to a *schedule activity* or *schedule network path*. The limit below which *float* is considered near critical is subject to *expert judgment* and varies from *project* to *project*.

Network Analysis. See *schedule network analysis*.

Network Logic. The collection of *schedule activity* dependencies that makes up a *project schedule network diagram*.

Network Path. Any continuous series of *schedule activities* connected with *logical relationships* in a *project schedule network diagram*.

Network. See *project schedule network diagram*.

Node. One of the defining points of a *schedule network*; a junction point joined to some or all of the other *dependency lines*. See also *arrow diagramming method* and *precedence diagramming method*.

Objective. Something toward which *work* is to be directed, a strategic position to be attained, or a purpose to be achieved, a *result* to be obtained, a *product* to be produced, or a *service* to be performed.

Open End. A *schedule activity* without any *predecessor activities* or *successor activities* creating an unintended break in a schedule *network path*. Open ends are usually caused by missing *logical relationships*.

Operations. An organizational function performing the ongoing execution of *activities* that produce the same *product* or provide a repetitive *service*. Examples are: production operations, manufacturing operations, and accounting operations.

Order-of-Magnitude Estimate. See *estimate*.

Original Duration (OD). The activity duration originally assigned to a schedule activity and not updated as progress is reported on the activity. Typically used for comparison when reporting schedule progress.

Organizational Breakdown Structure (OBS) [Tool]. A hierarchically organized depiction of the project organization arranged so as to relate the *work packages* to the *performing organizational units*.

Organizational Process Assets. Any or all *process* related assets, from any or all of the organizations involved in the *project* that can be or are used to influence the project's success. Process assets include formal and informal plans, policies, *procedures*, guidelines, communications technology, financial *systems*, and management *systems*. Organization process assets also include the organizations' learning and knowledge such as *lessons learned* and *historical information*.

Orphan Activity. See *open end*.

Output [Process Output]. A *product*, *result*, or *service* generated by a *process*. May be an input to a successor process.

Overlap. See *lead*.

Parametric Estimating [Technique]. An estimating *technique* that uses a statistical relationship between historical data and other variables (e.g., square footage in construction, lines of code in software development) to calculate an *estimate*.

Pareto Diagram [Tool]. A histogram, ordered by frequency of occurrence, that shows how many results were generated by each identified cause.

Path Convergence. The merging or joining of parallel schedule *network paths* into the same *node* in a *project schedule network diagram*.

Path Divergence. Extending or generating parallel schedule *network paths* from the same *node* in a *project schedule network diagram*

Path Float. See *total float*.

Path. See *network path*.

Percent Complete (PC). An *estimate*, expressed as a percent, of the amount of *work* that has been completed on an *activity* or a *work breakdown structure component*.

Perform Quality Assurance (QA) [Process]. The *process* of applying the planned, systematic quality *activities* (such as audits or per reviews) to ensure that the *project* will employ all processes needed to meet all stakeholder expectations.

Perform Quality Control (QC) [Process]. The *process* of monitoring specific *project* results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.

Performance Measurement Baseline. An approved plan against which deviations are compared for management *control*.

Performance Reports [Output/Input]. Documents and presentations that provide organized and summarized *work performance information, earned value management* parameters and calculations, and analyses of *project work* progress and status. Common formats for performance reports include *bar charts, S-curves, histograms, tables, project schedule network diagram* showing current schedule status.

Performing Organization. The enterprise whose employees are most directly involved in doing the *work of the project*.

Performance Reporting [Process]. The *process* of collecting and disseminating performance information. This includes status reporting, progress measurement, and forecasting.

Phase. See *project phase*.

Phase Closure. Completing the exit *criteria* of the *project phase*.

Phase Control. Using the monitoring of the project phase execution so that corrective action can be taken when necessary to *control* the *project phase*.

Phase Execution. Completing the *work* defined in the *project management plan* for the *project phase*.

Phase Initiation. Launching a *process* at the beginning of a *project phase* that can result in the continuation of the *project work*.

Phase Planning. Planning the *project activities* within the *project phase*.

Plan Contracting [Process]. The *process* of documenting the *materiel, products, goods, and services* requirements and identifying potential *sellers*.

Plan Purchases and Acquisitions [Process]. The *process* of determining what to purchase or acquire and when.

Planned Finish Date (PF). See *scheduled finish date*.

Planned Start Date (PS). See *scheduled start date*.

Planned Value (PV). The budget authorized for the work scheduled to be accomplished. More specifically called the budgeted cost of work scheduled (BCWS) for an *activity* or *work breakdown structure component*.

Planning Processes Group. Those *processes* performed to define and mature the project scope, develop the *project management plan*, and identify and schedule the project activities that occur within the *project*.

Portfolio. A collection of *projects* or *programs* and other work that are grouped together to facilitate effective management of that *work* to meet strategic business *objectives*. The projects or programs of the portfolio may not necessarily be interdependent or directly related.

Portfolio Management [Technique]. 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*.

Practice. A specific type of professional or management *activity* that contributes to the execution of a *process* and that may employ one or more *techniques* and *tools*.

Precedence Diagramming Method (PDM) [Technique]. A schedule network diagramming *technique* in which *schedule activities* are represented by boxes (or

nodes). Schedule activities are graphically linked by *logical relationships* to show the sequence in which the activities are to be performed.

Precedence Relationship. The term used in the *precedence diagramming method* for a *logical relationship*. In current usage, however, precedence relationship, logical relationship, and *dependency* are widely used interchangeably, regardless of the diagramming method used.

Predecessor Activity. 1) In the *precedence diagramming method*, the schedule activity that determines when the logical *successor activity* can begin or end. 2) In the *arrow diagramming method*, the *schedule activity* that enters a *node*.

Preventive Action. Documented direction to perform an *activity* that can reduce the probability of negative consequences associated with *project risks*.

Probability and Impact Matrix [Tool]. A common way to determine whether a *risk* is considered low, moderate, or high by combining the two dimensions of a risk: its probability of occurrence, and its impact on objectives if it occurs.

Procedure. A series of steps followed in a regular definitive order to accomplish something.

Process. A set of interrelated actions and *activities* performed to achieve a prespecified set of *products, results, or services*.

Process Flow Diagramming [Technique]. The depiction in a diagram format of the inputs, process actions, and outputs of one or more processes within a *system*.

Process Group. One or more *processes* associated by being executed for a similar singular purpose, with that purpose being to initiate, plan, execute, monitor and control, or close a *phase* or a *project*.

Procurement Documents. Those *documents* utilized in bid and proposal activities, which include *buyer's* Invitation for Bid, Invitation for Negotiations, Request for Information, Request for Quotation, Request for Proposal and *seller's* responses.

Procurement Management Plan [Output/Input]. The *document* that describes how procurement *processes* (from developing procurement documentation through *contract closure*) will be managed.

Product Scope. The features and functions that characterize a *product or service*.

Product Scope Description. The documented narrative description of the *product scope*.

Product. An artifact that is produced, is quantifiable, and can be either an end item in itself or a component item. Contrast with *result, service, and deliverable*.

Program. A group of related *projects* managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related *work* outside of the *scope* of the discrete projects in the program.

Program Evaluation and Review Technique (PERT) [Technique]. A technique used to improve the accuracy of the cost or duration estimates of project components when there is uncertainty. PERT uses weighted averages of optimistic, pessimistic, and most likely estimates (the well-known *three-point estimates*) of the components' cost or duration. Different weighting schemes represent different probability distributions of the possible cost or duration of a component. For instance, the typical formula is [(optimistic + 4 times the most likely + pessimistic) divided by 6], which approximates a beta distribution. The formula [(optimistic + most likely + pessimistic) divided by 3] represents the triangular distribution exactly. Estimates using these weighted averages will be more accurate, on average, than the most likely

estimates used alone when the optimistic and pessimistic estimates are not equally distant from the most likely. PERT is not equivalent to, or a substitute for, a quantitative risk analysis of cost or schedule, principally because it does not accurately represent project risk when there is structure in the model, such as with parametric cost estimates or *project schedule network diagrams* with parallel paths and *path convergence points*.

Program Management. The centralized coordinated management of a *program* to achieve the program's strategic *objectives* and benefits.

Program Management Office (PMO). The centralized management of a particular *program* or programs such that corporate benefit is realized by the sharing of *resources, methodologies, tools & techniques*, and related high-level project management focus.

Progressive Elaboration. A characteristic of *projects* that supports the concepts of temporary and unique. Progressive elaboration means developing thoroughly in steps, continuing steadily by increments.

Project. A temporary endeavor undertaken to create a unique *product, service, or result*.

Project Charter [Output/Input]. A *document* issued by the project *initiator* or *sponsor* that formally authorizes the existence of a *project*, and provides the *project manager* with the authority to apply organizational *resources* to project *activities*.

Project Communications Management [Knowledge Area]. See appendix G.

Project Cost Management [Knowledge Area]. See Appendix G.

Project Human Resource Management [Knowledge Area]. See Appendix G.

Project Initiation. Launching a *process* that can result in the authorization and *scope* definition of a new *project*.

Project Initiator. See *initiator*.

Project Life Cycle. A collection of generally sequential *project phases* whose name and number are determined by the control needs of the organization or organizations involved in the *project*. A life cycle can be documented with a *methodology*.

Project Management. The application of *knowledge, skills, tools, and techniques* to project *activities* to meet the project *requirements*.

Project Management Body of Knowledge (PMBOK®). An inclusive term that describes the sum of *knowledge* within the profession of *project management*. As with other professions such as law, medicine and accounting, the body of knowledge rests with the practitioners and academics that apply and advance it. The complete project management body of knowledge includes proven traditional *practices* that are widely applied and innovative practices that are emerging in the profession. The body of knowledge includes both published and unpublished material. The PMBOK® is constantly evolving.

Project Management Information System (PMIS) [Tool]. An information *system* consisting of the tools and techniques used to gather, integrate, and disseminate the outputs of project management processes. It is used to support all aspects of the project from initiating through closing, and can include both manual and automated *systems*.

Project Management Integration [Knowledge Area]. See Appendix G.

Project Management Office (PMO). An organizational body or entity assigned various responsibilities related to the centralized and coordinated management of those

projects under its domain. The responsibilities of a PMO can range from providing project management support functions to actually being responsible for the direct management of a project.

Project Management Plan [Output/Input]. A formal, approved *document* that defines how the project is executed, monitored and controlled. It may be summary or detailed and may be composed of one or more subsidiary management plans and other planning documents.

Project Management Professional (PMP®). An individual certified as such by the Project Management Institute (PMI®).

Project Management Software [Tool]. A class of computer software applications specifically designed to aid the project management team with planning and controlling the project, including: cost estimating, scheduling, communications, collaboration, configuration management; document control, and risk analysis.

Project Management System [Tool]. The *processes, tools, techniques, methodologies, resources, and procedures* to manage a project. The *system* is documented in the *project management plan* and its content will vary depending upon the *application area*, organizational influence, complexity of the project, and the availability of existing *systems*. A project management system, which can be formal or informal, aids a *project manager* in effectively guiding a *project* to completion. A project management system is a set of *processes* and the related monitoring and control functions that are consolidated and combined into a functioning unified whole.

Project Management Team. The members of the *project team* who are directly involved in *project management activities*. On some smaller *projects*, the project management team may include virtually all of the *project team members*.

Project Manager (PM). The individual responsible for managing a *project*.

Project Phase. A collection of logically related *project activities*, usually culminating in the completion of a major *deliverable*. Phases are mainly completed sequentially, but can overlap in some project situations. Phases can be subdivided into *components*, and this hierarchy is often represented in the *work breakdown structure*.

Project Process Groups. The five *process groups* required for any project that have clear dependencies and that are required to be performed in the same sequence on each project, independent of the *application area* or the specifics of the applied *project life cycle*.

Project Procurement Management [Knowledge Area]. See Appendix G.

Project Quality Management [Knowledge Area]. See Appendix G.

Project Risk Management [Knowledge Area]. See appendix G.

Project Schedule [Output/Input]. The planned dates for performing *schedule activities* and the planned dates for meeting *schedule milestones*.

Project Schedule Network Diagram [Output/Input]. Any schematic display of the *logical relationships* among the project *schedule activities*. Always drawn from left to right to reflect project *work chronology*.

Project Scope. The *work* that must be performed to deliver a *product, service, or result* with the specified features and functions.

Project Scope Management [Knowledge Area]. See Appendix G.

Project Scope Statement [Output/Input]. The narrative description of the *project scope*, including major *deliverables*, scope *objectives*, scope *assumptions*, scope *constraints*,

and a *statement of work*, that provides a documented basis for making future project decisions and for confirming or developing a common understanding of *project scope* among the *stakeholders*. The definition of the *project scope* – what needs to be accomplished.

Project Sponsor. See *sponsor*.

Project Stakeholder. See *stakeholder*.

Project Summary Work Breakdown Structure (PSWBS) [Tool]. A *work breakdown structure* for the project that is only developed down to the subproject level of detail within some legs of the WBS and where the detail of those subprojects are provided by use of *contract work breakdown structures (CWBS)*.

Project Team. All the *project team members*, including the *project management team*, the *project manager*, and for some projects the *project sponsor*.

Project Team Members. The people who report either directly or indirectly to the *project manager*, and who are responsible for performing *project work* as a regular part of their assigned duties.

Project Time Management [Knowledge Area]. See Appendix G.

Project Work. See *work*.

Projectized Organization. Any organizational structure in which the *project manager* has full authority to assign priorities and to direct the *work* of individuals assigned to the *project*.

Quality Management Plan [Output/Input]. The quality management plan describes how the *project management team* will implement the *performing organization's* quality policy. The quality management plan is a component or a subsidiary plan of the *project management plan*. The quality management plan may be formal or informal, highly detailed, or broadly framed, based on the *requirements* of the *project*.

Quality Planning [Process]. The *process* of identifying which quality standards are relevant to the *project* and determining how to satisfy them.

Qualitative Risk Analysis [Process]. The *process* of prioritizing *risks* for subsequent further analysis or action by assessing and combining their probability of occurrences and impacts.

Quantitative Risk Analysis [Process]. The *process* of analyzing numerically the effect on overall project *objectives* of identified *risks*.

Regulation. Governmental body imposed *requirements*, which establish *product*, *process* or *service* characteristics, including applicable administrative provisions, that have government mandated compliance.

Reliability. The probability of a *product* performing its intended function under specific conditions for a given period of time.

Remaining Duration (RD). The time in *calendar units*, between the *data date* of the *project schedule* and the *finish date* of the *schedule activity*. This represents the time needed to complete a *schedule activity*.

Request for Information. A type of *procurement document* whereby *buyer* requests a potential *seller* to provide various pieces of information related to a *product* or *service* or seller capability.

Request for Proposal (RFP). A type of *procurement document* used to request proposals from prospective *sellers* of *products* or *services*. In some *application areas*, it may have a narrower or more specific meaning.

Request for Quotation (RFQ). A type of *procurement document* used to request price quotations from prospective *sellers* of common or standard *products* or *services*.

Sometimes used in place of *request for proposal* and in some *application areas*, it may have a narrower or more specific meaning.

Request Seller Responses [Process]. The *process* of obtaining information, quotations, bids, offers, or proposals, as appropriate.

Requirement. A condition or capability that must be met or possessed by a *system*, *product*, *service*, *result*, or *component* to satisfy a *contract*, *standard*, *specification*, or other formally imposed *documents*.

Reserve. A provision in the *project management plan* to mitigate cost and/or schedule *risk*. Often used with a modifier (e.g., management reserve, contingency reserve) to provide further detail on what types of risk are meant to be mitigated. The specific meaning of the modified term varies by *application area*.

Residual Risk. A *risk* that remains after risk responses have been implemented.

Resource. Skilled human resources (specific disciplines either individually or in crews or teams), equipment, *services*, supplies, *commodities*, *materiel*, budgets, or funds.

Resource Constrained Schedule. See *resource-limited schedule*.

Resource Leveling [Technique]. Any form of *schedule network analysis* in which scheduling decisions (start and finish dates) are driven by resource constraints (e.g., limited resource availability or difficult-to-manage changes in resource availability levels).

Resource-Limited Schedule. A *project schedule* whose *activity start and finish dates* reflect expected resource availability. A resource-limited schedule does not have any early or late start or finish dates. The resource-limited schedule float is determined by calculating the difference between the critical path method *late finish date* and the resource limited *schedule finish date*. See also *resource leveling*.

Resource Planning. See *activity resource estimating*.

Responsibility Assignment Matrix (RAM) [Tool]. A structure that relates the project *organizational breakdown structure* to the *work breakdown structure* to help ensure that each component of the project's *scope of work* is assigned to a responsible individual.

Responsibility Chart. See *responsibility assignment matrix*.

Responsibility Matrix. See *responsibility assignment matrix*.

Result. One of the outputs from performing project management *processes* and *activities*. Results include outcomes (e.g., integrated *systems*, revised *process*, restructured organization, tests, trained personnel, etc.) and *documents* (e.g., policies, plans, studies, *procedures*, *specifications*, reports, etc.). Contrast with *product*, *service*, and *deliverable*.

Retainage. A portion of a *contract* payment that is withheld until contract completion to ensure full performance of the contract terms.

Rework. Action taken to bring a defective or nonconforming *component* into compliance with *requirements* or *specifications*.

Risk. An uncertain *event* or condition that, if it occurs, has a positive or negative effect on a *project's objectives*.

Risk Acceptance [Technique]. A risk response planning *technique* that indicates that the *project team* has decided not to change the *project management plan* to deal with a *risk*, or is unable to identify any other suitable response strategy.

Risk Avoidance [Technique]. A risk response planning *technique* that creates changes to the *project management plan* that are meant to either eliminate the risk or to protect the project objectives from its impact.

Risk Breakdown Structure (RBS) [Tool]. A hierarchically organized depiction of the identified project *risks* arranged by *risk category* and sub-category that relates risks to the *project work*.

Risk Category. A source of potential *risk* reflecting technical, *project management*, organizational, or external sources.

Risk Contingency Planning [Technique]. A risk response planning *technique* that develops a plan that identifies alternative strategies to be used to ensure *project* success if specified *risk events* occur.

Risk Database. A repository that provides for collection, maintenance, and analysis of data gathered and used in the risk management *processes*.

Risk Enhancement [Technique]. A risk response planning *technique* that seeks to modify the size of a positive risk by increasing the probability of occurrence and enhancing the positive impacts on the project, and that identifies and maximizes the key drives of those positive impacts.

Risk Exploitation [Technique]. A risk response planning *technique* that seeks to eliminate the uncertainty associated with a positive risk by making the opportunity definitely happen.

Risk Identification [Process]. The *process* of determining which *risks* might affect the *project* and documenting their characteristics.

Risk Management Plan [Output/Input]. The *document* describing how *project risk management* will be structured and performed on the *project*. It is contained in or is a subsidiary plan of the *project management plan*. The risk management plan can be informal and broadly framed, or formal and highly detailed, based on the needs of the project. Information in the risk management plan varies by *application area* and project size.

Risk Management Planning [Process]. The *process* of deciding how to approach, plan, and execute *risk management activities* for a *project*.

Risk Monitoring and Control [Process]. The *process* of tracking identified *risks*, monitoring residual risks, identifying new risks, executing risk reduction plans, and evaluating their effectiveness throughout the *project life cycle*.

Risk Mitigation [Technique]. A risk response planning *technique* that seeks to reduce the probability of occurrence or impact of a risk to below an acceptable threshold.

Risk Register [Output/Input]. The *document* containing the results of the risk analyses, risk prioritization, and planned risk responses. The risk register details all identified *risks*, including description, category, cause, probability of occurring, impact(s) on objectives, proposed responses, owners, and current status. The risk register is a component of the *project management plan*.

Risk Response Planning [Process]. The *process* of developing options and actions to enhance opportunities to reduce threats to *project objectives*.

Risk Sharing [Technique]. A risk response planning *technique* that involves allocating ownership of the risk to a third party who is better able to capture the opportunity for the benefit of the project.

Risk Transference [Technique]. A risk response planning *technique* that seeks to shift the impact of a risk to third party together with ownership of the response.

Schedule Activity. A discrete scheduled component of *work* performed during the course of a *project*. A schedule activity normally has an estimated duration, an estimated cost, and estimated resource requirements. Schedule activities are connected to other activities or milestones with *logical relationships*, and are decomposed from *work packages*.

Schedule Analysis. See Schedule *network analysis*.

Schedule Compression [Technique]. Shortening the *project schedule duration* without reducing the *project scope*. Schedule duration compression is not always possible and often requires an increase in project cost. See also *crashing* and *fast tracking*.

Schedule Control [Process]. The *process* of controlling changes to the *project schedule*.

Schedule Development [Process]. The *process* of analyzing *schedule activity* sequences, schedule activity durations, and *resource requirements* to create the *project schedule*.

Schedule Network Analysis [Technique]. The *process* of identifying early and late start and finish dates for the uncompleted portions of project *schedule activities*. See also *critical path method*.

Schedule Management Plan [Output/Input]. The *document* that establishes *criteria* and the *activities* for developing and controlling the *project schedule*. It is contained in or is a subsidiary plan of the *project management plan*. The schedule management plan may be formal and broadly framed, or formal and highly detailed, based on the needs of the *project*.

Schedule Performance Index (SPI) [Tool]. The schedule efficiency ratio of *earned value* accomplished against the *planned value*. The SPI describes what portion of the planned schedule was actually accomplished. The SPI = EV divided by PV. See also *earned value management*.

Schedule Variance (SV) [Tool]. Any difference between the scheduled completion of a *schedule activity* and the actual completion of that activity. SV = EV minus PV. See also *earned value management*.

Schedule. See *project schedule*.

Scheduled Finish Date (SF). The point in time that *work* was scheduled to finish on a *schedule activity*. The scheduled finish date is normally within the range of dates delimited by the *early finish date* and the *late finish date*. It may reflect *resource leveling* of scarce *resources*.

Schedule Milestone. A significant event in the *project schedule*, such as an event restraining future work or marking the completion of a major deliverable. Sometimes called a *milestone activity*. See also *milestone*.

Scheduled Start Date (SS). The point in time that *work* was scheduled to start on a *schedule activity*. The scheduled start date is normally within the range of dates delimited by the *early start date* and the *late start date*. It may reflect *resource leveling* of scarce *resources*.

S-Curve. Graphic display of cumulative costs, labor hours, percentage of work, or other quantities, plotted against time. The name derives from the S-like shape of the curve

(flatter at the beginning and end, steeper in the middle) produced on a project that starts slowly, accelerates, and then tails off. Also a term for the cumulative likelihood distribution that is a result of a simulation, a tool of *quantitative risk analysis*.

Scope. The sum of the *products, services, and results* to be provided as a project. See *project scope* and *product scope*.

Scope Baseline. See *baseline*.

Scope Change. Any change to the *project scope*. A *scope change* almost always requires an adjustment to the project cost or schedule.

Scope Control [Process]. The *process of controlling changes to the project scope*.

Scope Creep. Adding features and functionality (*project scope*) without addressing the effects on time, costs, and resources or without *customer approval*.

Scope Definition [Process]. The *process of developing a detailed project scope statement* as the basis for future project decisions.

Scope Management Plan [Output/Input]. The *document* that describes how the *scope* will be defined, verified, and controlled and how the *work breakdown structure* will be created and defined and that provides guidance on how *project scope* will be managed by the *project management team*. It is contained in or is a subsidiary plan of the *project management plan*. The scope management plan can be informal and broadly framed, or formal and highly detailed, based on the needs of the *project*.

Scope Planning [Process]. The *process of creating a scope management plan*

Scope Verification [Process]. The *process of formalizing acceptance of the completed project scope*.

Secondary Risk. A *risk* that arises as a direct result of implementing a risk response.

Select Sellers [Process]. The *process of reviewing offers, choosing from among potential sellers, and negotiating a written contract with seller*.

Seller. The provider or supplier of *products, materiel, goods, or services* to an organization.

Service. Useful *work* performed that does not produce a tangible *product or result*, such as performing any of the business functions supporting production or distribution. Contrast with *product, result, and deliverable*.

Should-Cost Estimate. An *estimate* of the cost of a *product or service* used to provide an assessment of the reasonableness of a prospective seller's proposed cost.

Simulation [Technique]. A simulation uses a *project model* that translates the uncertainties specified at a detailed level into their potential impact on *objectives* that are expressed at the level of the total *project*. Project simulations use computer models and estimates of *risk* at a detailed level, and are typically performed using the *Monte Carlo* technique.

Skill. Ability to use *knowledge*, a developed aptitude, and/or a capability to effectively and readily execute or perform an *activity*.

Slack. See *total float*.

Special Cause. A source of variation that is not inherent in the *system*, is not predictable, and is intermittent. It can be assigned to a defect in the *system*. On a *control chart*, points beyond the *control limits*, or non-random patterns within the control limits indicate it. Also referred to as assignable cause. See also *common cause*.

Specification. A *document* that specifies, in a complete, precise, verifiable manner, the *requirements, design, behavior, or other characteristics* of a *system, component*,

product, result, or service and, often, the *procedures* for determining whether these provisions have been satisfied. Examples are: requirement specification, design specification, product specification, and test specification.

Specification Limits. The area, on either side of the centerline, or mean, of data plotted on a *control chart* that meets the *customer's* expectation for a *product or service*. This area may be greater than or less than the area defined by the *control limits*. It can be different for each feature or expectation of the product or service. See also *control limits*.

Sponsor. The individual or group that provides the financial resources, in cash or in kind, for the project.

Staffing Management Plan [Process]. The *document* that describes when and how human *resource requirements* will be met. It is contained in or is a subsidiary plan of the *project management plan*. The staffing management plan can be informal and broadly framed, or formal and highly detailed, based on the needs of the *project*. Information in the staffing management plan varies by *application area* and project size.

Stakeholder. Individuals and organizations that are actively involved in the *project*, or whose interests may be positively or negatively affected by execution of the project or project completion. They may also exert influence over the project and its *deliverables*.

Standard. A *document* established by consensus and approved by a recognized body that provides, for common and repeated use, rules, guidelines or characteristics for *activities* or their *results*, aimed at the achievement of the optimum degree of order in a given context.

Start Date. A point in time associated with a *schedule activity*'s start, usually qualified by one of the following: actual, planned, estimated, scheduled, early, late, target, baseline, or current.

Start-to-Finish (SF). The *logical relationship* where completion of the *successor schedule activity* is dependent upon the initiation of the *predecessor schedule activity*. See also *logical relationship*.

Start-to-Start (SS). The *logical relationship* where initiation of work of the *successor schedule activity* depends upon the initiation of the work of the *predecessor schedule activity*. See also *logical relationship*.

Statement of Work (SOW) [Output/Input]. A narrative description of *products, services, or results* to be supplied.

Subnet. See *subnetwork*.

Subnetwork. A subdivision (fragment) of a *project schedule network diagram*, usually representing a *subproject* or a *work package*. Often used to illustrate or study some potential or proposed schedule condition such as changes in preferential schedule logic or project scope.

Subphase. A subdivision of a phase.

Subproject. A smaller portion of the overall *project* created when a *project* is subdivided into more manageable *components* or pieces. Subprojects are usually represented in the work breakdown structure. A subproject can be referred to as a project, managed as a project, and acquired from a seller.

Successor. See *successor activity*.

Successor Activity. 1) In the *precedence diagramming method*, the schedule activity that follows a *predecessor activity*, as determined by their *logical relationship*. 2) In the *arrow diagramming method*, the *schedule activity* that departs a node.

Summary Activity. A group of related *schedule activities* aggregated together at some summary level and shown and reported as a single activity at that summary level. See also *subproject* and *subnetwork*.

System. An *integrated* set of regularly interacting or interdependent *components* created to accomplish a defined *objective* and having defined and maintained relationships among its components, and where the whole produces or operates better than the simple sum of its components. Systems may be either physically *process* based or management process based, or more commonly a combination of both. Systems for *project management* are composed of *project management processes, techniques, methodologies, and tools* operated by the *project management team*.

Target Completion Date (TC). An imposed date that constrains or otherwise modifies the *schedule network analysis*.

Target Finish Date (TF). The date that *work* is planned (targeted) to finish on a *schedule activity*.

Target Schedule. See *baseline*.

Target Start Date (TS). The date that work is planned (targeted) to start on a *schedule activity*.

Task. A term for *work* whose meaning and placement within a structured plan for project work varies by the *application area*, industry, and brand of *project management software*.

Team Members. See *project team members*.

Technical Performance Measurement [Technique]. Technical performance measurement compares technical accomplishments during *project execution* to the project management plan's schedule of planned technical achievements.

Technique. A defined systematic *procedure* employed by a human *resource* to perform an *activity* to produce a *product or result or deliver a service*, and that may employ one or more *tools*.

Three Point Estimate [Technique]. An analytical *technique* that uses three *cost* or *duration* estimates to represent the optimistic, most likely, and pessimistic scenarios and that is applied to improve the accuracy of the *estimates* of cost or duration when the underlying *activity* or cost *component* is uncertain. See *Program Evaluation and Review Technique (PERT)*.

Threshold. A cost, time, quality, technical, or resource value used as a parameter limit and which may be included in *product specifications*. Crossing the threshold limit should trigger some action, such as generating an exception report.

Tight Matrix. A location where the *project team members* are physically located in proximity, often in the same room. (See also *Co-location*).

Time and Material Contract. A type of *contract* that is a hybrid contractual arrangement that contain aspects of both *cost-reimbursable* and *fixed-price-type* arrangements. Time and material contracts resemble cost-reimbursable type arrangements in that they are open ended, because the full value of the arrangement is not defined at the time of the award. Thus, time and material contracts can grow in contract value as if they were cost-reimbursable-type arrangements. Conversely, time

and material arrangements can also resemble fixed-priced arrangements. For example, the unit rates are preset by the buyer and seller, when both parties agree on the rates for the category of senior engineers or when the contact contains a not-to-exceed cost clause.

Time Now. See *data date*.

Time-Scaled Schedule Network Diagram [Tool]. Any *project schedule network diagram* drawn in such a way that the positioning and length of the *schedule activity* represents its duration. Essentially, it is a *bar chart* that includes schedule *network logic*.

Tool. Something tangible, such as a template or software program, used in performing an *activity* to produce a *product or result*.

Total Float (TF). The total amount of time that a *schedule activity* may be delayed from its *early start date* without delaying the project *finish date*, or violating a schedule *constraint*. Calculated using the *critical path method* technique. See also *free float*.

Total Quality Management (TQM) [Technique]. A common approach to implementing a quality improvement program within an organization.

Triggers. Triggers, sometimes called *risk symptoms* or *warning signs*, are indications that a risk has occurred or is about to occur. Triggers may be discovered in the *risk identification* process and watched in the *risk monitoring and control* process.

User. The individual or organization that will use the project's *product or service* (See also *Customer*).

Validation [Technique]. The technique of evaluating a *component or product* during or at the end of a *phase or project* to ensure it complies with the specified *requirements*. Contrast with *verification*.

Value Engineering (VE) [Technique]. A creative approach used to optimize life-cycle costs, save time, increase profits, improve quality, expand market share, solve problems, and/or use resources more effectively.

Verification [Technique]. The technique of evaluating a *component or product* at the end of a phase or project to assure or confirm it satisfies the conditions imposed. Contrast with *validation*.

Voice Of The Customer [Technique]. A strategic planning *technique* used to provide *products, services, and results* that truly reflect *customer needs and expectations* by translating customer *requirements* into the appropriate technical requirements for each phase of project product development.

War Room. A room used for project conferences and planning, often displaying charts of cost, schedule status, and other key project data.

Work. Sustained physical or mental effort, exertion, or exercise of *skill* to overcome obstacles and achieve an *objective*.

Workaround [Technique]. A response to a negative *risk event*. Distinguished from contingency plan in that a workaround is not planned in advance of the occurrence of the risk event.

Work Authorization System [Tool]. A subsystem of the overall *project management system*. It is a collection of formal documented *procedures* that defines how *project work* will be authorized (committed) to ensure that the work is done by the identified organization, at the right time, and in the proper sequence. It includes the steps,

documents, tracking system, and defined approval levels needed to issue work authorizations.

Work Authorization [Technique]. An authorization, typically written, to begin work on a specific scheduled *activity* or *work package* and is a method for sanctioning *project work* to ensure that the work is done by the identified organization, at the right time, and in the proper sequence.

Work Breakdown Structure (WBS) [Output/Input]. A *deliverable-oriented* hierarchy of decomposed project *components* that organizes and defines the total *scope* of the *project*. Each descending level represents an increasingly detailed definition of the *project work*. The WBS is decomposed into *work packages*. The *deliverable* orientation of the hierarchy includes both internal and external deliverables. See also *contract work breakdown structure* and *project summary work breakdown structure*.

Work Breakdown Structure Component. An entry in the *work breakdown structure* that can be at any level.

Work Breakdown Structure Dictionary [Output/Input]. A *document* that describes each component in the *work breakdown structure* (WBS). For each WBS component, the WBS dictionary includes a brief definition of the *scope* or *statement of work*, defined *deliverable(s)*, a list of associated *activities*, and a list of *milestones*. Other information may include: *responsible organization*, *start and end dates*, *resources* required, an *estimate* of cost, charge number, *contract* information, quality *requirements*, and technical references to facilitate performance of the *work*.

Work Item. Term no longer in common usage. See *activity* and *schedule activity*.

Work Package. A *deliverable* or project work *component* at the lowest level of each branch of the *work breakdown structure*. The work package includes the schedule *activities* and schedule *milestones* required to complete the work package *deliverable* or project work *component*. See also *control account*.

Work Performance Information [Output/Input]. Information and data, on the status of the project activities being performed to accomplish the project work, collected as part of the *direct and manage project execution* processes. Information includes: status of deliverables; implementation status for change requests, corrective actions, preventive actions, and defect repairs; forecasted estimates to complete; reported percent of work physically completed; start and finish dates of schedule activities.