A Guide to the
Project Management
Body of Knowledge
Third Edition

(PMBOK® Guide)
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This document supersedes A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – 2000 Edition, which was published as the second edition of the PMBOK® Guide. In the time since its publication, the Project Management Institute (PMI) received thousands of valuable recommendations for improvements to the PMBOK® Guide – 2000 Edition that have since been reviewed and, as appropriate, incorporated into the third edition.

As a result of those inputs and growth of the Project Management Body of Knowledge, PMI volunteers prepared an updated version of the PMBOK® Guide. The project charter 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 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.
- 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 Project Management Process Groups.
- Expand the treatment of integration and more appropriately convey its importance to a project.
- Expand treatment of the Initiating Process Group to more accurately describe the front-end of the project and the start of each phase.
- Expand the closing processes.
- 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 complied with its charter as described above. To assist practitioners and other interested parties who may be familiar with the PMBOK® Guide – 2000 Edition, the major differences between the editions are summarized below:

1. Across the entire third edition, in most instances when a new process was introduced, and in other selected cases where existing process names were revised, such process names are in a verb-object format for clarity.
2. The writing style was generally changed to the active voice.
3. The distinction between project life cycles and product life cycles was clarified.
4. The number of processes increased from 39 to 44. Seven processes were added, two processes were deleted, and 13 processes were renamed for a net gain of five new processes.
5. All graphics were numbered and labeled as either a table or figure.
6. The distinction between Project Management Process Groups and the Knowledge Areas was clarified. A greater emphasis was placed on the importance of Process Groups.
7. Chapter 3 was renamed “Project Management Processes for a Project” and moved from Section I to a new Section II, which is now called “The Standard for Project Management of a Project.” As part of this change, Chapter 3 was extensively revised to indicate that the Process Groups and inputs and outputs in the chapter are the basis of the standard for project management of a single project.
8. The project management processes were mapped to show process integration.
9. The glossary was significantly revised and augmented. Appropriate terms have been categorized to avoid confusion.
10. The following processes were added:
   - Develop Project Charter (Section 4.1)
   - Develop Preliminary 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)
11. All of the process inputs, tools, techniques, and outputs have been revised to support the improved integration and mapping of the processes.
12. Process flow diagrams have been added to Chapters 4 through 12 to provide added support to the integration of processes.
13. An introduction has been added to Section III to describe the process flow diagrams and provide a legend of the symbols.

Appendix A – Third Edition Changes details the changes made in the chapters.

The PMBOK® Guide – Third Edition was presented in an exposure draft document at the end of calendar year 2003, and a significant number of the comments sent in by reviewers were incorporated into this final release.

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PMBOK® Guide 2004 Update Project Team
Section I

The Project Management Framework

Chapter 1  Introduction
Chapter 2  Project Life Cycle and Organization
CHAPTER 1

Introduction

The Project Management Body of Knowledge 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 who apply and advance it. The complete Project Management Body of Knowledge includes proven traditional practices that are widely applied, as well as innovative practices that are emerging in the profession, including published and unpublished material. As a result, the Project Management Body of Knowledge is constantly evolving.

This chapter defines several key terms and provides an overview of the rest of A Guide to the Project Management Body of Knowledge (PMBOK® Guide) in the following major sections:

1.1 Purpose of the PMBOK® 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 Project Management Context

1.1 Purpose of the PMBOK® GUIDE

The primary purpose of the PMBOK® Guide is to identify that subset of the Project Management Body of Knowledge that is 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” means 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. Good practice does not mean that the knowledge described should always be applied uniformly on all projects; the project management team is responsible for determining what is appropriate for any given project.
The PMBOK® Guide also provides and promotes a common lexicon for discussing, 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 foundational, but not the sole, project management reference for its professional development programs including:

- Project Management Professional (PMP®) certification
- Project management education and training offered by PMI Registered Education Providers (R.E.P.s)
- Accreditation of educational programs in project management.

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

This standard addresses only single projects and the project management processes that are generally recognized as good practice. There are other standards on organizational project management maturity, project manager competency, and other topics that address what is generally recognized as good practices in those areas. Some of the material in those other standards impacts single projects. The other standards should be consulted for additional information and understanding of the broader context in which projects are accomplished.

Project management standards do not address all details of every topic. Topics 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 so general 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 project management activity. The organization or the project management team must decide how those activities are going to be addressed in the context and the circumstances of the project for which the PMBOK® Guide is being used.

1.1.1 Audience for the PMBOK® Guide

This standard provides a foundational 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 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
- Researchers 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, service or result created by the project. Most projects are undertaken to create a lasting outcome. For example, a project to erect a national monument will create a result expected to last centuries. Projects also 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 working 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 the team members reassigned when the project ends.

.2 Unique Products, Services, or Results

A project creates unique deliverables, which are products, services, or results. Projects can 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 outcomes or documents. For example, a research project develops knowledge that can be used to determine whether or not a trend is present or a new process will benefit society.

Uniqueness is an important characteristic of project deliverables. For example, many thousands of office buildings have been developed, but each individual facility is unique—different owner, different design, different location, different contractors, and so on. The presence of repetitive elements does not change the fundamental uniqueness of the project work.
.3 Progressive Elaboration

Progressive elaboration is a characteristic of projects that accompanies the concepts of temporary and unique. Progressive elaboration means developing in steps, and continuing 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 5.5).

Progressive elaboration of a project’s specifications needs to 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 Chapter 5 introductory material.

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

- 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 detailed 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 are 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.

- 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, but are not limited to:

- 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
- Running a campaign for political office
- Implementing a new business procedure or process
- Responding to a contract solicitation.

### 1.2.3 Projects and Strategic Planning

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)
- An organizational 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., a software firm authorizes a new project to develop a new generation of video games after the introduction of new game-playing equipment by electronics firms)
- 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 application and integration of the project management processes of initiating, planning, executing, monitoring and controlling, and closing. The project manager is the person responsible for accomplishing the project objectives.

Managing a project includes:

- 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, service or result 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 is likely to be affected. Project managers 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 those with the Project Management Professional (PMP®) certification 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 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, the team can then manage to a greater level of detail.

The term “project management” is sometimes used to describe an organizational or managerial approach to the management of projects and some ongoing operations, which can be redefined as projects, that is also referred to as “management by projects.” An organization that adopts this approach defines its activities as projects in a way that is consistent with the definition of a project provided in section 1.2.2. There has been a tendency in recent years to manage more activities in more application areas using project management. More organizations are using “management by project.” This is not to say that all operations can or should be organized into projects. The adoption of “management by project” is also related to the adoption of an organizational culture that is close to the project management culture described in Section 2.3. Although, an understanding of project management is critical to an organization that is using “management by projects,” a detailed discussion of the approach itself is outside the scope of this standard.
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 should 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 project management processes that are used by the project team to manage a project.

Chapter 3, *Project Management Processes for a Project*, describes the five required Project Management Process Groups for any project and their constituent project management processes. 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 Areas, organizes the 44 project management processes from the Chapter 3 Project Management Process Groups into nine Knowledge Areas, as described below. An introduction to Section III describes the legend for the process flow diagrams used in each Knowledge Area chapter and introductory material applicable to all the Knowledge Areas.

Chapter 4, *Project Integration Management*, describes the processes and activities that integrate the various elements of project management, which are identified, defined, combined, unified and coordinated within the Project Management Process Groups. It consists of the Develop Project Charter, Develop Preliminary Project Scope Statement, Develop Project Management Plan, Direct and Manage Project Execution, Monitor and Control Project Work, Integrated Change Control, and Close Project project management processes.

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 the Scope Planning, Scope Definition, Create WBS, Scope Verification, and Scope Control project management processes.
Chapter 6, **Project Time Management**, describes the processes concerning the timely completion of the project. It consists of the Activity Definition, Activity Sequencing, Activity Resource Estimating, Activity Duration Estimating, Schedule Development, and Schedule Control project management processes.

Chapter 7, **Project Cost Management**, describes the processes involved in planning, estimating, budgeting, and controlling costs so that the project is completed within the approved budget. It consists of the Cost Estimating, Cost Budgeting, and Cost Control project management 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 the Quality Planning, Perform Quality Assurance, and Perform Quality Control project management processes.

Chapter 9, **Project Human Resource Management**, describes the processes that organize and manage the project team. It consists of the Human Resource Planning, Acquire Project Team, Develop Project Team, and Manage Project Team project management 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 the Communications Planning, Information Distribution, Performance Reporting, and Manage Stakeholders project management processes.

Chapter 11, **Project Risk Management**, describes the processes concerned with conducting risk management on a project. It consists of the Risk Management Planning, Risk Identification, Qualitative Risk Analysis, Quantitative Risk Analysis, Risk Response Planning, and Risk Monitoring and Control project management processes.

Chapter 12, **Project Procurement Management**, describes the processes that purchase or acquire products, services or results, as well as contract management processes. It consists of the Plan Purchases and Acquisitions, Plan Contracting, Request Seller Responses, Select Sellers, Contract Administration, and Contract Closure project management processes.
4. Project Integration Management
- 4.1 Develop Project Charter
- 4.2 Develop Preliminary Project Scope Statement
- 4.3 Develop Project Management Plan
- 4.4 Direct and Manage Project Execution
- 4.5 Monitor and Control Project Work
- 4.6 Integrated Change Control
- 4.7 Close Project

5. Project Scope Management
- 5.1 Scope Planning
- 5.2 Scope Definition
- 5.3 Create WBS
- 5.4 Scope Verification
- 5.5 Scope Control

6. Project Time Management
- 6.1 Activity Definition
- 6.2 Activity Sequencing
- 6.3 Activity Resource Estimating
- 6.4 Activity Duration Estimating
- 6.5 Schedule Development
- 6.6 Schedule Control

7. Project Cost Management
- 7.1 Cost Estimating
- 7.2 Cost Budgeting
- 7.3 Cost Control

8. Project Quality Management
- 8.1 Quality Planning
- 8.2 Perform Quality Assurance
- 8.3 Perform Quality Control

- 9.1 Human Resource Planning
- 9.2 Acquire Project Team
- 9.3 Develop Project Team
- 9.4 Manage Project Team

10. Project Communications Management
- 10.1 Communications Planning
- 10.2 Information Distribution
- 10.3 Performance Reporting
- 10.4 Manage Stakeholders

11. Project Risk Management
- 11.1 Risk Management Planning
- 11.2 Risk Identification
- 11.3 Qualitative Risk Analysis
- 11.4 Quantitative Risk Analysis
- 11.5 Risk Response Planning
- 11.6 Risk Monitoring and Control

12. Project Procurement Management
- 12.1 Plan Purchase and Acquisitions
- 12.2 Plan Contracting
- 12.3 Request Seller Responses
- 12.4 Select Sellers
- 12.5 Contract Administration
- 12.6 Contract Closure

Figure 1-1. Overview of Project Management Knowledge Areas and Project Management Processes
1.5 Areas of Expertise

Much of the knowledge and many of the tools and techniques for managing projects are unique to project management, such as work breakdown structures, critical path analysis, and earned value management. However, understanding and applying the knowledge, skills, tools, and techniques, which are generally recognized as good practice, are not sufficient alone for effective project management. Effective project management requires that the project management team understand and use knowledge and skills from at least five areas of expertise:

- The Project Management Body of Knowledge
- Application area knowledge, standards, and regulations
- Understanding the project environment
- General management knowledge and skills
- Interpersonal 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. However, it is important that the project management team has full knowledge of the *PMBOK® Guide* and is conversant in the knowledge of the Project Management Body of Knowledge and the other four areas of management to effectively manage a project.

1.5.1 Project Management Body of Knowledge

The Project Management Body of Knowledge describes knowledge unique to the project management field and that overlaps other management disciplines. Figure 1-2 shows the common areas of expertise needed by the project team. The *PMBOK® Guide* is, therefore, a subset of the larger Project Management Body of Knowledge.

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

- Project life cycle definition (Chapter 2)
- Five Project Management Process Groups (Chapter 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 or engineering, and sometimes a specific kind of engineering, such as water and sanitation engineering or 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 follows²:
Chapter 1 – Introduction

- 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 disk sizes and the thermal stability specifications of hydraulic fluids.
- A regulation is a government-imposed requirement, which specifies product, process or service characteristics, including the applicable administrative provisions, with which compliance is mandatory. Building codes are an example of regulations.

There is an overlap in the concepts of standards and regulations that cause confusion. For example:
- Standards often begin as guidelines that describe a preferred approach and later, with widespread adoption, become generally accepted as if they were regulations
- Different organizational levels can mandate compliance, such as when a government agency, the management of the performing organization, or the project management team establishes specific policies and procedures.

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

1.5.3 Understanding the Project Environment

Virtually all projects are planned and implemented in a social, economic, and environmental context, and have intended and unintended positive and/or negative impacts. The project team should consider the project in its cultural, social, international, political, and physical environmental contexts.

- **Cultural and 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 role with accountability and authority for managing the project.

- **International and political environment.** Some team members may need to be familiar with applicable international, national, regional, and local laws and customs, as well as the political climate that could affect the project. Other international factors to consider are time-zone differences, national and regional holidays, travel requirements for face-to-face meetings, and the logistics of teleconferencing.

- **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.
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
- Information technology.

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

1.5.5 Interpersonal Skills

The management of interpersonal relationships includes:

- **Effective communication.** The exchange of information
- **Influencing the organization.** The ability to “get things done”
- **Leadership.** Developing a vision and strategy, and motivating people to achieve that vision and strategy
- **Motivation.** Energizing people to achieve high levels of performance 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, alternatives identification and analysis, and decision-making.
1.6 Project Management Context

Project management exists in a broader context that includes program management, portfolio management and project management office. 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.

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 series of projects built on previous efforts.
- Many nonprofit organizations have a “fundraising program,” 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 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 group of projects 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 in 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, although the individual subprojects 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 a series of even smaller subprojects.

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 supported or administered by the PMO may not be related other than by being managed together. Some PMOs, however, do coordinate and manage related projects. In many organizations, those projects are indeed grouped or are related in some manner based on the way the PMO will coordinate and manage those projects. 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.

PMOs can operate on a continuum, from providing project management support functions in the form of training, software, standardized policies, and procedures, to actual direct management and responsibility for achieving the project objectives. 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 projects administered by the PMO
- 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 projects administered by the PMO
- 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 management 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 managers and a PMO may include the following:

- Project managers and PMOs pursue different objectives and, as such, are driven by different requirements. All of these efforts, however, are 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 enterprise-wide 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 the interdependencies among projects.
- The project manager reports on project progress and other project specific information, while the PMO provides consolidated reporting and an enterprise view of projects under its purview.
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 it can select the life cycle phases, processes, and tools and techniques 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 outcome of such a preliminary effort is not clearly identifiable, it is best to treat such efforts as a separate project. The phases of a project life cycle are not the same as the Project Management Process Groups described in detail in Chapter 3.
The transition from one phase to another within a project’s life cycle generally involves, and is usually defined by, some form of technical transfer or handoff. Deliverables from one phase are usually reviewed for completeness and 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, normally done in sequence, is an example of the application of the schedule compression 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 the team’s project. Further, industry common practices will often lead to the use of a preferred life cycle within that industry.

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:

- Phases are generally sequential and are usually defined by some form of technical information transfer or technical component handoff.
- 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.
Figure 2-1. Typical Project Cost and Staffing Level Across the Project Life Cycle

- The level of uncertainty is highest and, hence, risk of failing to achieve the objectives is greatest 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 correcting errors generally increases as the project continues.

Figure 2-2. Stakeholders’ 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 its 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, detailed 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 with one or more specific deliverables for monitoring and control. The majority of these subphase deliverables are related to the primary phase deliverable, and the phases typically take their names from these phase deliverables: requirements, design, build, test, startup, turnover, and others, as appropriate.

A project phase is generally concluded with a review of the work accomplished and the deliverables to determine 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, for example, when the project manager chooses fast tracking as the course of action. Another example is when 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 and analyzed before the module is designed and constructed. While analysis of a module is being done, the requirements gathering for another module could also start in parallel.

Similarly, a phase can be closed without the decision to initiate any other phases. For example, the project is completed or the risk is deemed too great for the project to be allowed to continue.
Formal phase completion does not include authorizing the subsequent phase. For effective control, each phase is formally initiated to produce a phase-dependent output of the Initiating Process Group, 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. Phase-end reviews are also called phase exits, phase gates, or kill points.

![Typical Sequence of Phases in a Project Life Cycle](image)

**Figure 2-3. Typical Sequence of Phases in a Project Life Cycle**

### 2.1.3 Project Life Cycle and Product Life Cycle Relationships

Many projects are linked to the ongoing work of the performing organization. Some organizations formally approve projects only after 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 development projects, can be initiated informally for a limited amount of time to secure formal approval for additional phases or activities.

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 the product life cycle starting with the business plan, through idea, to product, ongoing operations and product divestment. The project life cycle goes through a series of phases to create the product. Additional projects can include a performance upgrade to the product. In some application areas, such as new product development or software development, organizations consider the project life cycle as part of the product life cycle.

![Figure 2-4. Relationship Between the Product and the Project Life Cycles](image)

### 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’s objectives and outcomes. The project management team must identify the stakeholders, determine their requirements and expectations, 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.
Figure 2-5. The Relationship Between Stakeholders and the Project

Stakeholders have varying levels of responsibility and authority when participating on a project and these can change over the course of the project’s life cycle. Their responsibility and authority range from occasional contributions in surveys and focus groups to full project sponsorship, which includes providing financial and political support. Stakeholders who ignore this responsibility can have a damaging impact on the project objectives. Likewise, project managers who ignore stakeholders can expect a damaging impact on project outcomes.

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. Failure to identify a key stakeholder can cause major problems for a project. For example, late recognition that the legal department was a significant stakeholder in a year 2000 rollover (Y2K) software upgrade project caused many additional documentation tasks to be added to the project’s requirements.

Stakeholders may have a positive or negative influence on a project. Positive stakeholders are those who would normally benefit from a successful outcome from the project, while negative stakeholders are those who see negative outcomes from the project’s success. For example, business leaders from a community that will benefit from an industrial expansion project may be positive stakeholders because they see economic benefit to the community from the project’s success. Conversely, environmental groups could be negative stakeholders if they view the project as doing harm to the environment. In the case of positive stakeholders, their interests are best served by helping the project succeed, for example, helping the project obtain the needed permits to proceed. The negative stakeholders’ interest would be better served by impeding the project’s progress by demanding more extensive environmental reviews. Negative stakeholders are often overlooked by the project team at the risk of failing to bring their projects to a successful end.
Key stakeholders on every project include:

- **Project manager.** The person responsible for managing the project.
- **Customer/user.** The person 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 product and users are those who will directly utilize 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.
- **Project management team.** The members of the project team who are directly involved in project management activities.
- **Sponsor.** The person or group that provides the financial resources, in cash or in kind, for the project.
- **Influencers.** People or groups that are not directly related to the acquisition or use of the project’s product, but due to an individual’s position in the customer organization or performing organization, can influence, positively or negatively, the course of the project.
- **PMO.** If it exists in the performing organization, the PMO can be a stakeholder if it has direct or indirect responsibility for the outcome of the project.

In addition to these key stakeholders, there are many different names and categories of project stakeholders, including internal and external, owners and investors, 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.

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.

2.3 Organizational Influences

Projects are typically part of an organization that is larger than the project. Examples of organizations include corporations, government agencies, healthcare institutions, international bodies, professional associations, and others. Even when the project is external (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 system, 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 may 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 sub-units that operate as project-based organizations with systems to support them. The project management team should be aware of how its organization’s structure and systems affect the project.

2.3.2 Organizational Cultures and Styles

Most organizations have developed unique and describable cultures. These cultures are reflected in numerous factors, including, but not limited to:

• Shared values, norms, beliefs, and expectations

• Policies and procedures

• View of authority relationships

• Work ethic and work hours.
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.

### 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.

<table>
<thead>
<tr>
<th>Project Structure</th>
<th>Functional</th>
<th>Matrix</th>
<th>Projectized</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Manager's Authority</td>
<td>Little or None</td>
<td>Limited</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>Resource Availability</td>
<td>Little or None</td>
<td>Limited</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>Who controls the project budget</td>
<td>Functional Manager</td>
<td>Functional Manager</td>
<td>Mixed</td>
</tr>
<tr>
<td>Project Manager's Role</td>
<td>Part-time</td>
<td>Part-time</td>
<td>Full-time</td>
</tr>
<tr>
<td>Project Management Administrative Staff</td>
<td>Part-time</td>
<td>Part-time</td>
<td>Full-time</td>
</tr>
</tbody>
</table>

**Figure 2-6. Organizational Structure Influences on Projects**

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 expediter 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. While the balanced matrix organization recognizes the need for a project manager, it does not provide the project manager with the full authority over the project and project funding (Figure 2-6).
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 team.
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.

2.3.4 The Role of the PMO in Organizational Structures

Many organizations realize the benefit of developing and implementing a PMO (Section 1.6.4). 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 2-6.

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. 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. The project manager reports directly to the PMO. 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 2-8 would have an additional box, labeled PMO, between the project manager layer and the chief executive layer. Similarly in Figures 2-11 and 2-12, the “manager of project managers” would normally be the PMO manager, whereas in the other organizational structures (Figures 2-9 and 2-10), the PMO usually does not directly report to the chief executive.
2.3.5 **Project Management System**

The project management system is the set of tools, techniques, methodologies, resources, and procedures used to manage a project. It can be formal or informal and aids a project manager in effectively guiding a project to completion. The system is a set of processes and the related control functions that are consolidated and combined into a functioning, unified whole.

The project management plan describes how the project management system will be used. The project management system content will vary depending upon the application area, organizational influence, complexity of the project, and availability of existing systems. The organizational influences shape the system for executing projects within that organization. The system will adjust or adapt to accommodate any influence imposed by the organization.

If a PMO exists in the performing organization, one of the functions of the PMO would typically be to manage the project management system, in order to ensure consistency in application and continuity on the various projects being performed.
Section II

The Standard for Project Management of a Project

Chapter 3 Project Management Processes for a Project
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. Project management is accomplished through processes, using project management knowledge, skills, tools, and techniques that receive inputs and generate outputs.

In order for a project to be successful, the project team must:

• Select appropriate processes within the Project Management Process Groups (also known as Process Groups) that are required to meet the project objectives
• Use a defined approach to adapt the product specifications and plans to meet project and product requirements
• Comply with requirements to meet stakeholder needs, wants and expectations
• Balance the competing demands of scope, time, cost, quality, resources, and risk to produce a quality product.

This standard documents information needed to initiate, plan, execute, monitor and control, and close a single project, and identifies those project management processes that have been recognized as good practice on most projects most of the time. These processes apply globally and across industry groups. Good practice means there is general agreement that the application of those project management processes has been shown to enhance the chances of success over a wide range of 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, and the appropriate degree of rigor for each process, for any given project.
In fact, project managers and their teams are advised to carefully consider 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 processes that they must consider in managing their project. This effort is known as tailoring.

A process is a set of interrelated actions and activities that are performed to achieve a pre-specified set of products, results, or services. The project processes are performed by the project team, and generally fall into one of two major categories:

- The project management processes common to most projects most of the time are associated with each other by their performance for an integrated purpose. The purpose is to initiate, plan, execute, monitor and control, and close a project. These processes interact with each other in complex ways that cannot be completely explained in a document or with graphics. However, an example of the interactions among the Process Groups is shown in Figure 3-4. The processes may also interact in relation to project scope, cost, schedule, etc., which are called Knowledge Areas, and are described in Chapters 4 through 12.

- Product-oriented processes specify and create the project's product. Product-oriented processes are typically defined by the project life cycle (discussed in Section 2.1) and vary by application area. Project management processes and product-oriented processes overlap and interact throughout the project. For example, the scope of the project cannot be defined in the absence of some basic understanding of how to create the specified product.

Project management is an integrative undertaking. Project management integration requires each project and product process to be appropriately aligned and connected with the other processes to facilitate their coordination. These process interactions often require tradeoffs among project requirements and objectives. A large and complex project may have some processes that will have to be iterated several times to define and meet stakeholder requirements and reach agreement on the processes outcome. Failure to take action during one process will usually affect that process and other related processes. 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 sponsor, customer and other stakeholder requirements.

This standard describes the 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 five groups, defined as the Project Management 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 of a single project 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 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 there is more than one way to manage a project. The specifics for a project are defined as objectives that must be accomplished based on complexity, risk, size, time frame, project team’s experience, access to resources, amount of historical information, the organization’s project management maturity, and industry and application area. The required Process Groups and their constituent processes are guides to apply appropriate project management knowledge and skills during the project. In addition, the application of the project management processes to a project is iterative and many processes are repeated and revised during the project. The project manager and the project team are responsible for determining what processes from the Process Groups 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 is the plan-do-check-act cycle (as defined by Shewhart and modified by Deming, in the ASQ Handbook, pages 13–14, American Society for Quality, 1999). This cycle is linked by results – the result from one part of the cycle becomes the input to another. See Figure 3-1.
The integrative nature of the Process Groups is more complex than the basic plan-do-check-act cycle (see Figure 3-2). However, the enhanced cycle can be applied to the interrelationships within and among the Process Groups. The Planning Process Group corresponds to the “plan” component of the plan-do-check-act cycle. The Executing Process Group corresponds to the “do” component and the Monitoring and Controlling Process Group corresponds to the “check and 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 requires the Monitoring and Controlling Process Group interaction with every aspect of the other Process Groups.

![Figure 3-2. Project Management Process Groups Mapped to the Plan-Do-Check-Act Cycle](image)

### 3.2 Project management Process Groups

This section identifies and describes the five Project Management Process Groups required for any project. These five 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 Process Groups and individual constituent processes are often iterated prior to completing the project. Constituent processes also can have interactions both within a Process Group and among Process Groups.

The symbols for the process flow diagrams are shown in Figure 3-3:

- **Process Groups**
- **Processes within the Process Groups**
- **Organizational Process Assets and Enterprise Environmental Factors**, shown as inputs to and outputs from the Process Groups, but external to the processes
- **Arrows** or **line arrows** indicate process or data flow among or within the Process Groups.
Note: Not all process interactions and data flow among the processes are shown in an effort to make the diagrams more readable.

**Flow Chart Legend**
Diagrams throughout the Guide show basic steps and interactions. Many additional interactions are possible.

- **Process Group**
- **Process**
- **External to Process**
- **Process flow**

**Figure 3-3. Flow Chart Legend**

The process flow diagram, Figure 3-4, provides an overall summary of the basic flow and interactions among the Process Groups. An individual process may define and constrain how inputs are used to produce outputs for that Process Group. A Process Group includes the constituent project management processes that are linked by the respective inputs and outputs, that is, the result or outcome of one process becomes the input to another. The Monitoring and Controlling Process Group, for example, not only monitors and controls the work being done during a Process Group, but also monitors and controls the entire project effort. The Monitoring and Controlling Process Group must also provide feedback to implement corrective or preventive actions to bring the project into compliance with the project management plan or to appropriately modify the project management plan. Many additional interactions among the Process Groups are likely. The **Process Groups are not project phases**. Where large or complex projects may be separated into distinct phases or sub-projects such as feasibility study, concept development, design, prototype, build, test, etc. all of the Process Group processes would normally be repeated for each phase or subproject.

The five Process Groups are:

- **Initiating Process Group**. Defines and authorizes the project or a project phase.
- **Planning Process Group**. Defines and refines objectives, and plans the course of action required to attain the objectives and scope that the project was undertaken to address.
- **Executing Process Group**. Integrates people and other resources to carry out the project management plan for the project.
- **Monitoring and Controlling Process Group**. Regularly measures and monitors progress to identify variances from the project management plan so that corrective action can be taken when necessary to meet project objectives.
- **Closing Process Group**. Formalizes acceptance of the product, service or result and brings the project or a project phase to an orderly end.
Chapter 3 – Project Management Processes for a Project

Figure 3-4. High Level Summary of Process Groups’ Interactions

Note: Not all process interactions and data flow among the Process Groups are shown.
3.2.1 Initiating Process Group

The Initiating Process Group consists of the processes that facilitate the formal authorization to start a new project or a project phase. Initiating processes are often done external to the project’s scope of control by the organization or by program or portfolio processes (Figure 3-5), which may blur the project boundaries for the initial project inputs. For example, before beginning the Initiation Process Group activities, the organization’s business needs or requirements are documented. The feasibility of the new undertaking may be established through a process of evaluating alternatives to pick the best one. Clear descriptions of the project objectives are developed, including the reasons why a specific project is the best alternative solution to satisfy the requirements. The documentation for this decision also contains a basic description of the project scope, the deliverables, project duration, and a forecast of the resources for the organization’s investment analysis. The framework of the project can be clarified by documenting the project selection processes. The relationship of the project to the organization’s strategic plan identifies the management responsibilities within the organization. In multi-phase projects, initiating processes are carried out during subsequent phases to validate the assumptions and decisions made during the original Develop Project Charter and Develop Preliminary Project Scope Statement processes.

![Figure 3-5. Project Boundaries](image)

The initial scope description and the resources that the organization is willing to invest are further refined during the initiation process. 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 management team may help write the Project Charter, approval and funding are handled external to the project boundaries.
As part of the Initiating Process Group, many large or complex projects may be divided into phases. Reviewing the initiating processes at the start of each phase helps to keep the project focused on the business need that the project was undertaken to address. The entry criteria are verified, including the availability of required resources. A decision is then made whether or not the project is ready to continue or whether the project should be delayed or discontinued. During subsequent project phases, further validation and development of the project scope for that phase is performed. Repeating the initiating processes at each subsequent phase also enables the project to be halted if the business need no longer exists or if the project is deemed unable to satisfy that business need.

Involving the customers and other stakeholders during initiation generally improves the probability of shared ownership, deliverable acceptance, and customer and other stakeholder satisfaction. Such acceptance is critical to project success. The Initiating Process Group (Figure 3-6) starts a project or project phase, and the output defines the project’s purpose, identifies objectives, and authorizes the project manager to start the project.

![Figure 3-6. Initiating Process Group](image)
The Initiating Process Group includes the following project management processes:

.1 Develop Project Charter
This process is primarily concerned with authorizing the project or, in a multi-phase project, a project phase. It is the process necessary for documenting the business needs and the new product, service, or other result that is intended to satisfy those requirements. This chartering links the project to the ongoing work of the organization and authorizes the project. Projects are chartered and authorized external to the project by the organization, a program or portfolio management body. In multi-phase projects, this process is used to validate or refine the decisions made during the previous Develop Project Charter process.

![Table 3-1. Develop Project Charter: Inputs and Outputs](image1)

.2 Develop Preliminary Project Scope Statement
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 project and deliverable requirements, product requirements, boundaries of the project, methods of acceptance, and high-level scope control. In multi-phase projects, this process validates or refines the project scope for each phase.

![Table 3-2. Develop Preliminary Project Scope: Inputs and Outputs](image2)
3.2.2 Planning Process Group

The project management team uses the Planning Process Group and its constituent processes and interactions to plan and manage a successful project for the organization. The Planning Process Group helps gather information from many sources with each having varying levels of completeness and confidence. The planning processes develop the project management plan. These processes also identify, define, and mature the project scope, project cost, and schedule the project activities that occur within the project. 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 occurring throughout the project life cycle trigger a need to revisit one or more of the planning processes and, possibly, some of the initiating processes.

The frequency of iterating the planning processes is also affected. 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 can be limited to the activities and issues associated with the execution of a 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 (see Figure 3-7).

While planning the project, the project team should involve all appropriate stakeholders, depending upon their influence on the project and its outcomes. The project team should use stakeholders in project planning since the stakeholders have skills and knowledge that can be leveraged in developing the project management plan and any subsidiary plans. The project team must create an environment in which stakeholders can contribute appropriately.

Since the feedback and refinement process cannot continue indefinitely, procedures set by the organization identify when the planning effort ends. These procedures will be affected by the nature of the project, the established project boundaries, appropriate monitoring and controlling activities, as well as the environment in which the project will be performed.

Other interactions among the processes within the Planning Process Group are 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. At that time, the team might recognize that the cost and schedule targets are overly aggressive, thus involving considerably more risk than previously understood. The results of the iterations are documented as updates to the project management plan.
Note: Not all process interactions and data flow among the processes are shown.

**Figure 3-7. Planning Process Group**

The Planning Process Group facilitates project planning across multiple processes. The following list identifies the processes the project team should address during the planning process to decide if they need to be done, and if so, by whom. The Planning Process Group includes the following project management processes:
.1 Develop Project Management Plan
This is the process necessary for defining, preparing, integrating and coordinating all subsidiary plans into a project management plan. The project management plan becomes the primary source of information for how the project will be planned, executed, monitored and controlled, and closed.

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

.2 Scope Planning
This is the process necessary for creating a project scope management plan that documents how the project scope will be defined, verified and controlled, and how the work breakdown structure will be created and defined.

Table 3-4. Scope Planning: 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.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Organizational process assets</td>
<td>.1 Project scope statement</td>
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<tr>
<td>.2 Project charter</td>
<td>.2 Requested changes</td>
</tr>
<tr>
<td>.3 Preliminary project scope statement</td>
<td>.3 Project scope management plan (updates)</td>
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<tr>
<td>.4 Project scope management plan</td>
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<tr>
<td>.5 Approved change requests</td>
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</tbody>
</table>

Table 3-5. Scope Definition: Inputs and Outputs

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

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td>.1 Organizational process assets</td>
<td>.1 Project scope statement</td>
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<td>.2 Project scope statement</td>
<td>.2 Requested changes</td>
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<td>.3 Project scope management plan</td>
<td>.3 Project scope management plan (updates)</td>
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<td>.4 Approved change requests</td>
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Table 3-6. Create WBS: Inputs and Outputs

.5 Activity Definition
This is the process necessary for identifying the specific activities that need to be performed to produce the various project deliverables.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>.1 Enterprise environmental factors</td>
<td>.1 Activity list</td>
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<tr>
<td>.2 Organizational process assets</td>
<td>.2 Activity attributes</td>
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<tr>
<td>.3 Project scope statement</td>
<td>.3 Milestone list</td>
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<tr>
<td>.4 Work breakdown structure</td>
<td>.4 Requested changes</td>
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<tr>
<td>.5 WBS dictionary</td>
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<td>.6 Project management plan</td>
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</table>

Table 3-7. Activity Definition: Inputs and Outputs
.6 Activity Sequencing
This is the process necessary for identifying and documenting dependencies among schedule activities.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>.1 Project scope statement</td>
<td>.1 Project schedule network diagrams</td>
</tr>
<tr>
<td>.2 Activity list</td>
<td>.2 Activity list (updates)</td>
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<tr>
<td>.3 Activity attributes</td>
<td>.3 Activity attributes (updates)</td>
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<tr>
<td>.4 Milestone list</td>
<td>.4 Requested changes</td>
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<tr>
<td>.5 Approved change requests</td>
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Table 3-8. Activity Sequencing: Inputs and Outputs

.7 Activity Resource Estimating
This is the process necessary for estimating the type and quantities of resources required to perform each schedule activity.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>.1 Enterprise environmental factors</td>
<td>.1 Activity resource requirements</td>
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<tr>
<td>.2 Organizational process assets</td>
<td>.2 Activity attributes (updates)</td>
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<tr>
<td>.3 Activity list</td>
<td>.3 Resource breakdown structure</td>
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<td>.4 Activity attributes</td>
<td>.4 Resource calendar (updates)</td>
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<td>.5 Resource availability</td>
<td>.5 Requested changes</td>
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<td>.6 Project management plan</td>
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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 schedule activities.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>.1 Enterprise environmental factors</td>
<td>.1 Activity duration estimates</td>
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<tr>
<td>.2 Organizational process assets</td>
<td>.2 Activity attributes (updates)</td>
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<tr>
<td>.3 Project scope statement</td>
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<td>.4 Activity list</td>
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<td>.5 Activity attributes</td>
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<tr>
<td>.6 Activity resource requirements</td>
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<td>.7 Resource calendar</td>
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<td>.8 Project management plan</td>
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<td>· Risk register</td>
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<td>· Activity cost estimates</td>
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</table>

Table 3-10. Activity Duration Estimating: Inputs and Outputs
.9 Schedule Development
This is the process necessary for analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organizational process assets</td>
<td>1. Project schedule</td>
</tr>
<tr>
<td>2. Project scope statement</td>
<td>2. Schedule model data</td>
</tr>
<tr>
<td>3. Activity list</td>
<td>3. Schedule baseline</td>
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<tr>
<td>4. Activity attributes</td>
<td>4. Resource requirements</td>
</tr>
<tr>
<td>5. Project schedule network diagrams</td>
<td>5. Activity attributes (updates)</td>
</tr>
<tr>
<td>6. Activity resource requirements</td>
<td>6. Project calendar (updates)</td>
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<tr>
<td>7. Resource calendars</td>
<td>7. Requested changes</td>
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<td>8. Activity duration estimates</td>
<td>8. Project management plan (updates)</td>
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<td>9. Project management plan</td>
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<tr>
<td>• Risk register</td>
<td>• Schedule management plan (updates)</td>
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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.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td>1. Enterprise environmental factors</td>
<td>1. Activity cost estimates</td>
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<tr>
<td>2. Organizational process assets</td>
<td>2. Activity cost estimate supporting detail</td>
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<tr>
<td>3. Project scope statement</td>
<td>3. Requested changes</td>
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<td>5. WBS dictionary</td>
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<td>6. Project management plan</td>
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<td>• Schedule management plan</td>
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<td>• Staffing management plan</td>
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<td>• Risk register</td>
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Table 3-12. Cost Estimating: 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.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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</thead>
<tbody>
<tr>
<td>1. Project scope statement</td>
<td>1. Cost baseline</td>
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<tr>
<td>2. Work breakdown structure</td>
<td>2. Project funding requirements</td>
</tr>
<tr>
<td>3. WBS dictionary</td>
<td>3. Cost management plan (updates)</td>
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<td>4. Activity cost estimates</td>
<td>4. Requested changes</td>
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<td>5. Activity cost estimate supporting detail</td>
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<td>6. Project schedule</td>
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<td>7. Resource calendars</td>
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<td>8. Contract</td>
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<td>9. Cost management plan</td>
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</table>

Table 3-13. Cost Budgeting: 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.

Table 3-14. Quality Planning: Inputs and Outputs

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

Table 3-15. Human Resource Planning: Inputs and Outputs

.14 Communications Planning
This is the process necessary for determining the information and communication needs of the project stakeholders.

Table 3-16. Communications Planning: Inputs and Outputs
.15 Risk Management Planning
This is the process necessary for deciding how to approach, plan and execute the risk management activities for a project.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
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<tbody>
<tr>
<td>.1 Enterprise environmental factors</td>
<td>.1 Risk management plan</td>
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<td>.2 Organizational process aspects</td>
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<td>.3 Project scope statement</td>
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<td>.4 Project management plan</td>
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Table 3-17. Risk Management Planning: Inputs and Outputs

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

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Enterprise environmental factors</td>
<td>.1 Risk register</td>
</tr>
<tr>
<td>.2 Organizational process aspects</td>
<td></td>
</tr>
<tr>
<td>.3 Project scope statement</td>
<td></td>
</tr>
<tr>
<td>.4 Risk management plan</td>
<td></td>
</tr>
<tr>
<td>.5 Project management plan</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-18. Risk Identification: Inputs and Outputs

.17 Qualitative Risk Analysis
This is the process necessary for prioritizing risks for subsequent further analysis or action by assessing and combining their probability of occurrence and impact.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Organizational process aspects</td>
<td>.1 Risk register (updates)</td>
</tr>
<tr>
<td>.2 Project scope statement</td>
<td></td>
</tr>
<tr>
<td>.3 Risk management plan</td>
<td></td>
</tr>
<tr>
<td>.4 Risk register</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-19. Qualitative Risk Analysis: Inputs and Outputs
.18 **Quantitative Risk Analysis**
This is the process necessary for numerically analyzing the effect on overall project objectives of identified risks.

<table>
<thead>
<tr>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organizational process assets</td>
</tr>
<tr>
<td>2. Project scope statement</td>
</tr>
<tr>
<td>3. Risk management plan</td>
</tr>
<tr>
<td>4. Risk register</td>
</tr>
<tr>
<td>5. Project management plan</td>
</tr>
<tr>
<td>- Project schedule management plan</td>
</tr>
<tr>
<td>- Project cost management plan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Risk register (updates)</td>
</tr>
</tbody>
</table>

Table 3-20. Quantitative Risk Analysis: Inputs and Outputs

.19 **Risk Response Planning**
This is the process necessary for developing options and actions to enhance opportunities and to reduce threats to project objectives.

<table>
<thead>
<tr>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Risk management plan</td>
</tr>
<tr>
<td>2. Risk register</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Risk register (updates)</td>
</tr>
<tr>
<td>2. Project management plan (updates)</td>
</tr>
<tr>
<td>3. Risk-related contractual agreements</td>
</tr>
</tbody>
</table>

Table 3-21. Risk Response Planning: Inputs and Outputs

.20 **Plan Purchases and Acquisitions**
This is the process necessary for determining what to purchase or acquire, and determining when and how.

<table>
<thead>
<tr>
<th>Inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enterprise environmental factors</td>
</tr>
<tr>
<td>2. Organizational process assets</td>
</tr>
<tr>
<td>3. Project scope statement</td>
</tr>
<tr>
<td>4. Work breakdown structure</td>
</tr>
<tr>
<td>5. WBS dictionary</td>
</tr>
<tr>
<td>6. Project management plan</td>
</tr>
<tr>
<td>- Risk register</td>
</tr>
<tr>
<td>- Risk-related contractual agreements</td>
</tr>
<tr>
<td>- Resource requirements</td>
</tr>
<tr>
<td>- Project schedule</td>
</tr>
<tr>
<td>- Activity cost estimates</td>
</tr>
<tr>
<td>- Cost baseline</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Procurement management plan</td>
</tr>
<tr>
<td>2. Contract statement of work</td>
</tr>
<tr>
<td>3. Make-or-buy decisions</td>
</tr>
<tr>
<td>4. Requested changes</td>
</tr>
</tbody>
</table>

Table 3-22. Plan Purchases and Acquisitions: Inputs and Outputs
.21 Plan Contracting
This is the process necessary for documenting products, services, and results requirements and identifying potential sellers.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Procurement management plan</td>
<td>1. Procurement documents</td>
</tr>
<tr>
<td>2. Contract statement of work</td>
<td>2. Evaluation criteria</td>
</tr>
<tr>
<td>3. Make-or-buy decisions</td>
<td>3. Contract statement of work (updates)</td>
</tr>
<tr>
<td>4. Project management plan</td>
<td></td>
</tr>
<tr>
<td>• Risk register</td>
<td></td>
</tr>
<tr>
<td>• Risk-related contractual agreements</td>
<td></td>
</tr>
<tr>
<td>• Resource requirements</td>
<td></td>
</tr>
<tr>
<td>• Project schedule</td>
<td></td>
</tr>
<tr>
<td>• Activity cost estimate</td>
<td></td>
</tr>
<tr>
<td>• Cost baseline</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-23. Plan Contracting: Inputs and Outputs

3.2.3 Executing Process Group
The Executing Process Group consists of the processes used to complete the work defined in the project management plan to accomplish the project’s requirements. The project team should determine which of the processes are required for the team’s specific project. This Process Group involves coordinating people and resources, as well as integrating and performing the activities of the project in accordance with the project management plan. This Process Group also addresses the scope defined in the project scope statement and implements approved changes (see Figure 3-8).

Note: Not all process interactions and data flow among the processes are shown.

Figure 3-8. Executing Process Group
Normal execution variances will cause some replanning. These variances can include activity durations, resource productivity and availability and unanticipated risks. Such variances may or may not affect the project management plan, but can require an analysis. The results of the analysis can trigger a change request that, if approved, would modify the project management plan and possibly require establishing a new baseline. The vast majority of the project’s budget will be expended in performing the Executing Process Group processes. The Executing Process Group includes the following project management processes:

.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 work defined in the project management plan. The deliverables are produced as outputs from the processes performed as defined in the project management plan. Information on the completion status of the deliverables and what work has been accomplished are collected as part of project execution and input to the performance reporting process.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Project management plan</td>
<td>1. Deliverables</td>
</tr>
<tr>
<td>2. Approved corrective actions</td>
<td>2. Requested changes</td>
</tr>
<tr>
<td>3. Approved preventive actions</td>
<td>3. Implemented change requests</td>
</tr>
<tr>
<td>4. Approved change requests</td>
<td>4. Implemented corrective actions</td>
</tr>
<tr>
<td>5. Approved defect repair</td>
<td>5. Implemented preventive actions</td>
</tr>
<tr>
<td>6. Validated defect repair</td>
<td>6. Implemented preventive actions</td>
</tr>
<tr>
<td>7. Administrative closure procedure</td>
<td>7. Work performance information</td>
</tr>
</tbody>
</table>

Table 3-24. Direct and Manage Project Execution: Inputs and Outputs

.2 Perform Quality Assurance
This is the process necessary for applying the planned, systematic quality activities to ensure that the project employs all processes needed to meet requirements.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quality management plan</td>
<td>1. Requested changes</td>
</tr>
<tr>
<td>2. Quality metrics</td>
<td>2. Recommended corrective actions</td>
</tr>
<tr>
<td>3. Process improvement plan</td>
<td>3. Organizational process assets (updates)</td>
</tr>
<tr>
<td>5. Approved change requests</td>
<td>6. Implemented corrective actions</td>
</tr>
<tr>
<td>7. Quality control measurements</td>
<td>7. Implemented defect repair</td>
</tr>
<tr>
<td>8. Implemented preventive actions</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-25. Perform Quality Assurance: Inputs and Outputs
.3 Acquire Project Team
This is the process necessary for obtaining the human resources needed to complete the project.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Enterprise environmental factors</td>
<td>.1 Project staff assignments</td>
</tr>
<tr>
<td>.2 Organizational process assets</td>
<td>.2 Resource availability</td>
</tr>
<tr>
<td>.3 Roles and responsibilities</td>
<td>.3 Staffing management plan (updates)</td>
</tr>
<tr>
<td>.4 Project organization charts</td>
<td></td>
</tr>
<tr>
<td>.5 Staffing management plan</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-26. Acquire Project Team: Inputs and Outputs

.4 Develop Project Team
This is the process necessary for improving the competencies and interaction of team members to enhance project performance.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Project staff assignments</td>
<td>.1 Team performance assessment</td>
</tr>
<tr>
<td>.2 Staffing management plan</td>
<td></td>
</tr>
<tr>
<td>.3 Resource availability</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-27. Develop Project Team: Inputs and Outputs

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

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Communications management plan</td>
<td>.1 Organizational process assets (updates)</td>
</tr>
<tr>
<td></td>
<td>.2 Requested changes</td>
</tr>
</tbody>
</table>

Table 3-28. Information Distribution: Inputs and Outputs
.6 Request Seller Responses
This is the process necessary for obtaining information, quotations, bids, offers or proposals.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Organizational process assets</td>
<td>.1 Qualified sellers list</td>
</tr>
<tr>
<td>.2 Procurement management plan</td>
<td>.2 Procurement document package</td>
</tr>
<tr>
<td>.3 Procurement documents</td>
<td>.3 Proposals</td>
</tr>
</tbody>
</table>

Table 3-29. Request Seller Responses: Inputs and Outputs

.7 Select Sellers
This is the process necessary for reviewing offers, choosing from among potential sellers, and negotiating a written contract with the seller.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Organizational process assets</td>
<td>.1 Selected sellers</td>
</tr>
<tr>
<td>.2 Procurement management plan</td>
<td>.2 Contract</td>
</tr>
<tr>
<td>.3 Evaluation criteria</td>
<td>.3 Contract management plan</td>
</tr>
<tr>
<td>.4 Procurement document package</td>
<td>.4 Resource availability</td>
</tr>
<tr>
<td>.5 Proposals</td>
<td>.5 Procurement management plan (updates)</td>
</tr>
<tr>
<td>.6 Qualified sellers list</td>
<td>.6 Requested changes</td>
</tr>
</tbody>
</table>
| .7 Project management plan  
  - Risk register  
  - Risk-related contractual agreements | |

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 observe project execution so that potential problems can be identified in a timely manner and corrective action can be taken, when necessary, to control the execution of the project. The project team should determine which of the processes are required for the team’s specific project. The key benefit of this Process Group is that project performance is observed and measured regularly to identify variances from the project management plan. The Monitoring and Controlling Process Group also includes controlling changes and recommending preventive action in anticipation of possible problems. 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 could circumvent integrated change control so only approved changes are implemented.

This continuous monitoring provides the project team insight into the health of the project and highlights any areas that require additional attention. The Monitoring and Controlling Process Group not only monitors and controls the work being done within a Process Group, but also monitors and controls the entire project effort. In multi-phase projects, the Monitoring and Controlling Process Group also provides feedback between project phases, 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 as part of the modified plan-do-check-act cycle. 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 3-9 indicates some of the process interactions that are essential to this Process Group.
Chapter 3 – Project Management Processes for a Project

Figure 3.9. Monitoring and Controlling Process Group

The Monitoring and Controlling Process Group includes the following project management processes:
.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 risk monitoring to ensure that risks are identified early, their status is reported, and appropriate risk plans are being executed. Monitoring includes status reporting, progress measurement, and forecasting. Performance reports provide information on the project’s performance with regard to scope, schedule, cost, resources, quality, and risk.

![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 throughout the project, from project initiation through project closure.

![Table 3-32. Integrated Change Control: Inputs and Outputs]
.3 **Scope Verification**
This is the process necessary for formalizing acceptance of the completed project deliverables.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Project scope statement</td>
<td>.1 Accepted deliverables</td>
</tr>
<tr>
<td>.2 WBS dictionary</td>
<td>.2 Requested changes</td>
</tr>
<tr>
<td>.3 Project scope management plan</td>
<td>.3 Recommended corrective actions</td>
</tr>
<tr>
<td>.4 Deliverables</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-33. Scope Verification: Inputs and Outputs

.4 **Scope Control**
This is the process necessary for controlling changes to the project scope.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Project scope statement (updates)</td>
<td>.1 Project scope statement</td>
</tr>
<tr>
<td>.2 Work breakdown structure (updates)</td>
<td>.2 Work breakdown structure</td>
</tr>
<tr>
<td>.3 WBS dictionary</td>
<td>.3 WBS dictionary</td>
</tr>
<tr>
<td>.4 Scope baseline (updates)</td>
<td>.4 Scope baseline</td>
</tr>
<tr>
<td>.5 Requested changes</td>
<td>.5 Requested changes</td>
</tr>
<tr>
<td>.6 Recommended corrective action</td>
<td>.6 Recommended corrective action</td>
</tr>
<tr>
<td>.7 Organizational process assets (updates)</td>
<td>.7 Organizational process assets</td>
</tr>
<tr>
<td>.8 Project management plan (updates)</td>
<td>.8 Project management plan</td>
</tr>
</tbody>
</table>

Table 3-34. Scope Control: Inputs and Outputs

.5 **Schedule Control**
This is the process necessary for controlling changes to the project schedule.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Schedule management plan</td>
<td>.1 Schedule model data (updates)</td>
</tr>
<tr>
<td>.2 Schedule baseline</td>
<td>.2 Schedule baseline (updates)</td>
</tr>
<tr>
<td>.3 Performance reports</td>
<td>.3 Performance measurements</td>
</tr>
<tr>
<td>.4 Approved change requests</td>
<td>.4 Requested changes</td>
</tr>
<tr>
<td>.5 Recommended corrective actions</td>
<td>.5 Recommended corrective actions</td>
</tr>
<tr>
<td>.6 Organizational process assets (updates)</td>
<td>.6 Organizational process assets</td>
</tr>
<tr>
<td>.7 Activity list (updates)</td>
<td>.7 Activity list</td>
</tr>
<tr>
<td>.8 Activity attributes (updates)</td>
<td>.8 Activity attributes</td>
</tr>
<tr>
<td>.9 Project management plan (updates)</td>
<td>.9 Project management plan</td>
</tr>
</tbody>
</table>

Table 3-35. Schedule Control: Inputs and Outputs
.6 Cost Control
The process of influencing the factors that create variances, and controlling changes to the project budget.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cost baseline</td>
<td>1. Cost estimate (updates)</td>
</tr>
<tr>
<td>2. Project funding requirements</td>
<td>2. Cost baseline (updates)</td>
</tr>
<tr>
<td>3. Performance reports</td>
<td>3. Performance measurements</td>
</tr>
<tr>
<td>5. Approved change requests</td>
<td>5. Requested changes</td>
</tr>
<tr>
<td>6. Project management plan</td>
<td>6. Recommended corrective actions</td>
</tr>
<tr>
<td></td>
<td>7. Organizational process assets (updates)</td>
</tr>
<tr>
<td></td>
<td>8. Project management plan (updates)</td>
</tr>
</tbody>
</table>

Table 3-36. Cost Control: Inputs and Outputs

.7 Perform Quality Control
This is the process necessary for monitoring specific project results to determine whether they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Quality management plan</td>
<td>1. Quality control</td>
</tr>
<tr>
<td>2. Quality metrics</td>
<td>2. Validated defect repair</td>
</tr>
<tr>
<td>3. Quality checklists</td>
<td>3. Quality baseline (updates)</td>
</tr>
<tr>
<td>4. Organizational process assets</td>
<td>4. Recommended corrective actions</td>
</tr>
<tr>
<td>5. Work performance information</td>
<td>5. Recommended preventive actions</td>
</tr>
<tr>
<td>6. Approved change requests</td>
<td>6. Requested changes</td>
</tr>
<tr>
<td>7. Deliverables</td>
<td>7. Recommended defect repair</td>
</tr>
<tr>
<td></td>
<td>8. Organization process assets (updates)</td>
</tr>
<tr>
<td></td>
<td>9. Validated deliverables</td>
</tr>
<tr>
<td></td>
<td>10. Project Management Plan (Updates)</td>
</tr>
</tbody>
</table>

Table 3-37. Perform Quality Control: Inputs and Outputs

.8 Manage Project Team
This is the process necessary for tracking team member performance, providing feedback, resolving issues, and coordinating changes to enhance project performance.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Organizational process assets</td>
<td>1. Requested changes</td>
</tr>
<tr>
<td>2. Project staff assignments</td>
<td>2. Recommended corrective actions</td>
</tr>
<tr>
<td>3. Roles and responsibilities</td>
<td>3. Recommended preventive actions</td>
</tr>
<tr>
<td>4. Project organization charts</td>
<td>4. Organizational process assets (updates)</td>
</tr>
<tr>
<td>5. Staffing management plan</td>
<td>5. Project management plan (updates)</td>
</tr>
<tr>
<td>6. Team performance assessment</td>
<td></td>
</tr>
<tr>
<td>7. Work performance information</td>
<td></td>
</tr>
<tr>
<td>8. Performance reports</td>
<td></td>
</tr>
</tbody>
</table>
.9 Performance Reporting
This is the process necessary for collecting and distributing performance information. This includes status reporting, progress measurement, and forecasting.

Table 3-39. Performance Reporting: Inputs and Outputs

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Work performance information</td>
<td>.1 Performance reports</td>
</tr>
<tr>
<td>.2 Performance measurements</td>
<td>.2 Forecasts</td>
</tr>
<tr>
<td>.3 Forecasted completion</td>
<td>.3 Requested changes</td>
</tr>
<tr>
<td>.4 Quality control measurements</td>
<td>.4 Recommended corrective actions</td>
</tr>
<tr>
<td>.5 Project management plan</td>
<td>.5 Organizational process assets (updates)</td>
</tr>
<tr>
<td>- Performance measurement baseline</td>
<td></td>
</tr>
<tr>
<td>.6 Approved change requests</td>
<td></td>
</tr>
<tr>
<td>.7 Deliverables</td>
<td></td>
</tr>
</tbody>
</table>

.10 Manage Stakeholders
This is the process necessary for managing communications to satisfy the requirements of, and resolve issues with, project stakeholders.

Table 3-40. Manage Stakeholders: Inputs and Outputs

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Communications management plan</td>
<td>.1 Resolved issues</td>
</tr>
<tr>
<td>.2 Organizational process assets</td>
<td>.2 Approved change requests</td>
</tr>
<tr>
<td></td>
<td>.3 Approved corrective actions</td>
</tr>
<tr>
<td></td>
<td>.4 Organizational process assets (updates)</td>
</tr>
<tr>
<td></td>
<td>.5 Project management plan (updates)</td>
</tr>
</tbody>
</table>
.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.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Risk management plan</td>
<td></td>
</tr>
<tr>
<td>.2 Risk register</td>
<td></td>
</tr>
<tr>
<td>.3 Approved change requests</td>
<td></td>
</tr>
<tr>
<td>.4 Work performance information</td>
<td></td>
</tr>
<tr>
<td>.5 Performance reports</td>
<td></td>
</tr>
<tr>
<td>.1 Risk register (updates)</td>
<td></td>
</tr>
<tr>
<td>.2 Requested changes</td>
<td></td>
</tr>
<tr>
<td>.3 Recommended corrective actions</td>
<td></td>
</tr>
<tr>
<td>.4 Recommended preventive actions</td>
<td></td>
</tr>
<tr>
<td>.5 Organizational process assets (updates)</td>
<td></td>
</tr>
<tr>
<td>.6 Project management plan (updates)</td>
<td></td>
</tr>
</tbody>
</table>

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

.12 Contract Administration
This is the process necessary for managing the contract and relationship between the buyer and seller, reviewing and documenting how a seller is performing or has performed and, when appropriate, managing the contractual relationship with the outside buyer of the project.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Contract</td>
<td></td>
</tr>
<tr>
<td>.2 Contract management plan</td>
<td></td>
</tr>
<tr>
<td>.3 Selected sellers</td>
<td></td>
</tr>
<tr>
<td>.4 Performance reports</td>
<td></td>
</tr>
<tr>
<td>.5 Approved change requests</td>
<td></td>
</tr>
<tr>
<td>.6 Work performance information</td>
<td></td>
</tr>
<tr>
<td>.1 Contract documentation</td>
<td></td>
</tr>
<tr>
<td>.2 Requested changes</td>
<td></td>
</tr>
<tr>
<td>.3 Recommended corrective actions</td>
<td></td>
</tr>
<tr>
<td>.4 Organizational process assets (updates)</td>
<td></td>
</tr>
<tr>
<td>.5 Project management plan (updates)</td>
<td></td>
</tr>
<tr>
<td>· Procurement management plan</td>
<td></td>
</tr>
<tr>
<td>· Contract management plan</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-42. Contract Administration: Inputs and Outputs
3.2.5 Closing Process Group

The Closing Process Group includes the processes used to formally terminate all activities of a project or a project phase, hand off the completed product to others or close a cancelled project. This Process Group, when completed, verifies that the defined processes are completed within all the Process Groups to close the project or a project phase, as appropriate, and formally establishes that the project or project phase is finished. See Figure 3-10.

![Figure 3-10. Closing Process Group](image-url)
The Closing Process Group includes the following project management processes:

.1 Close Project
This is the process necessary to finalize all activities across all of the Process Groups to formally close the project or a project phase.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Project management plan</td>
<td>.1 Administrative closure procedure</td>
</tr>
<tr>
<td>.2 Contract documentation</td>
<td>.2 Contract closure procedure</td>
</tr>
<tr>
<td>.3 Enterprise environmental factors</td>
<td>.3 Final product, service, or result</td>
</tr>
<tr>
<td>.4 Organizational process assets</td>
<td>.4 Organizational process assets (updates)</td>
</tr>
<tr>
<td>.5 Work performance information</td>
<td></td>
</tr>
<tr>
<td>.6 Deliverables</td>
<td></td>
</tr>
</tbody>
</table>

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, and closing each contract applicable to the project or a project phase.

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>.1 Procurement management plan</td>
<td>.1 Closed contracts</td>
</tr>
<tr>
<td>.2 Contract management plan</td>
<td>.2 Organizational process assets (updates)</td>
</tr>
<tr>
<td>.3 Contract documentation</td>
<td></td>
</tr>
<tr>
<td>.4 Contract closure procedure</td>
<td></td>
</tr>
</tbody>
</table>

Table 3-44. Contract Closure: Inputs and Outputs

3.3 Process Interactions
Project Management Process Groups are linked by the objectives they produce. The output of one process generally becomes an input to another process or is a deliverable of the project. The Planning Process Group provides the Executing Process Group a documented project management plan and project scope statement, and often updates the project management plan as the project progresses. In addition, the 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 3-11 illustrates how the Process Groups interact and the level of overlap at varying times within a project. If the project is divided into phases, the Process Groups interact within a project phase and also may cross the project phases.
Among the Process Groups and their processes, the process outputs are related and have an impact on the other Process Groups. For example, closing a design phase requires customer acceptance of the design document. Then, the design document defines the product description for the ensuing Executing Process Group. When a project is divided into phases, the Process Groups are normally repeated within each phase throughout the project’s life to effectively drive the project to completion. The Process Groups and their relationships are illustrated in Figure 3-12.
Figure 3-12. Project Management Process Group Triangle

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

- Projects that are dependent upon unique resources (e.g., commercial software development and biopharmaceuticals) can define roles and responsibilities prior to scope definition, since what can be done is dependent on who is available to do it.
- Some process inputs are 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 will often require scheduling backward from that date and 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 into the five Project Management Process Groups and the nine Project Management Knowledge Areas. Each of the required project management processes is shown in the Process Group in which 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.
<table>
<thead>
<tr>
<th>Knowledge Area Processes</th>
<th>Project Management Process Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Project Management Integration</td>
<td></td>
</tr>
<tr>
<td>Develop Project Charter 3.2.1.1 (4.1) Develop Preliminary Project Scope Statement 3.2.1.2 (4.2)</td>
<td>Initiating Process Group</td>
</tr>
<tr>
<td>Develop Project Management Plan 3.2.2.1 (4.3)</td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Direct and Manage Project Execution 3.2.3.1 (4.4)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td>Monitor and Control Project Work 3.2.4.1 (4.5) Integrated Change Control 3.2.4.2 (4.6)</td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>Close Project 3.2.5.1 (4.7)</td>
<td>Closing Process Group</td>
</tr>
<tr>
<td>5. Project Scope Management</td>
<td></td>
</tr>
<tr>
<td>Scope Planning 3.2.2.2 (5.1) Scope Definition 3.2.2.3 (5.2) Create WBS 3.2.2.4 (5.3)</td>
<td>Initiating Process Group</td>
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<tr>
<td></td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Scope Verification 3.2.4.3 (5.4) Scope Control 3.2.4.4 (5.5)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td></td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>6. Project Time Management</td>
<td></td>
</tr>
<tr>
<td>Activity Definition 3.2.2.5 (6.1) Activity Sequencing 3.2.2.6 (6.2) Activity Resource Estimating 3.2.2.7 (6.3) Activity Duration Estimating 3.2.2.8 (6.4) Schedule Development 3.2.2.9 (6.5)</td>
<td>Initiating Process Group</td>
</tr>
<tr>
<td></td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Schedule Control 3.2.4.5 (6.6)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td></td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>7. Project Cost Management</td>
<td></td>
</tr>
<tr>
<td>Cost Estimating 3.2.2.10 (7.1) Cost Budgeting 3.2.2.11 (7.2)</td>
<td>Initiating Process Group</td>
</tr>
<tr>
<td></td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Cost Control 3.2.4.6 (7.3)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td></td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>8. Project Quality Management</td>
<td></td>
</tr>
<tr>
<td>Quality Planning 3.2.2.12 (8.1)</td>
<td>Initiating Process Group</td>
</tr>
<tr>
<td></td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Perform Quality Assurance 3.2.3.2 (8.2)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td></td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>Human Resource Planning 3.2.2.13 (9.1)</td>
<td>Initiating Process Group</td>
</tr>
<tr>
<td></td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Acquire Project Team 3.2.3.3 (9.2) Develop Project Team 3.2.3.4 (9.3)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td></td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>Manage Project Team 3.2.4.8 (9.4)</td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>10. Project Communications Management</td>
<td></td>
</tr>
<tr>
<td>Communications Planning 3.2.2.14 (10.1)</td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Information Distribution 3.2.3.5 (10.2)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td>Performance Reporting 3.2.4.9 (10.3) Manage Stakeholders 3.2.4.10 (10.4)</td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>11. Project Risk Management</td>
<td></td>
</tr>
<tr>
<td>Risk Management Planning 3.2.2.15 (11.1) Risk Identification 3.2.2.16 (11.2) Qualitative Risk Analysis 3.2.2.17 (11.3) Quantitative Risk Analysis 3.2.2.18 (11.4) Risk Response Planning 3.2.2.19 (11.5)</td>
<td>Planning Process Group</td>
</tr>
<tr>
<td></td>
<td>Executing Process Group</td>
</tr>
<tr>
<td>Risk Monitoring and Control 3.2.4.11 (11.6)</td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
<tr>
<td>12. Project Procurement Management</td>
<td></td>
</tr>
<tr>
<td>Plan Purchases and Acquisitions 3.2.2.20 (12.1) Plan Contracting 3.2.2.21 (12.2)</td>
<td>Initiating Process Group</td>
</tr>
<tr>
<td>Request Seller Responses 3.2.3.6 (12.3) Select Sellers 3.2.3.7 (12.4)</td>
<td>Planning Process Group</td>
</tr>
<tr>
<td>Contract Administration 3.2.4.12 (12.5)</td>
<td>Executing Process Group</td>
</tr>
<tr>
<td>Contract Close 3.2.5.2 (12.6)</td>
<td>Monitoring &amp; Controlling Process Group</td>
</tr>
</tbody>
</table>

Table 3-45. Mapping of the Project Management Processes to the Project Management Process Groups and the Knowledge Areas
Section III

The Project Management Knowledge Areas

Section III  Introduction
Chapter 4    Project Integration Management
Chapter 5    Project Scope Management
Chapter 6    Project Time Management
Chapter 7    Project Cost Management
Chapter 8    Project Quality Management
Chapter 9    Project Human Resource Management
Chapter 10   Project Communications Management
Chapter 11   Project Risk Management
Chapter 12   Project Procurement Management
SECTION III

Introduction

Process Flow Diagrams

A process flow diagram is provided in each Knowledge Area chapter (Chapters 4 through 12). The process flow diagram is a summary level depiction of the process inputs and process outputs that flow down through all the processes within a specific Knowledge Area. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they are iterative and can overlap and interact in ways not detailed here.

Figure III-1. Process Flow Diagram Legend

Process flow diagrams show basic steps and interactions. Many additional interactions are possible.
The symbols for the process flow diagrams are explained in Figure III-1 and depict three types of information:

1. Knowledge Area processes, their interaction with other processes within the Knowledge Area, and their outputs to Chapter 4 integration processes.
2. Processes external to the Knowledge Area, whose outputs are used as inputs to the Knowledge Area processes under discussion.
3. Organizational process assets and enterprise environmental factors are shown as inputs to the first process.

The project management plan, and its subsidiary plans and components that are external to the Knowledge Area, are provided as input into the first process of the diagram, and are considered to be available in each subsequent process in their latest updated form.

The organizational process assets and enterprise environmental factors are shown as inputs to the first process to provide those items of information, policy, and procedure that are external to the project, but can impact the project planning and execution. These assets and factors, plus the external process outputs used as an input to a Knowledge Area process, are also considered to be available in each subsequent process in their latest updated form.

The process flow diagram is not detailed and does not show all the possible interfaces with all external processes. It also does not show possible alternate process flow paths or feedback loops among the specific Knowledge Area processes or with processes external to the Knowledge Area. The iterative nature of most projects makes the permutations of the process flows and feedback loops very complex. Therefore, in the interest of keeping the flow diagrams easier to follow, alternate or iterative paths were not included with the diagrams.
Figure III-2. Three Major Project Documents and their Relationship to their Components
Major Project Documents

There are three major documents described within the *PMBOK® Guide* and each has a specific purpose:

- **Project Charter.** Formally authorizes the project.
- **Project Scope Statement.** States what work is to be accomplished and what deliverables need to be produced.
- **Project Management Plan.** States how the work will be performed.

Figure III-2 depicts these three documents and their relationship to their components.

The project management plan is composed of the plans and documents generated by the various processes. Those items are the subsidiary plans and components of the project management plan.
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 project management activities within the Project Management 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 customer and other stakeholder requirements, and managing 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 these issues before they become critical, and coordinating 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 the planning processes described in greater detail in the Project Cost Management processes, Project Time Management processes, and Project Risk Management processes. When additional risks associated with various staffing alternatives are identified, then one or more of those processes must be revisited. The project deliverables also need to be integrated with ongoing operations of either the performing organization or the customer’s organization, or with the 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 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 project and product requirements, criteria, assumptions, constraints, and other influences related to a project, and how each will be managed or addressed within the project.
- Document specific criteria of the product requirements.
- Understand how to take the identified information and transform it into a project management plan using the Planning Process Group described in the *PMBOK® Guide*.
- Prepare the work breakdown structure.
- Take appropriate action to have the project performed in accordance with the project management plan, the planned set of integrated processes, and the planned scope.
- Measure and monitor project status, processes and products.
- Analyze project risks.

Among the processes in the Project Management 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 facilitates updates to the project management plan if changes occur as the project progresses.

Integration is primarily concerned with effectively integrating the processes among the Project Management Process Groups that are required to accomplish project objectives within an organization’s defined procedures. Figure 4-1 provides an overview of the major project management integrative processes. Figure 4-2 provides a process flow diagram of those processes and their inputs, outputs and other related Knowledge Area processes. The integrative project management processes include:

4.1 **Develop Project Charter** – developing the project charter that formally authorizes a project or a project phase.

4.2 **Develop Preliminary Project Scope Statement** – developing the preliminary project scope statement that provides a high-level scope narrative.

4.3 **Develop Project Management Plan** – documenting 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 requirements defined in the project scope statement.

4.5 **Monitor and Control Project Work** – monitoring and controlling the processes used 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 Management Process Groups to formally close the project or a project phase.

Figure 4-1. Project Integration Management Overview
Chapter 4 – Project Integration Management

Note: Not all process interactions and data flow among the processes are shown.

Figure 4-2. Project Integration Management Processes Flow Diagram
4.1 Develop Project Charter

The project charter is the document that formally authorizes a project. 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.

A project initiator or sponsor external to the project organization, at a level that is appropriate to funding the project, issues the project charter. Projects are usually chartered and authorized external to 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 (e.g., a car company authorizing a project to build more fuel-efficient cars in response to gasoline shortages)
- A business need (e.g., a training company authorizing a project to create a new course to increase its revenues)
- A customer request (e.g., an electric utility authorizing a project to build a new substation to serve a new industrial park)
- A technological advance (e.g., an electronics firm authorizing a new project to develop a faster, cheaper, and smaller laptop after advances in computer memory and electronics technology)
- A legal requirement (e.g., a paint manufacturer authorizing a project to establish guidelines for handling toxic materials)
- A social need (e.g., a nongovernmental organization in a developing country authorizing a project to provide potable water systems, latrines, and sanitation education to 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 or sponsor and may include other organizational decision criteria. Project selection also applies to choosing alternative ways of executing the project.

Chartering a project links the project to the ongoing work of the 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 separately initiated. Developing the project charter 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 is intended to satisfy those requirements. The project charter, either directly, or by reference to other documents, should address the following information:
Chapter 4 – Project Integration Management

- Requirements that satisfy customer, sponsor, and other stakeholder needs, wants and expectations
- Business needs, high-level project description, or product requirements that the project is undertaken to address
- Project purpose or justification
- Assigned Project Manager and authority level
- Summary milestone schedule
- Stakeholder influences
- Functional organizations and their participation
- Organizational, environmental and external assumptions
- Organizational, environmental and external constraints
- Business case justifying the project, including return on investment
- Summary budget.

During subsequent phases of multi-phase projects, the Develop Project Charter process validates the decisions made during the original chartering of the project. If required, it also authorizes the next project phase, and updates the charter.

**Figure 4-3. Develop Project Charter: Inputs, Tools & Techniques, and Outputs**

### 4.1.1 Develop Project Charter: Inputs

1. **Contract (When Applicable)**
   A contract from the customer’s acquiring organization is an input if the project is being done for an external customer.

2. **Project Statement of Work**
   The statement of work (SOW) 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, 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 should support the organization’s strategic goals. The strategic plan of the performing organization should be considered as a factor when making project selection decisions.

3 Enterprise Environmental Factors
When developing the project charter, any and all of the organization’s enterprise environmental factors and systems that surround and influence the project’s success must be considered. This includes items such as, but not limited to:

• Organizational or company culture and structure
• Governmental or industry standards (e.g., regulatory agency regulations, product standards, quality standards, and workmanship standards)
• Infrastructure (e.g., existing facilities and capital equipment)
• Existing human resources (e.g., skills, disciplines, and knowledge, such as design, development, legal, contracting, and purchasing)
• Personnel administration (e.g., hiring and firing guidelines, employee performance reviews, and training records)
• Company work authorization system
• Marketplace conditions
• Stakeholder risk tolerances
• Commercial databases (e.g., standardized cost estimating data, industry risk study information, and risk databases)
• Project management information systems (e.g., an automated tool suite, such as a scheduling software tool, a configuration management system, an information collection and distribution system, or web interfaces to other online automated systems).
.4 Organizational Process Assets

When developing the project charter and subsequent project documentation, any and all of the assets that are used to influence the project’s success can be drawn from organizational process assets. Any and all of the organizations involved in the project can have formal and informal policies, procedures, plans, and guidelines whose effects must be considered. Organizational process assets also represent the organizations’ learning and knowledge from previous projects; for example, completed schedules, risk data, and earned value data. Organizational process assets can be organized differently, depending on the type of industry, organization, and application area. For example, the organizational process assets could be grouped into two categories:

- Organization’s processes and procedures for conducting work:
  - Organizational standard processes, such as standards, policies (e.g., safety and health policy, and project management policy), standard product and project life cycles, and quality policies and procedures (e.g., process audits, improvement targets, checklists, and standardized process definitions for use in the organization)
  - Standardized guidelines, work instructions, proposal evaluation criteria, and performance measurement criteria
  - Templates (e.g., risk templates, work breakdown structure templates, and project schedule network diagram templates)
  - Guidelines and criteria for tailoring the organization’s set of standard processes to satisfy the specific needs of the project
  - Organization communication requirements (e.g., specific communication technology available, allowed communication media, record retention, and security requirements)
  - Project closure guidelines or requirements (e.g., final project audits, project evaluations, product validations, and acceptance criteria)
  - Financial controls procedures (e.g., 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
  - Change control procedures, including the steps by which official company standards, policies, plans, and procedures—or 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 approving and issuing work authorizations.
• Organizational corporate knowledge base for storing and retrieving information:
  ♦ Process measurement database used to collect and make available measurement data on processes and products
  ♦ Project files (e.g., scope, cost, schedule, and quality baselines, performance measurement baselines, project calendars, project schedule network diagrams, risk registers, planned response actions, and defined risk impact)
  ♦ Historical information and lessons learned knowledge base (e.g., project records and documents, all project closure information and documentation, information about both the results of previous project selection decisions and previous project performance information, and information from the risk management effort)
  ♦ Issue and defect management database containing issue and defect status, control information, issue and defect resolution, and action item results
  ♦ Configuration management knowledge base containing the versions and baselines of all official company standards, policies, procedures, and any project documents
  ♦ Financial database containing information such as labor hours, incurred costs, budgets, and any project cost overruns.

4.1.2 Develop Project Charter: Tools and Techniques

.1 Project Selection Methods
Project selection methods are used to determine which project the 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, or multi-objective programming algorithms.

.2 Project Management Methodology
A project management methodology defines a set of Project Management Process Groups, their related processes and the related control functions that are consolidated and combined into a functioning unified whole. A project management methodology may or may not be an elaboration of a project management standard. A project management methodology can be either a formal mature process or an informal technique that aids a project management team in effectively developing a project charter.
.3 Project Management Information System
The 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 Judgment
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 organization
- Consultants
- Stakeholders, including customers or sponsors
- Professional and technical associations
- Industry groups.

4.1.3 Develop Project Charter: Outputs

.1 Project Charter
Described in the introduction to Section 4.1.

4.2 Develop Preliminary Project Scope Statement
The project scope statement is the definition of the project—what needs to be accomplished. The Develop Preliminary Project Scope Statement 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 product objectives
- Product or service requirements and characteristics
- Product acceptance criteria
- Project boundaries
- Project requirements and deliverables
- Project constraints
- Project assumptions
- Initial project organization
- Initial defined risks
- Schedule milestones
- Initial WBS
- Order of magnitude cost estimate
- Project configuration management requirements
• Approval requirements.

The preliminary project scope statement is developed from information provided by the initiator or sponsor. The project management team in the Scope Definition process further refines the preliminary project scope statement into the project scope statement. 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. During subsequent phases of multi-phase projects, the Develop Preliminary Project Scope Statement process validates and refines, if required, the project scope defined for that phase.

Figure 4-4. Develop Preliminary Project Scope Statement: Inputs, Tools & Techniques, and Outputs

4.2.1 Develop Preliminary Project Scope Statement: Inputs

.1 Project Charter
Described in Section 4.1.

.2 Project Statement of Work
Described in Section 4.1.1.2.

.3 Enterprise Environmental Factors
Described in Section 4.1.1.3.

.4 Organizational Process Assets
Described in Section 4.1.1.4.

4.2.2 Develop Preliminary Project Scope Statement: Tools and Techniques

.1 Project Management Methodology
The project management methodology defines a process that aids a project management team in developing and controlling changes to the preliminary project scope statement.
Chapter 4 – Project Integration Management

.2 Project Management Information System
The project management information system, an automated 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 Preliminary Project Scope Statement: Outputs

.1 Preliminary Project Scope Statement
Described in the introduction to Section 4.2.

4.3 Develop Project Management Plan
The Develop Project Management Plan process includes the actions necessary to define, integrate, and coordinate all subsidiary 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, and closed. The project management plan documents the collection of outputs of the planning processes of the Planning Process Group and includes:

• The project management processes selected by the project management team  
• The level of implementation of each selected process  
• The descriptions of the tools and techniques to be used for accomplishing those processes  
• 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 configuration management will be performed  
• How integrity of the performance measurement baselines will be maintained and used  
• The need and techniques for communication among stakeholders  
• The selected project life cycle and, for multi-phase projects, the associated project phases  
• Key management reviews for content, extent, and timing to facilitate addressing open issues and pending decisions.
The project management plan can be either summary level or detailed, and can be composed of one or more subsidiary plans and other components. Each of the subsidiary plans and components is detailed to the extent required by the specific project. These subsidiary plans include, but are not limited to:

- Project scope management plan (Section 5.1.3.1)
- Schedule management plan (Chapter 6 introductory material)
- Cost management plan (Chapter 7 introductory material)
- Quality management plan (Section 8.1.3.1)
- Process improvement plan (Section 8.1.3.4)
- Staffing management plan (Section 9.1.3.3)
- Communication management plan (Section 10.1.3.1)
- Risk management plan (Section 11.1.3.1)
- Procurement management plan (Section 12.1.3.1).

These other components include, but are not limited to:

- Milestone list (Section 6.1.3.3)
- Resource calendar (Section 6.3.3.4)
- Schedule baseline (Section 6.5.3.3)
- Cost baseline (Section 7.2.3.1)
- Quality baseline (Section 8.1.3.5)
- Risk register (Section 11.2.3.1)

![Figure 4-5. Develop Project Management Plan: Inputs, Tools & Techniques, and Outputs](image)

### 4.3.1 Develop Project Management Plan: Inputs

1. **Preliminary Project Scope Statement**
   Described in Section 4.2.

2. **Project Management Processes**
   Described in Chapters 5 through 12.
4.3.2 Develop Project Management Plan: Tools and Techniques

.1 Project Management Methodology
The project management methodology defines a process, which aids a project management team in developing and controlling changes to the project management plan.

.2 Project Management Information System
The project management information system, an automated 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.

- Configuration Management System
The configuration management system is a subsystem of the overall project management information system. The system includes the process for submitting proposed changes, tracking systems for reviewing and approving proposed changes, defining approval levels for authorizing changes, and providing 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.

- 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 can include the specifications (scripts, source code, data definition language, etc.) for each software component.

.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 the introduction to Section 4.3.

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 objectives
- Expend effort and spend funds to accomplish the project objectives
- Staff, train, and manage the project team members assigned to the project
- 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, control, verify, and validate project deliverables
- Manage risks and implement risk response activities
- Manage sellers
- Adapt approved changes into the project’s scope, plans, and environment
- Establish and manage project communication channels, both external and internal to the project team
- Collect project 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, along with 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 about the completion status of the deliverables, and what has been accomplished, is collected as part of project execution and is fed into the performance reporting process. 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.
Direct and Manage Project Execution also requires implementation of:

- Approved corrective actions that will bring anticipated project performance into compliance 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 4-6. Direct and Manage Project Execution: Inputs, Tools & Techniques, and Outputs

4.4.1 Direct and Manage Project Execution: Inputs

.1 Project Management Plan
   Described in the introduction to 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.

.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. The approved change requests can also modify policies, project management plans, procedures, costs or budgets, 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 request for product correction of a defect found during the quality inspection or the audit process.
.6 Validated Defect Repair
Notification that reinspected repaired items have either been accepted or rejected.

.7 Administrative Closure Procedure
The administrative closure procedure documents all the activities, interactions, and related roles and responsibilities needed in executing the administrative closure procedure for the project.

4.4.2 Direct and Manage Project Execution: Tools and Techniques

.1 Project Management Methodology
The project management methodology defines a process that aids a project team in executing the project management plan.

.2 Project Management Information System
The project management information system is an automated system used by the project management team to aid execution of 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 that is identified in the project management planning documentation, and 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 can be optional or legally/contractually mandated.

.3 Implemented Change Requests
Approved change requests that have been implemented by the project management team during project execution.

.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**
During project execution, the project management team has implemented approved product defect corrections.

.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
- Deliverables that have been completed and those not completed
- Schedule activities that have started and those that have been finished
- Extent to which quality standards are being met
- Costs authorized and incurred
- Estimates to complete the schedule activities that have started
- Percent physically complete of the in-progress schedule activities
- Documented lessons learned posted to the lessons learned knowledge base
- Resource utilization detail.

4.5 **Monitor and Control Project Work**
The Monitor and Control Project Work process is performed to monitor project processes associated with initiating, planning, executing, and closing. Corrective or preventive actions are taken to control the project performance. Monitoring is an aspect of project management performed throughout the project. 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
- 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
- Maintaining an accurate, timely information base concerning the project’s product(s) and their associated documentation through project completion
- Providing information to support status reporting, progress measurement, and forecasting
- Providing forecasts to update current cost and current schedule information
- Monitoring implementation of approved changes when and as they occur.
4.5.1 Monitor and Control Project Work: Inputs

1. Project Management Plan
   Described in the introduction to Section 4.3.

2. Work Performance Information
   Described in Section 4.4.3.7.

3. Rejected Change Requests
   Rejected change requests include the change requests, their supporting
documentation, and their change review status showing a disposition of rejected
change requests.

4.5.2 Monitor and Control Project Work: Tools and Techniques

1. Project Management Methodology
   The project management methodology defines a process that 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
   The project management information system (PMIS), an automated system, is used
by the project management team to monitor and control the execution of activities
that are planned and scheduled in the project management plan. The PMIS is also
used to create new forecasts as needed.

3. Earned Value Technique
   The earned value technique measures performance of the project as it moves from
project initiation through project closure. 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.

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

.3 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 reissued based on work performance information provided as the project is executed. This information is about the project’s past performance that could impact the project in the future; for example, estimate at completion and estimate to complete.

.4 Recommended Defect Repair
Some defects, which are found during the quality inspection and audit process, are recommended for correction.

.5 Requested Changes
Described in Section 4.4.3.2.

4.6 Integrated Change Control
The Integrated Change Control process is performed from project inception through completion. Change control is necessary because projects seldom run exactly according to the project management plan. The project management plan, the project scope statement, and other deliverables must be maintained by carefully and continuously managing changes, either by rejecting changes or by approving changes so those approved changes are incorporated into a revised baseline. 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 or has occurred.
- Influencing the factors that circumvent integrated change control so that only approved changes are implemented.
- Reviewing and approving requested changes.
- Managing the approved changes when and as they occur, by regulating the flow of requested changes.
- Maintaining the integrity of baselines by releasing only approved changes for incorporation into project products or services, and maintaining their related configuration and planning documentation.
- Reviewing and approving all recommended corrective and preventive actions.
• Controlling and updating the scope, cost, budget, schedule and quality requirements based upon approved changes, by coordinating changes across the entire project. For example, a proposed schedule change will often affect cost, risk, quality, and staffing.
• Documenting the complete impact of requested changes.
• Validating defect repair.
• Controlling project quality to standards based on quality reports.

Proposed changes can require new or revised cost estimates, schedule activity sequences, schedule dates, resource requirements, and analysis of risk response alternatives. These changes can require adjustments to the project management plan, project scope statement, or other project deliverables. The configuration management system with change control provides a standardized, effective, and efficient process to centrally manage changes within a project. Configuration management with change control includes identifying, documenting, and controlling changes to the baseline. The applied level of change control is dependent upon the application area, 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 by considering the impact of each change
• Provides the mechanism for the project management team to consistently communicate all changes to the stakeholders.

Some of the configuration management activities included in the integrated change control process are:
• **Configuration Identification.** Providing the basis from which the configuration of products is 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 Auditing.** Establishing that the performance and functional requirements defined in the configuration documentation have been met.
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, sponsor, or customer. Many times, the integrated change control process includes a change control board responsible for approving and rejecting the requested changes. The roles and responsibilities of these boards are clearly defined within the configuration control and change control procedures, and are agreed to by the sponsor, customer, and other stakeholders. Many large organizations provide for a multi-tiered board structure, separating responsibilities among the boards. If the project is being provided under a contract, then some proposed changes would need to be approved by the customer.

Figure 4-8. Integrated Change Control: Inputs, Tools & Techniques, and Outputs

### 4.6.1 Integrated Change Control: Inputs

1. **Project Management Plan**
   Described in the introduction to Section 4.3.

2. **Requested Changes**
   Described in Section 4.4.3.2.

3. **Work Performance Information**
   Described in Section 4.4.3.7.

4. **Recommended Preventive Actions**
   Described in Section 4.5.3.2.

5. **Recommended Corrective Actions**
   Described in Section 4.5.3.1.

6. **Recommended Defect Repair**
   Described in Section 4.5.3.4.

7. **Deliverables**
   Described in Section 4.4.3.1.
4.6.2 Integrated Change Control: Tools and Techniques

.1 Project Management Methodology
   The project management methodology defines a process that aids a project management team in implementing Integrated Change Control for the project.

.2 Project Management Information System
   The project management information system, an automated system, is used by the project management team as an aid for the implementing an Integrated Change Control process for the project, facilitate feedback for the project and control changes across the project.

.3 Expert Judgment
   The project management team uses stakeholders with expert judgment on the change control board 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 4.4.1.4.

.2 Rejected Change Requests
   Described in Section 4.5.1.3.

.3 Project Management Plan (Updates)
   Described in the introduction to Section 4.3.

.4 Project Scope Statement (Updates)
   Described in Section 5.3.3.1.

.5 Approved Corrective Actions
   Described in Section 4.4.1.2.

.6 Approved Preventive Actions
   Described in Section 4.4.1.3.

.7 Approved Defect Repair
   Described in Section 4.4.1.5.

.8 Validated Defect Repair
   Described in Section 4.4.1.6.

.9 Deliverables
   Described in Section 4.4.3.1 and approved by the Integrated Change Control process (Section 4.6).
4.7 Close Project

The Close Project process involves performing the project closure portion of the project management plan. In multi-phase projects, the Close Project process closes out the portion of the project scope and associated activities applicable to a given phase. This process includes finalizing all activities completed across all Project Management Process Groups to formally close the project or a project phase, and transfer the completed or cancelled project 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 developed to establish the interactions necessary to perform the closure activities across the entire project or for a project phase:

- **Administrative closure procedure.** This procedure details all the activities, interactions, and related roles and responsibilities of the project team members and other stakeholders involved in executing the administrative closure procedure for the project. Performing the administrative closure process also includes integrated activities needed to collect project records, analyze project success or failure, gather lessons learned, and archive project information for future use by the organization.

- **Contract closure procedure.** Includes all activities and interactions needed to settle and close any contract agreement established for the project, as well as define those 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 that information for future use). The contract terms and conditions can also prescribe specifications 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. This procedure is an input to the Close Contract process.

![Figure 4-9. Close Project: Inputs, Tools & Techniques, and Outputs](image-url)
4.7.1 Close Project: Inputs

.1 Project Management Plan
Described in the introduction to Section 4.3.

.2 Contract Documentation
Contract documentation is an input used to perform the contract closure process, and includes the contract itself, as well as changes to the contract and other documentation (such as the technical approach, product description, or deliverable acceptance criteria and procedures).

.3 Enterprise Environmental Factors
Described in Section 4.1.1.3.

.4 Organizational Process Assets
Described in Section 4.1.1.4.

.5 Work Performance Information
Described in Section 4.4.3.7.

.6 Deliverables
Described in Section 4.4.3.1 and approved by the Integrated Change Control process (Section 4.6).

4.7.2 Close Project: Tools and Techniques

.1 Project Management Methodology
The project management methodology defines a process that aids a project management team in performing both administrative and contract closure procedures for the project.

.2 Project Management Information System
The project management team uses the project management information system to perform both administrative and contract closure procedures across the project.

.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 of the project team members involved in executing the administrative closure procedure. The procedures to transfer the project products or services to production and/or operations are developed and established. This procedure provides a step-by-step methodology for administrative closure that addresses:
• Actions and activities to define the stakeholder approval requirements for changes and all levels of deliverables
• Actions and activities that are necessary to confirm that the project has met all sponsor, customer, and other stakeholders’ requirements, verify that all deliverables have been provided and accepted, and validate that completion and exit criteria have been met
• Actions and activities necessary to satisfy completion or exit criteria for the project.

.2 Contract Closure Procedure
This procedure is developed to provide a step-by-step methodology that addresses the terms and conditions of the contracts and any required completion or exit criteria for contract closure. It contains all activities and related responsibilities of the project team members, customers, and other stakeholders involved in the contract closure process. The actions performed formally close all contacts associated with the completed project.

.3 Final Product, Service, or Result
Formal acceptance and handover of the final product, service, or result that the project was authorized to produce. The acceptance includes receipt of a formal statement that the terms of the contract have been met.

.4 Organizational Process Assets (Updates)
Closure will include the development of the index and location of project documentation using the configuration management system (Section 4.3).
• Formal Acceptance Documentation. Formal confirmation has been received from the customer or sponsor that customer requirements and specifications for the project’s product, service, or result have been met. This document formally indicates that the customer or sponsor has officially accepted the deliverables.
• Project Files. Documentation resulting from the project’s activities; for example, project management plan, scope, cost, schedule and quality baselines, project calendars, risk registers, planned risk response actions, and risk impact.
• 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 formalizes the procedures for the transfer of the finished and unfinished deliverables 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. Project 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 project scope management plan that documents how the project scope will be defined, verified, 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 deliverables.

5.5 **Scope Control** – controlling changes to the project scope.

These processes interact with each other and with processes in the other Knowledge Areas as well. Each process can involve effort from one or more persons or groups of persons, based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. 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 Chapter 3.
In the project context, the term scope can refer to:

- **Product scope.** The features and functions that characterize a product, service, or result.

- **Project scope.** The work that needs to be accomplished to deliver a product, service, or result with the specified features and functions.

This chapter focuses on the processes used to manage the project scope. These project scope management processes, and their associated tools and techniques, vary by application area, are usually defined as part of the project life cycle (Section 2.1), and are documented in the project scope management plan. The approved detailed project scope statement and its associated WBS and WBS dictionary are the scope baseline for the project.

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 (Section 4.3), the project scope statement, and its associated WBS and WBS dictionary, but completion of the product scope is measured against the product requirements. Project scope management needs to be well integrated with the other Knowledge Area processes, so that the work of the project will result in delivery of the specified product scope.
Figure 5-1. Project Scope Management Overview
Chapter 5 – Project Scope Management

Figure 5-2. Project Scope Management Process Flow Diagram

Note: Not all process interactions and data flow among the processes are shown.
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 these scope management decisions in the project scope management plan. The project scope management plan is a planning tool describing how the team will define the project scope, develop the detailed project scope statement, define and develop the work breakdown structure, verify the project scope, and control the project scope. The development of the project scope management plan and the detailing of the project scope begin with the analysis of information contained in the project charter (Section 4.1), the preliminary project scope statement (Section 4.2), the latest approved version of the project management plan (Section 4.3), historical information contained in the organizational process assets (Section 4.1.1.4), and any relevant enterprise environmental factors (Section 4.1.1.3).

Figure 5-3. Scope Planning: Inputs, Tools & Techniques, and Outputs

5.1.1 Scope Planning: Inputs

.1 Enterprise Environmental Factors
Enterprise environmental factors include items such as the organization’s culture, infrastructure, tools, human resources, personnel policies, and marketplace conditions that could affect how project scope is managed.

.2 Organizational Process Assets
Organizational process assets are the formal and informal policies, procedures, and guidelines that could impact how the project’s scope is managed. Those of particular interest to project scope planning include:
• Organizational policies as they pertain to project scope planning and management
• Organizational procedures related to project scope planning and management
• Historical information about previous projects that may be located in the lessons learned knowledge base.

.3 **Project Charter**
Described in Section 4.1.

.4 **Preliminary Project Scope Statement**
Described in Section 4.2.

.5 **Project Management Plan**
Described in the introduction to Section 4.3.

## 5.1.2 Scope Planning: Tools and Techniques

.1 **Expert Judgment**
Expert judgment related to how equivalent projects have managed scope is used in developing the project scope management plan.

.2 **Templates, Forms, Standards**
Templates could include work breakdown structure templates, scope management plan templates, and project scope change control forms.

## 5.1.3 Scope Planning: Outputs

.1 **Project Scope Management Plan**
The project scope management plan provides guidance on how project scope will be defined, documented, verified, managed, and controlled by the project management team. The components of a project scope management plan include:

• A process to prepare a detailed project scope statement based upon the preliminary project scope statement
• A process that enables the creation of the WBS from the detailed project scope statement, and establishes how the WBS will be maintained and approved
• A process that specifies how formal verification and acceptance of the completed project deliverables 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 the integrated change control process (Section 4.6).

A project scope management plan is contained in, or is a subsidiary of, the project management plan. The project 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 is critical to project success and builds upon the major deliverables, assumptions, and constraints that are documented during project initiation in the preliminary project scope statement. During planning, the project scope is defined and described with greater specificity because more information about the project is known. Stakeholder needs, wants, and expectations are analyzed and converted into requirements. The assumptions and constraints are analyzed for completeness, with additional assumptions and constraints added as necessary. The project team and other stakeholders, who have additional insight into the preliminary project scope statement, can perform and prepare the analyses.

Figure 5-4. Scope Definition: Inputs, Tools & Techniques, and Outputs

5.2.1 Scope Definition: Inputs

.1 Organizational Process Assets
Described in Section 4.1.1.4.

.2 Project Charter
If a project charter is not used in a performing organization, then comparable information needs to be acquired or developed, and used to develop the detailed project scope statement.

.3 Preliminary Project Scope Statement
If a preliminary project scope statement is not used in a performing organization, then comparable information, including the product scope description, needs to be acquired or developed and used to develop the detailed project scope statement.

.4 Project Scope Management Plan
Described in Section 5.1.3.1.

.5 Approved Change Requests
Approved change requests (Section 4.4) can cause a change to project scope, project quality, estimated costs, or project schedule. Changes are often identified and approved while the work of the project is ongoing.
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 and requirements. Product analysis includes techniques such as product breakdown, systems analysis, systems engineering, value engineering, value analysis, and functional analysis.

.2 Alternatives Identification
Identifying alternatives is a technique used to generate different approaches to execute and perform the work of the project. A variety of general management techniques is 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 develop portions of the detailed project scope statement.

.4 Stakeholder Analysis
Stakeholder analysis identifies the influence and interests of the various stakeholders and documents their needs, wants, and expectations. The analysis then selects, prioritizes, and quantifies the needs, wants, and expectations to create requirements. Unquantifiable expectations, such as customer satisfaction, are subjective and entail a high risk of being successfully accomplished. Stakeholders’ interests may be positively or negatively affected by execution or completion of the project and they may also exert influence over the project and its deliverables.

5.2.3 Scope Definition: Outputs

.1 Project Scope Statement
The project scope statement describes, in detail, the project’s deliverables and the work required to create those deliverables. The project scope statement also provides a common understanding of the project scope among all project stakeholders and describes the project’s major objectives. It also enables the project team to perform more detailed planning, guides the project team’s work during execution, and provides the baseline for evaluating whether requests for changes or additional work are contained within or outside the project’s boundaries.

The degree and level of detail to which the project scope statement defines what work will be performed and what work is excluded can determine how well the project management team can control the overall project scope. Managing the project scope, in turn, can determine how well the project management team can plan, manage, and control the execution of the project. The detailed project scope statement includes, either directly or by reference to other documents:
• **Project objectives.** Project 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. Each project objective has attributes such as cost, a metric such as United States dollars, and an absolute or relative value such as less than 1.5 million dollars.

• **Product scope description.** Describes the characteristics of the product, service, or result that the project was undertaken to create. These characteristics 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 characteristics will vary, the scope description should always provide sufficient detail to support later project scope planning.

• **Project requirements.** Describes the conditions or capabilities that must be met or possessed by the deliverables of the project to satisfy a contract, standard, specification, or other formally imposed documents. Stakeholder analyses of all stakeholder needs, wants, and expectations are translated into prioritized requirements.

• **Project boundaries.** Identifies generally what is included within the project. It states explicitly what is excluded from the project, if a stakeholder might assume that a particular product, service, or result could be a component of the project.

• **Project deliverables.** Deliverables (Section 4.4.3.1) include both the outputs that comprise the product or service of the project, as well as ancillary results, 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.** Defines the process and criteria for accepting completed products.

• **Project constraints.** Lists and describes the specific project constraints associated with the project scope that limit the team’s options. For example, a predefined budget or any imposed dates (schedule milestones) that are issued by the customer or performing organization are included. When a project is performed under contract, contractual provisions will generally be constraints. The constraints listed in the detailed project scope statement are typically more numerous and more detailed than the constraints listed in the project charter.

• **Project assumptions.** Lists and describes the specific project assumptions associated with the project 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 detailed 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 project team, as well as stakeholders, are identified. The organization of the project is also documented.

• **Initial defined risks.** Identifies the known risks.

• **Schedule milestones.** The customer or performing organization can identify milestones and can place imposed dates on those schedule milestones. These dates can be addressed as schedule constraints.

• **Fund limitation.** Describes any limitation placed upon funding for the project, whether in total value or over specified time frames.

• **Cost estimate.** The project’s cost estimate factors into the project’s expected overall cost, and is usually preceded by a modifier that provides some indication of accuracy, such as conceptual or definitive.

• **Project configuration management requirements.** Describes the level of configuration management and change control to be implemented on the project.

• **Project specifications.** Identifies those specification documents with which the project should comply.

• **Approval requirements.** Identifies approval requirements that can be applied to items such as project objectives, deliverables, documents, and work.

### 5.2 Requested Changes

Requested changes to the project management plan and its subsidiary plans may be developed during the Scope Definition process. Requested changes are processed for review and disposition through the Integrated Change Control process.

### 5.3 Project Scope Management Plan (Updates)

The project scope management plan component of the project management plan may need to be updated to include approved change requests resulting from the project’s Scope Definition process.

### 5.3 Create WBS

The WBS is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team, to accomplish the project objectives and create the required deliverables. The WBS organizes and defines the total scope of the project. The WBS subdivides the project work into smaller, more manageable pieces of work, with each descending level of the WBS representing an increasingly detailed definition of the project work. The planned work contained within the lowest-level WBS components, which are called work packages, can be scheduled, cost estimated, monitored, and controlled.

The WBS represents the work specified in the current approved project scope statement. Components comprising the WBS assist the stakeholders in viewing the deliverables (Section 4.4.3.1) of the project.
5.3.1 Create WBS: Inputs

.1 Organizational Process Assets
   Described in Section 4.1.1.4.

.2 Project Scope Statement
   Described in Section 5.2.3.1.

.3 Project Scope Management Plan
   Described in Section 5.2.1.4.

.4 Approved Change Requests
   Described in Section 4.4.1.4.

5.3.2 Create WBS: Tools and Techniques

.1 Work Breakdown Structure Templates
   Although each project is unique, a WBS from a previous project can often be used
   as a template for a new project, since some projects will resemble another prior
   project to some extent. For example, most projects within a given organization will
   have the same or similar project life cycles and, therefore, have the same or similar
   deliverables required from each phase. Many application areas or performing
   organizations have standard WBS templates.

   The Project Management Institute Practice Standard for Work Breakdown
   Structures provides guidance for the generation, development, and application of
   work breakdown structures. This publication contains industry-specific examples of
   WBS templates that can be tailored to specific projects in a particular application
   area. A portion of a WBS 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 work and deliverables are defined to the work package level. The work package level is the lowest level in the WBS, and is the point at which the cost and schedule for the work can be reliably estimated. The level of detail for work packages will vary with the size and complexity of the project.

Decomposition may not be possible for a deliverable or subproject that will be accomplished far into the future. The project management team usually waits until the deliverable or subproject is clarified so the details of the WBS can be developed. This technique is sometimes referred to as rolling wave planning.

Different deliverables can have different levels of decomposition. To arrive at a manageable work effort (i.e., a work package), the work for some deliverables needs to be decomposed only to the next level, while others need more levels of decomposition. As the work is decomposed to lower levels of detail, the ability to plan, manage, and control the work is enhanced. However, excessive decomposition can lead to non-productive management effort, inefficient use of resources, and decreased efficiency in performing the work. The project team needs to seek a balance between too little and too much in the level of WBS planning detail.
Decomposition of the total project work generally involves the following activities:

- Identifying the deliverables and related work
- Structuring and organizing the WBS
- Decomposing the upper WBS levels into lower level detailed components
- Developing and assigning identification codes to the WBS components
- Verifying that the degree of decomposition of the work is necessary and sufficient.

Identifying the major deliverables of the project and the work needed to produce those deliverables requires analyzing the detailed project scope statement. This analysis requires a degree of expert judgment to identify all the work including project management deliverables and those deliverables required by contract.

Structuring and organizing the deliverables and associated project work into a WBS that can meet the control and management requirements of the project management team is an analytical technique that may be done with the use of a WBS template. The resulting structure can take a number of forms, such as:

- Using the major deliverables and subprojects as the first level of decomposition, as shown in Figure 5-6.
- Using 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. The seller then develops the supporting contract work breakdown structure as part of the contracted work.
- 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, where test and evaluation is a phase, the air vehicle is a product, and training is a supporting service.

Decomposition of the upper level WBS components requires subdividing the work for each of the deliverables or subprojects into its fundamental components, where the WBS components represent verifiable products, services, or results. Each component should be clearly and completely defined and assigned to a specific performing organizational unit that accepts responsibility for the WBS component’s completion. The components are defined in terms of how the work of the project will actually be executed and controlled. For example, the status-reporting component of project management could include weekly status reports, while a product to be manufactured might include several individual physical components plus the final assembly.
Verifying the correctness of the decomposition requires determining that the lower-level WBS components are those that are necessary and sufficient for completion of the corresponding higher-level deliverables.

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

Figure 5-8. Sample Work Breakdown for Defense Materiel Items
5.3.3 Create WBS: Outputs

1 Project Scope Statement (Updates)
If approved change requests result from the Create WBS process, then the project
scope statement is updated to include those approved changes.

2 Work Breakdown Structure
The key document generated by the Create WBS process is the actual WBS. Each
WBS component, including work package and control accounts within a WBS, is
generally assigned a unique identifier from a code of accounts. These identifiers
provide a structure for hierarchical summation of costs, schedule, and resource
information.

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

- **Organizational Breakdown Structure (OBS)**. 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 (BOM)**. Presents a hierarchical tabulation of the physical
  assemblies, subassemblies, and components needed to fabricate a
  manufactured product.

- **Risk Breakdown Structure (RBS)**. A hierarchically organized depiction of
  the identified project risks arranged by risk category.

- **Resource Breakdown Structure (RBS)**. A hierarchically organized
  depiction of the resources by type to be used on the project.

3 WBS Dictionary
The document generated by the Create WBS process that supports the WBS is
called the WBS dictionary and is a companion document to the WBS. The detailed
content of the components contained in a WBS, including work packages and
control accounts, can be described in the WBS dictionary. For each WBS
component, the WBS dictionary includes a code of account identifier, a statement
of work, responsible organization, and a list of schedule milestones. Other
information for a WBS component can include contract information, quality
requirements, and technical references to facilitate performance of the work. Other
information for a control account would be a charge number. Other information for
a work package can include a list of associated schedule activities, resources
required, and an estimate of cost. Each WBS component is cross-referenced, as
appropriate, to other WBS components in the WBS dictionary.

4 Scope Baseline
The approved detailed project scope statement (Section 5.2.3.1) and its associated
WBS and WBS dictionary are the scope baseline for the project.
.5 Project Scope Management Plan (Updates)
If approved change requests result from the Create WBS process, then the project scope management plan may need to be updated to include approved changes.

.6 Requested Changes
Requested changes to the project scope statement and its components may be generated from the Create WBS process, and are processed for review and approval through the integrated change control process.

5.4 Scope Verification
Scope verification is the process of obtaining the stakeholders’ formal acceptance of the completed project scope and associated deliverables. Verifying the project scope includes reviewing deliverables to ensure that each is completed satisfactorily. If the project is terminated early, the project scope verification process should establish and document the level and extent of completion. Scope verification differs from quality control in that scope verification is primarily concerned with acceptance of the deliverables, while quality control is primarily concerned with meeting the quality requirements specified for the deliverables. Quality control is generally performed before scope verification, but these two processes can be performed in parallel.

Figure 5-9. Scope Verification: Inputs, Tools & Techniques, and Outputs

5.4.1 Scope Verification: Inputs

.1 Project Scope Statement
The project scope statement includes the product scope description that describes the project’s product to be reviewed and the product acceptance criteria.

.2 WBS Dictionary
The WBS dictionary is a component of the detailed project scope definition, and is used to verify that the deliverables being produced and accepted are included in the approved project scope.
.3 Project Scope Management Plan
Described in Section 5.1.3.1.

.4 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).

5.4.2 Scope Verification: Tools and Techniques

.1 Inspection
Inspection includes activities such as measuring, examining, and verifying to determine whether work and deliverables meet requirements and product acceptance criteria. 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: Outputs

.1 Accepted Deliverables
The Scope Verification process documents those completed deliverables that have been accepted. Those completed deliverables that have not been accepted are documented, along with the reasons for non-acceptance. Scope verification includes supporting documentation received from the customer or sponsor and acknowledging stakeholder acceptance of the project’s deliverables.

.2 Requested Changes
Requested changes may be generated from the Scope Verification process, and are processed for review and disposition through the Integrated Change Control process.

.3 Recommended Corrective Actions
Described in Section 4.5.3.1.

5.5 Scope Control
Project scope control is concerned with influencing the factors that create project scope changes and controlling the impact of those changes. Scope control assures all requested changes and recommended corrective actions are processed through the project Integrated Change Control process. Project scope control is also used to manage the actual changes when they occur and is integrated with the other control processes. Uncontrolled changes are often referred to as project scope creep. Change is inevitable, thereby mandating some type of change control process.
5.5.1 Scope Control: Inputs

.1 Project Scope Statement
The project scope statement, along with its associated WBS and WBS dictionary (Section 5.3), defines the project’s scope baseline and product scope.

.2 Work Breakdown Structure
Described in Section 5.3.3.2.

.3 WBS Dictionary
Described in Section 5.3.3.3.

.4 Project Scope Management Plan
Described in Section 5.1.3.1.

.5 Performance Reports
Performance reports provide information on project work performance, such as interim deliverables that have been completed.

.6 Approved Change Requests
An approved change request (Section 4.4.1.4) impacting project scope is any modification to the agreed-upon project scope baseline, as defined by the approved project scope statement, WBS, and WBS dictionary.

.7 Work Performance Information
Described in Section 4.4.3.7.
5.5.2 Scope Control: Tools and Techniques

.1 Change Control System
A project scope change control system, documented in the project scope management plan, defines the procedures by which the project scope and product scope can be changed. The system includes the documentation, tracking systems, and approval levels necessary for authorizing changes. The scope change control system is integrated with any overall project management information system (Section 4.6.2.2) to control project scope. When the project is managed under a contract, the change control system also complies with all relevant contractual provisions.

.2 Variance Analysis
Project performance measurements are used to assess the magnitude of variation. Important aspects of project scope control include determining the cause of variance relative to the scope baseline (Section 5.3.3.4) and deciding whether corrective action is required.

.3 Replanning
Approved change requests affecting the project scope can require modifications to the WBS and WBS dictionary, the project scope statement, and the project scope management plan. These approved change requests can cause updates to components of the project management plan.

.4 Configuration Management System
A formal configuration management system (Section 4.3.2.2) provides procedures for the status of the deliverables, and assures that requested changes to the project scope and product scope are thoroughly considered and documented before being processed through the Integrated Change Control process.

5.5.3 Scope Control: Outputs

.1 Project Scope Statement (Updates)
If the approved change requests have an effect upon the project scope, then the project scope statement is revised and reissued to reflect the approved changes. The updated project scope statement becomes the new project scope baseline for future changes.

.2 Work Breakdown Structure (Updates)
If the approved change requests have an effect upon the project scope, then the WBS is revised and reissued to reflect the approved changes.

.3 WBS Dictionary (Updates)
If the approved change requests have an effect upon the project scope, then the WBS dictionary is revised and reissued to reflect the approved changes.
.4 **Scope Baseline (Updates)**
Described in Section 5.3.3.4.

.5 **Requested Changes**
The results of project scope control can generate requested changes, which are processed for review and disposition according to the project Integrated Change Control process.

.6 **Recommended Corrective Action**
A recommended corrective action is any step recommended to bring expected future project performance in line with the project management plan and project scope statement.

.7 **Organizational Process Assets (Updates)**
The causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned from project scope change control are documented and updated in the historical database of the organizational process assets.

.8 **Project Management Plan (Updates)**
If the approved change requests have an effect on the project scope, then the corresponding component documents and cost baseline, and schedule baselines of the project management plan, are revised and reissued to reflect the approved changes.
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 schedule activities that need to be performed to produce the various project deliverables.

6.2 Activity Sequencing – identifying and documenting dependencies among schedule activities.

6.3 Activity Resource Estimating – estimating the type and quantities of resources required to perform each schedule activity.

6.4 Activity Duration Estimating – estimating the number of work periods that will be needed to complete individual schedule activities.

6.5 Schedule Development – analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.

6.6 Schedule Control – controlling changes to the project schedule.

These processes interact with each other and with processes in the other Knowledge Areas as well. Each process can involve effort from one or more persons or groups of persons, based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. 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 Chapter 3.
On some projects, especially ones of smaller scope, activity sequencing, activity resource estimating, activity duration estimating, and schedule development are so tightly linked that they are viewed as a single process that can be performed by a person 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 discrete 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 is part of the Develop Project Management Plan process (Section 4.3), which produces a schedule management plan that sets the format and establishes criteria for developing and controlling the project schedule. The project time management processes, and their associated tools and techniques, vary by application area, are usually defined as part of the project life cycle (Section 2.1), and are documented in the schedule management plan. The schedule management plan is contained in, or is a subsidiary plan of, the project management plan (introduction to Section 4.3), and may be formal or informal, highly detailed or broadly framed, based upon the needs of the project.
Figure 6-1. Project Time Management Overview
Chapter 6 – Project Time Management

Note: Not all process interactions and data flow among the processes are shown.

Figure 6-2. Project Time Management Process Flow Diagram
6.1 Activity Definition

Defining the schedule activities involves identifying and documenting the work that is planned to be performed. The Activity Definition process will identify the deliverables at the lowest level in the work breakdown structure (WBS), which is called the work package. Project work packages are planned (decomposed) into smaller components called schedule activities to provide a basis for estimating, scheduling, executing, and monitoring and controlling the project work. Implicit in this process is defining and planning the schedule activities such that the project objectives will be met.

Figure 6-3. Activity Definition: Inputs, Tools & Techniques, and Outputs

6.1.1 Activity Definition: Inputs

.1 Enterprise Environmental Factors

Enterprise environmental factors (Section 4.1.1.3) that can be considered include availability of project management information systems and scheduling software tools.

.2 Organizational Process Assets

Organizational process assets (Section 4.1.1.4) contain the existing formal and informal activity planning-related policies, procedures, and guidelines that are 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 schedule activities.

.3 Project Scope Statement

The project deliverables, constraints, and assumptions documented in the project scope statement (Section 5.2.3.1) are considered explicitly during activity definition. Constraints are factors that will limit the project management team’s options, such as schedule milestones with imposed completion dates that are required either by management or contract. Assumptions are factors that are considered to be true for project schedule planning, such as work hours per week or the time of the year that construction work will be performed.
.4 Work Breakdown Structure
The work breakdown structure (Section 5.3.3.2) is a primary input to schedule activity definition.

.5 WBS Dictionary
The WBS dictionary (Section 5.3.3.3) is a primary input to schedule activity definition.

.6 Project Management Plan
The project management plan contains the schedule management plan (Chapter 6 introductory material), which provides guidance on the development and planning of schedule activities and the project scope management plan.

6.1.2 Activity Definition: Tools and Techniques

.1 Decomposition
The technique of decomposition, as it is applied to activity definition, involves subdividing the project work packages into smaller, more manageable components called schedule activities. The Activity Definition process defines the final outputs as schedule activities rather than as deliverables, as is done in the Create WBS process (Section 5.3).

The activity list, WBS, and WBS dictionary can be developed either sequentially or concurrently, with the WBS and WBS dictionary being the basis for development of the final activity list. Each work package within the WBS is decomposed into the schedule activities required to produce the work package deliverables. This activity definition is often performed by the project team members responsible for the work package.

.2 Templates
A standard activity list or a portion of an activity list from a previous project is often usable as a template (Section 4.1.1.4) for a new project. The related activity attributes 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 schedule milestones.

.3 Rolling Wave Planning
The WBS and WBS dictionary reflect the project scope evolution as it becomes more detailed until the work package level is reached. Rolling wave planning is a form of progressive elaboration (Section 1.2.1.3) planning where the work to be accomplished in the near term is planned in detail at a low level of the WBS, while work far in the future is planned for WBS components that are at a relatively high level of the WBS. The work to be performed within another one or two reporting periods in the near future is planned in detail as work is being completed during the current period. Therefore, schedule 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.
.4 Expert Judgment
Project team members or other experts who are experienced and skilled in developing detailed project scope statements, WBSs, and project schedules can provide expertise in defining activities.

.5 Planning Component
When insufficient definition of the project scope is available to decompose a branch of the WBS down to the work package level, the last component in that branch of the WBS can be used to develop a high-level project schedule for that component. These planning components are selected and used by the project team to plan and schedule future work at various higher levels within the WBS. The schedule activities used for these planning components may be summary activities that are not enough to support detailed estimating, scheduling, executing, monitoring, or controlling of the project work. Two planning components are:

- **Control Account.** A management control point can be placed at selected management points (specific components at selected levels) of the work breakdown structure above the work package level. These control points are used as a basis for planning when associated work packages have not yet been planned. All work and effort performed within a control account is documented in a control account plan.

- **Planning Package.** A planning package is a WBS component below the control account, but above the work package. This component is used for planning known work content that does not have detailed schedule activities.

6.1.3 Activity Definition: Outputs

.1 Activity List
The activity list is a comprehensive list including all schedule activities that are planned to be performed on the project. The activity list does not include any schedule activities that are not required as part of the project scope. The activity list includes the activity identifier and a scope of work description for each schedule activity in sufficient detail to ensure that project team members understand what work is required to be completed. The schedule 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. The activity list is used in the schedule model and is a component of the project management plan (Section 4.3). The schedule activities are discrete components of the project schedule, but are not components of the WBS.
.2 Activity Attributes
These activity attributes are an extension of the activity attributes in the activity list and identify the multiple attributes associated with each schedule activity. Activity attributes for each schedule activity include the activity identifier, activity codes, activity description, predecessor activities, successor activities, logical relationships, leads and lags, resource requirements, imposed dates, constraints, and assumptions. Activity attributes can also include the person responsible for executing the work, geographic area or place where the work has to be performed, and schedule activity type such as level of effort, discrete effort, and apportioned effort. These attributes are used for project schedule development and for selecting, ordering, and sorting the planned schedule activities in various ways within reports. The number of attributes varies by application area. The activity attributes are used in the schedule model.

.3 Milestone List
The list of schedule milestones identifies all milestones and indicates whether the milestone is mandatory (required by the contract) or optional (based upon project requirements or historical information). The milestone list is a component of the project management plan (Section 4.3) and the milestones are used in the schedule model.

.4 Requested Changes
The Activity Definition process can generate requested changes (Section 4.4.3.2) that can affect the project scope statement and WBS. Requested changes are processed for review and disposition through the Integrated Change Control process (Section 4.6).

6.2 Activity Sequencing
Activity sequencing involves identifying and documenting the logical relationships among schedule activities. Schedule activities can be logically sequenced with proper precedence relationships, as well as leads and lags to support later development of a realistic and achievable project 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: Inputs, Tools & Techniques, and Outputs](image-url)
6.2.1 Activity Sequencing: Inputs

.1 Project Scope Statement
The project scope statement (Section 5.2.3.1) contains the product scope description, which includes product characteristics that often can 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 is generally reviewed to ensure accuracy.

.2 Activity List
Described in Section 6.1.3.1.

.3 Activity Attributes
Described in Section 6.1.3.2.

.4 Milestone List
Described in Section 6.1.3.3.

.5 Approved Change Requests
Described in Section 4.4.1.4.

Figure 6-5. Precedence Diagram Method
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 project schedule network 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 successor activity depends upon the completion of the predecessor activity.
- **Finish-to-Finish.** The completion of the successor activity depends upon the completion of the predecessor activity.
- **Start-to-Start.** The initiation of the successor activity depends upon the initiation of the predecessor activity.
- **Start-to-Finish.** The completion of the successor activity depends upon the initiation of the predecessor activity.

In PDM, finish-to-start is the most commonly used type of precedence relationship. Start-to-finish relationships are rarely used.

![Figure 6-6. Arrow Diagram Method](image-url)
.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, it is still used in teaching schedule network theory and in some application areas.

ADM uses only finish-to-start dependencies and can require the use of “dummy” relationships called dummy activities, which are shown as dashed lines, to define all logical relationships correctly. Since dummy activities are not actual schedule activities (they have no work content), they are given a zero value duration for schedule network analysis purposes. For example, in Figure 6-6 schedule activity “F” is dependent upon the completion of schedule activities “A” and “K,” in addition to the completion of schedule activity “H.”

.3 Schedule Network Templates
Standardized project schedule network diagram templates can be used to expedite the preparation of networks of project schedule activities. They can include an entire project or only a portion of it. Portions of a project schedule network diagram 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 deliverables, 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.
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- **Discretionary dependencies.** The project management team determines which dependencies are discretionary during the process of establishing the sequence of activities. Discretionary dependencies are fully documented since they can create arbitrary total 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 or some unusual aspect of the project where a specific sequence is desired, even though there are other acceptable sequences. Some discretionary dependencies include preferred schedule 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 schedule activity in a software project can be dependent on delivery of hardware from an external source, or governmental 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 4.1.1.4) from previous projects of a similar nature or from seller contracts or proposals (Section 12.4.3.2).

.5 **Applying Leads and Lags**
The project management team determines the dependencies (Section 6.2.2.4) that may require a lead or a lag to accurately define the logical relationship. The use of leads and lags and their related assumptions are documented.

A lead allows an acceleration of the successor activity. For example, a technical writing team can begin writing the second draft of a large document (the successor activity) fifteen days before they finish writing the entire first draft (the predecessor activity). This could be accomplished by a finish-to-start relationship with a fifteen-day lead time.

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 on a finish-to-start relationship could be used, which means the successor activity cannot start until ten days after the predecessor is completed.
6.2.3 Activity Sequencing: Outputs

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

.2 Activity List (Updates)
If approved change requests (Section 4.4.1.4) result from the Activity Sequencing process, then the activity list (Section 6.1.3.1) is updated to include those approved changes.

.3 Activity Attributes (Updates)
The activity attributes (Section 6.1.3.2) are updated to include the defined logical relationships and any associated leads and lags. If approved change requests (Section 4.4.1.4) resulting from the Activity Sequencing process affect the activity list, then the related items in the activity attributes are updated to include those approved changes.

.4 Requested Changes
Preparation of project logical relationships, leads, and lags might reveal instances that can generate a requested change (Section 4.4.3.2) to the activity list or the activity attributes. Examples include where a schedule activity can be divided or otherwise redefined, where dependencies can be refined, or where a lead or lag is adjusted to adequately diagram the correct logical relationships. Requested changes are processed for review and disposition through the Integrated Change Control process (Section 4.6).

6.3 Activity Resource Estimating
Estimating schedule activity resources involves determining what resources (persons, equipment, or materiel) and what quantities of each resource will be used, and when each resource will be available to perform project activities. The Activity Resource Estimating process is closely coordinated with the Cost Estimating process (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 will need to 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: Inputs, Tools & Techniques, and Outputs](image)

### 6.3.1 Activity Resource Estimating: Inputs

**.1 Enterprise Environmental Factors**
The Activity Resource Estimating process uses the infrastructure resource availability information included in enterprise environmental factors (Section 4.1.1.3).

**.2 Organizational Process Assets**
Organizational process assets (Section 4.1.1.4) provide the policies of the performing organization regarding staffing and the rental or purchase of supplies and equipment that are considered during activity resource estimating. If available, historical information regarding what types of resources were required for similar work on previous projects are reviewed.

**.3 Activity List**
The activity list (Section 6.1.3.1) identifies the schedule activities for resources that are estimated.

**.4 Activity Attributes**
The activity attributes (Section 6.1.3.2) developed during the activity definition process provide the primary data input for use in estimating those resources required for each schedule activity in the activity list.
5 Resource Availability
Information on which resources (such as people, equipment, and materiel) are potentially available (Sections 9.2.3.2 and 12.4.3.4) is used for estimating the resource types. This knowledge includes consideration of various geographical locations from which the resources originate and when they may be available. For example, during the early phases of an engineering design project, the pool of resources 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 of the project.

6 Project Management Plan
The schedule management plan is a component part of the project management plan (Section 4.3) that is used in Activity Resource Estimating.

6.3.2 Activity Resource Estimating: Tools and Techniques

.1 Expert Judgment
Expert judgment is often required to assess the resource-related inputs to this process. Any group or person with specialized knowledge in resource planning and estimating can provide such expertise.

.2 Alternatives Analysis
Many schedule 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), and make-or-buy decisions regarding the resource (Section 12.1.3.3).

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

.4 Project Management Software
Project management software has the capability to help plan, organize, and manage resource pools and develop resource estimates. Depending upon the sophistication of the software, resource breakdown structures, resource availabilities, and resource rates can be defined, as well as various resource calendars.

.5 Bottom-up Estimating
When a schedule activity cannot be estimated with a reasonable degree of confidence, the work within the schedule activity is decomposed into more detail. The resource needs of each lower, more detailed piece of work are estimated, and these estimates are then aggregated into a total quantity for each of the schedule activity’s resources. Schedule 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 is reflected in the estimated requirements of the schedule activity and is documented.
6.3.3 Activity Resource Estimating: Outputs

.1 Activity Resource Requirements
The output of the Activity Resource Estimating process is an identification and description of the types and quantities of resources required for each schedule activity in a work package. These requirements can then be aggregated to determine the estimated resources for each work package. The amount of detail and the level of specificity of the resource requirement descriptions can vary by application area. The resource requirements documentation for each schedule activity can include the basis of estimate for each resource, as well as the assumptions that were made in determining which types of resources are applied, their availability, and what quantity are used. The Schedule Development process (Section 6.5) determines when the resources are needed.

.2 Activity Attributes (Updates)
The types and quantities of resources required for each schedule activity are incorporated into the activity attributes. If approved change requests (Section 4.6.3.1) result from the Activity Resource Estimating process, then the activity list (Section 6.2.3.2) and activity attributes (Section 6.2.3.3) are updated to include those approved changes.

.3 Resource Breakdown Structure
The resource breakdown structure (RBS) is a hierarchical structure of the identified resources by resource category and resource type.

.4 Resource Calendar (Updates)
A composite resource calendar for the project documents working days and nonworking days that determine those dates on which a specific resource, whether a person or materiel, can be active or is idle. The project resource calendar typically identifies resource-specific holidays and resource availability periods. The project resource calendar identifies the quantity of each resource available during each availability period.

.5 Requested Changes
The Activity Resource Estimating process can result in requested changes (Section 4.4.3.2) to add or delete planned schedule activities within the activity list. Requested changes are processed for review and disposition through the Integrated Change Control process (Section 4.6).
6.4 **Activity Duration Estimating**

The process of estimating schedule activity durations uses information on schedule activity scope of work, required resource types, estimated resource quantities, and resource calendars with resource availabilities. The inputs for the estimates of schedule activity 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 schedule 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 better quality.

The Activity Duration Estimating process requires that the amount of work effort required to complete the schedule activity is estimated, the assumed amount of resources to be applied to complete the schedule activity is estimated, and the number of work periods needed to complete the schedule activity is determined. All data and assumptions that support duration estimating are documented for each activity duration estimate.

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

Overall project duration is calculated as an output of the Schedule Development process (Section 6.5).

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**Figure 6-8. Activity Duration Estimating: Inputs, Tools & Techniques, and Outputs**

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Tools &amp; Techniques</th>
<th>Outputs</th>
</tr>
</thead>
</table>
| .1 Enterprise environmental factors | .1 Expert judgment  
| .2 Organizational process assets    | .2 Analogous estimating  
| .3 Project scope statement         | .3 Parametric estimating  
| .4 Activity list                   | .4 Three-point estimates     
| .5 Activity attributes             | .5 Reserve analysis         
| .6 Activity resource requirements  |                       |
| .7 Resource calendar               |                       |
| .8 Project management plan         |                       |
| • Risk register                    |                       |
| • Activity cost estimates          |                       |
6.4.1 Activity Duration Estimating: Inputs

.1 Enterprise Environmental Factors
One or more of the organizations involved in the project may maintain duration estimating databases and other historical reference data. This type of reference information is also 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 or how long a government agency usually takes to respond to certain types of requests).

.2 Organizational Process Assets
Historical information (Section 4.1.1.4) on the likely durations of many categories of activities is often available. 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. The organizational process assets (Section 4.1.1.4) of the performing organization may have some asset items that can be used in Activity Duration Estimating, such as the project calendar (a calendar of working days or shifts on which schedule activities are worked, and nonworking days on which schedule activities are idle).

.3 Project Scope Statement
The constraints and assumptions from the project scope statement (Section 5.2.3.1) are considered when estimating the schedule activity durations. An example of an assumption would be the length of the reporting periods for the project that could dictate maximum schedule activity durations. An example of a constraint would be document submittals, reviews, and similar non-deliverable schedule activities that often have frequency and durations specified by contract or within the performing organization’s policies.

.4 Activity List
Described in Section 6.1.3.1.

.5 Activity Attributes
Described in Section 6.1.3.2.

.6 Activity Resource Requirements
The estimated activity resource requirements (Section 6.3.3.1) will have an effect on the duration of the schedule activity, since the resources assigned to the schedule activity, and the availability of those resources, will significantly influence the duration of most activities. For example, if a schedule activity requires two engineers working together to efficiently complete a design activity, but only one person is applied to the work, the schedule activity will generally take at least twice as much time to complete. However, as additional resources are added or lower skilled resources are applied to some schedule activities, projects can experience a reduction in efficiency. This inefficiency, in turn, could result in a work production increase of less than the equivalent percentage increase in resources applied.
.7 Resource Calendar
The composite resource calendar (Section 6.3), developed as part of the Activity Resource Estimating process, includes the availability, capabilities, and skills of human resources (Section 9.2). The type, quantity, availability, and capability, when applicable, of both equipment and materiel resources (Section 12.4) that could significantly influence the duration of schedule activities are also considered. 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 schedule activity in less time than a junior staff member.

.8 Project Management Plan
The project management plan contains the risk register (Sections 11.2 through 11.6) and project cost estimates (Section 7.1).

- **Risk Register.** The risk register has information on identified project risks that the project team considers when producing estimates of activity durations and adjusting those durations for risks. The project team considers the extent to which the effects of risks are included in the baseline duration estimate for each schedule activity, in particular those risks with ratings of high probability or high impact.

- **Activity Cost Estimates.** The project activity cost estimates, if already completed, can be developed in sufficient detail to provide estimated resource quantities for each schedule activity in the project activity list.

6.4.2 Activity Duration Estimating: Tools and Techniques

.1 Expert Judgment
Activity 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. The individual project team members may also provide duration estimate information or recommended maximum activity durations from prior similar projects. If such expertise is not available, the duration estimates are more uncertain and risky.

.2 Analogous Estimating
Analogous duration estimating means using the actual duration of a previous, similar schedule activity as the basis for estimating the duration of a future schedule activity. It is frequently used to estimate project duration when there is a limited amount of detailed information about the project for example, in the early phases of a project. Analogous estimating uses historical information (Section 4.1.1.4) and 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 Parametric Estimating
Estimating the basis for activity durations can be quantitatively determined by multiplying the quantity of work to be performed by the productivity rate. For example, productivity rates can be estimated on a design project by the number of drawings times labor hours per drawing, or a cable installation in meters of cable times labor hours per meter. The total resource quantities are 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.

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

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

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

.5 Reserve Analysis
Project teams can choose to incorporate additional time referred to as contingency reserves, time reserves or buffers, into the overall project schedule as recognition of schedule risk. The contingency reserve can be a percentage of the estimated activity duration, a fixed number of work periods, or developed by quantitative schedule risk analysis (Section 11.4.2.2.). The contingency reserve can be used completely or partially, or can later be reduced or eliminated, as more precise information about the project becomes available. Such contingency reserve is documented along with other related data and assumptions.

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 a schedule activity. Activity duration estimates include some indication of the range of possible results. For example:

- 2 weeks ± 2 days to indicate that the schedule 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 schedule activity will take three weeks or less.
.2 Activity Attributes (Updates)

The activity attributes (Section 6.1.3.2) are updated to include the durations for each schedule activity, the assumptions made in developing the activity duration estimates, and any contingency reserves.

6.5 Schedule Development

Project schedule development, an iterative process, determines planned start and finish dates for project activities. Schedule development can require that duration estimates and resource estimates are 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 anticipated risk events occur or disappear as new risks are identified.

Figure 6-9. Schedule Development Overview: Inputs, Tools & Techniques, and Outputs

6.5.1 Schedule Development: Inputs

.1 Organizational Process Assets

The organizational process assets (Section 4.1.1.4) of the performing organization may have some asset items that can be used in Schedule Development, such as a project calendar (a calendar of working days or shifts that establishes dates on which schedule activities are worked, and nonworking days on which schedule activities are idle).

.2 Project Scope Statement

The project scope statement (Section 5.2.3.1) contains assumptions and constraints that can impact the development of the project schedule. Assumptions are those documented schedule-related factors that, for schedule development purposes, are considered to be true, real, or certain. Constraints are factors that will limit the project management team’s options when performing schedule network analysis.

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 materiel from parties not represented in the project schedule.

• The project sponsor, 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 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.

.3 Activity List
Described in Section 6.1.3.1.

.4 Activity Attributes
Described in Section 6.1.3.2.

.5 Project Schedule Network Diagrams
Described in Section 6.2.3.1.

.6 Activity Resource Requirements
Described in Section 6.3.3.1.

.7 Resource Calendars
Described in Sections 6.3.3.4.

.8 Activity Duration Estimates
Described in Section 6.4.3.1.

.9 Project Management Plan
The project management plan contains the schedule management plan, cost management plan, project scope management plan, and risk management plan. These plans guide the schedule development, as well as components that directly support the Schedule Development process. One such component is the risk register.

• Risk Register. The risk register (Sections 11.1 through 11.5) identifies the project risks and associated risk response plans that are needed to support the Schedule Development process.
6.5.2 Schedule Development: Tools and Techniques

1. Schedule Network Analysis
   Schedule network analysis is a technique that generates the project schedule. It employs a schedule model and various analytical techniques, such as critical path method, critical chain method, what-if analysis, and resource leveling to calculate the early and late start and finish dates, and scheduled start and finish dates for the uncompleted portions of project schedule activities. If the schedule network diagram used in the model has any network loops or network open ends, then those loops and open ends are adjusted before one of the analytical techniques is applied. Some network paths may have points of path convergence or path divergence that can be identified and used in schedule compression analysis or other analyses.

2. Critical Path Method
   The critical path method is a schedule network analysis technique that is performed using the schedule model. The critical path method calculates the theoretical early start and finish dates, and late start and finish dates, for all schedule activities without regard for any resource limitations, by performing a forward pass analysis and a backward pass analysis through the project schedule network paths. The resulting early and late start and finish dates are not necessarily the project schedule; rather, they indicate the time periods within which the schedule activity should be scheduled, given activity durations, logical relationships, leads, lags, and other known constraints.

   Calculated early start and finish dates, and late start and finish dates, may or may not be the same on any network path since total float, which provides schedule flexibility, may be positive, negative, or zero. On any network path, the schedule flexibility is measured by the positive difference between early and late dates, and is termed “total float.” Critical paths have either a zero or negative total float, and schedule activities on a critical path are called “critical activities.” Adjustments to activity durations, logical relationships, leads and lags, or other schedule constraints may be necessary to produce network paths with a zero or positive total float. Once the total float for a network path is zero or positive, then the free float — the amount of time that a schedule activity can be delayed without delaying the early start date of any immediate successor activity within the network path — can also be determined.

3. 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.** A schedule compression technique in which phases or activities that normally would be done in sequence are performed in parallel. An example would be to construct the foundation for a building before 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 project schedule.

.4 **What-If Scenario Analysis**
This is an analysis of the question “What if the situation represented by scenario ‘X’ happens?” A schedule network analysis is performed using the schedule model 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 scenario analysis can be used to assess the feasibility of the project 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 11.4.2.2), in which a distribution of possible activity durations is defined for each schedule activity and used to calculate a distribution of possible outcomes for the total project.

.5 **Resource Leveling**
Resource leveling is a schedule network analysis technique applied to a schedule model that has already been analyzed by the critical path method. Resource leveling is used to address schedule activities that need to be performed to meet specified delivery dates, to address the situation where shared or critical required resources are only available at certain times or are only available in limited quantities, or to keep selected resource usage at a constant level during specific time periods of the project work. This resource usage leveling approach can cause the original critical path to change.
The critical path method calculation (Section 6.5.2.2) 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 project schedule that reflects such constraints. Resource leveling often results in a projected duration for the project that is longer than the preliminary project 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 back on track, or as close as possible, to its originally intended overall duration. Utilization of extended hours, weekends, or multiple shifts for selected resources can also be considered using different resource calendars to reduce the durations of critical activities. Resource productivity increases are another way to shorten durations that have extended the preliminary project schedule. Different technologies or machinery, such as reuse of computer code, automatic welding, electric pipe cutters, and automated processes, can all have an impact on resource productivity. Some projects can have a finite and critical project resource. In this case, the resource is scheduled in reverse from the project ending date, which is known as reverse resource allocation scheduling, and may not result in an optimal project schedule. The resource leveling technique produces a resource-limited schedule, sometimes called a resource-constrained schedule, with scheduled start dates and scheduled finish dates.

6 Critical Chain Method

Critical chain is another schedule network analysis technique that modifies the project schedule to account for limited resources. Critical chain combines deterministic and probabilistic approaches. Initially, the project schedule network diagram is built using non-conservative estimates for activity durations within the schedule model, with required dependencies and defined constraints as inputs. The critical path is then calculated. After the critical path is identified, resource availability is entered and the resource-limited schedule result is determined. The resulting schedule often has an altered critical path.

The critical chain method adds duration buffers that are non-work schedule activities to maintain focus on the planned activity durations. Once the buffer schedule activities are determined, the planned activities are scheduled to their latest possible planned start and finish dates. Consequently, in lieu of managing the total float of network paths, the critical chain method focuses on managing the buffer activity durations and the resources applied to planned schedule activities.
.7 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 cost estimating by time period (Section 7.1.2.5) and schedule simulation in quantitative risk analysis (Section 11.4.2.2). These products automate the calculation of the mathematical forward pass 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.

.8 Applying Calendars
Project calendars (Section 4.1.1.4) and resource calendars (Section 6.3.3.4) identify periods when work is allowed. Project calendars affect all activities. For example, it may not be possible to work on the site during certain periods of the year because of weather. Resource calendars affect a specific resource or category of resources. Resource calendars reflect how some resources work only during normal business hours, while others work three full shifts, or a project team member might be unavailable, such as on vacation or in a training program, or a labor contract can limit certain workers to certain days of the week.

.9 Adjusting Leads and Lags
Since the improper use of leads or lags can distort the project schedule, the leads or lags are adjusted during schedule network analysis to develop a viable project schedule.

.10 Schedule Model
Schedule data and information are compiled into the schedule model for the project. The schedule model tool and the supporting schedule model data are used in conjunction with manual methods or project management software to perform schedule network analysis to generate the project schedule.
6.5.3 Schedule Development: Outputs

.1 Project Schedule

The project schedule includes at least a planned start date and planned finish date for each schedule activity. If resource planning is done at an early stage, then the project schedule would remain preliminary until resource assignments have been confirmed, and scheduled start dates and finish dates are established. This process usually happens no later than completion of the project management plan (Section 4.3). A project target schedule may also be developed with defined target start dates and target finish dates for each schedule activity. The project schedule can be presented in summary form, sometimes referred to as the master schedule or milestone schedule, or presented in detail. Although a project schedule 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 diagrams, with activity date information, usually show both the project network logic and the project’s critical path schedule activities. These diagrams can be presented in the activity-on-node diagram format, as shown in Figure 6-5, or presented in a time-scaled schedule network diagram format that is sometimes called a logic bar chart, as shown for the detailed schedule in Figure 6-10. This example also shows how each work package is planned as a series of related schedule activities.

- **Bar charts.** These charts, with bars representing activities, show activity start and end dates, as well as expected durations. Bar charts are relatively easy to read, and are frequently used in management presentations. For control and management communication, the broader, more comprehensive summary activity, sometimes referred to as a hammock activity, is used between milestones or across multiple interdependent work packages, and is displayed in bar chart reports. An example is the summary schedule portion of Figure 6-10 that is presented in a WBS structured format.

- **Milestone charts.** These charts are similar to bar charts, but only identify the scheduled start or completion of major deliverables and key external interfaces. An example is the milestone schedule portion of Figure 6-10.
Figure 6-10. Project Schedule – Graphic Examples
Figure 6-10 shows the schedule for a sample project being executed, with the work in progress reported through the data date, which is sometimes also called the as-of date or time now date. The figure shows the actual start date, actual duration, and actual finish date for completed schedule activities, the actual start date, remaining duration, and current finish date for schedule activities with work in progress, and the current start date, original duration, and current finish date for schedule activities where work has not yet started. For a simple project schedule, Figure 6-10 gives a graphic display of a Milestone Schedule, a Summary Schedule, and a Detailed Schedule. Figure 6-10 also visually shows the relationships among the three different levels of schedule presentation.

.2 Schedule Model Data
Supporting data for the project schedule includes at least the schedule milestones, schedule activities, activity attributes and documentation of all identified assumptions and constraints. The amount of additional data 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 an electronics design project, the schedule model data might include such items as human resource histograms, cash-flow projections, and order and delivery schedules.

.3 Schedule Baseline
A schedule baseline is a specific version of the project schedule developed from the schedule network analysis of the schedule model. It is accepted and approved by the project management team as the schedule baseline with baseline start dates and baseline finish dates.

.4 Resource Requirements (Updates)
Resource leveling can have a significant effect on preliminary estimates of the types and quantities of resources required. If the resource-leveling analysis changes the project resource requirements, then the resource requirements are updated.

.5 Activity Attributes (Updates)
The activity attributes (Section 6.2.3.3) are updated to include any revised resource requirements and any other related approved changes (Section 4.4.1.4) generated by the Schedule Development process.
.6 **Project Calendar (Updates)**
A project calendar is a calendar of working days or shifts that establishes those dates on which schedule activities are worked. It also establishes nonworking days that determine dates on which schedule activities are idle, such as holidays, weekends, and non-shift hours. The calendar for each project may use different calendar units as the basis for scheduling the project.

.7 **Requested Changes**
The Schedule Development process can create requested changes (Section 4.4.3.2) that are processed for review and disposition through the Integrated Change Control process (Section 4.6).

.8 **Project Management Plan (Updates)**
The project management plan (Section 4.3) is updated to reflect any approved changes in how the project schedule will be managed.

- **Schedule Management Plan (Updates).** If approved change requests (Section 4.4.1.4) result from the Project Time Management processes, then the schedule management plan (Chapter 6 introductory material) component of the project management plan (Section 4.3) may need to be updated to include those approved changes.

### 6.6 Schedule Control

Schedule control is concerned with:

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

Schedule control is a portion of the Integrated Change Control process (Section 4.6).

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**Figure 6-11. Schedule Control Overview: Inputs, Tools & Techniques, and Outputs**

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6.6.1 Schedule Control: Inputs

1 Schedule Management Plan
The project management plan (Section 4.3) contains the schedule management plan (Chapter 6 introductory material) that establishes how the project schedule will be managed and controlled.

2 Schedule Baseline
The project schedule (Section 6.5.3.1) used for control is the approved project schedule, which is referred to as the schedule baseline (Section 6.5.3.3). The schedule baseline is a component of the project management plan (Section 4.3). It provides the basis for measuring and reporting schedule performance as part of the performance measurement baseline.

3 Performance Reports
Performance reports (Section 10.3.3.1) 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.

4 Approved Change Requests
Only approved change requests (Section 4.4.1.4) that have been previously processed through the Integrated Change Control process (Section 4.6) are used to update the project schedule baseline or other components of the project management plan (Section 4.3).

6.6.2 Schedule Control: Tools and Techniques

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

2 Schedule Change Control System
The 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. The schedule change control system is operated as part of the Integrated Change Control process (Section 4.6).
.3 Performance Measurement
Performance measurement techniques produce the Schedule Variance (SV) (Section 7.3.2.2) and Schedule Performance Index (SPI) (Section 7.3.2.2), which are used to assess the magnitude of any project 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 schedule activity not on the critical path may have little effect on the overall project schedule, while a much shorter delay on a critical or near-critical activity may require immediate action.

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

.5 Variance Analysis
Performing 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 total float variance is also an essential planning component to evaluate project time performance.

.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 schedule activity. One bar shows the current actual status and the other shows the status of the approved project schedule baseline. This shows graphically where the schedule has progressed as planned or where slippage has occurred.

6.6.3 Schedule Control: Outputs

.1 Schedule Model Data (Updates)
A project schedule update is any modification to the project schedule model information that is used to manage the project. Appropriate stakeholders are notified of significant modifications as they occur.

New project schedule network diagrams are developed to display approved remaining durations and modifications to the work plan. In some cases, project schedule delays can be so severe that development of a new target schedule with revised target start and finish dates is needed to provide realistic data for directing the work, and for measuring performance and progress.
.2 Schedule Baseline (Updates)
Schedule revisions are a special category of project schedule updates. Revisions are changes to the schedule’s start and finish dates in the approved schedule baseline. These changes are generally incorporated in response to approved change requests (Section 4.4.1.4) related to project scope changes or changes to estimates. Development of a revised schedule baseline can only occur as a result of approved changes. The original schedule baseline and schedule model are saved before creating the new schedule baseline to prevent loss of historical data for the project schedule.

.3 Performance Measurements
The calculated schedule variance (SV) and schedule performance index (SPI) values for WBS components, in particular the work packages and control accounts, are documented and communicated (Section 10.3.3.1) to stakeholders.

.4 Requested Changes
Schedule variance analysis, along with review of progress reports, results of performance measures, and modifications to the project schedule model can result in requested changes (Section 4.4.3.2) to the project schedule baseline. Project schedule changes might or might not require adjustments to other components of the project management plan. Requested changes are processed for review and disposition through the Integrated Change Control process (Section 4.6).

.5 Recommended Corrective Actions
A corrective action is anything done to bring expected future project schedule performance in line with the approved project schedule baseline. Corrective action in the area of time management often involves expediting, which includes special actions taken to ensure completion of a schedule activity on time or with the least possible delay. Corrective action frequently requires root cause analysis to identify the cause of the variation. The analysis may address schedule activities other than the schedule activity actually causing the deviation; therefore, schedule recovery from the variance can be planned and executed using schedule activities delineated later in the project schedule.

.6 Organizational Process Assets (Updates)
Lessons learned documentation of the causes of variance, the reasoning behind the corrective actions chosen, and other types of lessons learned from schedule control are documented in the organizational process assets (Section 4.1.1.4), so that they become part of the historical database for both the project and other projects of the performing organization.
.7 **Activity List (Updates)**  
Described in Section 6.1.3.1.

.8 **Activity Attributes (Updates)**  
Described in Section 6.1.3.2.

.9 **Project Management Plan (Updates)**  
The schedule management plan (Chapter 6 introductory material) component of the project management plan (Section 4.3) is updated to reflect any approved changes resulting from the Schedule Control process, and how the project schedule will be managed.
CHAPTER 7

Project Cost Management

Project Cost Management includes the processes involved in planning, estimating, budgeting, and controlling 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 these 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 cost variances and controlling changes to the project budget.

These processes interact with each other and with processes in the other Knowledge Areas as well. Each process can involve effort from one or more persons or groups of persons based upon the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although 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 Chapter 3.

Project Cost Management is primarily concerned with the cost of the resources needed to complete schedule activities. However, Project Cost Management should also consider the effect of project decisions on the cost of using, maintaining, and supporting the product, service, or result of the project. 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, can improve decision-making and is used to reduce cost and execution time and to improve the quality and performance of the project deliverable.
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 a capital facilities project, Project Cost Management can include this work. When such predictions and analyses are included, Project Cost Management will address additional processes and numerous general management techniques such as return on investment, discounted cash flow, and investment payback analysis.

Project Cost Management considers the information requirements 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 or committed, the order is placed, the item is delivered, and the actual cost is incurred or recorded for project accounting purposes.

On some projects, especially ones of smaller scope, cost estimating and cost budgeting are so tightly linked that they are viewed as a single process that can be performed by a single person 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 is part of the Develop Project Management Plan process (Section 4.3), which produces a cost management plan that sets out the format and establishes the criteria for planning, structuring, estimating, budgeting, and controlling project costs. The cost management processes and their associated tools and techniques vary by application area, are usually selected during the project life cycle (Section 2.1) definition, and are documented in the cost management plan.

For example, the cost management plan can establish:

- **Precision level.** Schedule activity cost estimates will adhere to a rounding of the data to a prescribed precision (e.g., $100, $1,000), based on the scope of the activities and magnitude of the project, and may include an amount for contingencies.

- **Units of measure.** Each unit used in measurements is defined, such as staff hours, staff days, week, lump sum, etc., for each of the resources.

- **Organizational procedures links.** The WBS component used for the project cost accounting is called a control account (CA). Each control account is assigned a code or account number that is linked directly to the performing organization’s accounting system. If cost estimates for planning packages are included in the control account, then the method for budgeting planning packages is included.

- **Control thresholds.** Variance thresholds for costs or other indicators (e.g., person-days, volume of product) at designated time points over the duration of the project can be defined to indicate the agreed amount of variation allowed.
- **Earned value rules.** Three examples are: 1) Earned value management computation formulas for determining the estimate to complete are defined, 2) Earned value credit criteria (e.g., 0-100, 0-50-100, etc.) are established, and 3) Define the WBS level at which earned value technique analysis will be performed.

- **Reporting formats.** The formats for the various cost reports are defined.

- **Process descriptions.** Descriptions of each of the three cost management processes are documented.

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

The cost management planning effort occurs early in project planning and sets the framework for each of the cost management processes, so that performance of the processes will be efficient and coordinated.

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**Figure 7-1. Project Cost Management Overview**
Note: Not all process interactions and data flow among the processes are shown.

Figure 7-2. Project Cost Management Process Flow Diagram
7.1 Cost Estimating

Estimating schedule activity costs involves developing an approximation of the costs of the resources needed to complete each schedule activity. In approximating costs, the estimator considers the possible causes of variation of the cost estimates, 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 and product operations. The cost estimating process considers whether the expected savings can offset the cost of the additional design work.

Cost estimates are generally expressed in units of currency (dollars, euro, 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 refinement during the course of the project to reflect the additional detail available. The accuracy of a project estimate will increase as the project progresses through the project life cycle. For example, a project in the initiation phase could have a rough order of magnitude (ROM) estimate in the range of -50 to +100%. Later in the project, as more information is known, estimates could narrow to a range of -10 to +15%. In some application areas, there are guidelines for when such refinements are made and for what degree of accuracy is expected.

Sources of input information come in the form of outputs from the project processes in Chapters 4 through 6 and 9 through 12. Once received, all of this information will remain available as inputs to all three of the cost management processes.

The costs for schedule activities are estimated for all resources that will be charged to the project. This includes, but is not limited to, labor, materials, equipment, services, and facilities, as well as special categories such as an inflation allowance or a contingency cost. A schedule activity cost estimate is a quantitative assessment of the likely costs of the resources required to complete the schedule activity.

If the performing organization does not have formally trained project cost estimators, then the project team will need to supply both the resources and the expertise to perform project cost estimating activities.
7.1.1 Cost Estimating: Inputs

.1 Enterprise Environmental Factors

The Cost Estimating process considers:

- **Marketplace conditions.** What products, services, and results are available in the marketplace, from whom, and under what terms and conditions (Section 4.1.1.3).

- **Commercial databases.** Resource cost rate information is often available from commercial databases that track skills and human resource costs, and provide standard costs for material and equipment. Published seller price lists are another source.

.2 Organizational Process Assets

Existing formal and informal cost estimating-related policies, procedures, and guidelines (Section 4.1.1) are considered in developing the cost management plan, selecting the cost estimating tools, and monitoring and reporting methods to be used.

- **Cost estimating policies.** Some organizations have predefined approaches to cost estimating. Where these exist, the project operates within the boundaries defined by these policies.

- **Cost estimating templates.** Some organizations have developed templates (or a pro forma standard) for use by the project team. The organization can continuously improve the template based on its application and usefulness in prior projects.

- **Historical information.** Information that pertains to the project’s product or service, and is obtained from various sources within the organization, can influence the cost of the project.

- **Project files.** One or more of the organizations involved in the project will maintain records of previous project performance that are detailed enough to aid in developing cost estimates. In some application areas, individual team members may maintain such records.
• **Project team knowledge.** Members of the project team may recall previous actual costs or cost estimates. While such recollections can be useful, they are generally far less reliable than documented performance.

• **Lessons learned.** Lessons learned could include cost estimates obtained from previous projects that are similar in scope and size.

.3 **Project Scope Statement**

The project scope statement (Section 5.2.3.1) describes the business need, justification, requirements, and current boundaries for the project. It provides important information about project requirements that is considered during cost estimating. The project scope statement includes 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 limited project budget. Other constraints can involve required delivery dates, available skilled resources, and organizational policies. Assumptions are factors that 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 are considered when developing the cost estimates.

The project scope statement also provides the list of deliverables, and acceptance criteria for the project and its products, services, and results. All factors are considered when developing the project cost estimate. The product scope description, within the project scope statement, provides product and service descriptions, and important information about any technical issues or concerns that are considered during cost estimating.

.4 **Work Breakdown Structure**

The project’s work breakdown structure (WBS) (Section 5.3.3.2) provides the relationship among all the components of the project and the project deliverables (Section 4.4.3.1).

.5 **WBS Dictionary**

The WBS dictionary (Section 5.3.3.3) and related detailed statements of work provide an identification of the deliverables and a description of the work in each WBS component required to produce each deliverable.

.6 **Project Management Plan**

The project management plan (Section 4.3) provides the overall plan for executing, monitoring, and controlling the project, and includes subsidiary plans that provide guidance and direction for cost management planning and control. To the extent that other planning outputs are available, they are considered during cost estimating.
• **Schedule management plan.** The type and quantity of resources and the amount of time those resources are applied to complete the work of the project is a major part of determining the project cost. Schedule activity resources and their respective durations are used as key inputs to this process. Activity Resource Estimating (Section 6.3) involves determining the availability and quantities required of staff, equipment, and materiel needed to perform schedule activities. It is closely coordinated with cost estimating. Activity Duration Estimating (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 schedule activity. Schedule 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.

• **Staffing management plan.** Project staffing attributes and personnel rates (Section 9.1.3.3) are necessary components for developing the schedule cost estimates.

• **Risk register.** The cost estimator considers information on risk responses (Section 11.2.3.1) when producing cost estimates. Risks, which can be either threats or opportunities, typically have an impact on both schedule activity and project costs. As a general rule, when the project experiences a negative risk event, the cost of the project will nearly always increase, and there will be a delay in the project schedule.

### 7.1.2 Cost Estimating: Tools and Techniques

1. **Analogous Estimating**

   Analogous cost estimating means using the actual cost of previous, similar projects as the basis for estimating the cost of the current project. 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 uses expert judgment.

   Analogous cost estimating is generally less costly than other techniques, but it is also generally less accurate. It is most reliable when previous projects are similar in fact, and not just in appearance, and the persons or groups preparing the estimates have the needed expertise.
.2 Determine Resource Cost Rates
The person determining the rates or the group preparing the estimates must know
the unit cost rates, such as staff cost per hour and bulk material cost per cubic yard,
for each resource to estimate schedule activity costs. Gathering quotes (Section
12.3) is one method of obtaining rates. For products, services, or results to be
obtained under contract, standard rates with escalation factors can be included in
the contract. Obtaining data from commercial databases and seller published price
lists is another source of cost rates. If the actual rates are not known, then the rates
themselves will have to be estimated.

.3 Bottom-up Estimating
This technique involves estimating the cost of individual work packages or
individual schedule activities with the lowest level of detail. This detailed cost is
then summarized or “rolled up” to higher levels for reporting and tracking
purposes. The cost and accuracy of bottom-up cost estimating is typically
motivated by the size and complexity of the individual schedule activity or work
package. Generally, activities with smaller associated effort increase the accuracy
of the schedule activity cost estimates.

.4 Parametric Estimating
Parametric estimating is a technique that uses a statistical relationship between
historical data and other variables (e.g., square footage in construction, lines of
code in software development, required labor hours) to calculate a cost estimate for
a schedule activity resource. This technique can produce higher levels of accuracy
depending upon the sophistication, as well as the underlying resource quantity and
cost data built into the model. A cost-related example involves multiplying the
planned quantity of work to be performed by the historical cost per unit to obtain
the estimated cost.

.5 Project Management Software
Project management software, such as cost estimating software applications,
computerized spreadsheets, and simulation and statistical tools, are widely used to
assist with cost estimating. Such tools can simplify the use of some cost estimating
techniques and thereby facilitate rapid consideration of various cost estimate
alternatives.

.6 Vendor Bid Analysis
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.
7 Reserve Analysis

Many cost estimators include reserves, also called contingency allowances, as costs in many schedule activity cost estimates. This has the inherent problem of potentially overstating the cost estimate for the schedule activity. Contingency reserves are estimated costs to be used at the discretion of the project manager to deal with anticipated, but not certain, events. These events are “known unknowns” and are part of the project scope and cost baselines.

One option to manage cost contingency reserves is to aggregate each schedule activity’s cost contingency reserve for a group of related activities into a single contingency reserve that is assigned to a schedule activity. This schedule activity may be a zero duration activity that is placed across the network path for that group of schedule activities, and is used to hold the cost contingency reserve. An example of this solution to managing cost contingency reserves is to assign them at the work package level to a zero duration activity, which spans from the start to the end of the work package subnetwork. As the schedule activities progress, the contingency reserve, as measured by resource consumption of the non-zero duration schedule activities, can be adjusted. As a result, the activity cost variances for the related group of schedule activities are more accurate because they are based on cost estimates that are not pessimistic.

Alternatively, the schedule activity may be a buffer activity in the critical chain method, and is intentionally placed directly at the end of the network path for that group of schedule activities. As the schedule activities progress, the contingency reserve, as measured by resource consumption of the non-buffer schedule activities, can be adjusted. As a result, the activity cost variances for the related group of schedule activities are more accurate because they are based on cost estimates that are not pessimistic.

8 Cost of Quality

Cost of quality (Section 8.1.2.4) can also be used to prepare the schedule activity cost estimate.

7.1.3 Cost Estimating: Outputs

1 Activity Cost Estimates
An activity cost estimate is a quantitative assessment of the likely costs of the resources required to complete schedule activities. This type of estimate can be presented in summary form or in detail. Costs are estimated for all resources that are applied to the activity cost estimate. This includes, but is not limited to, labor, materials, equipment, services, facilities, information technology, and special categories such as an inflation allowance or cost contingency reserve.
.2 Activity Cost Estimate Supporting Detail
The amount and type of additional details supporting the schedule activity 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 schedule activity’s project scope of work
• Documentation of the basis for the estimate (i.e., how it was developed)
• Documentation of any assumptions made
• Documentation of any constraints
• Indication of the range of possible estimates (e.g., $10,000 (-10% / +15%) to indicate that the item is expected to cost between $9,000 and $11,500).

.3 Requested Changes
The Cost Estimating process may generate requested changes (Section 4.4.3.2) that may affect the cost management plan (Chapter 7 introductory material), activity resource requirements (Section 6.3.3.1), and other components of the project management plan. Requested changes are processed for review and disposition through the Integrated Change Control process (Section 4.6).

.4 Cost Management Plan (Updates)
If approved change requests (Section 4.4.1.4) result from the Cost Estimating process, then the cost management plan component of the project management plan (Chapter 7 introductory material) is updated if those approved changes impact the management of costs.

7.2 Cost Budgeting
Cost budgeting involves aggregating the estimated costs of individual schedule activities or work packages to establish a total cost baseline for measuring project performance. The project scope statement provides the summary budget. However, schedule activity or work package cost estimates are prepared prior to the detailed budget requests and work authorization.
7.2.1 Cost Budgeting: Inputs

.1 Project Scope Statement
Formal periodic limitations of the expenditure of project funds can be given in the project charter (Section 4.1.3.1) or contract. These funding constraints are reflected in the project scope statement, and can be due to annual funding authorizations by the buyer’s organization or other entities like government agencies.

.2 Work Breakdown Structure
The project work breakdown structure (WBS) (Section 5.3.3.2) provides the relationship among all the components of the project and the project deliverables (Section 4.4.3.1).

.3 WBS Dictionary
The WBS dictionary (Section 5.3.3.3) and related detailed statements of work provide an identification of the deliverables and a description of the work in each WBS component required to produce each deliverable.

.4 Activity Cost Estimates
The cost estimates (Section 7.1.3.1) for each schedule activity within a work package are aggregated to obtain a cost estimate for each work package.

.5 Activity Cost Estimate Supporting Detail
Described in Section 7.1.3.2.

.6 Project Schedule
The project schedule (Section 6.5.3.1) includes planned start and finish dates for the project’s schedule activities, schedule milestones, work packages, planning packages, and control accounts. This information is used to aggregate costs to the calendar periods when the costs are planned to be incurred.

.7 Resource Calendars
Described in Section 6.3.3.4.

.8 Contract
Contract (Section 12.4.3.2) information related to what products, services, or results have been purchased — and their costs — are used in developing the budget.

.9 Cost Management Plan
The cost management plan component of the project management plan and other subsidiary plans are considered during cost budgeting.
7.2.2 Cost Budgeting: Tools and Techniques

.1 Cost Aggregation
Schedule activity cost estimates are aggregated by work packages in accordance with the WBS. The work package cost estimates are then aggregated for the higher component levels of the WBS, such as control accounts, and ultimately for the entire project.

.2 Reserve Analysis
Reserve analysis (Section 11.6.2.5) establishes contingency reserves, such as the management contingency reserve, that are allowances for unplanned, but potentially required, changes. Such changes may result from risks identified in the risk register.

Management contingency reserves are budgets reserved for unplanned, but potentially required, changes to project scope and cost. These are “unknown unknowns,” and the project manager must obtain approval before obligating or spending this reserve. Management contingency 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 Estimating
The parametric estimating technique involves using project characteristics (parameters) in a mathematical model to predict total project costs. Models can be simple (e.g., residential home construction will cost a certain amount per square foot of living space) or complex (e.g., 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 large project as well as a small one.

.4 Funding Limit Reconciliation
Large variations in the periodic expenditure of funds are usually undesirable for organizational operations. Therefore, the expenditure of funds is reconciled with the funding limits set by the customer or performing organization on the disbursement of funds for the project. Reconciliation will necessitate the scheduling of work to be adjusted to smooth or regulate those expenditures, which is accomplished by placing imposed date constraints for some work packages, schedule milestones, or WBS components into the project schedule. Rescheduling can impact the allocation of resources. If funds were used as a limiting resource in the Schedule Development process, then the process is repeated using the new imposed date constraints. The final product of these planning iterations is a cost baseline.
7.2.3 Cost Budgeting: Outputs

.1 Cost Baseline
The cost baseline is a time-phased budget that is used as a basis against which to measure, monitor, and control 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 7-5. The cost baseline is a component of the project management plan.

Many projects, especially large ones, have multiple cost or resource baselines, and consumables production baselines (e.g., cubic yards of concrete per day) to measure different aspects of project performance. For example, management may require that the project manager track internal costs (labor) separately from external costs (contractors and construction materials) or total labor hours.

.2 Project Funding Requirements
Funding requirements, total and periodic (e.g., annual or quarterly), are derived from the cost baseline and can be established to exceed, usually by a margin, to allow for either early progress or cost overruns. Funding usually occurs in incremental amounts that 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 contingency reserve amount. Some portion of the management contingency reserve can be included incrementally in each funding step or funded when needed, depending on organizational policies.

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

![Figure 7-5. Cash Flow, Cost Baseline and Funding Display](image-url)
.3 Cost Management Plan (Updates)
If approved change requests (Section 4.4.1.4) result from the Cost Budgeting process, then the cost management plan component of the project management plan is updated if those approved changes impact the management of costs.

.4 Requested Changes
The Cost Budgeting process can generate requested changes (Section 4.4.3.2) that affect the cost management plan or other components of the project management plan. Requested changes are processed for review and disposition through the Integrated Change Control process (Section 4.6).

7.3 Cost Control
Project cost control includes:
• Influencing the factors that create changes to the cost baseline
• Ensuring requested changes are agreed upon
• Managing the actual changes when and as they occur
• Assuring that potential cost overruns do not exceed the authorized funding periodically and in total for the project
• Monitoring cost performance to detect and understand variances from the cost baseline
• Recording all appropriate changes accurately against the cost baseline
• Preventing incorrect, inappropriate, or unapproved changes from being included in the reported cost or resource usage
• Informing appropriate stakeholders of approved changes
• Acting to bring expected cost overruns within acceptable limits.

Project cost control searches out the causes of 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: Inputs, Tools & Techniques, and Outputs](image)
7.3.1 Cost Control: Inputs

.1 Cost Baseline
Described in Section 7.2.3.1.

.2 Project Funding Requirements
Described in Section 7.2.3.2.

.3 Performance Reports
Performance reports (Section 10.3.3.1) provide information on cost and resource performance as a result of actual work progress.

.4 Work Performance Information
Work performance information (Section 4.4.3.7) pertaining to the status and cost of project activities being performed is collected. This information includes, but is not limited to:
- Deliverables that have been completed and those not yet completed
- Costs authorized and incurred
- Estimates to complete the schedule activities
- Percent physically complete of the schedule activities.

.5 Approved Change Requests
Approved change requests (Section 4.4.1.4) from the Integrated Change Control process (Section 4.6) can include modifications to the cost terms of the contract, project scope, cost baseline, or cost management plan.

.6 Project Management Plan
The project management plan and its cost management plan component and other subsidiary plans are considered when performing the Cost Control process.

7.3.2 Cost Control: Tools and Techniques

.1 Cost Change Control System
A cost change control system, documented in the cost management plan, defines the procedures by which the cost baseline can be changed. It includes the forms, documentation, tracking systems, and approval levels necessary for authorizing changes. The cost change control system is integrated with the integrated change control process (Section 4.6).

.2 Performance Measurement Analysis
Performance measurement techniques help to assess the magnitude of any variances that will invariably occur. The earned value technique (EVT) compares the cumulative value of the budgeted cost of work performed (earned) at the original allocated budget amount to both the budgeted cost of work scheduled (planned) and to the actual cost of work performed (actual). This technique is especially useful for cost control, resource management, and production.
An important part of cost control is to determine the cause of a variance, the magnitude of the variance, and to decide if the variance requires corrective action. The earned value technique uses the cost baseline (Section 7.2.3.1) contained in the project management plan (Section 4.3) to assess project progress and the magnitude of any variations that occur.

The earned value technique involves developing these key values for each schedule activity, work package, or control account:

- **Planned value (PV).** PV is the budgeted cost for the work scheduled to be completed on an activity or WBS component up to a given point in time.
- **Earned value (EV).** EV is the budgeted amount for the work actually completed on the schedule activity or WBS component during a given time period.
- **Actual cost (AC).** AC is the total cost incurred in accomplishing work on the schedule activity or WBS component during a given time period. This AC must correspond in definition and coverage to whatever was budgeted for the PV and the EV (e.g., direct hours only, direct costs only, or all costs including indirect costs).
- **Estimate to complete (ETC) and estimate at completion (EAC).** See ETC and EAC development, described in the following technique on forecasting.

The PV, EV, and AC values are used in combination to provide performance measures of whether or not work is being accomplished as planned at any given point in time. The most commonly used measures are cost variance (CV) and schedule variance (SV). The amount of variance of the CV and SV values tend to decrease as the project reaches completion due to the compensating effect of more work being accomplished. Predetermined acceptable variance values that will decrease over time as the project progresses towards completion can be established in the cost management plan.

- **Cost variance (CV).** CV equals earned value (EV) minus actual cost (AC). The cost variance at the end of the project will be the difference between the budget at completion (BAC) and the actual amount spent. Formula: CV = EV – AC
- **Schedule variance (SV).** SV equals earned value (EV) minus planned value (PV). Schedule variance will ultimately equal zero when the project is completed because all of the planned values will have been earned. Formula: 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.

- **Cost performance index (CPI).** A CPI value less than 1.0 indicates a cost overrun of the estimates. A CPI value greater than 1.0 indicates a cost underrun of the estimates. CPI equals the ratio of the EV to the AC. The CPI is the most commonly used cost-efficiency indicator. Formula: CPI = EV/AC
- **Cumulative CPI (CPI\(^C\)).** The cumulative CPI is widely used to forecast project costs at completion. CPI\(^C\) equals the sum of the periodic earned values (EV\(^C\)) divided by the sum of the individual actual costs (AC\(^C\)). Formula: CPI\(^C\) = EV\(^C\)/AC\(^C\)
- **Schedule performance index (SPI).** The SPI is used, in addition to the schedule status (Section 6.6.2.1), to predict the completion date and is sometimes used in conjunction with the CPI to forecast the project completion estimates. SPI equals the ratio of the EV to the PV. Formula: SPI = EV/PV

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

![Figure 7-7. Illustrative Graphic Performance Report](image)

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

.3 **Forecasting**
Forecasting includes making estimates or predictions of conditions in the project’s future based on information and knowledge available at the time of the forecast. Forecasts are generated, updated, and reissued based on work performance information (Section 4.4.3.7) provided as the project is executed and progressed. The work performance information is about the project’s past performance and any information that could impact the project in the future, for example, estimate at completion and estimate to complete.
The earned value technique parameters of BAC, actual cost (AC<sup>c</sup>) to date, and the cumulative CPIC efficiency indicator are used to calculate ETC and EAC, where the BAC is equal to the total PV at completion for a schedule activity, work package, control account, or other WBS component. Formula: BAC = total cumulative PV at completion

Forecasting techniques help to assess the cost or the amount of work to complete schedule activities, which is called the EAC. Forecasting techniques also help to determine the ETC, which is the estimate for completing the remaining work for a schedule activity, work package, or control account. While the earned value technique of determining EAC and ETC is quick and automatic, it is not as valuable or accurate as a manual forecasting of the remaining work to be done by the project team. The ETC forecasting technique based upon the performing organization providing the estimate to complete is:

- **ETC based on new estimate.** ETC equals the revised estimate for the work remaining, as determined by the performing organization. This more accurate and comprehensive completion estimate is an independent, non-calculated estimate to complete for all the work remaining, and considers the performance or production of the resource(s) to date.

  Alternatively, to calculate ETC using earned value data, one of two formulas is typically used:

  - **ETC based on atypical variances.** 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. ETC equals the BAC minus the cumulative earned value to date (EV<sup>c</sup>). Formula: ETC = (BAC - EV<sup>c</sup>)

  - **ETC based on typical variances.** This approach is most often used when current variances are seen as typical of future variances. ETC equals the BAC minus the cumulative EV<sup>c</sup> (the remaining PV) divided by the cumulative cost performance index (CPI)<sup>c</sup>. Formula: ETC = (BAC - EV<sup>c</sup>) / CPI<sup>c</sup>

An EAC is a forecast of the most likely total value based on project performance (Section 4.4) and risk quantification (Section 11.4). EAC is the projected or anticipated total final value for a schedule activity, WBS component, or project when the defined work of the project is completed. One EAC forecasting technique is based upon the performing organization providing an estimate at completion:

- **EAC using a new estimate.** EAC equals the actual costs to date (AC<sup>c</sup>) plus a new ETC that is provided by the performing organization. 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 due to a change in conditions. Formula: EAC = AC<sup>c</sup> + ETC
The two most common forecasting techniques for calculating EAC using earned value data are some variation of:

- **EAC using remaining budget.** EAC equals AC\(^C\) plus the budget required to complete the remaining work, which is the budget at completion (BAC) minus the earned value (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: \(EAC = AC^C + BAC - EV\)

- **EAC using CPI\(^C\).** EAC equals actual costs to date (AC\(^C\)) plus the budget required to complete the remaining project work, which is the BAC minus the EV, modified by a performance factor (often the CPI\(^C\)). This approach is most often used when current variances are seen as typical of future variances. Formula: \(EAC = AC^C + \frac{(BAC - EV)}{CPI^C}\)

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 are not within acceptable tolerances.

### .4 Project Performance Reviews

Performance reviews compare cost performance over time, schedule activities or work packages overrunning and underrunning budget (planned value), milestones due, and milestones met.

Performance reviews are meetings held to assess schedule activity, work package, or cost account status and progress, and are typically used in conjunction with one or more of the following performance-reporting techniques:

- **Variance analysis.** Variance analysis involves comparing actual project performance to planned or expected performance. Cost and schedule variances are the most frequently analyzed, but variances from plan in the areas of project scope, resource, quality, and risk are often of equal or greater importance.

- **Trend analysis.** Trend analysis involves examining project performance over time to determine if performance is improving or deteriorating.

- **Earned value technique.** The earned value technique compares planned performance to actual performance.

### .5 Project Management Software

Project management software, such as computerized spreadsheets, is often used to monitor PV versus AC, and to forecast the effects of changes or variances.

### .6 Variance Management

The cost management plan (Section 7.1.3.4) describes how cost variances will be managed, for example, having different responses to major or minor problems. The amount of variance tends to decrease as more work is accomplished. The larger variances allowed at the start of the project can be decreased as the project nears completion.
7.3.3 Cost Control: Outputs

.1 Cost Estimates (Updates)
Revised schedule activity cost estimates are modifications to the cost information used to manage the project. Appropriate stakeholders are notified as needed. Revised cost estimates may require adjustments to other aspects of the project management plan.

.2 Cost Baseline (Updates)
Budget updates are changes to an approved cost baseline. These values are generally revised only in response to approved changes in project scope. However, in some cases, cost variances can be so severe that a revised cost baseline is needed to provide a realistic basis for performance measurement.

.3 Performance Measurements
The calculated CV, SV, CPI, and SPI values for WBS components, in particular the work packages and control accounts, are documented and communicated (Section 10.3.3.1) to stakeholders.

.4 Forecasted Completion
Either a calculated EAC value or a performing organization-reported EAC value is documented and the value communicated (Section 10.3.3.1) to stakeholders. Either a calculated ETC value or a reported ETC value provided by the performing organization is documented and the value communicated to stakeholders.

.5 Requested Changes
Analysis of project performance can generate a request for a change to some aspect of the project. Identified changes can require increasing or decreasing the budget. Requested changes (Section 4.4.3.2) are processed for review and disposition through the Integrated Change Control process (Section 4.6).

.6 Recommended Corrective Actions
A corrective action is anything done to bring expected future performance of the project in line with the project management plan. Corrective action in the area of cost management often involves adjusting schedule activity budgets, such as special actions taken to balance cost variances.

.7 Organizational Process Assets (Updates)
Lessons learned are documented so they can become part of the historical databases for both the project and the performing organization. Lessons learned documentation includes the root causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned from cost, resource, or resource production control.
.8 Project Management Plan (Updates)
Schedule activity, work package, or planning package cost estimates (Chapter 7 introductory material), as well as the cost baseline (Section 7.2.3.1), cost management plan, and project budget documents are components of the project management plan. All approved change requests (Section 4.4.1.4) affecting those documents are incorporated as updates to those documents.
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, and 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 to ensure that the project employs all processes needed to meet requirements.  
8.3 Perform Quality Control – monitoring specific project results to determine whether 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 can involve effort from one or more persons or groups of persons based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although 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 Chapter 3.
The basic approach to quality management described in this section is intended to be compatible with that of the International Organization for Standardization (ISO). 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 and Effect Analysis, Design Reviews, Voice of the Customer, Cost of Quality (COQ), and Continuous Improvement.

Project Quality Management must address 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 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 degree to which a set of inherent characteristics fulfill requirements.” Stated and implied needs are the inputs to developing project requirements. A critical element of quality management in the project context is to turn stakeholder needs, wants, and expectations into requirements through Stakeholder Analysis (Section 5.2.2.4), performed during 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 defects, readable manual) and low grade (a limited number of features), or of low quality (many defects, 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, evaluating, defining, and managing expectations so that customer requirements 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 must satisfy real needs).

- **Prevention over inspection.** The cost of preventing mistakes is generally 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 is the basis for quality improvement (as defined by Shewhart and modified by Deming, in the ASQ Handbook, pages 13–14, American Society for Quality, 1999). 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. Process improvement models include Malcolm Baldrige, CMM®, and CMMI®.

The cost of quality refers to the total cost of all efforts related to quality. Project decisions can impact operational costs of quality as a result of product returns, warranty claims, and recall campaigns. However, 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.
## 8.1 Quality Planning

### Inputs
1. Enterprise environmental factors
2. Organizational process assets
3. Project scope statement
4. Project management plan

### Tools and Techniques
1. Cost-benefit analysis
2. Benchmarking
3. Design of experiments
4. Cost of quality (COQ)
5. Additional quality planning tools

### Outputs
1. Quality management plan
2. Quality metrics
3. Quality checklist
4. Process improvement plan
5. Quality baseline
6. Project management plan (updates)

## 8.2 Perform Quality Assurance

### Inputs
1. Quality management plan
2. Quality metrics
3. Process improvement plan
4. Work performance information
5. Approved change requests
6. Quality control measurements
7. Implemented change requests
8. Implemented corrective actions
9. Implemented defect repair
10. Implemented preventive actions

### Tools and Techniques
1. Quality planning tools and techniques
2. Quality audits
3. Process analysis
4. Quality control tools and techniques

### Outputs
1. Requested changes
2. Recommended corrective actions
3. Organizational process assets (updates)
4. Project management plan (updates)

## 8.3 Perform Quality Control

### Inputs
1. Quality management plan
2. Quality metrics
3. Quality checklists
4. Organizational process assets
5. Work performance information
6. Approved change requests
7. Deliverables

### Tools and Techniques
1. Cause and effect diagram
2. Control charts
3. Flowcharting
4. Histogram
5. Pareto chart
6. Run chart
7. Scatter diagram
8. Statistical sampling
9. Inspection
10. Defect repair review

### Outputs
1. Quality control measurements
2. Validated defect repair
3. Quality baseline (updates)
4. Recommended corrective actions
5. Recommended preventive actions
6. Requested changes
7. Recommended defect repair
8. Organization process assets (updates)
9. Validated deliverables
10. Project management plan (updates)

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**Figure 8-1. Project Quality Management Overview**
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 when doing the Planning Process Group (Section 3.3) and during development of the project management plan (Sections 4.3), and should be performed 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. One of the fundamental tenets of modern quality management is: quality is planned, designed, and built in—not inspected in.

![Figure 8-3. Quality Planning: Inputs, Tools & Techniques, and Outputs](image)

### 8.1.1 Quality Planning: Inputs

1. **Enterprise Environmental Factors**
   - Governmental agency regulations, rules, standards, and guidelines specific to the application area may affect the project (Section 4.1.1.3).

2. **Organizational Process Assets**
   - Organizational quality policies, procedures and guidelines, historical databases and lessons learned from previous projects specific to the application area may affect the project (Section 4.1.1.4).
   
   The quality policy, as endorsed by senior management, is the intended direction of a performing organization with regard to quality. 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.

   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 10.2.3.1).

3. **Project Scope Statement**
   - The project scope statement (Section 5.2.3.1) is a key input to quality planning since it documents major project deliverables, the project objectives that serve to define requirements (which were derived from stakeholder needs, wants, and expectations), thresholds, and acceptance criteria.
Thresholds, which are defined as cost, time, or resource values used as parameters, can be part of the project scope statement. 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. Formal acceptance (Section 5.4.3.1) validates that the acceptance criteria have been satisfied. The product scope description, embodied in the project scope statement (Section 5.2.3.1), will often contain details of technical issues and other concerns that can affect quality planning.

### 4 Project Management Plan
Described in Section 4.3.

#### 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 basis by which to measure performance. These other projects can be within the performing organization or outside of it, and can be within the same or in another application area.

##### 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 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.