The PMBOK® Guide—Fifth Edition

{ED NOTE: All graphics will be professionally drawn and a References section will be added prior to publication.}

CHAPTER 1

INTRODUCTION

A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Fifth Edition contains the recognized standard for the project management profession (found in Annex A1). A standard is a formal document that describes established norms, methods, processes, and practices. As with other professions such as law, medicine, and accounting, the knowledge contained in this standard evolves from the recognized good practices of project management practitioners who contributed to the development of this standard.

The first two chapters of the *PMBOK® Guide* provide an introduction to key concepts in the project management field. Chapter 3 summarizes the Process Groups and provides an overview of process interactions among the ten Knowledge Areas and five Process Groups. Chapters 4 through 13 are the guide to the project management body of knowledge. These sections expand on the information in the standard by describing the inputs and outputs, as well as tools and techniques used in managing projects. Annex A1 is the standard for project management and presents the processes, inputs, and outputs that are considered good practice on most projects most of the time.

The *PMBOK® Guide* provides guidelines for managing individual projects and defines project management related concepts. It also describes the project management life cycle and its related processes.

This chapter defines several key terms and identifies internal and external environmental factors that surround or influence a project's success. An overview of the *PMBOK®* Guide is found within the following sections:

1.1 Purpose of the PMBOK® Guide
1.2 What is a Project?
1.3 What is Project Management?
1.4 Relationship Among Project Management, Program Management, and Portfolio Management
1.5 The Relationship Among Project Management, Operations Management, and Organizational Strategy
1.6 Business Value
1.7 Role of a Project Manager
1.8 Project Management Body of Knowledge

1.1 Purpose of the PMBOK® Guide

The increasing acceptance of project management indicates that the application of appropriate knowledge, processes, skills, tools, and techniques can have a significant impact on project success. The *PMBOK® Guide* identifies that subset of the project management body of knowledge that is generally recognized as good practice. "Generally recognized" means the knowledge and practices described are applicable to most projects most of the time, and there is consensus about their value and usefulness. "Good practice" means there is general agreement that the application of these skills, tools, and techniques can enhance the chances of success over a wide range of projects. "Good practice" does not mean the knowledge described should always be applied uniformly to all projects; the organization and/or project management team is responsible for determining what is appropriate for any given project.

The *PMBOK® Guide* also provides and promotes a common vocabulary within the project management profession for discussing, writing, and applying project management concepts. Such a standard vocabulary is an essential element of a professional discipline. The *Project Management Lexicon* published by the Project Management Institute (PMI)® provides the foundational professional vocabulary that can be consistently applied by project, program, and portfolio managers.

PMI views Annex A1 as the standard foundation for its project management professional development programs and certifications. As a foundational reference, Annex A1 is neither complete nor all-inclusive; the standard is a guide rather than a methodology. One can use different methodologies and tools (e.g., Agile) to implement the framework. Appendix X4 discusses application area extensions while Appendix X5 lists sources of further information on project management.

In addition to the standards that establish guidelines for project management processes, tools, and techniques, the *Project Management Institute Code of Ethics and Professional Conduct* guides practitioners of the profession of project management and describes the expectations that practitioners should have of themselves and others. The *Project Management Institute Code of Ethics and Professional Conduct* is specific about the basic

obligation of responsibility, respect, fairness, and honesty. It requires that practitioners demonstrate a commitment to ethical and professional conduct. It carries the obligation to comply with laws, regulations, and organizational and professional policies. Since practitioners come from diverse backgrounds and cultures, the *Project Management Institute Code of Ethics and Professional Conduct* applies globally. When dealing with any stakeholder, practitioners should be committed to honest and fair practices and respectful dealings. The *Project Management Institute Code of Ethics and Professional Conduct* is posted on the PMI website (http://www.pmi.org). Acceptance of the code is a requirement for the following PMI® exams:

- Certified Associate in Project Management (CAPM)®
- Project Management Professional (PMP)®
- Program Management Professional (PgMP)®
- PMI Agile Certified Practitioner (PMI-ACP)SM
- PMI Risk Management Professional (PMI-RMP)®
- PMI Scheduling Professional (PMI-SP)®

1.2 What is a Project?

A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists. Temporary does not necessarily mean short in duration. 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 build a national monument will create a result expected to last centuries. Projects can also have social, economic, and environmental impacts that far outlast the projects themselves. Every project creates a unique product, service, or result. Although repetitive elements may be present in some project deliverables, this repetition does not change the fundamental uniqueness of the project work. For example, office buildings can be constructed with the same or similar materials and by the same or different teams. However, each building project remains unique with a different location design, different circumstances, different contractors, and so on.

An ongoing work effort is generally a repetitive process because it follows an organization's existing procedures. In contrast, because of the unique nature of projects, there may be uncertainties about the products, services, or results that the project creates. Project tasks can be new to a project team, which necessitates more dedicated planning than other routine work. In addition, projects are undertaken at all organizational levels. A project can involve a single person, a single organizational unit, or multiple organizational units.

A project can create:

- A product that can be either a component of another item or an end item in itself;
- A capability to perform a service (e.g., a business function that supports production or distribution); or
- A result, such as an outcome or document (e.g., a research project that develops knowledge that can be used to determine whether a trend is present or a new process will benefit society).

Examples of projects include, but are not limited to:

- Developing a new product or service;
- Effecting a change in the structure, staffing, or style of an organization;
- Developing or acquiring a new or modified information system;
- Constructing a building or infrastructure; or
- Implementing a new business process or procedure.

1.2.1. The Relationships Among Portfolios, Programs, and Projects

The relationship among portfolios, programs, and projects is such that a portfolio refers to a collection of projects, programs, subportfolios, and operations grouped together in order to facilitate the effective management of that work to meet strategic business objectives. Programs are grouped within a portfolio and are comprised of subprograms, projects, or other work that are managed in a coordinated fashion in support of the portfolio. Individual projects that are either within or outside of a program are still considered part of a portfolio. Although the projects or programs within the portfolio may not necessarily be interdependent or directly related, they are linked to the organization's strategic plan by means of the organization's portfolio.

As Figure 1-1 illustrates, organizational strategies and priorities are linked and have relationships between portfolios and programs, and between programs and individual projects. Organizational planning impacts the projects by means of project prioritization based on risk, funding, and other considerations relevant to the organization's strategic plan. Organizational planning can direct the management of resources, and support for the component projects on the basis of risk categories, specific lines of business, or general types of projects, such as infrastructure and process improvement.

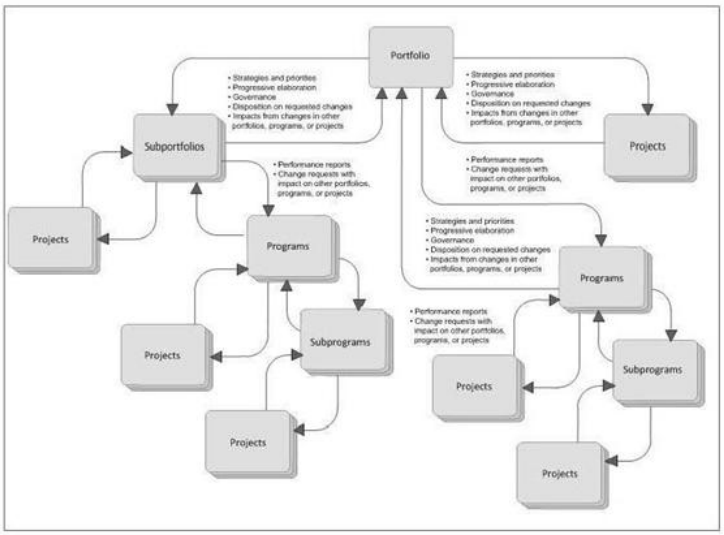


Figure 1-1. Portfolio, Program, and Project Management Interactions

1.3 What is Project Management?

Project management is the application of knowledge, skills, tools, and techniques for project activities to meet the project requirements. Project management is accomplished through the appropriate application and integration of the 47 logically grouped project management processes comprising five Process Groups. These five Process Groups are:

- Initiating,
- Planning,
- Executing,
- Monitoring and Controlling, and
- Closing.

Managing a project typically includes:

- Identifying requirements;
- Addressing the various needs, concerns, and expectations of the stakeholders as the project is planned and carried out;
- Setting and maintaining active communication with stakeholders;
- Balancing the competing project constraints, which include, but are not limited to:
    - Scope,
    - Quality,
    - Schedule,
    - Budget,
    - Resources, and
    - Risk.

The specific project circumstances will influence the constraints on which the project manager needs to focus.

The relationship among these factors is such that if any one factor changes, at least one other factor is likely to be affected. For example, if the schedule is shortened, often the budget needs to be increased to add additional resources to complete the same amount of work in less time. If a budget increase is not possible, the scope or quality may be reduced to deliver a product in less time for the same budget amount. Project stakeholders may have differing ideas as to which factors are the most important, creating an even greater challenge. Changing the project requirements may create additional risks. The project team must be able to assess the situation, balance the demands, and maintain active communication with stakeholders in order to deliver a successful project.

Because of the potential for change, the project management plan is iterative and goes through progressive elaboration throughout the project's life cycle. Progressive elaboration involves continuously improving and detailing a plan as more detailed and specific information and more accurate estimates become available. Progressive elaboration allows a project management team to manage to a greater level of detail as the project evolves.

1.4 Relationships Among Portfolio Management, Program Management, Project Management, and Organizational Project Management

In order to understand portfolio, program, and project management, it is important to recognize the similarities and differences among these disciplines. It is also helpful to understand how they relate to organizational project management (OPM). OPM is a strategy execution framework utilizing project, program, and portfolio management as well as organizational enabling practices to consistently and predictably deliver organizational strategy producing better performance, better results, and a sustainable competitive advantage.

Portfolio, program, and project management should be aligned with or be driven by organizational strategies. Conversely, portfolio, program, and project management differ in the way each contributes to the achievement of strategic goals. Portfolio management aligns with organizational strategies by selecting the right programs or projects, prioritizing the work, and providing the needed resources, whereas program management harmonizes its projects and program components and controls interdependencies in order to realize specified benefits. Project management develops and implements plans to achieve a specific scope that is driven by the objectives of the program or portfolio it is subjected to and, ultimately, to organizational strategies. OPM advances organizational capability by linking project, program, and portfolio management principles and practices with organizational enablers (e.g. structural, cultural, technological, and human resource practices) to support strategic goals. An organization measures its capabilities, then plans and implements improvements towards the systematic achievement of best practices. Table 1-1 shows the comparison of project, program, and portfolio views across several dimensions within the organization.

Table 1-1. Comparative Overview of Project, Program, and Portfolio Management

Organizational Project Management			
	PROJECTS	PROGRAMS	PORTFOLIOS
Scope	Projects have defined objectives. Scope is progressively elaborated throughout the project life cycle.	Programs have a larger scope and provide more significant benefits.	Portfolios have an organizational scope that changes with the strategic objectives of the organization.
Change	Project managers expect change and implement processes to keep change managed and controlled.	Program managers expect change from both inside and outside the program and are prepared to manage it.	Portfolio managers continuously monitor changes in the broader internal and external environment.
Planning	Project managers progressively elaborate high-level information into detailed plans throughout the project life cycle.	Program managers develop the overall program plan and create high-level plans to guide detailed planning at the component level.	Portfolio managers create and maintain necessary processes and communication relative to the aggregate portfolio.
Management	Project managers manage the project team to meet the project objectives.	Program managers manage the program staff and the project managers; they provide vision and overall leadership.	Portfolio managers may manage or coordinate portfolio management staff, or program and project staff that may have reporting responsibilities into the aggregate portfolio.
Success	Success is measured by product and project quality, timeliness, budget compliance, and degree of customer satisfaction.	Success is measured by the degree to which the program satisfies the needs and benefits for which it was undertaken.	Success is measured in terms of the aggregate investment performance and benefit realization of the portfolio.
Monitoring	Project managers monitor and control the work of producing the products, services or results that the project was undertaken to produce.	Program managers monitor the progress of program components to ensure the overall goals, schedules, budget, and benefits of the program will be met.	Portfolio managers monitor strategic changes and aggregate resource allocation, performance results, and risk of the portfolio.

1.4.1 Portfolio Management

A portfolio refers to a collection of projects or programs and other work that are grouped

together to facilitate effective management of that work to meet strategic business objectives. The projects or programs of the portfolio may not necessarily be interdependent or directly related. For example, an infrastructure firm that has the strategic objective of "maximizing the return on its investments" may put together a portfolio that includes a mix of projects in oil and gas, power, water, roads, rail, and airports. From this mix, the firm may choose to manage related projects as one program. All of the power projects may be grouped together as a power program. Similarly, all of the water projects may be grouped together as a water program.

Portfolio management refers to the centralized management of one or more portfolios to achieve strategic objectives.

Portfolio management focuses on ensuring that projects and programs are reviewed to prioritize resource allocation, and that the management of the portfolio is consistent with and aligned to organizational strategies.

1.4.2 Program Management

A program is defined as a group of related projects that is managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work outside the scope of the discrete projects in the program. A project may or may not be part of a program but a program will always have projects.

Program management is the application of knowledge, skills, tools, and techniques to a program in order to meet the program requirements and to obtain benefits and control not available by managing the component projects individually.

Projects within a program are related through the common outcome or collective capability. If the relationship between projects is only that of a shared client, seller, technology, or resource, the effort should be managed as a portfolio of projects rather than as a program.

Program management focuses on the project interdependencies and helps to determine the optimal approach for managing them. Actions related to these interdependencies may include:

- Resolving resource constraints and/or conflicts that affect multiple projects within the program,
- Aligning organizational/strategic direction that affects project and program goals and objectives, and
- Resolving issues and change management within a shared governance structure.

An example of a program is a new communications satellite system with projects for design of the satellite and the ground stations, the construction of each, the integration of the system, and the launch of the satellite.

1.4.3 Projects and Strategic Planning

Projects are often utilized as a means of achieving an organization's strategic plan. Projects are typically authorized as a result of one or more of the following strategic considerations:

- Market demand (e.g., a car company authorizing a project to build more fuel-efficient cars in response to gasoline shortages);
- Strategic opportunity/business need (e.g., a training company authorizing a project to create a new course to increase its revenues);
- 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);
- Environmental considerations (e.g., a public company authorizing a project to create a new service of electric car sharing to reduce pollution);
- Customer request (e.g., an electric utility authorizing a project to build a new substation to serve a new industrial park);
- Technological advance (e.g., an electronics firm authorizing a new project to develop a faster, cheaper, and smaller laptop based on advances in computer memory and electronics technology); and
- Legal requirements (e.g., a chemical manufacturer authorizes a project to establish guidelines for the handling of a new toxic material).

Projects, within programs or portfolios, are a means of achieving organizational goals and objectives, often in the context of a strategic plan. Although a group of projects within a program can have discrete benefits, they can also contribute to the benefits of the program, to the objectives of the portfolio, and to the strategic plan of the organization.

Organizations manage portfolios based on their strategic plan, which may dictate a hierarchy to the portfolio, program, or projects involved. One goal of portfolio management is to maximize the value of the portfolio through careful examination of its components—the constituent programs, projects, and other related work. Those components contributing the least to the portfolio's strategic objectives may be excluded. In this way, an organization's strategic plan becomes the primary factor guiding investments in projects. At the same time, projects provide feedback to programs and portfolios by means of status reports and change requests that may help identify impacts to other projects, programs, or portfolios. The needs of the projects, including the resource needs, are rolled up and communicated back to the portfolio level, which in turn sets the direction

for organizational planning.

1.4.4 Project Management Office

A project management office (PMO) is an organizational body or entity assigned various responsibilities related to the centralized and coordinated management of those projects under its domain. The responsibilities of a PMO can range from providing project management support functions to actually being responsible for the direct management of a project.

There are several types of PMO organizations, each varying in the degree of control and influence they have on projects within the organization, such as:

- **Supportive.** Supportive PMOs provide a consultative role to projects by supplying templates, best practices, access to information and lessons learned from other projects. This type of PMO serves as a project repository. The degree of control provided by the PMO is low.
- **Controlling.** Controlling PMOs provide support and require compliance through various means. Compliance may involve adopting project management frameworks or methodologies, using specific templates, forms and tools, or conformance to governance. The degree of control provided by the PMO is moderate.
- **Directive.** Directive PMOs take control of the projects by directly managing the projects. The degree of control provided by the PMO is high.

The PMO is one of the best options to integrate data and information from corporate strategic projects and evaluate how higher level strategic objectives are being fulfilled. The PMO is the natural liaison between a company's portfolios, programs, and projects, and the corporate measurement systems, such as the balanced scorecard.

The projects supported or administered by the PMO may not be related, other than by being managed together. The specific form, function, and structure of a PMO are dependent upon the needs of the organization that it supports.

A PMO may have the authority to act as an integral stakeholder and a key decision maker during the beginning of each project, to make recommendations, or to terminate projects or take other actions, as required, to keep business objectives consistent. In addition, the PMO may be involved in the selection, management, and deployment of shared or dedicated project resources.

A primary function of a PMO is to support project managers in a variety of ways which may include, but are not limited to:

- Managing shared resources across all projects administered by the PMO;
- Identifying and developing project management methodology, best practices, and standards;
- Coaching, mentoring, training, and oversight;
- Monitoring compliance with project management standards, policies, procedures, and templates by means of project audits;
- Developing and managing project policies, procedures, templates, and other shared documentation (organizational process assets); and
- Coordinating communication across projects.

Project managers and PMOs pursue different objectives and, as such, are driven by different requirements. All of these efforts are aligned with the strategic needs of the organization. Differences between the role of project managers and a PMO may include the following:

- The project manager focuses on the specified project objectives, while the PMO manages major program scope changes which may be seen 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 constraints (scope, schedule, cost, and quality, etc.) of the individual projects, while the PMO manages the methodologies, standards, overall risk/opportunity, metrics, and interdependencies among projects at the enterprise level.

1.5 The Relationship Among Project Management,

Operations Management, and Organizational Strategy

Operations are an organizational function performing the ongoing execution of activities that produce the same product or provide a repetitive service. Operations evolve to support the day-to-day business, and are necessary to achieve strategic and tactical goals of the business. Examples include: production operations, manufacturing operations, accounting operations, software production support and maintenance.

Though temporary in nature, projects can help achieve the organizational goals when they are aligned with the organization's strategy. Organizations sometimes change their operations, products, or systems by creating strategic business initiatives that are developed and implemented through projects. Projects require project management activities and skill sets, while operations require business process management and operations management activities and skill sets. Operations management is an area of management concerned with overseeing, designing, and redesigning business operations in the

production of goods and/or services.

1.5.1 Operational Issues and Project Management

When a project delivers a new product or service, organizations have to redesign their ongoing business operations to accommodate their inclusion in the business. Changes in business operations may be the focus of a dedicated project— especially if there are substantial changes to business operations as a result of a new product or service delivery. Ongoing operations are outside of the scope of a project; however, there are intersecting points where the two areas cross.

Projects can intersect with operations at various points during the product life cycle, such as:

- At each closeout phase;
- When developing a new product, upgrading a product, or expanding outputs;
- While improving operations or the product development process; or
- Until the divestment of operations at the end of the product life cycle.

At each point, deliverables and knowledge are transferred between the project and operations for implementation of the delivered work. This occurs through a transfer of project resources to operations toward the end of the project, or through a transfer of operational resources to the project at the start.

Operations are permanent endeavors that produce repetitive outputs, with resources assigned to do basically the same set of tasks according to the standards institutionalized in a product life cycle. Unlike the ongoing nature of operations, projects are temporary endeavors.

1.5.1.1 Operations Management

Operations management is a subject area that is outside the scope of formal project management as described in the *PMBOK® Guide*.

Operations management is an area of management concerned with ongoing production of goods and/or services. It involves ensuring that business operations continues efficiently by using the optimum resources needed and meeting customer demand. It is concerned with managing processes that transform inputs (e.g., materials, components, energy, and labor) into outputs (e.g., products, goods and/or services).

1.5.1.2 Operational Stakeholders in Project Management

While it is clear that operations management is different from project management (see Section 1.5.1.1), the stakeholders who perform and conduct business operations are important considerations in projects that will affect their future work and endeavors. Project managers who consider and appropriately include operational stakeholders in the planning, execution, monitoring and controlling, and closing of projects gain insight and avoid unnecessary surprises that often arise when their input is overlooked.

Operational stakeholders should be included and their needs identified as part of the stakeholder register, and their influence (positive or negative) should be addressed as part of the risk management plan.

The following list includes examples of operational stakeholders (depending upon the business):

- Plant operators,
- Manufacturing line supervisors,
- Help desk staff,
- Production system support analysts,
- Customer service representative,
- Salespersons,
- Maintenance workers,
- Telephone sales personnel,
- Call center personnel,
- Retail workers,
- Line managers, and
- Training officers.

1.5.2 Organizational Issues and Project Management

Governance usually sets high-level strategic direction and performance parameters. The strategy provides the purpose, expectations, goals, and actions necessary to guide business pursuit, and is aligned with business objectives. Project management activities should be aligned with top-level business direction, and if there is a change, then project objectives need to be realigned. In a project environment, this affects project efficiency and success. If the business alignment for a project is constant, the chance for project success greatly increases because the project is aligned with the strategic direction of the organization. Should something change, projects change accordingly.

1.5.2.1 Project-Based Organizations

Project-based organizations (PBOs) refer to various organizational forms that create

temporary systems for carrying out their work. PBOs can be created by different types of organizations (i.e., functional, matrix, or projectized). The use of PBOs weakens the hierarchy and bureaucracy inside the organizations as the success of the work is measured by the final result rather than position or politics.

PBOs conduct the majority of their work as projects and/or provide project over functional approaches. They can refer to either entire firms (as in telecommunications, oil and gas, construction, consultancy and professional services) or multi-firm consortia or networks; it is also possible that some large project-based organizations have functional support areas or that the PBO is nested within subsidiaries or divisions of larger corporations.

1.5.2.2 The Link Between Project Management and Organizational Governance

Projects (and programs) are undertaken to achieve strategic business outcomes, for which many organizations now adopt formal organizational governance processes and procedures. Organizational governance criteria can impose constraints on projects—particularly if the project delivers a service which will be subject to strict organizational governance. Because project success may be judged on the basis of how well the resultant product or service supports organizational governance, it is important for the project manager to stay up to date on corporate/organizational governance policies and procedures pertaining to the subject matter of the product or service (e.g., if an organization has adopted policies in support of sustainability practices and the project involves construction of a new office building, the project manager should be aware of sustainability requirements related to building construction.)

1.5.2.3 The Relationship Between Project Management and Organizational Strategy

Organizational strategy should provide guidance and direction to project management—especially when one considers that projects exist to support organizational strategies. If the goals of a project are in conflict with an established organizational strategy, it is incumbent upon the project manager to document and identify such conflicts as early as possible in the project. At times the development of an organizational strategy could be the goal of a project rather than the guiding principles. In such a case, it is important for the project to specifically define what constitutes an appropriate organizational strategy that will sustain the organization.

1.6 Business Value

Business value is a concept that is unique to each organization. Business value is defined as the entire value of the business; the total sum of all tangible and intangible elements. Examples of tangible elements include monetary assets, fixtures, stockholder equity, and utility. Examples of intangible elements include good will, brand recognition, public benefit, and trademarks. Depending on the organization, business value scope can be short-, medium-, or long-term. Value may be created through the effective management of ongoing operations. However, through the effective use of portfolio, program, and project management, organizations will possess the ability to employ reliable, established processes to meet strategic objectives and obtain greater business value from their project investments. While not all organizations are business driven, all organizations conduct business-related activities. Whether an organization is a government agency or a nonprofit organization, all organizations focus on attaining business value for their activities.

Successful business value realization begins with comprehensive strategic planning and management. Organizational strategy can be expressed through the organization’s mission and vision, including orientation to markets, competition, and other environmental factors. Effective organizational strategy provides defined directions for development and growth, in addition to performance metrics for success. In order to bridge the gap between organizational strategy and successful business value realization, the use of portfolio, program, and project management techniques is essential.

Portfolio management aligns components (projects, programs or operations) to the organizational strategy, organized into portfolios or subportfolios to optimize project or program objectives, dependencies, costs, timelines, benefits, resources, and risks. This allows organizations to have an overall view of how the strategic goals are reflected in the portfolio, institute appropriate governance management, and authorize human, financial, or material resources to be allocated based on expected performance and benefits.

Using program management, organizations have the ability to align multiple projects for optimized or integrated costs, schedule, effort, and benefits. Program management focuses on project interdependencies and helps to determine the optimal approach for managing and realizing the desired benefits.

With project management, organizations have the ability to apply knowledge, processes, skills, and tools and techniques that enhance the likelihood of success over a wide range of projects. Project management focuses on the successful delivery of products, services, or results. Within programs and portfolios, projects are a means of achieving organizational strategy and objectives.

Organizations can further facilitate the alignment of these portfolio, program, and project management activities by strengthening organizational enablers such as structural,

cultural, technological, and human resource practices. By continuously conducting portfolio strategic alignment and optimization, performing business impact analyses, and developing robust organizational enablers, organizations can achieve successful transitions within the portfolio, program, and project domains and attain effective investment management and business value realization.

1.7 Role of a Project Manager

The project manager is the person assigned by the performing organization to lead the team that is responsible for achieving the project objectives. The role of a project manager is distinct from a functional manager or operations manager. Typically the functional manager is focused on providing management oversight for a functional or a business unit, and operations managers are responsible for ensuring that business operations are efficient. Depending on the organizational structure, a project manager may report to a functional manager. In other cases, a project manager may be one of several project managers who report to a portfolio or program manager that is ultimately responsible for enterprise-wide projects. In this type of structure, the project manager works closely with the portfolio or program manager to achieve the project objectives and to ensure the project plan aligns with the overarching program plan.

As a rule, project managers must satisfy the following set of needs: task needs, team needs, and individual needs. As project management is a critical strategic tool, the project manager becomes the link between the strategy and the team. Projects are essential to the growth and survival of organizations today. Projects create value in the form of improved business processes, are indispensable in the development of new products and services, and make it easier for companies to respond to changes in the environment, competition and the marketplace. The project manager's role therefore becomes increasingly strategic. Many of the tools and techniques for managing projects are specific to project management. However, understanding and applying the knowledge, tools, and techniques that are recognized as good practice is not sufficient for effective project management. In addition to any area-specific skills and general management proficiencies required for the project, effective project management requires that the project manager possess the following competencies:

- **Knowledge** This refers to what the project manager knows about project management.
- **Performance.** This refers to what the project manager is able to do or accomplish while applying his or her project management knowledge.
- **Personal.** This refers to how the project manager behaves when performing the project or related activity. Personal effectiveness encompasses attitudes, core personality characteristics, and leadership, which provides the ability to guide the project team while achieving project objectives and balancing the project constraints.

1.7.1 Interpersonal Skills of a Project Manager

Project managers accomplish work through the project team and other stakeholders. Effective project managers acquire a balance of ethical, interpersonal, and conceptual skills that help them analyze situations and interact appropriately. Appendix X6 on Interpersonal Skills describes important interpersonal skills, such as:

- Leadership,
- Team building,
- Motivation,
- Communication,
- Influencing,
- Decision making,
- Political and cultural awareness, and
- Negotiation.

1.8 Project Management Body of Knowledge

The *PMBOK® Guide* contains the standard for managing most projects most of the time across many types of industries. The standard, included in Annex A1, describes the project management processes, tools, and techniques used to manage a project toward a successful outcome.

This standard is unique to the project management field and has interrelationships to other project management disciplines such as program management and portfolio management. Project management standards do not address all details of every topic. This standard is limited to single projects and the project management processes that are generally recognized as good practice. Other standards may be consulted for additional information on the broader context in which projects are accomplished, such as:

- *The Standard for Program Management* addresses the management of programs.
- *The Standard for Portfolio Management* addresses the management of portfolios,
- *Organizational Project Management Maturity Model (OPM3®)* examines an enterprise's project management process capabilities.

CHAPTER 2

PROJECT LIFE CYCLE AND ORGANIZATION

Projects and project management take place in an environment that is broader than that of the project itself. Understanding this broader context helps ensure that work is carried out in alignment with the organization's goals and managed in accordance with the organization's established practice methodologies. This chapter describes how organizational influences affect the way the project is staffed, managed, and executed. It discusses the influence of stakeholders on the project and its governance, the project team's structure and membership, and different approaches to the phasing and relationship of activities within the project's life cycle. The following major sections are addressed:

2.1 Organizational Influences on Project Management
2.2 Project Stakeholders and Governance
2.3 The Project Team
2.4 The Project Life Cycle—Overview

2.1 Organizational Influences on Project Management

An organization's culture, style, and structure influence how its projects are performed. The organization's level of project management maturity and its project management systems can also influence the project. When a project involves external entities as part of a joint venture or partnering, the project will be influenced by more than one enterprise. The following sections describe organizational characteristics, factors, and assets within an enterprise that are likely to influence the project.

2.1.1 Organizational Cultures and Styles

Organizations are systematic arrangements of entities (persons and/or departments) aimed at accomplishing a purpose, which may involve undertaking projects. When organizations sponsor or perform projects, they directly influence the project and its conduct depending on the organization's culture and style. Cultures and styles are group phenomena known as cultural norms, which develop over time. The norms include established approaches to initiating and planning projects, the means considered acceptable for getting the work done, and recognized authorities who make or influence decisions.

Organizational culture is shaped by the common experiences of members of the organization and most organizations have developed unique cultures over time by practice and common usage. These manifest in numerous ways including, but not limited to:

- Shared visions, values, beliefs, and expectations;
- Policies, methods, and procedures;
- Motivation and reward systems;
- Risk tolerance;
- View of leadership, hierarchy, authority relationships; and
- Work ethic and work hours.

The organization's culture is an enterprise environmental factor, as described in Section 2.1.5. Cultures and styles are learned and shared and may have a strong influence on a project's ability to meet its objectives. A project manager should therefore understand the different organizational styles and cultures that may affect a project. For example, the person shown at the top of an organization chart may be a figurehead who is not truly in charge. The project manager needs to know which individuals in the organization are the decision makers or influencers and work with them to increase the probability of project success.

Knowledge of the cultural influence that sponsoring or performing organizations have on a project becomes critical for a project manager in light of globalization, where these organizations may often be multinationals or international organizations. Another effect of globalization is the increasing number of projects involving diverse organizations and locations around the world. Culture, in this scenario, becomes a critical factor in defining project success; the project manager will need to exhibit the project management imperative of cultural, multicultural and/or cross-cultural competence. Project managers need to consider the primary cultural orientations of the various organizations involved in the project, as well as their own and those of the project team members.

2.1.2 Organizational Communications

In the face of globalization of the project management profession, project management success in an organization is highly dependent on an effective organizational communication style. This has been made possible with the advent of global mass media and other forms of technological development such as the internet. Many organizations have consequently adopted computer networks, electronic mail, and videoconferencing as de facto communication styles, which enable project governance and organization across different time zones.

Organizational communications capabilities have greatly influenced how projects are conducted. As a consequence, project managers in distant locations are able to effectively communicate with all relevant stakeholders within the organizational structure to facilitate decision making. Stakeholders and project team members can also use electronic mail and other means to communicate with the project manager formally or informally. A project manager must be able to recognize and understand the difference between formal and informal styles of communication.

2.1.3 Organizational Structures

Organizational structure is an enterprise environmental factor which can affect the availability of resources and influence how projects are conducted. Organizational structures range from functional to projectized, with a variety of matrix structures in between. Table 2-1 shows key project-related characteristics of the major types of organizational structures.

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

Table 2-1. Organizational Influences on Projects

The classic functional organization, shown in Figure 2-1, 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. Specialties may be further subdivided into functional organizations, such as mechanical and electrical engineering. Each department in a functional organization will do its project work independently of other departments.

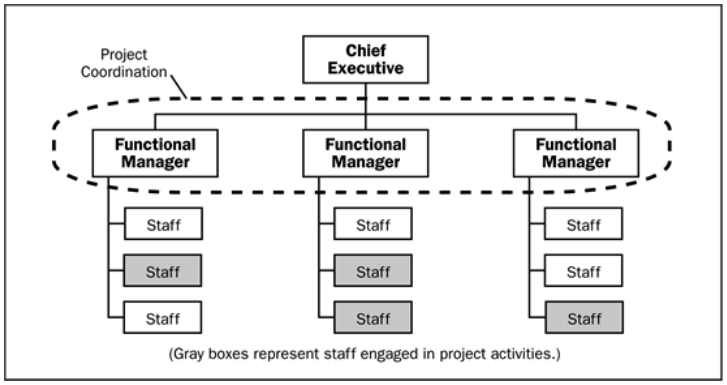
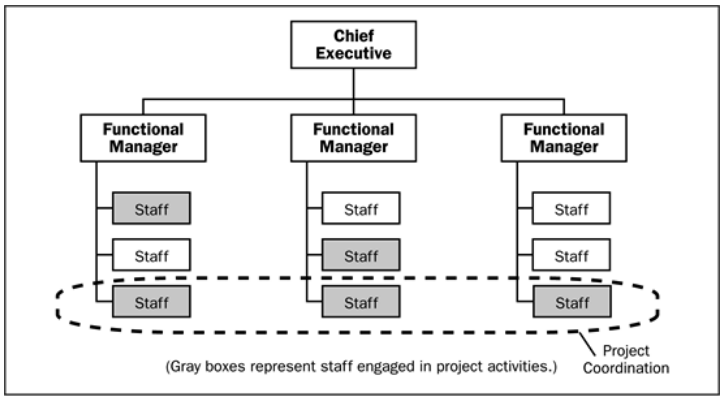


Figure 2-1. Functional Organization

Matrix organizations, as shown in Figures 2-2 through 2-4, reflect a blend of functional and projectized characteristics. Weak matrices maintain many of the characteristics of a functional organization, and the project manager role is that of a coordinator or expediter rather than a project manager. 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. Table 2-1 provides additional details of the various matrix organizational structures.



649 Figure 2-2. Weak Matrix Organization
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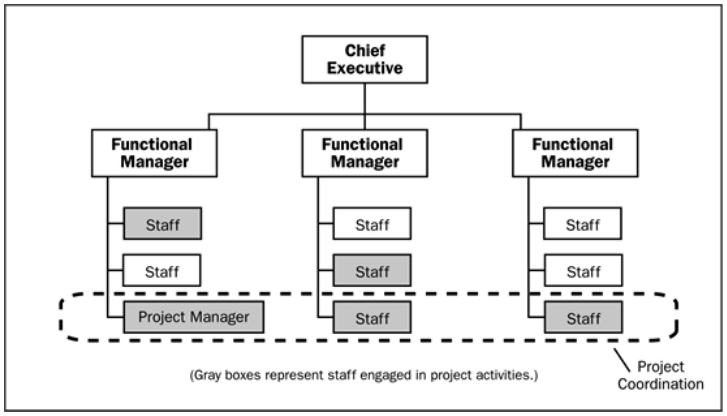

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652 Figure 2-3. Balanced Matrix Organization
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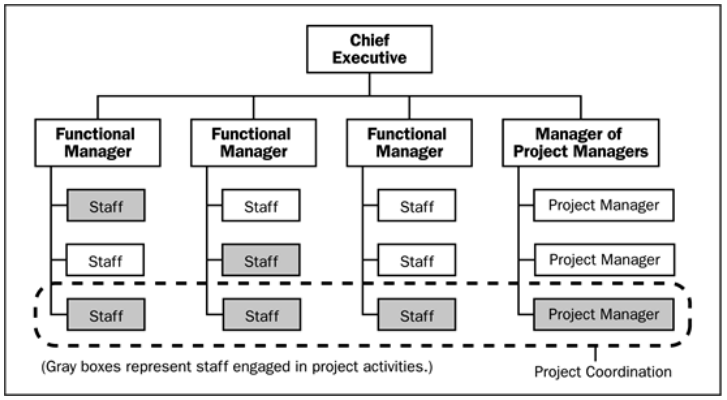
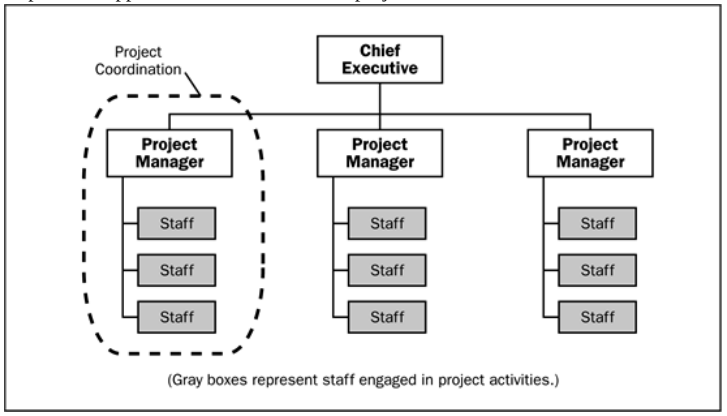


654
655 Figure 2-4. Strong Matrix Organization
656

657 At the opposite end of the spectrum to the functional organization is the projectized
658 organization, shown in Figure 2-5. In a projectized organization, team members are often
659 colocated, most of the organization's resources are involved in project work, and project
660 managers have a great deal of independence and authority. Projectized organizations often
661 have organizational units called departments, but these groups either report directly to
662 the project manager or provide support services to the various projects.



663
664 Figure 2-5. Projectized Organization
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Many organizations involve all these structures at various levels, as shown in Figure 2-6 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 of the standard, formalized reporting structure.

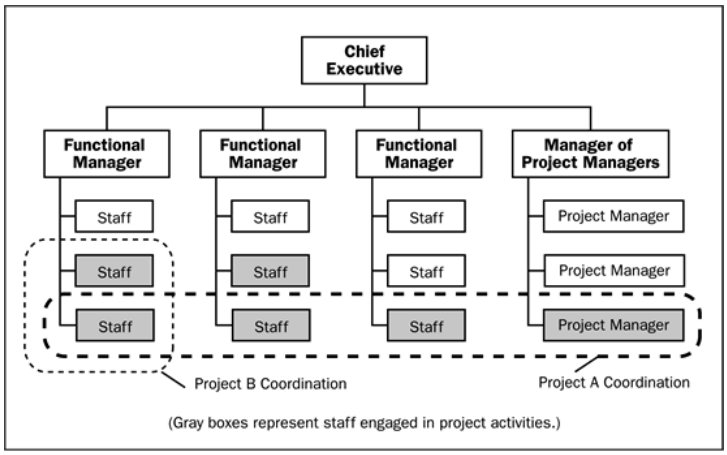


Figure 2-6. Composite Organization

Also, many organizational structures consist of strategic, middle management, and operational levels. As shown in Figure 2-7, the project manager may interact with all three levels depending on the strategic importance of the project, the organization's degree of project management maturity, its project management systems, and its organizational communications. This interaction determines project characteristics such as:

- Project manager's authority;
- Resource availability;
- Who controls the project budget;
- Project manager's role; and
- Project team composition.

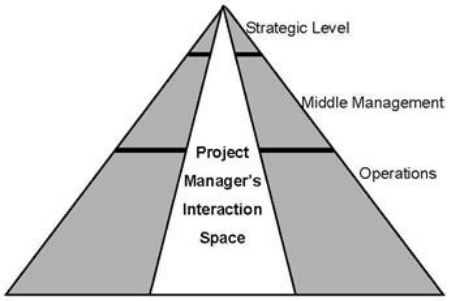


Figure 2-7. Interaction Space of a Project Manager in an Organization

2.1.4 Organizational Process Assets

Organizational process assets include any artifact or concept from any or all of the organizations involved in the project that can be used to perform or govern the project. These process assets include formal and informal plans, processes, policies, procedures, and knowledge bases, specific to and used by the performing organization. The process assets also include the organization's knowledge bases such as lessons learned and historical information. Organizational process assets may include completed schedules, risk data, and earned value data. Updating and adding to the organizational process assets as necessary throughout the project are the responsibility of the project team members. Organizational process assets may be grouped into two categories:

2.1.4.1 Processes and Procedures

The organization's processes and procedures for conducting work include, but are not limited to:

- Initiating and Planning:
    - Guidelines and criteria for tailoring the organization's set of standard processes to satisfy the specific needs of the project;
    - Specific organizational standards such as policies (e.g., safety and health policy, ethics policy, and project management policy), 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); and

- Templates (e.g., risk, work breakdown structure, project schedule network diagram, and contract templates).
- Executing, Monitoring and Controlling:
  - 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;
  - 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;
  - Organization communication requirements (e.g., specific communication technology available, allowed communication media, record retention policies, and security requirements);
  - Procedures for prioritizing, approving, and issuing work authorizations;
  - Risk control procedures, including risk categories, probability definition and impact, and probability and impact matrix; and
  - Standardized guidelines, work instructions, proposal evaluation criteria, and performance measurement criteria.
- Closing:
  - Project closure guidelines or requirements (e.g., final project audits, project evaluations, product validations, and acceptance criteria).

2.1.4.2 Corporate Knowledge Base

The organizational corporate knowledge base for storing and retrieving information includes, but is not limited to:

- Configuration management knowledge bases containing the versions and baselines of all official company standards, policies, procedures, and any project documents;
- Financial databases containing information such as labor hours, incurred costs, budgets and any project cost overruns;
- Historical information and lessons learned knowledge bases (e.g., project records and documents, all project closure information and documentation, information regarding both the results of previous project selection decisions and previous project performance information, and information from the risk management activities);
- Issue and defect management databases containing issue and defect status, control information, issue and defect resolution, and action item results;
- Process measurement databases used to collect and make available measurement data on processes and products; and
- Project files (e.g., scope, cost, schedule, and performance measurement baselines, project calendars, project schedule network diagrams, risk registers, planned response actions, and defined risk impact).

2.1.5 Enterprise Environmental Factors

Enterprise environmental factors refer to internal or external conditions, not under the control of the project team, that influence, constrain, or direct the project. Enterprise environmental factors may enhance or constrain project management options and may have a positive or negative influence on the outcome. They are considered as inputs to most planning processes.

These enterprise environmental factors can range and vary widely in type or nature. These traditionally include the structure of the organization, its culture, all infrastructural components, commercial databases, market conditions, resources that may currently exist, and project management software that the project team may have ready access to should it be needed.

Enterprise environmental factors include, but are not limited to:

- Organizational culture, structure, and processes;
- Government or industry standards (e.g., regulatory agency regulations, codes of conduct, 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, law, contracting, and purchasing);
- Personnel administration (e.g., staffing and retention guidelines, employee performance reviews and training records, overtime policy, and time tracking);
- Company work authorization systems;
- Marketplace conditions;
- Stakeholder risk tolerances;
- Political climate;
- Organization’s established communications channels;
- Commercial databases (e.g., standardized cost estimating data, industry risk study information, and risk databases); and
- Project management information systems (e.g., an automated tool, such as a scheduling software tool, a configuration management system, an information collection and distribution system, or web interfaces to other online automated systems).

2.2 Project Stakeholders and Governance

A stakeholder is an individual, group, or organization who may affect, be affected by, or perceive itself to be affected by a decision, activity, or outcome of a project. Stakeholders may be actively involved in the project or have interests that may be positively or negatively affected by the performance or completion of the project. Stakeholders may also exert influence over the project, its deliverables, and the project team members in order to achieve a set of outcomes that satisfy strategic business needs. Project governance—the alignment of the project with stakeholders' strategic objectives—is critical to the successful management of stakeholder expectations and the achievement of organizational objectives. Project governance enables organizations to consistently manage project portfolios to maximize the value of project outcomes and align the projects with business strategy. It provides a framework in which the project manager can make decisions that satisfy both stakeholder expectations and organizational strategic objectives.

2.2.1 Project Stakeholders

Stakeholders include members of the project team as well as interested entities who are internal and external to the organization. The project team must identify internal and external, active and passive, and performing and advising stakeholders in order to determine the project requirements and the expectations of all parties involved. The project manager must manage the influences of these various stakeholders in relation to the project requirements to ensure a successful outcome. Figure 2-8 illustrates the relationship between the project, the project team, and customary stakeholders.

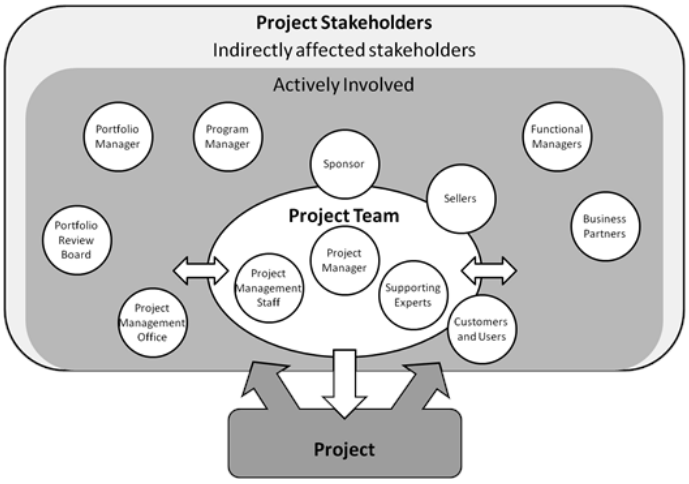


Figure 2-8. Project Stakeholders and Project Team

Stakeholders have varying levels of responsibility and authority when participating on a project, which can change over the course of the project life cycle. Their involvement may range from occasional contributions in surveys and focus groups to full project sponsorship, which includes providing financial and political support.
Stakeholder identification is a continuous process and can be challenging. Identifying stakeholders and understanding their relative degree of influence on a project is critical to the success of the project. Failure to do so can lead to delays, cost increases, and other negative consequences. An example is late recognition that the legal department is a significant stakeholder, which results in delays and increased expenses due to legal requirements that must be met before the project can be completed or a product released. Just as stakeholders can positively or adversely impact the project objectives, a project can be perceived by the stakeholders as having positive or negative results. For example, business leaders from a community who will benefit from an industrial expansion project will see positive economic benefits to the community in the form of additional jobs, supporting infrastructure, and taxes. In the case of stakeholders with positive expectations from the project, their interests are best served by helping the project succeed. The interests of negatively affected stakeholders, such as nearby homeowners or small business owners who may lose property, be forced to relocate, or accept an unwanted change in the local environment, can be served by impeding the project's progress. Overlooking negative stakeholder interests can result in an increased likelihood of failure or delays in the project.
An important part of a project manager's responsibility is to manage stakeholder expectations. This can be difficult because stakeholders often have very different or conflicting objectives. Part of the project manager's responsibility is to balance these interests and ensure that the project team interacts with stakeholders in a professional and cooperative manner. The following are some examples of project stakeholders:

- **Customers and users.** Customers and users are the persons or organizations that will use the project's product, service, or result. Customers and users may be internal or external to the performing organization and may also exist in multiple layers. For

example, the customers for a new pharmaceutical product could include the doctors who prescribe it, the patients who use it, and the insurers who pay for it. In some application areas, customers and users are synonymous, while in others, customers refer to the entity acquiring the project's product, and users refer to those who will directly utilize the project's product.

- **Sponsor.** A sponsor is the person or group that provides resources and support for the project and is accountable for enabling the project's success. From initial conception through project closure, the sponsor champions the project. This includes serving as spokesperson to higher levels of management to gather support throughout the organization and promote the benefits that the project will bring. The sponsor leads the project through the initiating processes until formally authorized, and plays a significant role in the development of the initial scope and charter. For issues that are beyond the control of the project manager, the sponsor serves as an escalation path. The sponsor may also be involved in other important issues such as authorizing changes in scope, phase-end reviews, and go/no-go decisions when risks are particularly high. The sponsor also ensures a smooth transfer of the project's deliverables into the business of the requesting organization after project closure.
- **Sellers and business partners.** Sellers, also called vendors, suppliers, or contractors, are external companies that enter into a contractual agreement to provide components or services necessary for the project. Business partners are also external companies, but they have a special relationship with the enterprise, sometimes attained through a certification process. Business partners provide specialized expertise or fill a specified role such as installation, customization, training, or support.
- **Organizational groups.** Organizational groups are internal stakeholders who are affected by the activities of the project team. Examples of various business elements of an organization that may be affected by the project include marketing and sales, human resources, legal, finance, operations, manufacturing, and customer service. These groups support the business environment where projects are executed, and are therefore affected by the activities of the project. As a result, there is generally a significant amount of interaction between the various business elements of an organization and the project team as they work together to achieve project goals.
- **Functional managers.** Functional managers who provide direct support to the project are considered members of the project team, such as in a matrix organization. The amount of resources supplied from these business units may vary from project to project and from phase to phase within a single project. One example of this interaction is when individuals from operations are assigned as dedicated project resources. Their operational expertise is used to carry out and assist in the completion of project deliverables by working with the rest of the project team to complete the project.
- **Other stakeholders**. Additional stakeholders, such as procurement entities, financial institutions, government regulators, subject matter experts and consultants, may have a financial interest in the project, contribute inputs to the project, or have an interest in the outcome of the project.

2.2.2 Project Governance

Project governance is the alignment of project objectives with the strategy of the larger organization by the project sponsor and project team. It provides a comprehensive, consistent method of controlling the project and ensuring its success by defining and documenting reliable, repeatable project practices. It includes a framework for making project decisions, defines responsibility and accountability for the success of the project, and determines the effectiveness of the project manager. A project's governance is defined by and must fit within the larger context of the program or organization sponsoring it but is separate from organizational governance. Project governance includes stakeholders as well as documented policy, procedures, and standards. Examples of items included in project governance are:

- Project success criteria;
- The process to identify, escalate, and resolve issues that arise during the project;
- The relationship among the project team, organizational groups, and external stakeholders;
- A project organization chart that identifies project roles;
- Processes and procedures for the communication of information;
- Project decision-making processes;
- Guidelines for aligning project governance and organizational strategy;
- The project life cycle approach;
- Identification of processes that add value; and
- A process to align internal stakeholders with project process requirements.

Within those constraints, as well as the additional limitations of time and budget, it is up to the project manager and the project team to determine the most appropriate method of carrying out the project. While project governance is the framework in which the project team performs, the team is still responsible for planning, executing, controlling and closing the project. The project governance approach should be described in the project management plan. Decisions are made regarding who will be involved, what resources are necessary, and the general approach to completing the work. Another important consideration is whether more than one phase will be involved and, if so, the specific life cycle for the individual project.

2.3 The Project Team

The project team is the set of individuals who support the project manager in performing the work of the project to achieve its objectives. The project team includes the project manager, project management staff, and other team members who carry out the work but who are not necessarily involved with management of the project. This team is comprised of individuals from different groups with specific subject matter knowledge or with a specific skill set who can carry out the work of the project. The structure and characteristics of a project team can vary widely, but one constant is the project manager's role as the leader of the team, regardless of what authority the project manager may have over its members.

Project teams are comprised of such roles as:

- **Project management staff.** The members of the project team who perform project management activities such as schedule, communications, and risk management. This role may be performed by a project management office.
- **Supporting experts.** Supporting experts perform tasks required to develop or execute the project management plan. These can include such roles as contracting, financial management, logistics, legal, safety, engineering, test, or quality control. Depending on the size of the project and level of support required, supporting experts may be assigned to work full time or may just participate on the team when their particular skills are required.
- **Users or Customers.** Members of the organization that will accept the deliverables or products of the project may be assigned to act as representatives or liaisons to ensure proper coordination, advise on requirements, or validate the acceptability of the project's results.
- **Sellers/business partners.** The project manager is often assigned the responsibility to oversee the performance and acceptance of sellers' deliverables or services. If the seller bears a large share of the risk for delivering the project's results, it may play a significant role on the project team.
- **Business partners.** Members of business partners' organizations may be assigned as members of the project team to ensure proper coordination.

2.3.1 Composition of Project Teams

The composition of project teams varies based on factors such as organizational culture, scope, and location. The relationship between the project manager and the team vary depending on the authority of the project manager. In some cases, a project manager may be the team's line manager, with full authority over its members. In other cases, a project manager may have little or no authority over the team and may be brought in to work on the project on a part-time basis or under contract. The following are examples of basic project team compositions:

- **Dedicated.** In a dedicated team, all or the majority of the project team members are assigned to work full-time on the project. The project team may be colocated and report directly to the project manager. This is the simplest structure for a project manager, as the lines of authority are clear and team members can focus on the project's objectives.
- **Part-Time.** Some projects are established as temporary additional work, where the project manager and team members work on the project while remaining in their existing organizations and continue to carry out their normal functions. The functional managers maintain control over the team members and the resources allocated to the project, and the project manager is likely to continue performing normal duties.

Dedicated and part-time project team compositions may exist in any of the organizational structures. Dedicated project teams are often seen in projectized organizations, where most of the organization's resources are involved in project work and project managers have a great deal of independence and authority. Part-time project teams are common within functional organizations, and matrix organizations use both dedicated and part-time project teams.

Project team composition may also vary based on the organizations involved in the project or the geographic location of its members. Two examples are partnership-based project teams and virtual project teams:

- **Partnership**. A project may be established as a partnership or alliance among several organizations through contracts or agreements. In this structure, one organization takes the lead and assigns a project manager to coordinate the efforts among the partners. Partnership-based projects offer flexibility at low cost. These advantages may be offset by the project manager's lack of control over team members and the need for strong mechanisms for communication and monitoring progress.
- **Virtual**. Telecommunications allow team members in different locations or countries to work as virtual teams. Virtual teams rely on collaborative tools such as shared online workspaces and video conferences to coordinate their activities and exchange of information about the project. A virtual team can exist with any type of organization structure and team composition. A project manager who is leading a virtual team needs to accommodate differences in the culture, working hours, local conditions, and languages.

2.4 The Project Life Cycle—Overview

A project life cycle is the series of phases that a project passes through from its initiation to its closure. The phases are generally sequential and, sometimes the name and number are determined by the management and control needs of the organization or organizations involved in the project, the nature of the project itself, and its area of application. A life cycle can be documented within a methodology. The project life cycle can be determined or shaped by the unique aspects of the organization, industry, or technology employed. While every project has a definite start and a definite end, the specific deliverables and activities that take place in between will vary widely with the project. The life cycle provides the basic framework for managing the project, regardless of the specific work involved.

Project life cycles can be described as falling somewhere in a continuum from predictive or plan-driven approaches at one end to adaptive or change-driven approaches at the other. In a predictive life cycle, the product and deliverables are defined at the beginning of the project and any changes to scope are carefully managed. In an adaptive life cycle, the product is developed over multiple iterations and scope is defined for each iteration only as the iteration begins.

2.4.1 Characteristics of the Project Life Cycle

Projects vary in size and complexity. All projects can be mapped to the following life cycle structure (see Figure 2-9):

- Starting the project,
- Organizing and preparing,
- Carrying out the project work, and
- Closing the project.

This generic life cycle structure is often referred to when communicating with upper management or other entities less familiar with the details of the project. It should not be confused with the Project Management Process Groups, because the processes in a group may be performed within each phase of a project as well as for the project as a whole. This high-level view can provide a common frame of reference for comparing projects—even if they are dissimilar in nature.

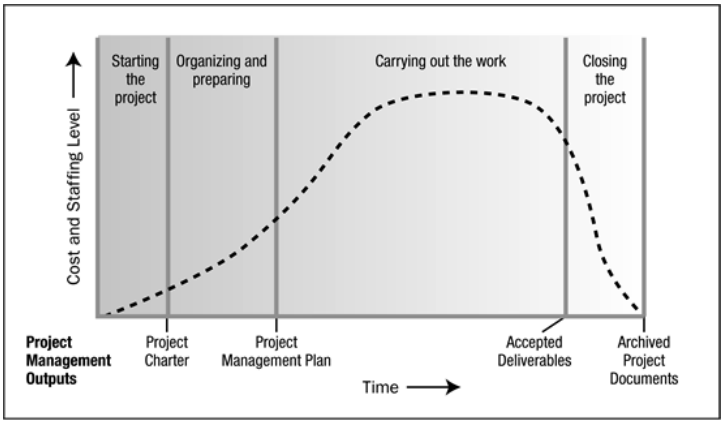


Figure 2-9. Typical Cost and Staffing Levels Across the Project Life Cycle

The generic life cycle structure generally displays the following characteristics:

- Cost and staffing levels are low at the start, peak as the work is carried out, and drop rapidly as the project draws to a close. The dashed line in Figure 2-9 illustrates this typical pattern.
- Stakeholder influences, risk, and uncertainty, (as illustrated in Figure 2-10) are greatest at the start of the project. These factors decrease over the life of the project as decisions are reached and as deliverables are accepted.
- Ability to influence the final characteristics of the project's product, without significantly impacting cost, is highest at the start of the project and decreases as the project progresses towards completion. Figure 2-10 illustrates the idea that the cost of changes and correcting errors typically increases substantially as the project approaches completion.

While these characteristics remain present to some extent in almost all project life cycles, they are not always present to the same degree. Adaptive life cycles, in particular, are developed with the intent of keeping stakeholder influences higher and the cost of change lower throughout the life cycle than in predictive life cycles.

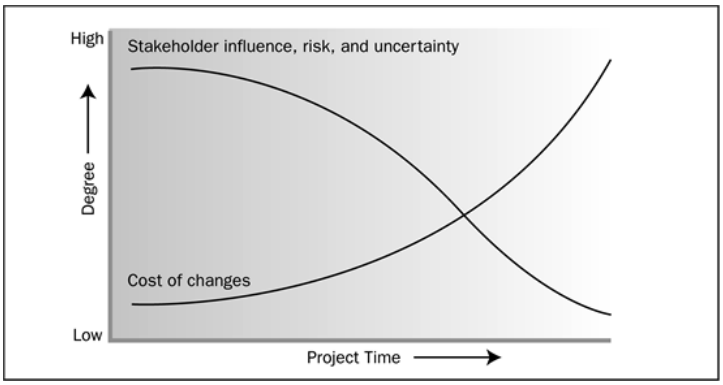


Figure 2-10. Impact of Variable Based on Project Time

Within the context of the generic life cycle structure, a project manager may determine the need for more effective control over certain deliverables or that certain deliverables must be completed before the project scope can be completely defined. Large and complex projects in particular may require this additional level of control. In such instances, the work carried out to complete the project's objective may benefit from being formally divided into phases.

2.4.2 Project Phases

A project may be divided into any number of phases. A project phase is a collection of logically related project activities that culminates in the completion of one or more deliverables. Project phases are used when the nature of the work to be performed is unique to a portion of the project, and are typically linked to the development of a specific major deliverable. A phase may emphasize processes from a particular Project Management Process Group, but it is likely that most or all processes will be executed in some form in each phase. Project phases are typically completed sequentially, but can overlap in some project situations. Different phases typically have a different duration or length. The high-level nature of project phases makes them an element of the project life cycle.

The phase structure allows the project to be segmented into logical subsets for ease of management, planning, and control. The number of phases, the need for phases, and the degree of control applied depend on the size, complexity, and potential impact of the project. Regardless of the number of phases comprising a project, all phases have similar characteristics:

- The work has a distinct focus that differs from any other phase. This often involves different organizations and different skill sets.
- The primary deliverable or objective of a phase requires an extra degree of control to be successfully achieved. The repetition of processes across all five Process Groups, as described in Chapter 3, provides that additional degree of control and defines the boundaries of the phase.
- The close of a phase ends with some form of transfer or handoff of the work product produced as the phase deliverable. This phase end represents a natural point to reassess the activities underway and to change or terminate the project if necessary. These points are referred to as phase exits, milestones, phase gates, decision gates, stage gates, or kill points.

There is no one way to define the ideal structure for a project. Although industry common practices will often lead to the use of a preferred structure, projects in the same industry—or even in the same organization—may have significant variation. Some will have only one phase, as shown in Figure 2-11. Other projects may have many phases.

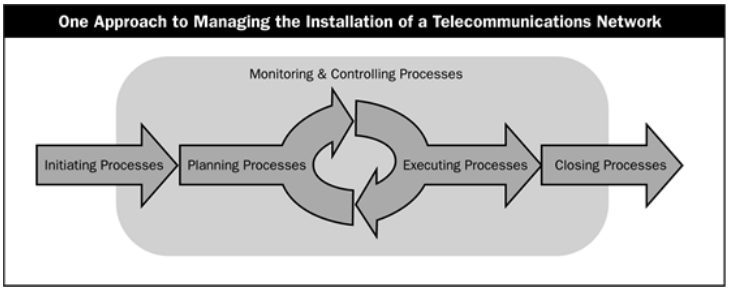


Figure 2-11. Example of a Single-Phase Project

Some organizations have established policies that standardize all projects, while others allow the project team to choose the most appropriate approach for their individual project. For instance, one organization may treat a feasibility study as routine preproject work, another may treat it as the first phase of a project, and a third may treat the feasibility study as a separate, stand-alone project. Likewise, one project team may divide a project into two phases, whereas another project team may choose to manage

all the work as a single phase. Much depends on the nature of the specific project and the style of the project team or organization.

2.4.2.1 Phase-to-Phase Relationships

When projects have more than one phase, the phases are part of a generally sequential process designed to ensure proper control of the project and attain the desired product, service, or result. However, there are situations when a project might benefit from overlapping or concurrent phases.

There are two basic types of phase-to-phase relationships:

- **Sequential relationship.** In a sequential relationship, a phase starts only when the previous phase is complete. Figure 2-12 shows an example of a project with three entirely sequential phases. The step-by-step nature of this approach reduces uncertainty, but may eliminate options for reducing the schedule.

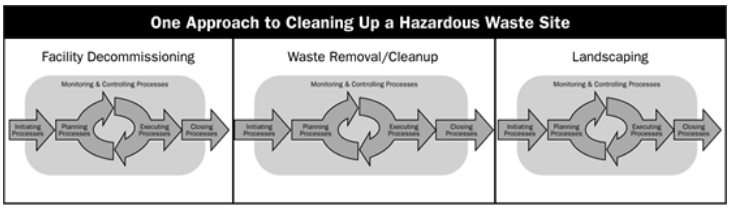


Figure 2-12. Example of a Three-Phase Project

- **Overlapping relationship.** In an overlapping relationship, a phase starts prior to completion of the previous one (see Figure 2-13). This can sometimes be applied as an example of the schedule compression technique called fast tracking. Overlapping phases may increase risk and can result in rework if a subsequent phase progresses before accurate information is available from the previous phase.

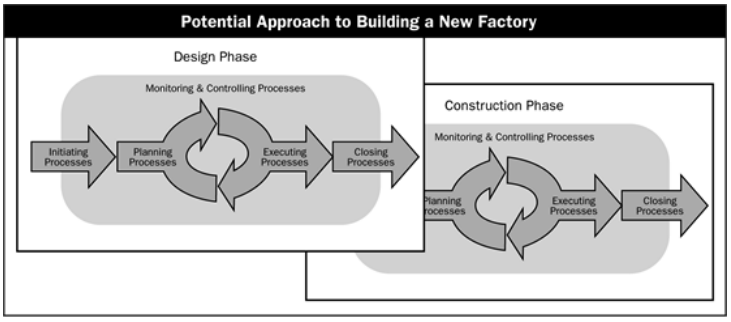


Figure 2-13. Example of a Project with Overlapping Phases

For multiphase projects, more than one phase-to-phase relationship could occur during the project life cycle. Considerations such as level of control required, effectiveness, and degree of uncertainty determine the relationship to be applied between phases. Based on those considerations, both relationships could occur between different phases of a single project.

2.4.2.2 Predictive Life Cycles

Predictive life cycles (also known as plan-driven or waterfall methodologies) are ones in which the project scope, and the time and cost required to deliver that scope, are determined as early in the project life cycle as practically possible. As shown in Figure 2-14, these projects proceed through a series of sequential or overlapping phases, with each phase generally focusing on a subset of project activities and project management processes. The work performed in each phase is usually different in nature to that in the preceding and subsequent phases, therefore, the skills required and the makeup of the project team may vary from phase to phase.

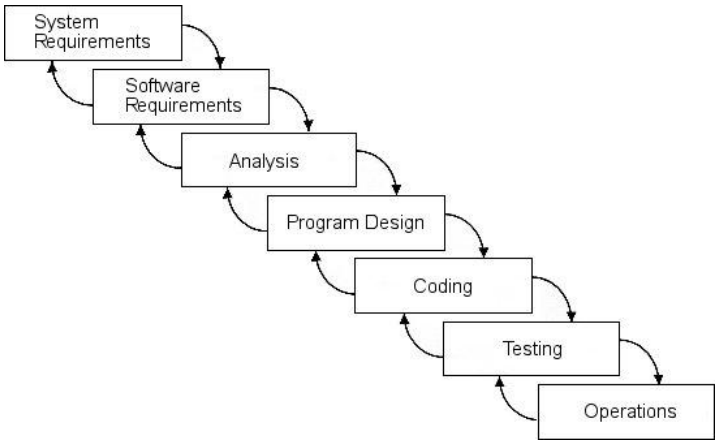


Figure 2-14. Example of Predictive Life Cycle (Waterfall)

When the project is initiated, the project team will focus on defining the overall scope for the product and project, develop a plan to deliver the product (and any associated deliverables), and then proceed through phases to execute the plan within that scope. Changes to the project scope are carefully managed and require replanning and formal acceptance of the new scope.
Predictive life cycles are generally preferred when the product to be delivered is well understood or where a product must be delivered in full to have value to stakeholder groups.

2.4.2.3 Iterative and Incremental Life Cycles

Iterative and incremental life cycles are ones in which the project scope is generally determined early in the project life cycle, but time and cost estimates are routinely modified as the project team understanding of the product increases. Iterations develop the product through a series of repeated cycles, while increments successively add to the functionality of the product. Most life cycles develop the product both iteratively and incrementally.
Iterative and incremental projects may proceed in phases, and the iterations themselves may be performed in a sequential or overlapping fashion. During an iteration, activities from all Project Management Process Groups will be performed. At the end of each iteration, a set of deliverables will be completed. Future iterations may enhance those deliverables or create new ones. Each iteration incrementally builds the deliverables until the exit criteria for the phase are met, allowing the project team to incorporate feedback.
In most iterative life cycles, a high-level vision will be developed for the overall undertaking, but the detailed scope is determined one iteration at a time and the planning for the next is carried out as work progresses on the current project scope and deliverables. The work required for a given set of deliverables may vary in length, and the project team may change between, or during, iterations. Those deliverables that are not addressed within the scope of the current iteration are typically scoped at a high level only and may be tentatively assigned to a specific future iteration. Changes to the scope of an iteration are carefully managed once work begins.
Iterative and incremental life cycles are generally preferred when an organization needs to manage changing objectives and scope, to reduce the complexity of a project, or when partial delivery of a product is beneficial for one or more stakeholder groups. Large and complex projects are frequently executed in an iterative fashion to reduce risk by allowing the team to incorporate feedback and experience between iterations.

2.4.2.4 Adaptive Life Cycles

Adaptive life cycles (also known as change-driven or agile methods) are intended to facilitate change and require a high degree of ongoing stakeholder involvement. Adaptive methods are also iterative and incremental, but differ in that iterations are very rapid (usually 2 to 4 weeks in length) and are fixed in time and resources. Adaptive projects generally perform all processes in each iteration, although early iterations may concentrate on planning activities.
The overall scope of the project will be maintained as a set of requirements and work to be performed. At the beginning of an iteration, the team will work to determine how many of the highest priority items on that list can be delivered within the next iteration. At the end of each iteration, the product, including all new features must be ready for release. This does not mean that the customer is required to accept delivery, just that the product should not include unfinished, incomplete, or unusable features. The customer must be continuously engaged with the project to provide feedback on deliverables as they are created and to ensure that the product backlog reflects their current needs.
Adaptive methods are generally preferred when dealing with a rapidly changing environment, when requirements and scope are difficult to define in advance, and when it is possible to define small incremental improvements that will deliver value to stakeholders.

CHAPTER 3

PROJECT MANAGEMENT PROCESSES FOR A PROJECT

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements. This application of knowledge requires the effective management of appropriate processes.

A process is a set of interrelated actions and activities performed to achieve a pre-specified product, result, or service. Each process is characterized by its inputs, the tools and techniques that can be applied, and the resulting outputs. As explained in Chapters 1 and 2, the project manager needs to consider organizational process assets and enterprise environmental factors. These should be taken into account for every process, even if they are not explicitly listed as inputs in the process specification. Organizational process assets provide guidelines and criteria for tailoring the organization's processes to the specific needs of the project. Enterprise environmental factors may constrain the project management options.

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

- Select appropriate processes required to meet the project objectives;
- Use a defined approach that can be adopted to meet requirements;
- Establish and maintain appropriate communication and engagement with stakeholders;
- Comply with requirements to meet stakeholder needs and expectations; and
- Balance the competing demands of scope, time, cost, quality, resources, and risk

to produce the specified product, service, or result.

The project processes are performed by the project team and generally fall into one of two major categories:

- **Project management processes.** These processes ensure the effective flow of the project throughout its existence. These processes encompass the tools and techniques involved in applying the skills and capabilities described in the Knowledge Areas (Chapters 4 through 13).
- **Product-oriented processes.** These processes specify and create the project's product. Product-oriented processes are typically defined by the project life cycle (as discussed in Section 2.4) and vary by application area as well as the stage of the product life cycle. The scope of the project cannot be defined without some basic understanding of how to create the specified product. For example, various construction techniques and tools need to be considered when determining the overall complexity of the house to be built.

The *PMBOK® Guide* describes only the project management processes. Although product-oriented processes are outside the scope of this standard, they should not be ignored by the project manager. Project management processes and product-oriented processes overlap and interact throughout the life of a project.

Project management processes apply globally and across industry groups. Good practice means there is general agreement that the application of 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. For any given project, the project manager, in collaboration with the project team, is always responsible for determining which processes are appropriate, and the appropriate degree of rigor for each process.

Project managers and their teams should carefully address each process and its inputs and outputs. The *PMBOK® Guide* should be used as a guide in managing a project while considering the overall approach and methodology to be followed for the project. This effort is known as tailoring.

Project management is an integrative undertaking that requires each project and product process to be appropriately aligned and connected with the other processes to facilitate coordination. Actions taken during one process typically affect that process and other related processes. For example, a scope change typically affects project cost, but may not affect the communications management plan or product quality. These process interactions often require tradeoffs among project requirements and objectives, and the specific performance tradeoffs will vary from project to project and organization to organization. Successful project management includes actively managing these interactions to meet sponsor, customer, and other stakeholder requirements. In some circumstances, a process or set of processes will need to be iterated several times in order to achieve the required outcome.

Projects exist within an organization and cannot operate as a closed system. They require input data from the organization and beyond, and deliver capabilities back to the organization. The project processes may generate information to improve the management of future projects.

The *PMBOK® Guide* describes the nature of project management processes in terms of the integration between the processes, their interactions, and the purposes they serve.

Project management processes are grouped into five categories known as Project Management

Process Groups (or Process Groups):

- **Initiating Process Group.** Those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase.
- **Planning Process Group.** Those processes required to establish the scope of the project, refine the objectives, and define the course of action required to attain the objectives that the project was undertaken to achieve.
- **Executing Process Group.** Those processes performed to complete the work defined in the project management plan to satisfy the project specifications.
- **Monitoring and Controlling Process Group.** Those processes required to track, review, and regulate the progress and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes.
- **Closing Process Group.** Those processes performed to finalize all activities across all Process Groups to formally close the project or phase.

The remainder of this chapter provides information for project management of a single project organized as a network of interlinked processes, details the project management processes, and includes the following major sections:

3.1 Common Project Management Process Interactions

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 required Process Groups and their processes are guides for applying appropriate project management knowledge and skills during the project. The application of the project management processes is iterative, and many processes are repeated during the project.

The integrative nature of project management requires the Monitoring and Controlling Process Group to interact with the other Process Groups, as shown in Figure 3-1. In addition, since management of a project is a finite undertaking, the Initiating Process Group begins the project, and the Closing Process Group ends it.

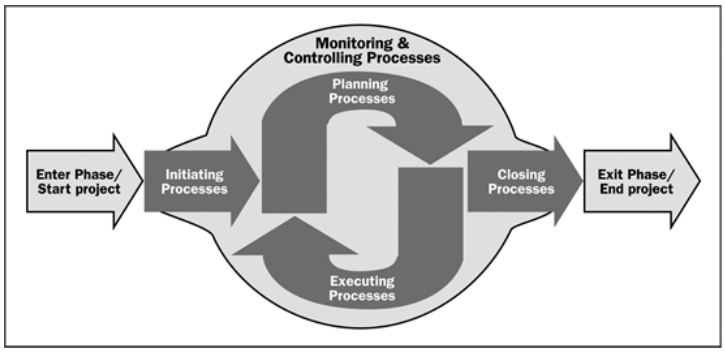


Figure 3-1. Project Management Process Groups

Project Management Process Groups are linked by the outputs they produce. The Process Groups are seldom either discrete or one-time events; they are overlapping activities that occur throughout the project. 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 with the project management plan and project documents, and, as the project progresses, it often entails updates to the project management plan and the project documents. Figure 3-2 illustrates how the Process Groups interact and shows the level of overlap at various times. If the project is divided into phases, the Process Groups interact within each phase.

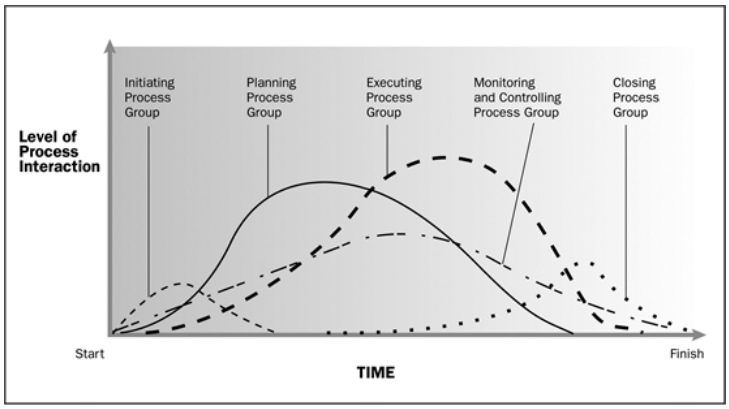


Figure 3-2. Process Groups Interact in a Phase or Project

An example of this would be the exit of a design phase, which requires customer acceptance of the design document. Once it is available, the design document provides the product description for the Planning and Executing Process Groups in one or more subsequent phases. When a project is divided into phases, the Process Groups are used, as appropriate, to effectively drive the project to completion in a controlled manner. In multiphase projects, processes are repeated within each phase until the criteria for phase completion have been satisfied. Additional information on project organization, life cycles, and project phases is provided in Chapter 2.

3.2 Project Management Process Groups

The following sections identify and describe the five Project Management Process Groups required for any project. These five Process Groups have clear dependencies and are typically performed in the same sequence on each project. They are independent of application areas or industry focus. Individual Process Groups and individual processes are often iterated prior to completing the project. The processes can have interactions within a Process Group and among Process Groups. The nature of these interactions varies from project to project and may or may not be performed in a particular order.
The process flow diagram, Figure 3-3, provides an overall summary of the basic flow and interactions among Process Groups and specific stakeholders. A Process Group includes the project management processes that are linked by the respective inputs and outputs where the result or outcome of one process becomes the input to another. **The Process Groups are not project phases.** As projects are separated into distinct phases or subprojects, such as feasibility study, concept development, design, prototype, build, or test, etc., all of the Process Groups would normally be repeated for each phase or subproject.
The project management processes are shown in the Process Group in which most of the activity takes place. For example, when a process that normally takes place in the Planning Process Group is updated in the Executing Process Group, it is not considered a new process. The iterative nature of project management means that processes from any group may be used throughout the project life cycle. For example, executing a risk response may trigger the Perform Quantitative Risk Analysis process to evaluate the impact.

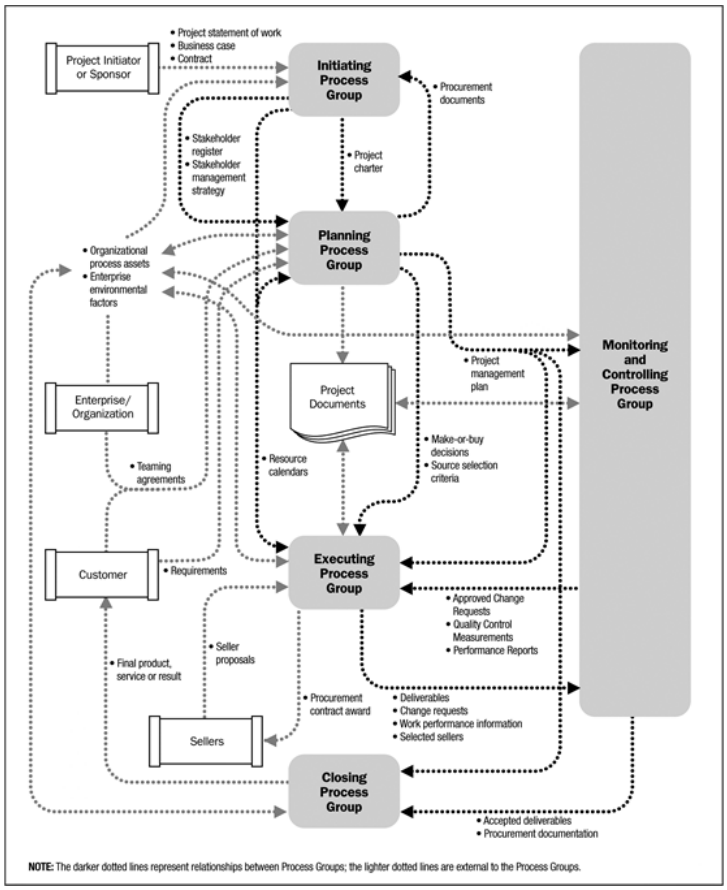


Figure 3-3. Project Management Process Interactions

3.3 Initiating Process Group

The Initiating Process Group consists of those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase. Within the initiating processes, the initial scope is defined and initial financial resources are committed. Internal and external stakeholders who will interact and influence the overall outcome of the project are identified. If not already assigned, the project manager will be selected. This information is captured in the project charter and stakeholder register. When the project charter is approved, the project becomes officially authorized. Although the project management team may help write the project charter, approval and funding are handled externally to the project boundaries (Figure 3-4). The key purpose of this Process Group is to align the stakeholders' expectations and give them visibility about the scope, objectives, and possible participation in the project or phase. These processes help set the vision of the project, what is needed to be accomplished.

As part of the Initiating Process Group, many large or complex projects may be divided into separate phases. In such projects, the Initiating processes are carried out during subsequent phases to validate the decisions made during the original Develop Project Charter and Identify Stakeholders processes. Performing 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 success criteria are verified, and the influence and objectives of the project stakeholders are reviewed. A decision is then made as to whether the project should be continued, delayed, or discontinued.

Involving the customers and other stakeholders during initiation generally improves the probability of shared ownership, deliverable acceptance, and customer and other stakeholder satisfaction.

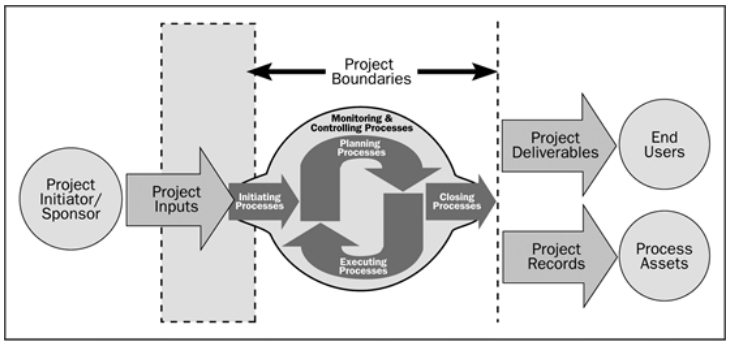


Figure 3-4. Project Boundaries

Initiating processes may be performed by organizational, program, or portfolio processes external to the project's scope of control. For example, prior to commencing a project, the need for high-level requirements may be documented as part of a larger organizational initiative. The feasibility of the new undertaking may be established through a process of evaluating alternatives. Clear descriptions of the project objectives are developed, including the reasons why a specific project is the best alternative to satisfy the requirements. The documentation for this decision may also contain the initial project scope statement, deliverables, project duration, and a forecast of the resources for the organization's investment analysis. As part of the Initiating processes the project manager is given the authority to apply organizational resources to the subsequent project activities.

3.4 Planning Process Group

The Planning Process Group consists of those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives. The planning processes develop the project management plan and the project documents that will be used to carry out the project. The multidimensional nature of project management creates repeated feedback loops for additional analysis. As more project information or characteristics are gathered and understood, additional planning 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. This progressive detailing of the project management plan is called progressive elaboration, indicating that planning and documentation are iterative and ongoing processes. The key benefit of this Process Group is to delineate the strategy and tactics as well as the course of action or a path to successfully complete the project or phase. When the Planning Process Group is well managed, it is much easier to get stakeholder buy-in and engagement. These processes express how this will be done, setting the route to the desired objective.

The project management plan and project documents developed as outputs from the Planning Process Group will explore all aspects of the scope, time, costs, quality, communication, human resources, risk, and procurements.

Updates arising from approved changes during the project may significantly impact parts of the project management plan and the project documents. Updates to these documents provide greater precision with respect to schedule, costs, and resource requirements to meet the defined project scope.

The project team should encourage involvement from all appropriate stakeholders when planning the project and developing the project management plan and project documents. While the act of collecting feedback and refining the documents cannot continue indefinitely, procedures set by the organization dictate when the initial planning 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 upon the nature of the project. For example, for some projects there will be little or no identifiable risk until after significant 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 or project documents.

3.5 Executing Process Group

The Executing Process Group consists of those processes performed to complete the work defined in the project management plan to satisfy the project specifications. 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.

During project execution, results may require planning updates and rebaselining. This may include changes to expected activity durations, changes in resource productivity and availability, and unanticipated risks. Such variances may affect the project management plan or project documents and may require detailed analysis and development of appropriate

project management responses. The results of the analysis can trigger change requests that, if approved, may modify the project management plan or other project documents and possibly require establishing new baselines. A large portion of the project's budget will be expended in performing the Executing Process Group processes.

3.6 Monitoring and Controlling Process Group

The Monitoring and Controlling Process Group consists of those processes required to track, review, and orchestrate the progress and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes. The key benefit of this Process Group is that project performance is measured and analyzed at regular intervals to identify variances from the project management plan. The Monitoring and Controlling Process Group also involves:

- Controlling changes and recommending preventive action in anticipation of possible problems,
- Monitoring the ongoing project activities against the project management plan and the project performance baseline, and
- Influencing the factors that could circumvent integrated change control or configuration management (as applicable in certain industrial sectors) so only approved changes are implemented.

This continuous monitoring provides the project team insight into the health of the project and identifies any areas requiring 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 multiphase projects, the Monitoring and Controlling Process Group coordinates project phases in order to implement corrective or preventive actions to bring the project into compliance with the project management plan. This review can result in recommended and approved updates to the project management plan. For example, a missed activity finish date may require adjustments to the current staffing plan, reliance on overtime, or trade-offs between budget and schedule objectives.

3.7 Closing Process Group

The Closing Process Group consists of those processes performed to conclude all activities across all Project Management Process Groups to formally complete the project, phase, or contractual obligations. This Process Group, when completed, verifies that the defined processes are completed within all of the Process Groups to close the project or a project phase, as appropriate, and formally establishes that the project or project phase is complete.

This Process Group also formally establishes that a prematurely closed project or a phase is complete in all facets. Prematurely closed projects include aborted projects, cancelled projects, and projects in exception, etc.

At project or phase closure, the following may occur:

- Obtain acceptance by the customer or sponsor to formally close the project or phase,
- Conduct post-project or phase-end review,
- Record impacts of tailoring to any process,
- Document lessons learned,
- Apply appropriate updates to organizational process assets,
- Archive all relevant project documents in the project management information system (PMIS) to be used as historical data, and
- Close out all procurements.

3.8 Project Information

Throughout the execution of the project, a significant amount of data and information is collected, analyzed, transformed, and redistributed in various formats to project team members and stakeholders. Various measurements on project activities and deliverables are collected during various controlling processes. This primary data is compared with other collected data elements, analyzed in context, and aggregated and transformed to become project information. The information can then be communicated verbally or stored and distributed as reports in various document formats.

Due to the fluid aspect of project data being collected and analyzed into contextual information continuously during project execution, the terms data and information are often used interchangeably. The indiscriminate use of these terms can lead to confusion and misunderstandings by the various project stakeholders. The following guidelines help minimize miscommunication and help the project team use the correct terminology:

- **Work performance data.** The raw observations and measurements identified during activities being performed to carry out the project work. Examples include reported percent of work physically completed, technical performance measures, start and finish dates of schedule activities, number of change requests, number of defects, actual costs, actual durations etc.
- **Work performance information.** The performance data collected from various controlling processes, analyzed in context and integrated based on relationships across areas. Examples of performance information are status of deliverables, implementation

status for change requests, forecasted estimates to complete.

- **Work performance reports**. The physical or electronic representation of work performance information compiled in project documents, intended to generate decisions, actions, or awareness. Examples include status reports, memos, justifications, information notes, recommendations, and updates.

Figure 3-5 illustrates the general flow of project information across the various processes used to manage the project.

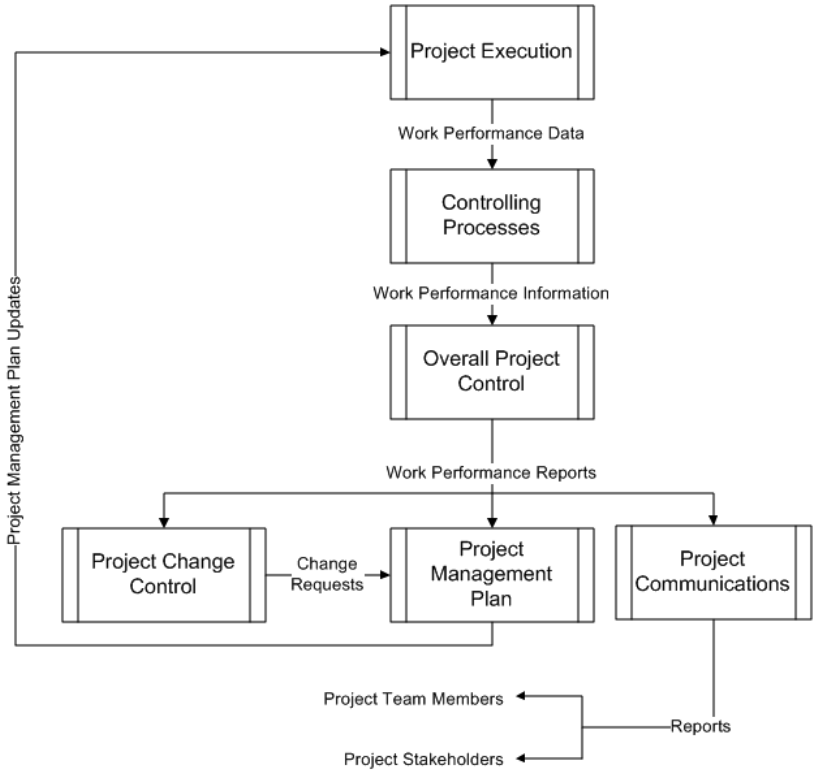


Figure 3-5. Project Information Flow

3.9 Role of the Knowledge Areas

The 47 project management processes identified in the *PMBOK® Guide* are further organized into ten separate Knowledge Areas. A Knowledge Area represents a complete set of concepts, terms, and activities that make up a professional domain, project management domain, or area of specialization. These ten Knowledge Areas are used on most projects most of the time. Project teams should address these ten areas and others, as appropriate, for their specific project. The Knowledge Areas are: Integration, Scope, Time, Cost, Quality, Human Resource, Communications, Risk, Procurement, and Stakeholder Management. Each Knowledge Area within the *PMBOK® Guide* is contained in a separate section.

The *PMBOK® Guide* defines the important aspects of each Knowledge Area and how it integrates with the five Process Groups. As supporting elements, the Knowledge Area chapters provide a detailed amplification of the process inputs and outputs along with a descriptive explanation of tools and techniques used within each Knowledge Area to produce each outcome.

Table 3-1 reflects the mapping of the 47 project management processes within the 5 Project Management Process Groups and the 10 Project Management Knowledge Areas.

3.10 The Standard for Project Management of a Project

In October 1998, PMI was accredited as a standards developer by the American National Standards Institute (ANSI). Annex A1 now serves as the standard for project management of a project.

Table 3-1. Project Management Process Group and Knowledge Area Mapping

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

CHAPTER 4

PROJECT INTEGRATION MANAGEMENT

Project Integration Management 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 managing stakeholder expectations, and meeting requirements. Project Integration Management entails making choices about resource allocation, making trade-offs among competing objectives and alternatives, and managing the interdependencies among the project management Knowledge Areas. The project management processes are usually presented as discrete processes with defined interfaces while, in practice, they overlap and interact in ways that cannot be completely detailed in the *PMBOK® Guide*.

Figure 4-1 provides an overview of Project Integration Management processes, which are as follows:

4.1 Develop Project Charter—The process of developing a document that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities.

4.2 Develop Project Management Plan—The process of defining, preparing, and coordinating all subsidiary plans to integrate them into a comprehensive project management plan.

4.3 Direct and Manage Project Work—The process of performing the work defined in the project management plan to achieve the project's objectives.

4.4 Monitor and Control Project Work—The process of tracking, reviewing, and regulating the progress to meet the performance objectives defined in the project management plan.

4.5 Perform Integrated Change Control—The process whereby modifications to documents, deliverables, or baselines associated with the project are identified, documented, approved, or rejected.

4.6 Close Project or Phase—The process of finalizing all activities across all of the Project Management Process Groups to formally complete the project or phase.

These processes interact with each other and with processes in the other Knowledge Areas

as described in detail in Chapter 3.
The need for Project Integration Management is evident in situations where individual processes interact. For example, a cost estimate needed for a contingency plan involves integrating the processes in the Project Cost, Time, and Risk Management Knowledge Areas. When additional risks associated with various staffing alternatives are identified, then one or more of those processes may be revisited. The project deliverables may 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. Project Integration Management also includes the activities needed to manage project documents to ensure consistency with the project management plan and product deliverables.
Most experienced project management practitioners know there is no single way to manage a project. They apply project management knowledge, skills, and required processes in a preferred order and with varying 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 need to address every process to determine the level of implementation for each process for each project. If a project has more than one phase, the same level of rigor should be applied to processes within each phase of the project.
The integrative nature of projects and project management can be understood by thinking of other types of activities performed while completing a project. Examples of some activities performed by the project management team are:

- 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;
- Understand how to take the identified information and then transform it into a project management plan using a structured approach as described in the *PMBOK® Guide*;
- Perform activities to produce project deliverables; and
- Measure and monitor all aspects of the project's progress and take appropriate action to meet project objectives.

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.

Figure 4-1. Project Integration Management Overview

4.1 Develop Project Charter

Develop Project Charter is the process of developing a document that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities. The key benefit of this process is that the project has a well-defined start and the process provides an upfront way for senior management to formally accept the project. The inputs, tools and techniques, and outputs for this process are shown in Figure 4-2. Figure 4-3 depicts the data flow diagram of the process.

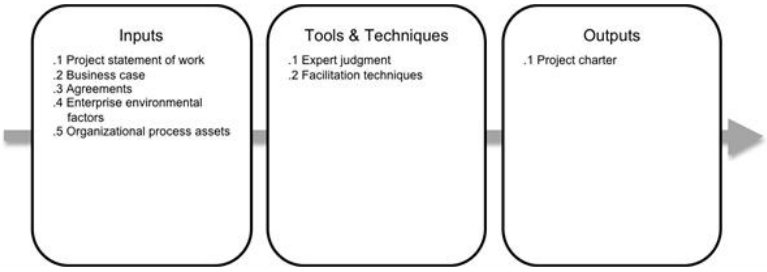


Figure 4-2. Develop Project Charter: Inputs, Tools and Techniques, and Outputs

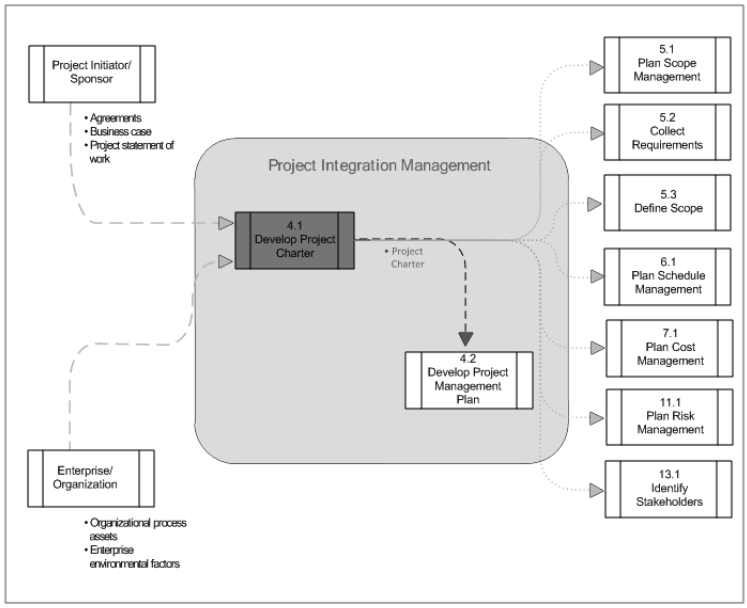


Figure 4-3. Develop Project Charter Data Flow Diagram

The project charter establishes a partnership between the performing organization and the requesting organization (or customer, in the case of external projects). The approved project charter formally initiates the project. A project manager is identified and assigned as early in the project as is feasible, preferably while the project charter is being developed and always prior to the start of planning. It is recommended that the project manager participate in the development of the project charter, as the project charter provides the project manager with the authority to apply resources to project activities.

Projects are authorized by someone external to the project such as a sponsor, program or project management office (PMO), or portfolio steering committee. The project initiator or sponsor should be at a level that is appropriate to procure funding for the project. Projects are authorized due to internal business needs or external influences. This usually triggers the creation of a needs analysis, business case, or description of the situation that the project will address. Chartering a project links the project to the strategy and ongoing work of the organization.

4.1.1 Develop Project Charter: Inputs

4.1.1.1 Project Statement of Work

The statement of work (SOW) is a narrative description of products or services to be delivered 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, a request for proposal, request for information, or request for bid, or as part of a contract. The SOW references the following:

- **Business need.** An organization's business need may be based on a market demand, technological advance, legal requirement, or government regulation.
- **Product scope description**. The product scope description documents the characteristics of the product that the project will be undertaken to create. The description should also document the relationship between the products or services being created and the business need that the project will address.
- **Strategic plan**. The strategic plan documents the organization's strategic goals. Therefore, all projects should be aligned with the strategic plan.

4.1.1.2 Business Case

The business case or similar document provides the necessary information from a business standpoint to determine whether or not the project is worth the required investment. Typically, the business need and the cost-benefit analysis are contained in the business case to justify the project. The requesting organization or customer, in the case of external projects, may write the business case. The business case is created as a result of one or more of the following:

- Market demand (e.g., a car company authorizing a project to build more fuel-efficient cars in response to gasoline shortages),
- Organizational need (e.g., a training company authorizing a project to create a new course to increase its revenues),
- Customer request (e.g., an electric utility authorizing a project to build a new substation to serve a new industrial park),
- 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),
- Legal requirement (e.g., a paint manufacturer authorizing a project to establish guidelines for handling toxic materials),
- Ecological impacts (e.g., a company undertakes a project to lessen its environmental impact), or
- 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).

In the case of multiphase projects, the business case may be periodically reviewed to ensure that the project is on track to deliver the business benefits. In the early stages of the project life cycle, periodic review of the business case by the sponsoring organization also helps to confirm that the project is still required.

4.1.1.3 Agreements

Agreements are used to define initial intentions for a project. Agreements may take the form of a contract, a memorandum of understanding (MOU), letters of agreement, verbal agreements, email, etc. A contract is the typical form if the project is being performed for an external customer.

4.1.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Develop Project Charter process include, but are not limited to:

- Governmental or industry standards,
- Organization infrastructure, and
- Marketplace conditions.

4.1.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Develop Project Charter process include, but are not limited to:

- Organizational standard processes, policies, and standardized process definitions for use in the organization,
- Templates (e.g., project charter template), and
- Historical information and lessons learned knowledge base.

4.1.2 Develop Project Charter: Tools and Techniques

4.1.2.1 Expert Judgment

Expert judgment is often used to assess the inputs used to develop the project charter. Expert 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,
- Subject matter experts, and
- Project management office (PMO).

4.1.2.2 Facilitation Techniques

Facilitation techniques have broad application within project management processes and guide the development of the project charter. Brainstorming, conflict resolution, problem solving, and meeting management are key techniques used by facilitators to help teams and individuals accomplish project activities.

4.1.3 Develop Project Charter: Outputs

4.1.3.1 Project Charter

The project charter documents the business needs, current understanding of the customer's needs and the new product, service, or result that it is intended to satisfy, such as:

- Project purpose or justification,
- Measurable project objectives and related success criteria,
- High-level requirements,
- High-level project description,
- High-level risks,
- Summary milestone schedule,
- Summary budget,
- Stakeholder list (includes customer needs),
- Project approval requirements (what constitutes project success, who decides the project is successful, and who signs off on the project),
- Assigned project manager, responsibility, and authority level, and
- Name and authority of the sponsor or other person(s) authorizing the project charter.

4.2 Develop Project Management Plan

Develop Project Management Plan is the process of defining, preparing, and coordinating all subsidiary plans and integrating them into a comprehensive project management plan. The key benefit of this process is a central document that defines the basis of all project work. The inputs, tools and techniques, and outputs for this process are depicted in Figure 4-4. Figure 4-5 depicts the data flow diagram of the process.

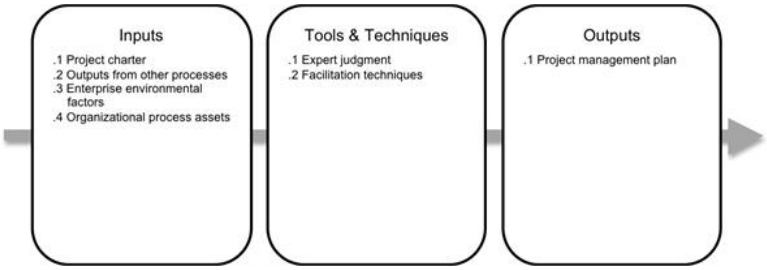


Figure 4-4. Develop Project Management Plan: Inputs, Tools and Techniques, and Outputs

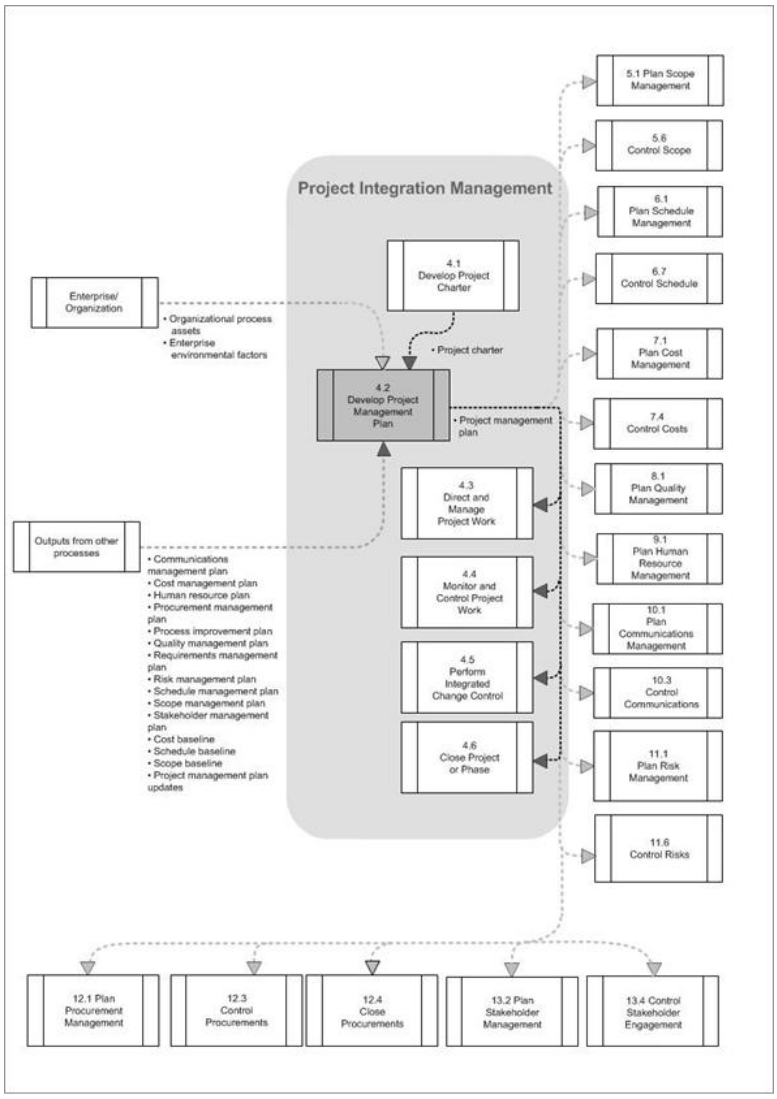


Figure 4-5. Develop Project Management Plan Data Flow Diagram

The project management plan defines how the project is executed, monitored and controlled, and closed. The project management plan's content will vary depending upon the application area and complexity of the project. It is developed through a series of integrated processes extending through project closure. This process results in a project management plan that is progressively elaborated by updates and controlled and approved through the Perform Integrated Change Control (Section 4.5) process. Projects that exist in the context of a program should develop a project management plan that is consistent with the program management plan. For example, if the program management plan indicates all changes above a certain dollar amount need to be reviewed by the change control board (CCB), the project management plan should have the same threshold and process defined.

4.2.1 Develop Project Management Plan: Inputs

4.2.1.1 Project Charter

Described in Section 4.1.3.1. The project charter may be a short document of only a few pages in length. At a minimum, the project charter should define the boundaries of the project. The project manager uses the project charter as the starting point for initial planning during the Initiating Process Group.

4.2.1.2 Outputs from Other Processes

Outputs from many of the other processes described in Chapters 5 through 13 are integrated to create the project management plan. Any baselines and subsidiary management plans that are an output from other planning processes are inputs to this process. In addition, updates to these documents can necessitate updates to the project management plan.

4.2.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the

Develop Project Management Plan process include, but are not limited to:
- Governmental or industry standards,
- Project management body of knowledge for market vertical (e.g., construction) and/or focus area (e.g. environmental, safety, risk, or agile software development),
- Project management information systems (e.g., an automated tool, such as a scheduling software tool, a configuration management system, an information collection and distribution system, or web interfaces to other online automated systems),
- Organizational structure, culture, and sustainability,
- Infrastructure (e.g., existing facilities and capital equipment), and
- Personnel administration (e.g., hiring and firing guidelines, employee performance reviews, and training records).

4.2.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Develop Project Management Plan process include, but are not limited to:
- Standardized guidelines, work instructions, proposal evaluation criteria, and performance measurement criteria;
- Project management plan template, including:
    - Guidelines and criteria for tailoring the organization's set of standard processes to satisfy the specific needs of the project, and
    - Project closure guidelines or requirements like the product validation and acceptance criteria;
- 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;
- Project files from past projects (e.g., scope, cost, schedule and 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; and
- Configuration management knowledge base containing the versions and baselines of all official company standards, policies, procedures, and any project documents.

4.2.2 Develop Project Management Plan: Tools and Techniques

4.2.2.1 Expert Judgment

When developing the project management plan, expert judgment is utilized to:
- Tailor the process to meet the project needs,
- Develop technical and management details to be included in the project management plan,
- Determine resources and skill levels needed to perform project work,
- Define the level of configuration management to apply on the project, and
- Determine which project documents will be subject to the formal change control process.

4.2.2.2 Facilitation Techniques

Described in Section 4.1.2.2. Facilitation techniques have broad application within project management processes and are used to guide the development of the project management plan. Brainstorming, conflict resolution, problem solving, and meeting management are key techniques used by facilitators to help teams and individuals accomplish project activities through consensus.

4.2.3 Develop Project Management Plan: Outputs

4.2.3.1 Project Management Plan

The project management plan integrates and consolidates all of the subsidiary management plans and baselines from the planning processes. Among other things, it addresses:
- Life cycle selected for the project and the processes that will be applied to each phase;
- Results of the tailoring by the project management team as follows:
    - Project management processes selected by the project management team,
    - Level of implementation of each selected process,
    - Descriptions of the tools and techniques to be used for accomplishing those processes, and
    - Description of 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.
- Description of how work will be executed to accomplish the project objectives;
- Change management plan that documents how changes will be monitored and controlled;
- Configuration management plan that documents how configuration management will be performed;
- Description of how integrity of the performance measurement baseline will be maintained;
- Requirements and techniques for communication among stakeholders; and
- Key management reviews for content, extent, and timing to address open issues and

pending decisions.
The project management plan may be either summary level or detailed, and may be composed of one or more subsidiary plans. Each of the subsidiary plans is detailed to the extent required by the specific project. Once the project management plan is baselined, it may only be changed when a change request is generated and approved through the Perform Integrated Change Control process.
Project baselines include, but are not limited to:

- Schedule baseline,
- Cost baseline, and
- Scope baseline.

Subsidiary plans include, but are not limited to:

- Scope management plan (Section 5.1.3.1),
- Requirements management plan (Section 5.1.3.2),
- Schedule management plan (Section 6.1.3.1),
- Cost management plan (Section 7.1.3.1),
- Quality management plan (Section 8.1.3.1),
- Process improvement plan (Section 8.1.3.2),
- Human resource plan (Section 9.1.3.1),
- Communication management plan (Section 10.1.3.1),
- Risk management plan (Section 11.1.3.1),
- Procurement management plan (Section 12.1.3.1), and
- Stakeholder management plan (Section 13.2.3.1).

4.3 Direct and Manage Project Work

Direct and Manage Project Work is the process of performing the work defined in the project management plan to achieve the project's objectives. The key benefit of this process is that it provides overall management of the project, including change control, cost and schedule management, and successful delivery of the project. The inputs, tools and techniques, and outputs of this process are depicted in Figure 4-6. Figure 4-7 depicts the data flow diagram of the process.

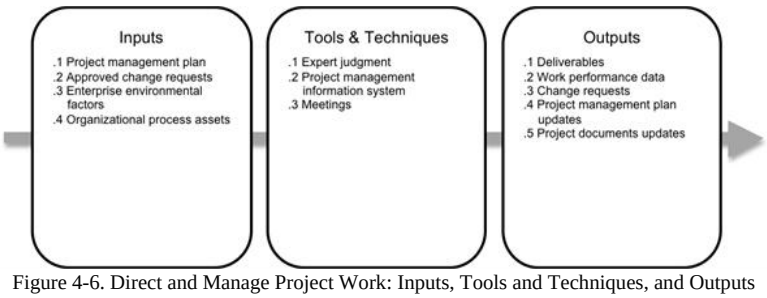


Figure 4-6. Direct and Manage Project Work: Inputs, Tools and Techniques, and Outputs

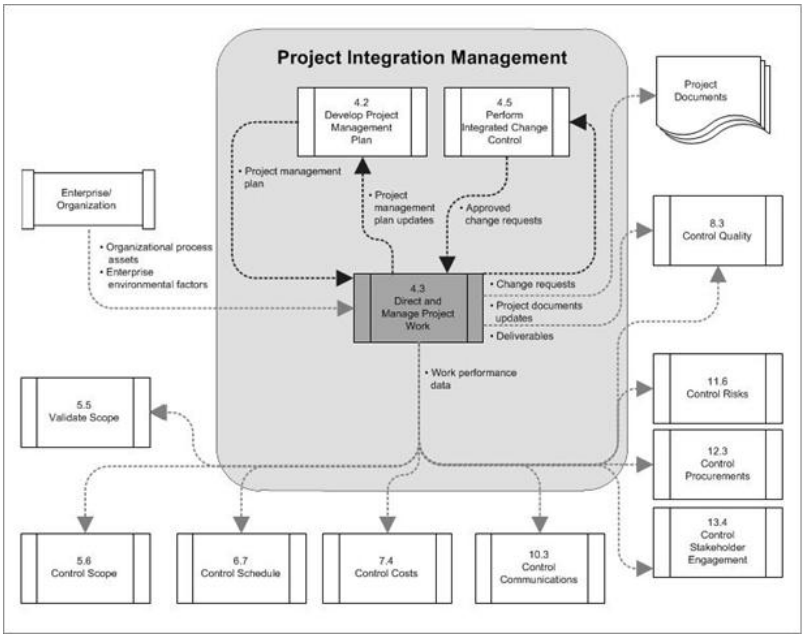


Figure 4-7. Direct and Manage Project Work: Data Flow Diagram

Direct and Manage Project Work activities include, but are not limited to:

- Perform activities to accomplish project requirements;
- Create project deliverables;
- Staff, train, and manage the team members assigned to the project;
- Obtain, manage, and use resources including materials, tools, equipment, and facilities;

- Implement the planned methods and standards;
- Establish and manage project communication channels, both external and internal to the project team;
- Generate project data, such as cost, schedule, technical and quality progress, and status to facilitate forecasting;
- Issue change requests and adapt approved changes into the project's scope, plans, and environment;
- Manage risks and implement risk response activities;
- Manage sellers and suppliers;
- Manage stakeholders and their engagement; and
- 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 Work process is directly affected by the project application area. Deliverables are produced as outputs from processes performed to accomplish the project work planned and scheduled in the project management plan. Work performance data, information about the completion status of the deliverables, and information as to what has been accomplished are collected as part of project execution and are fed into the performance reporting process. The work performance data will also be used as an input to the Monitoring and Controlling Process Group.

Direct and Manage Project Work also requires implementation of approved changes addressing:

- **Corrective action**—An intentional activity that realigns the performance of the project work with the project management plan;
- **Preventive action**—An intentional activity undertaken to avoid an event that would impact the performance of the project; and/or
- **Defect repair**—An intentional activity whose purpose is to correct a nonconforming product or product component.

4.3.1 Direct and Manage Project Work: Inputs

4.3.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan contains subsidiary plans concerning all aspects of the project. Those subsidiary plans related to project work include, but are not limited to:

- Scope management plan (Section 5.1.3.1),
- Requirements management plan (Section 5.1.3.2),
- Schedule management plan (Section 6.1.3.1), and
- Cost management plan (Section 7.1.3.1).

4.3.1.2 Approved Change Requests

As part of the Perform Integrated Change Control process, a change control status update indicates that some changes are approved and some are not. Approved change requests are scheduled for implementation by the project team and are the documented, authorized changes to expand or reduce the project scope. The approved change requests can also modify policies, the project management plan, procedures, costs, or budgets, or revise schedules. Approved change requests may require implementation of preventive or corrective actions.

4.3.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors which can influence the Direct and Manage Project Work process include, but are not limited to:

- Organizational, company or customer culture, and structure;
- Infrastructure (e.g., existing facilities and capital equipment);
- Personnel administration (e.g., hiring and firing guidelines, employee performance reviews, and training records);
- Stakeholder risk tolerances; and
- 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).

4.3.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Direct and Manage Project Work process include, but are not limited to:

- Standardized guidelines and work instructions;
- Communication requirements defining allowed communication media, record retention, and security requirements;
- Issue and defect management procedures defining issue and defect controls, issue

and defect identification and resolution, and action item tracking;
- Process measurement database used to collect and make available measurement data on processes and products;
- Project files from prior projects (e.g., scope, cost, schedule, performance measurement baselines, project calendars, project schedule, network diagrams, risk registers, planned response actions, and defined risk impact); and
- Issue and defect management database containing historical issue and defect status, control information, issue and defect resolution, and action item results.

4.3.2 Direct and Manage Project Work: Tools and Techniques

4.3.2.1 Expert Judgment

Expert judgment is used to assess the inputs needed to direct and manage execution of the project management plan. Such judgment and expertise are applied to all technical and management details during this process. This expertise is provided by the project manager and the project management team using specialized knowledge or training. Additional expertise is available from many sources, including:
- Other units within the organization,
- Consultants,
- Stakeholders, including customers or sponsors, and
- Professional and technical associations.

4.3.2.2 Project Management Information System

The project management information system, which is part of the enterprise environmental factors, provides access to an automated tool, such as a scheduling software tool, a configuration management system, an information collection and distribution system, or web interfaces to other online automated systems used during the Direct and Manage Project Work.

4.3.2.3 Meetings

Meetings are used to discuss and agree on major aspects when directing and managing project execution. Examples of topics addressed include: most relevant risks, possible scope change, possible schedule change, cost overrun, etc. Attendees at these meetings may include the project manager, the project management team, and appropriate stakeholders involved or affected by the topics discussed.
Meetings should be prepared with a well-defined agenda and purpose and should be appropriately documented with meeting minutes and action items.

4.3.3 Direct and Manage Project Work: Outputs

4.3.3.1 Deliverables

An approved deliverable is any unique and verifiable product, result, or capability to perform a service that must be produced to complete a process, phase, or project.

4.3.3.2 Work Performance Data

Work performance data are the raw observations and measurements identified during activities being performed to carry out the project work. Various measurements on project activities and deliverables are collected during various controlling processes. Data are often viewed as the lowest level of abstraction from which information is derived by other processes.
Examples of work performance data include reported percent of work physically completed, technical performance measures, start and finish dates of schedule activities, number of change requests, number of defects, actual costs, and actual durations, etc.

4.3.3.3 Change Requests

A change request is a formal proposal to modify any document, deliverable, or baseline. When issues are found while project work is being performed, change requests are issued which may modify project policies or procedures, project scope, project cost or budget, project schedule, or project quality. Other change requests cover the needed preventive or corrective actions to forestall negative impact later in the project. Requests for a change can be direct or indirect, externally or internally initiated, and can be optional or legally/contractually mandated and may include:
- **Corrective action—**An intentional activity that realigns the performance of the project work with the project management plan;
- **Preventive action—**An intentional activity undertaken to avoid an event that would impact the performance of the project;
- **Defect repair—**An intentional activity whose purpose is to correct a nonconforming

product or product component; and/or

- **Updates—**Changes to formally controlled documentation, plans, etc., to reflect modified or additional ideas or content.

4.3.3.4 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- Requirements management plan,
- Schedule management plan,
- Cost management plan,
- Quality management plan,
- Human resource plan,
- Communications management plan,
- Risk management plan,
- Procurement management plan,
- Stakeholder management plan, and
- Performance measurement baseline.

4.3.3.5 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Requirements documentation,
- Project logs (issue, assumptions, etc.),
- Risk register, and
- Stakeholder register.

4.4 Monitor and Control Project Work

Monitor and Control Project Work is the process of tracking, reviewing, and regulating the progress to meet the performance objectives defined in the project management plan. The key benefit of this process is that it allows stakeholders to understand the current state of the project, the steps taken, and budget, schedule and scope forecasts. The inputs, tools and techniques, and outputs for this process are depicted in Figure 4-8. Figure 4-9 depicts the data flow diagram of the process.

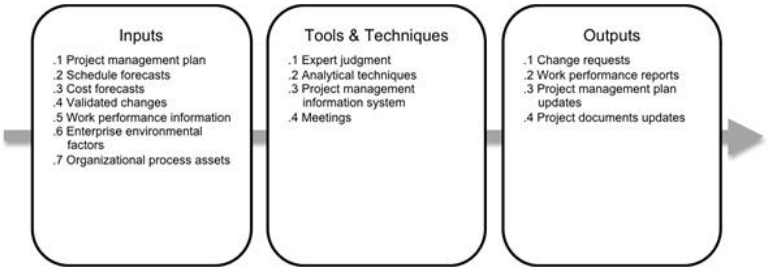


Figure 4-8. Monitor and Control Project Work: Inputs, Tools & Techniques, and Outputs

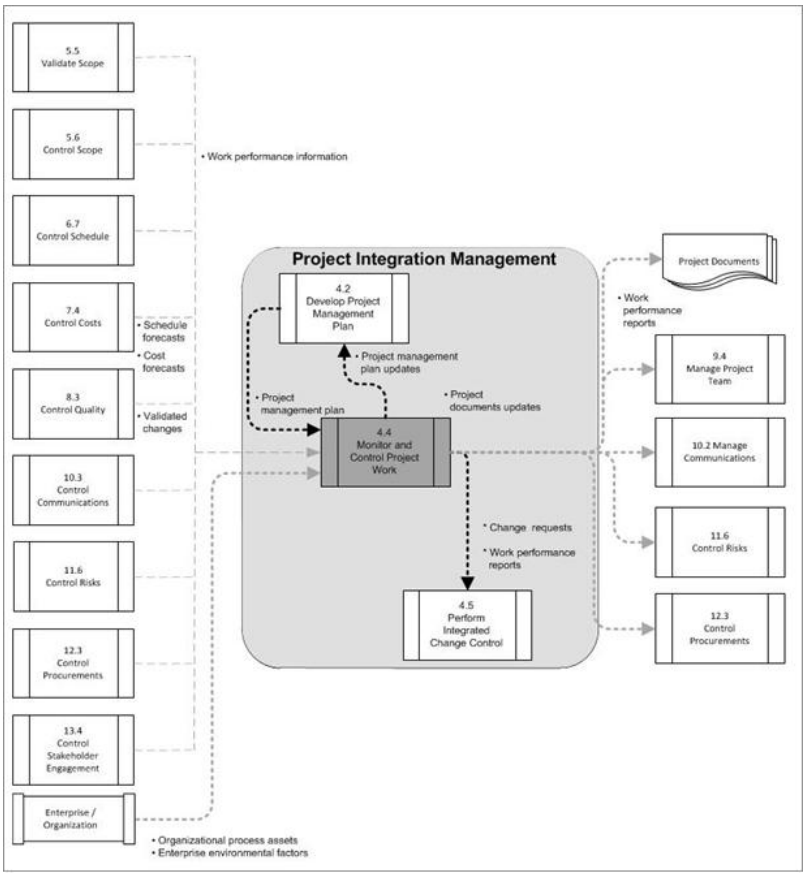


Figure 4-9. Monitor and Control Project Work Data Flow Diagram

Monitoring is an aspect of project management performed throughout the project. Monitoring includes collecting, measuring, and distributing 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 may require special attention. Control includes determining corrective or preventive actions or replanning and following up on action plans to determine whether the actions taken resolved the performance issue. 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;
- Identifying new risks and analyzing, tracking, and monitoring existing 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 as they occur; and
- Providing appropriate reporting on project progress and status to program management when the project is part of an overall program.

4.4.1 Monitor and Control Project Work: Inputs

4.4.1.1 Project Management Plan

Described in Section 4.2.3.1. Monitoring and controlling project work involves looking at all aspects of the project. Subsidiary plans within the project management plan form the basis for controlling the project. Subsidiary plans include, but are not limited to:

- Scope management plan (Section 5.1.3.1),
- Requirements management plan (Section 5.1.3.2),
- Schedule management plan (Section 6.1.3.1),
- Cost management plan (Section 7.1.3.1),
- Quality management plan (Section 8.1.3.1),
- Process improvement plan (Section 8.1.3.2),
- Human resource plan (Section 9.1.3.1),
- Communications management plan (Section 10.1.3.1),
- Risk management plan (Section 11.1.3.1),
- Procurement management plan (Section 12.1.3.1), and

- Stakeholder management plan (Section 13.2.3.1).

4.4.1.2 Schedule Forecasts

Described in Section 7.4.2.2. The schedule forecasts are derived from progress against the schedule baseline and computed estimates to complete (ETC). This is typically expressed in terms of schedule variance (SV) and schedule performance index (SPI).
The forecast may be used to determine if the project is still within defined tolerance ranges and identify any necessary change requests.

4.4.1.3 Cost Forecasts

Described in Section 7.4.2.1. The cost forecasts are derived from progress against the cost baseline and computed estimates to complete. This is typically expressed in terms of cost variance (CV) and cost performance index (CPI). An estimate at completion (EAC) can be compared to the budget at completion (BAC) to see if the project is still within tolerance ranges or if a change request is required.

4.4.1.4 Validated Changes

Described in Section 8.3.3.2. Approved changes that result from the Perform Integrated Change Control process require validation to ensure that the change was appropriately implemented. A validated change provides the necessary data to confirm that the change was appropriately executed.

4.4.1.5 Work Performance Information

Work performance information is the performance data collected from various controlling processes, analyzed in context, and integrated based on relationships across areas. Thus work performance data has been transformed into work performance information. Data in itself cannot be used in the decision-making process as it has only out-of-context meaning. Information however is correlated and contextualized, and provides a sound foundation for project decisions.
Work performance information is circulated through communication processes. Examples of performance information are status of deliverables, implementation status for change requests, and forecasted estimates to complete.

4.4.1.6 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Monitor and Control Project Work process include, but are not limited to:
- Governmental or industry standards (e.g., regulatory agency regulations, product standards, quality standards, and workmanship standards),
- Company work authorization system,
- Stakeholder risk tolerances, and
- 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).

4.4.1.7 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Monitor and Control Project Work process include, but are not limited to:
- Organization communication requirements;
- Financial controls procedures (e.g., time reporting, accounting codes, expenditure and disbursement reviews, and standard contract provisions);
- Issue and defect management procedures;
- Change control procedures, including schedule and cost variance tolerances;
- Risk control procedures including risk categories, probability definition and impact, and probability and impact matrix;
- Process measurement database used to make available measurement data on processes and products; and
- Lessons learned database.

4.4.2 Monitor and Control Project Work: Tools and Techniques

4.4.2.1 Expert Judgment

Expert judgment is used by the project management team to interpret the information provided by the monitor and control processes. The project manager, in collaboration with the team, determines the actions required to ensure project performance matches expectations.

4.4.2.2 Analytical Techniques

Analytical techniques are applied in project management to forecast potential outcomes based on possible variations of project or environmental variables and their relationships with other variables. Examples of analytical techniques used in projects are:

- Regression analysis,
- Grouping methods (e.g. exploratory study),
- Multiple equation models (e.g. causal analysis, root cause analysis),
- Failure mode and effect analysis (FMEA),
- Reserve analysis, and
- Trend analysis.

4.4.2.3 Project Management Information System

The project management information system, which is part of enterprise environmental factors, provides access to automated tools, such as a scheduling, cost, and resourcing tools, performance indicators, databases, project records, and financials used during the Monitor and Control Project Work process.

4.4.2.4 Meetings

Described in Section 4.3.2.3. Meetings may be face-to-face, virtual, formal, or informal. This may include project team members, stakeholders and others involved in or affected by the project. Types of meetings include, but are not limited to, kick-off meetings, user groups, and review meetings.

4.4.3 Monitor and Control Project Work: Outputs

4.4.3.1 Change Requests

As a result of comparing planned results to actual results, change requests may be issued to expand, adjust, or reduce project or product scope. Changes can impact the project management plan, project documents, or product deliverables. Changes may include, but are not limited to, the following:

- **Corrective action—**An intentional activity that realigns the performance of the project work with the project management plan;
- **Preventive action**—An intentional activity undertaken to avoid an event that would impact the performance of the project; and
- **Defect repair**—An intentional activity whose purpose is to correct a nonconforming product or product component.

4.4.3.2 Work Performance Reports

Work performance reports are the physical or electronic representation of work performance information compiled in project documents, intended to generate decisions, actions, or awareness. Project information may be communicated verbally from person to person. However, in order to record, store, and sometimes distribute work performance information, the information has to have a physical or electronic representation in the form of project documents. Work performance reports are a subset of project documents, which are intended to create awareness and generate decisions or actions.
Examples of work performance reports include status reports, memos, justifications, information notes, recommendations, and updates.

4.4.3.3 Project Management Plan Updates

Project management plan elements that may be updated include, but are not limited to:

- Schedule management plan,
- Cost management plan,
- Quality management plan,
- Scope baseline,
- Schedule baseline, and
- Cost baseline.

4.4.3.4 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Forecasts,
- Performance reports, and
- Issue log.

4.5 Perform Integrated Change Control

Perform Integrated Change Control is the process whereby modifications to documents, deliverables, or baselines associated with the project are identified, documented, approved or rejected. The key benefit of this process is that it allows for documented changes within the project. The inputs, tools and techniques, and outputs of this process are depicted in Figure 4-10. Figure 4-11 depicts the data flow diagram of the process.

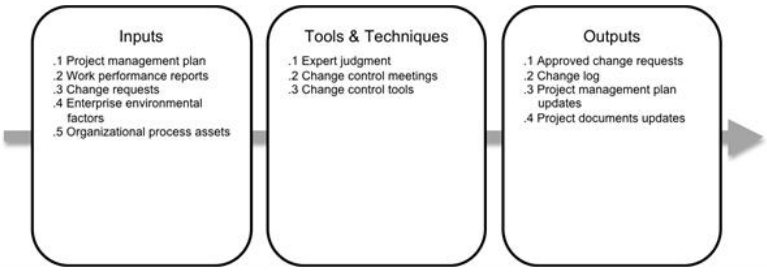


Figure 4-10. Perform Integrated Change Control: Inputs, Tools & Techniques, and Outputs

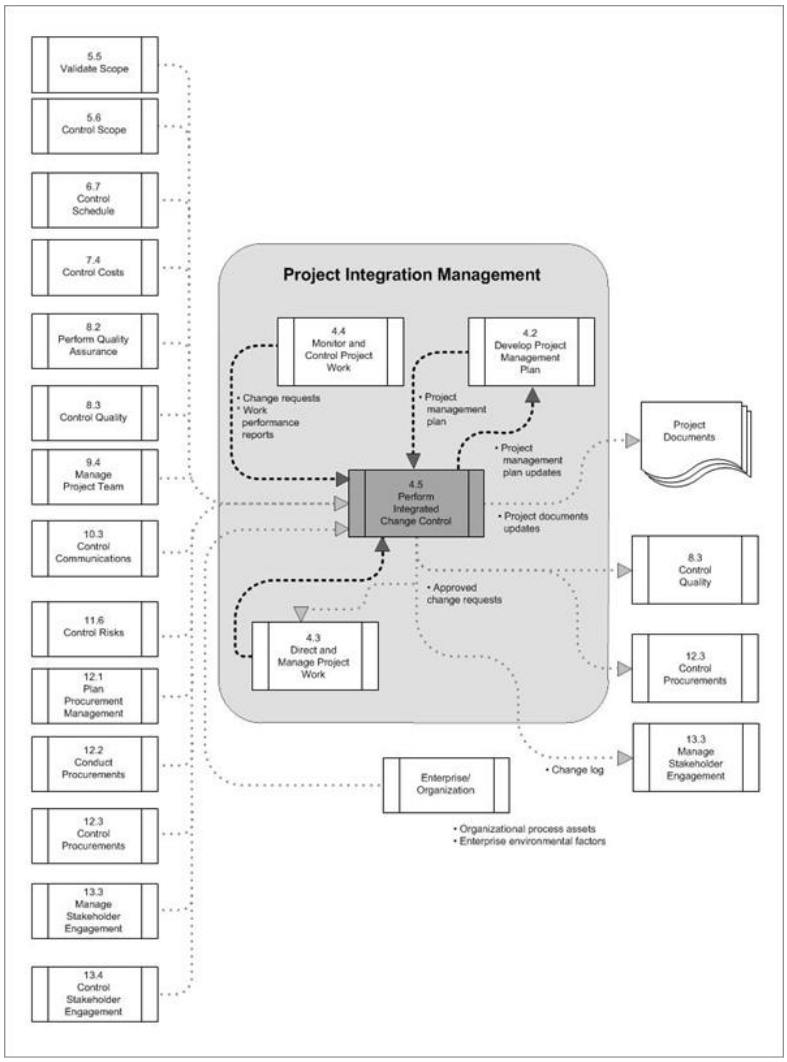


Figure 4-11. Perform Integrated Change Control Data Flow Diagram

The Perform Integrated Change Control process is conducted from project inception through completion. The project management plan, the project scope statement, and other deliverables are maintained by carefully and continuously managing changes, either by rejecting changes or by approving changes, thereby assuring that only approved changes are incorporated into a revised baseline.

Changes may be requested by any stakeholder involved with the project. Although changes may be initiated verbally, they should always be recorded in written form and entered into the change management and/or configuration management system. Change requests are subject to the process specified in the change control and configuration control systems. Those change request processes may require information on estimated time impacts and estimated cost impacts.

Every documented change request needs to be either approved or rejected by a responsible

individual, usually the project sponsor or project manager. When required, the Perform Integrated Change Control process includes a change control board (CCB), which is a formally chartered group responsible for reviewing, evaluating, approving, postponing, or rejecting changes to the project, and for recording and communicating such decisions. Approved change requests can require new or revised cost estimates, activity sequences, schedule dates, resource requirements, and analysis of risk response alternatives. These changes can require adjustments to the project management plan or other project management plans and documents. 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.

Configuration control is focused on the specification of both the deliverables and the processes; change control is focused on identifying, documenting, and approving or rejecting changes to the project documents, deliverables, or baselines.

Some of the configuration management activities included in the Perform Integrated Change Control process are as follows:

- **Configuration identification.** Selection and identification of a configuration item provide the basis for which the product configuration is defined and verified, products and documents are labeled, changes are managed, and accountability is maintained.
- **Configuration status accounting.** Information is recorded and reported as to when appropriate data about the configuration item should be provided. This information includes a listing of approved configuration identification, status of proposed changes to the configuration, and the implementation status of approved changes.
- **Configuration verification and audit.** Configuration verification and configuration audits ensure the composition of a project's configuration items is correct and that corresponding changes are registered, assessed, approved, tracked, and correctly implemented. This ensures the functional requirements defined in the configuration documentation have been met.

4.5.1 Perform Integrated Change Control: Inputs

4.5.1.1 Project Management Plan

Described in Section 4.2.3.1. Elements of the project management plan that may be used include, but are not limited to:

- The scope management plan, which contains the procedures for scope changes;
- The scope baseline, which provides product definition; and
- The change management plan, which provides the direction for managing the change control process and documents the formal change control board.

Changes are documented and updated within the project management plan as part of the change and configuration management processes.

4.5.1.2 Work Performance Reports

Described in Section 4.4.3.2. Work performance reports of particular interest to the Perform Integrated Change Control process include resource availability, schedule and cost data, and earned value management (EVM) reports.

4.5.1.3 Change Requests

All of the Monitoring and Controlling processes and many of the Executing processes produce change requests as an output. Change requests can include corrective action, preventive action, and defect repairs. However, corrective and preventive actions do not normally affect the project baselines—only the performance against the baselines.

4.5.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. The following enterprise environmental factor can influence the Perform Integrated Change Control process: project management information system. Project management information systems include the scheduling software tool, a configuration management system, an information collection and distribution system, and web interfaces to other online automated systems.

4.5.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Perform Integrated Change Control process include, but are not limited to:

- Change control procedures, including the steps by which official company standards, policies, plans, and other project documents will be modified, and how any changes will be approved, validated, and implemented;
- Procedures for approving and issuing change authorizations;
- Process measurement database used to collect and make available measurement data on processes and products;
- Project files (e.g., scope, cost, schedule and performance measurement baselines, project calendars, project schedule network diagrams, risk registers, planned response

actions, and defined risk impact); and
- Configuration management knowledge base containing the versions and baselines of all official company standards, policies, procedures, and any project documents.

4.5.2 Perform Integrated Change Control: Tools and Techniques

4.5.2.1 Expert Judgment

In addition to the project management team's expert judgment, stakeholders may be asked to provide their expertise and may be asked to sit on the change control board (CCB). Such judgment and expertise are applied to any technical and management details during this process and may be provided by various sources, for example:
- Consultants,
- Stakeholders, including customers or sponsors,
- Professional and technical associations,
- Industry groups,
- Subject matter experts, and
- Project management office (PMO).

4.5.2.2 Change Control Meetings

A change control board is responsible for meeting and reviewing the change requests and approving or rejecting those change requests. The roles and responsibilities of these boards are clearly defined and are agreed upon by appropriate stakeholders. All change control board decisions are documented and communicated to the stakeholders for information and follow-up actions.

4.5.2.3 Change Control Tools

In order to facilitate configuration and change management, manual or automated tools may be used. Tool selection should be based on the needs of the project stakeholders including organizational and environmental considerations and/or constraints.
Tools are used to manage the change requests and the decisions made by the CCB. Additional considerations should be made for communication to assist the CCB members in their duties as well as distribute the decisions to the appropriate stakeholders.

4.5.3 Perform Integrated Change Control: Outputs

4.5.3.1 Approved Change Requests

Change requests are processed according to the change control system by the project manager or by an assigned team member. Approved change requests will be implemented by the Direct and Manage Project Work process. The status of all changes approved or not, will be updated in the change request log as part of updates to the project documents.

4.5.3.2 Change Log

A change log is used to document changes that occur during a project. These changes and their impact to the project in terms of time, cost, and risk, must be communicated to the appropriate stakeholders.

4.5.3.3 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:
- Any subsidiary management plans, and
- Baselines that are subject to the formal change control process.

Changes to baselines should only show the changes from the current time forward. Past performance may not be changed. This protects the integrity of the baselines and the historical data of past performance.

4.5.3.4 Project Documents Updates

Project documents that may be updated as a result of the Perform Integrated Change Control process include the change request log and any documents that are subject to the formal change control process.

4.6 Close Project or Phase

Close Project or Phase is the process of finalizing all activities across all of the Project Management Process Groups to formally complete the project or phase. The key benefit of this process is that it provides lessons learned and the formal ending of

project related work. The inputs, tools and techniques, and outputs of this process are depicted in Figure 4-12. Figure 4-13 depicts the data flow diagram of the process.

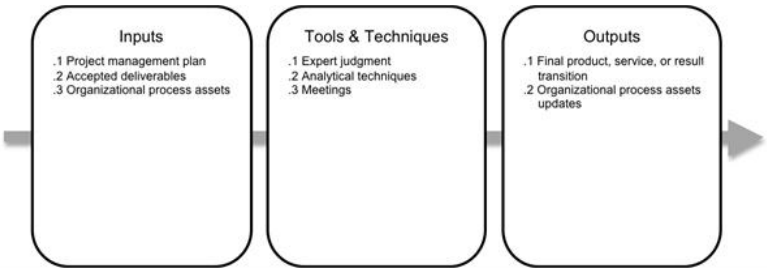


Figure 4-12. Close Project or Phase: Inputs, Tools & Techniques, and Outputs

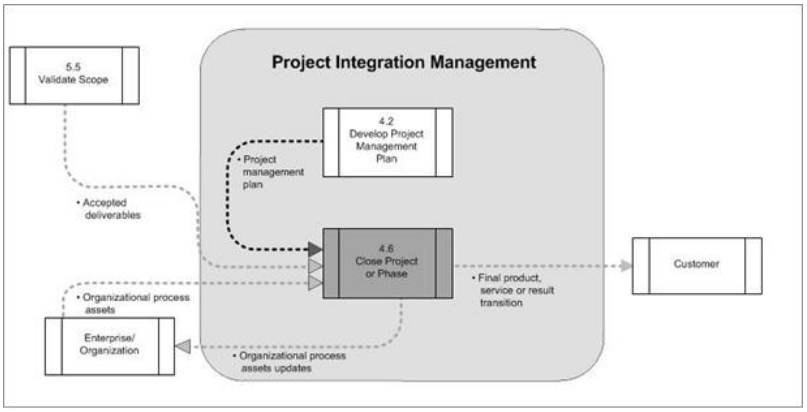


Figure 4-13. Close Project or Phase Data Flow Diagram

When closing the project, the project manager reviews all prior information from the previous phase closures to ensure that all project work is complete and that the project has met its objectives. Since project scope is measured against the project management plan, the project manager reviews that document to ensure completion before considering the project closed. The Close Project or Phase process also establishes the procedures to investigate and document the reasons for actions taken if a project is terminated before completion. In order to successfully achieve this, the project manager needs to engage all the proper stakeholders in the process.

This includes all of the activities necessary for administrative closure of the project or phase, including step-by-step methodologies that address:

- Actions and activities necessary to satisfy completion or exit criteria for the phase or project;
- Actions and activities necessary to transfer the project's products, services, or results to the next phase or to production and/or operations; and
- Activities needed to collect project or phase records, audit project success or failure, gather lessons learned and archive project information for future use by the organization.

4.6.1 Close Project or Phase: Inputs

4.6.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan becomes the "contract" between the project manager and project sponsor, defining what constitutes project completion.

4.6.1.2 Accepted Deliverables

Described in Section 5.5. Deliverables may include approved product specifications, delivery receipts, and work performance documents.

4.6.1.3 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Close Project or Phase process include, but are not limited to:

- Project or phase closure guidelines or requirements (e.g., project audits, project evaluations, and transition criteria); and
- 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 activity).

4.6.2 Close Project or Phase: Tools and Techniques

4.6.2.1 Expert Judgment

Expert judgment is applied when performing administrative closure activities. These experts ensure the project or phase closure is performed to the appropriate standards.

4.6.2.2 Analytical Techniques

Described in Section 4.4.2.2. Examples of analytical techniques used in project closeout are:

- Regression analysis, and
- Trend analysis.

4.6.2.3 Meetings

Described in Section 4.3.2.3. Meetings may be face-to-face, virtual, formal, or informal. This may include project team members, stakeholders, and others involved in or affected by the project. Types of meetings include, but are not limited to lessons learned, closeout, user group, and review meetings.

4.6.3 Close Project or Phase: Outputs

4.6.3.1 Final Product, Service, or Result Transition

This output refers to the transition of the final product, service, or result that the project was authorized to produce (or in the case of phase closure, the intermediate product, service, or result of that phase).

4.6.3.2 Organizational Process Assets Updates

The organizational process assets that are updated as a result of the Close Project or Phase process include, but are not limited to:

- **Project files**—Documentation resulting from the project's activities, for example, project management plan, scope, cost, schedule and project calendars, risk registers, change management documentation, planned risk response actions, and risk impact.
- **Project or phase closure documents**—Project or phase closure documents, consisting of formal documentation that indicates completion of the project or phase and the transfer of the completed project or phase deliverables to others, such as an operations group or to the next phase. During project closure, the project manager reviews prior phase documentation, customer acceptance documentation from the Validate Scope process (Section 5.4) and the contract (if applicable), to ensure that all project requirements are complete prior to finalizing the closure of the project. 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 or phases. This can include information on issues and risks as well as techniques that worked well that can be applied to 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. Managing the project scope 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, which include the following:
5.1 Plan Scope Management—The process of creating a scope management plan that documents how the project scope will be defined, validated, and controlled.
5.2 Collect Requirements—The process of planning for, defining, and documenting stakeholders' needs to meet the project objectives.
5.3 Define Scope—The process of developing a detailed description of the project and product.
5.4 Create WBS—The process of subdividing project deliverables and project work into smaller, more manageable components.

5.5 Validate Scope—The process of formalizing acceptance of the completed project deliverables.

5.6 Control Scope—The process of monitoring the status of the project and product scope and managing changes to the scope baseline.

These processes interact with each other and with the processes in the other Knowledge Area as described 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; and/or
- **Project scope.** The work performed to deliver a product, service, or result with the specified features and functions. The term project scope is frequently viewed as including product scope.

The processes used to manage project scope, as well as the supporting tools and techniques, vary by application area and are usually defined as part of the project life cycle. The scope baseline for the project is the approved version of the project scope statement, work breakdown structure (WBS), and its associated WBS dictionary. A baseline can be changed only through formal change control procedures and is used as a basis for comparison.

Completion of the project scope is measured against the project management plan (Section 4.2.3.1). Completion of the product scope is measured against the product requirements (Section 5.2). The Project Scope Management processes need 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.

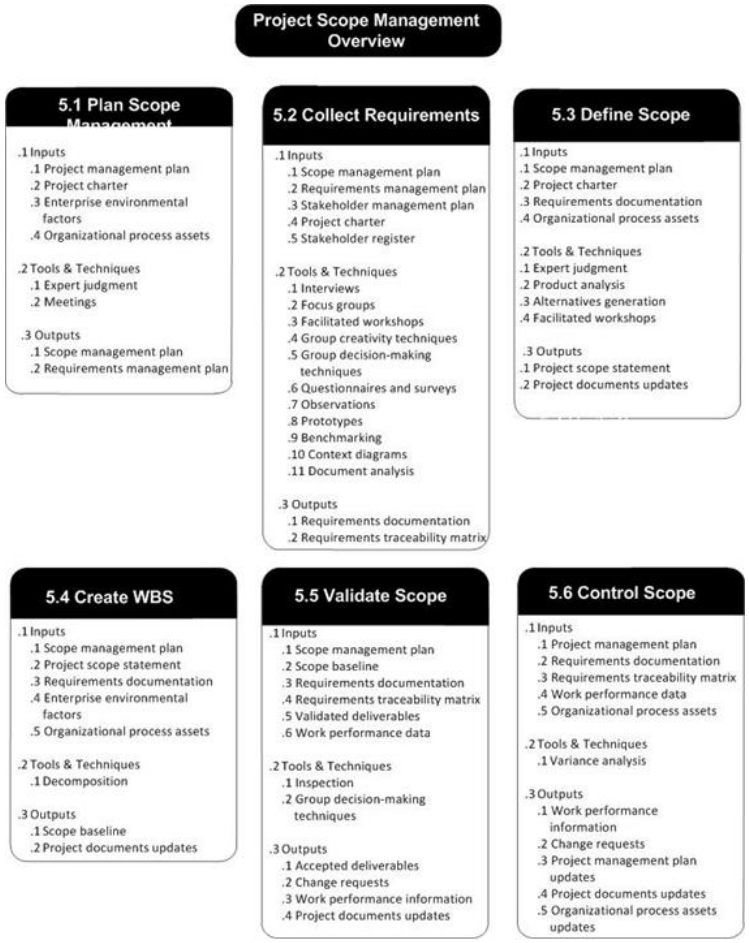


Figure 5-1. Project Scope Management Overview

5.1 Plan Scope Management

Plan Scope Management is the process of creating a scope management plan that documents how the project scope will be defined, validated, and controlled. The key benefit of this process is that it provides guidance and direction on how scope will be managed throughout the project. The inputs, tools and techniques, and outputs of this process are depicted in Figure 5-2. Figure 5-3 depicts the data flow diagram of the process.

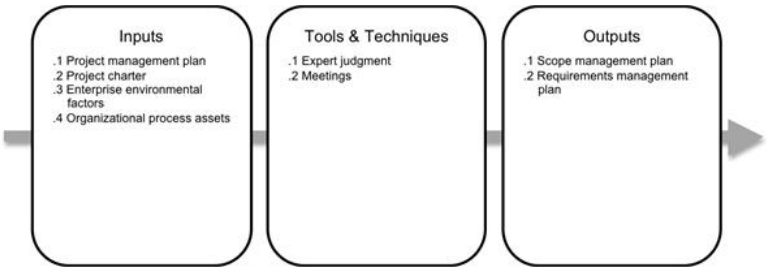


Figure 5-2. Plan Scope Management: Inputs, Tools & Techniques, and Outputs

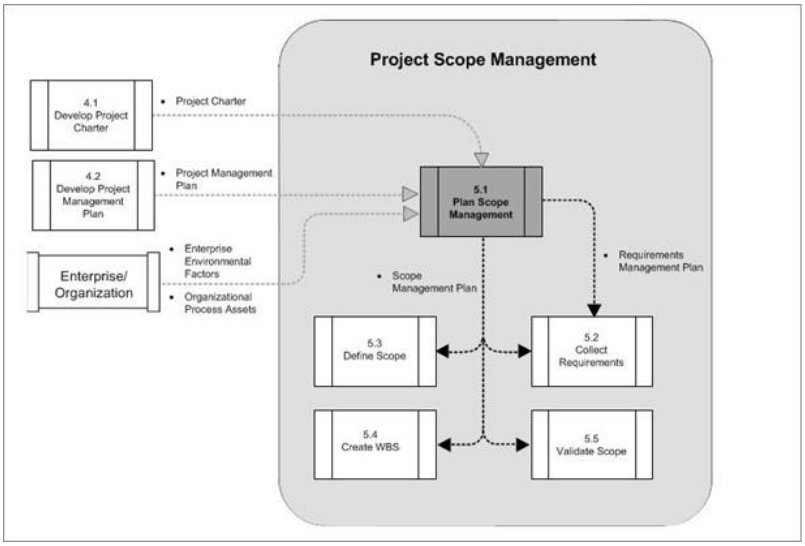


Figure 5-3. Plan Scope Management Data Flow Diagram

The scope management plan is a component of the project or program management plan that describes how the project scope will be defined, developed, monitored, controlled and verified. The development of the 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 latest approved version of the project management plan (Section 4.2.3.1), historical information contained in the organizational process assets (Section 2.1.4), and any other relevant enterprise environmental factors (Section 2.1.5).

5.1.1 Plan Scope Management: Inputs

5.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan is used to create the scope management plan to ensure consistency.

5.1.1.2 Project Charter

Described in Section 4.1.3.1. The project charter is used to provide the project context needed to plan the scope management processes. It provides the high-level project description and product characteristics.

5.1.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Plan Scope Management process include, but are not limited to:

- Organization's culture,
- Infrastructure,
- Personnel administration, and
- Marketplace conditions.

5.1.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Plan Scope Management process include, but are not limited to:

- Policies and procedures, and
- Historical information and lessons learned knowledge base.

5.1.2 Plan Scope Management: Tools and Techniques

5.1.2.1 Expert Judgment

Expert judgment based on how equivalent projects have managed scope is used in developing the project scope management plan.

5.1.2.2 Meetings

Project teams may hold planning meetings to develop the scope management plan. Attendees at these meetings may include the project manager, the project sponsor, selected project team members, selected stakeholders, anyone with responsibility for any of the scope management process, and others as needed.

5.1.3 Plan Scope Management: Outputs

5.1.3.1 Scope Management Plan

The scope management plan is a component of the project management plan that describes how the project scope will be defined, developed, monitored, controlled, and verified. The components of a scope management plan include:

- Process for preparing a detailed project scope statement;
- Process that enables the creation of the WBS from the detailed project scope statement;
- Process that establishes how the WBS will be maintained and approved;
- Process that specifies how formal acceptance of the completed project deliverables will be obtained; and
- Process to control how requests for changes to the detailed project scope statement will be processed. This process is directly linked to the Perform Integrated Change Control process (Section 4.5).

The scope management plan is a subsidiary plan of the project management plan. The scope management plan can be informal and broadly framed, or formal and highly detailed, based on the needs of the project.

5.1.3.2 Requirements Management Plan

The requirements management plan is a component of the project or program management plan that describes how the project requirements will be analyzed, documented, and managed. The phase-to-phase relationship, described in Section 2.4.2.1, strongly influences how requirements are managed. The project manager must choose the most effective relationship for the project and document this approach in the requirements management plan. Many of the requirements management plan components are based on that relationship. Components of the requirements management plan can include, but are not limited to:

- How requirements activities will be planned, tracked, and reported;
- Configuration management activities such as: how changes to the product will be initiated, how impacts will be analyzed, how they will be traced, tracked, and reported, as well as the authorization levels required to approve these changes;
- Requirements prioritization process;
- Product metrics that will be used and the rationale for using them; and
- Traceability structure to reflect which requirement attributes will be captured on the traceability matrix.

5.2 Collect Requirements

Collect Requirements is the process of planning for, defining, and documenting stakeholders' needs to meet the project objectives. The key benefit of this process is that it provides the basis for defining and managing the project scope including product scope. The inputs, tools and techniques, and outputs of this process are depicted in Figure 5-4. Figure 5-5 depicts the data flow diagram of the process.

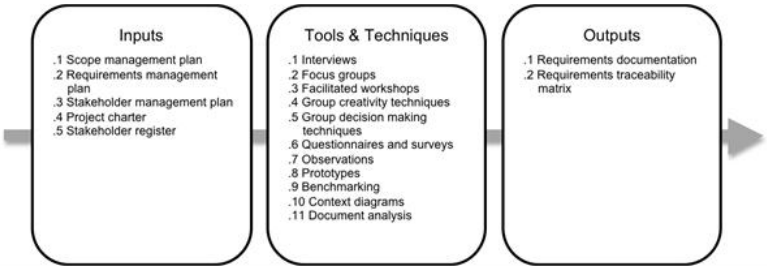


Figure 5-4. Collect Requirements: Inputs, Tools & Techniques, and Outputs

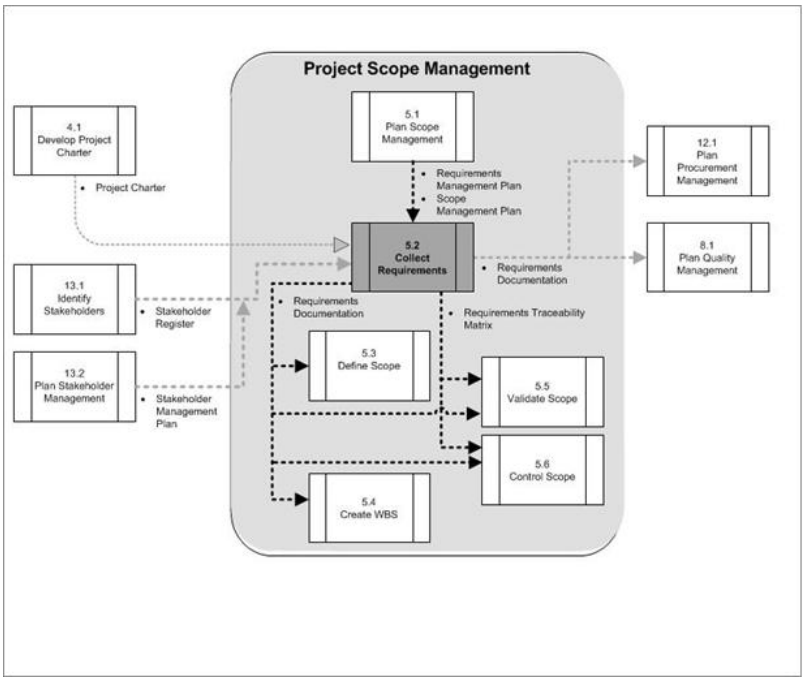


Figure 5-5. Collect Requirements Data Flow Diagram

The project's success is directly influenced by the care taken in planning for and capturing the requirements of the overall project as well as the requirements of the product, service, or result of the project. Requirements include conditions or capabilities that must be met by the project or present in the product, service, or result to satisfy an agreement or other formally imposed specification. Requirements include the quantified and documented needs and expectations of the sponsor, customer, and other stakeholders. These requirements need to be elicited, analyzed, and recorded in enough detail to be included in the scope baseline and be measured once project execution begins. Requirements become the foundation of the WBS. Cost, schedule, and quality planning are all based upon these requirements. The development of requirements begins with an analysis of the information contained in the project charter (Section 4.1.3.1), the stakeholder register (Section 13.1.3.1), and the stakeholder management plan (Section 13.2.3.1). Many organizations categorize requirements into different types, such as business and technical, the former referring to stakeholder needs and the latter to how those needs will be implemented. Requirements can also be grouped into classifications allowing for further refinement and detail as the requirements are elaborated. These classifications include:

- Business requirements, which describe the higher-level needs of the organization as a whole, such as the businesses issues or opportunities, and why a project has been undertaken.
- Stakeholder requirements, which describe needs of a stakeholder or stakeholder group.
- Solution requirements, which describe features, functions, and characteristics of the product, service or result that will meet the business and stakeholder requirements. Solution requirements are further grouped into functional and nonfunctional requirements.
    - Functional requirements describe the behaviors of the product. Examples include processes, data, and interactions with the product.
    - Nonfunctional requirements supplement functional requirements and describe the environmental conditions or qualities required for the product to be effective. Examples include: reliability, security, performance, safety. level of service, supportability, retention/purge, etc.
- Transition requirements describe temporary capabilities, such as data conversion and training requirements, needed to transition from the current "as-is" state to the future "to-be" state.
- Project requirements, which describe the actions, processes, or other conditions the project needs to meet.
- Quality requirements, which capture any condition or criteria needed to validate the successful completion of a project deliverable or fulfillment of other project requirements.

5.2.1 Collect Requirements: Inputs

5.2.1.1 Scope Management Plan

Described in Section 5.1.3.1. The scope management plan provides clarity as to how project teams will determine which type of requirements need to be collected for the project.

5.2.1.2 Requirements Management Plan

Described in Section 5.1.3.2. The requirements management plan provides the processes that will be used throughout Collect Requirements to define and document the stakeholder needs.

5.2.1.3 Stakeholder Management Plan

Described in Section 13.2.3.1. The stakeholder management plan is used to understand stakeholder communication requirements and the level of stakeholder engagement in order to assess the level of stakeholder participation in requirements activities.

5.2.1.4 Project Charter

Described in Section 4.1.3.1. The project charter is used to provide the high-level description of the product, service, or result of the project so that detailed product requirements can be developed.

5.2.1.5 Stakeholder Register

Described in Section 13.1.3.1. The stakeholder register is used to identify stakeholders who can provide information on the requirements.

5.2.2 Collect Requirements: Tools and Techniques

5.2.2.1 Interviews

An interview is a formal or informal approach to elicit information from stakeholders by talking to them directly. It is typically performed by asking prepared and spontaneous questions and recording the responses. Interviews are often conducted on an individual basis between an interviewer and an interviewee, but may involve multiple interviewers and/or multiple interviewees. Interviewing experienced project participants, stakeholders, and subject matter experts can aid in identifying and defining the features and functions of the desired product deliverables.

5.2.2.2 Focus Groups

Focus groups bring together prequalified stakeholders and subject matter experts to learn about their expectations and attitudes about a proposed product, service, or result. A trained moderator guides the group through an interactive discussion, designed to be more conversational than a one-on-one interview.

5.2.2.3 Facilitated Workshops

Facilitated workshops are focused sessions that bring key cross-functional stakeholders together to define product requirements. Workshops are considered a primary technique for quickly defining cross-functional requirements and reconciling stakeholder differences. Because of their interactive group nature, well-facilitated sessions can build trust, foster relationships, and improve communication among the participants, which can lead to increased stakeholder consensus. Another benefit of this technique is that issues can be discovered and resolved more quickly than in individual sessions.
For example, facilitated workshops called joint application design/development (JAD) sessions are used in the software development industry. These facilitated sessions focus on bringing business subject matter experts and the development team together to improve the software development process. In the manufacturing industry, Quality Function Deployment (QFD) is another example of a facilitated workshop technique that helps determine critical characteristics for new product development. QFD starts by collecting customer needs, also known as Voice of the Customer (VOC). These needs are then objectively sorted and prioritized, and goals are set for achieving them. User stories, which are short, textual descriptions of required functionality, are often developed during a requirements workshop. User stories describe the stakeholder who benefits from the feature (role), what the stakeholder needs to accomplish (goal), and the benefit to the stakeholder (motivation).

5.2.2.4 Group Creativity Techniques

Several group activities can be organized to identify project and product requirements. Some of the group creativity techniques that can be used are:

- **Brainstorming.** A technique used to generate and collect multiple ideas related to project and product requirements.
- **Nominal group technique.** A technique that enhances brainstorming with a voting process used to rank the most useful ideas for further brainstorming or for prioritization.
- **Idea/mind mapping.** A technique in which ideas created through individual

brainstorming sessions are consolidated into a single map to reflect commonality and differences in understanding and generate new ideas.

- **Affinity diagram.** A technique that allows large numbers of ideas to be classified into groups for review and analysis.
- **Multicriteria decision analysis.** A technique that utilizes a decision matrix to provide a systematic analytical approach for establishing criteria, such as risk levels, uncertainty, and valuation, to evaluate and rank many ideas.

5.2.2.5 Group Decision-Making Techniques

A group decision-making technique is an assessment process having multiple alternatives with an expected outcome in the form of future actions resolution. These techniques can be used to generate, classify, and prioritize product requirements.

There are various methods of reaching a group decision, such as:

- **Unanimity.** A decision that is reached whereby everyone agrees on a single course of action. One way to reach unanimity is the Delphi technique, in which a selected group of experts answers questionnaires and provides feedback regarding the responses from each round of requirements gathering. The responses are only available to the facilitator to maintain anonymity.
- **Majority.** A decision that is reached with support obtained from more than 50 % of the members of the group.
- **Plurality.** A decision that is reached whereby the largest block in a group decides, even if a majority is not achieved.
- **Dictatorship.** In this method, one individual makes the decision for the group.

All of these decision methods can be applied to the group techniques used in the requirements gathering process.

5.2.2.6 Questionnaires and Surveys

Questionnaires and surveys are written sets of questions designed to quickly accumulate information from a large number of respondents. Questionnaires and/or surveys are most appropriate with varied audiences, when a quick turnaround is needed, and where statistical analysis is appropriate.

5.2.2.7 Observations

Observations provide a direct way of viewing individuals in their environment and how they perform their jobs or tasks and carry out processes. It is particularly helpful for detailed processes when the people that use the product have difficulty or are reluctant to articulate their requirements. Observation is also known as “job shadowing.” It is usually done externally by an observer viewing a business expert performing a job. It can also be done by a “participant observer” who actually performs a process or procedure to experience how it is done to uncover hidden requirements.

5.2.2.8 Prototypes

Prototyping is a method of obtaining early feedback on requirements by providing a working model of the expected product before actually building it. Since prototypes are tangible, it allows stakeholders to experiment with a model of their final product rather than only discussing abstract representations of their requirements. Prototypes support the concept of progressive elaboration in iterative cycles of mock-up creation, user experimentation, feedback generation, and prototype revision. When enough feedback cycles have been performed, the requirements obtained from the prototype are sufficiently complete to move to a design or build phase. Storyboarding is a prototyping technique showing sequence or navigation through a series of images or illustrations. In software development, storyboards use mock-ups to show navigation paths through web pages, screens, or other user interfaces.

5.2.2.9 Benchmarking

Benchmarking involves comparing actual or planned practices, such as processes and operations, to those of comparable organizations to identify best practices, generate ideas for improvement, and provide a basis for measuring performance. The organizations compared during benchmarking can be internal or external.

5.2.2.10 Context Diagrams

The context diagram is an example of a scope model. Context diagrams visually depict the product scope by showing a business system (process, equipment, computer system, etc.), and how people and other systems (actors) interact with it. Context diagrams show inputs to the business system, the actor(s) providing the input, the outputs from the business system, and the actor(s) receiving the output.

5.2.2.11 Document Analysis

Document analysis is used to elicit requirements by analyzing existing documentation and identifying information relevant to the requirements. Examples of documents that can be analyzed include, but are not limited to: business plans, marketing literature, agreements, requests for proposal, current process flows, logical data models, business rules repositories, application software documentation, requirements documentation, problem/issue logs, etc.

5.2.3 Collect Requirements: Outputs

5.2.3.1 Requirements Documentation

Requirements documentation describes how individual requirements meet the business need for the project. Requirements may start out at a high level and become progressively more detailed as more is known. Before being baselined, requirements need to be unambiguous (measurable and testable), traceable, complete, consistent, and acceptable to key stakeholders. The format of a requirements document may range from a simple document listing all the requirements categorized by stakeholder and priority, to more elaborate forms containing executive summary, detailed descriptions, and attachments.
Components of requirements documentation can include, but are not limited to:

- Business requirements;
- Business and project objectives for traceability;
- Stakeholder requirements;
- Solution requirements, including functional and nonfunctional requirements.

Solution requirements can be documented textually, in models, or both;

- Project requirements, such as levels of service, performance, safety, compliance, supportability, reporting, etc.;
- Quality requirements;
- Transition requirements;
- Acceptance criteria;
- Business rules stating the guiding principles of the organization;
- Impacts to other organizational areas, such as the call center, sales force, technology groups;
- Impacts to other entities inside or outside the performing organization;
- Support and training requirements; and
- Requirements assumptions and constraints.

5.2.3.2 Requirements Traceability Matrix

The requirements traceability matrix is a grid that links product requirements from their origin to the deliverables that satisfy them. The implementation of a requirements traceability matrix helps ensure that each requirement adds business value by linking it to the business and project objectives. It provides a means to track requirements throughout the project life cycle, helping to ensure that requirements approved in the requirements documentation are delivered at the end of the project. Finally, it provides a structure for managing changes to the product scope.
This process includes, but is not limited to, tracing:

- Requirements to business needs, opportunities, goals, and objectives;
- Requirements to project objectives;
- Requirements to project scope/WBS deliverables;
- Requirements to product design;
- Requirements to product development;
- Requirements to test strategy and test scenarios; and
- High-level requirements to more detailed requirements.

Attributes associated with each requirement can be recorded in the requirements traceability matrix. These attributes help to define key information about the requirement. Typical attributes used in the requirements traceability matrix may include: a unique identifier, a textual description of the requirement, the rationale for inclusion, owner, source, priority, version, current status (such as active, cancelled, deferred, added, approved), and date completed. Additional attributes to ensure that the requirement has met stakeholders' satisfaction may include stability, complexity, and acceptance criteria. Figure 5-6 provides an example of a requirements traceability matrix with its associated attributes.

REQUIREMENTS TRACEABILITY MATRIX								
Project Name:		<optional>						
Cost Center:		<required>						
Project Description:		<required>						
ID	Assoc ID	Requirements Description	Business Needs, Opportunities, Goals, Objectives	Project Objectives	WBS Deliverables	Product Design	Product development	Test Cases
001	1.0							
	1.1							
	1.2							
	1.2.1							
002	2.0							
	2.1							
	2.1.1							
003	3.0							
	3.1							
	3.2							
004	4.0							
005	5.0							

Figure 5-6. Requirements Traceability Matrix

5.3 Define Scope

Define Scope is the process of developing a detailed description of the project and product. The key benefit of this process is that it describes the project boundaries. The inputs, tools and techniques, and outputs of this process are depicted in Figure 5-7. Figure 5-8 depicts the data flow diagram of the process.

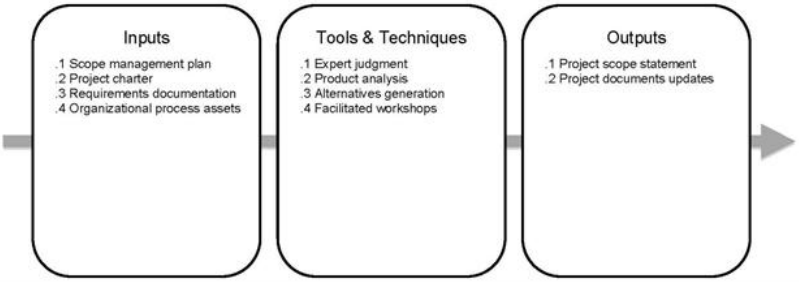


Figure 5-7. Define Scope: Inputs, Tools & Techniques, and Outputs

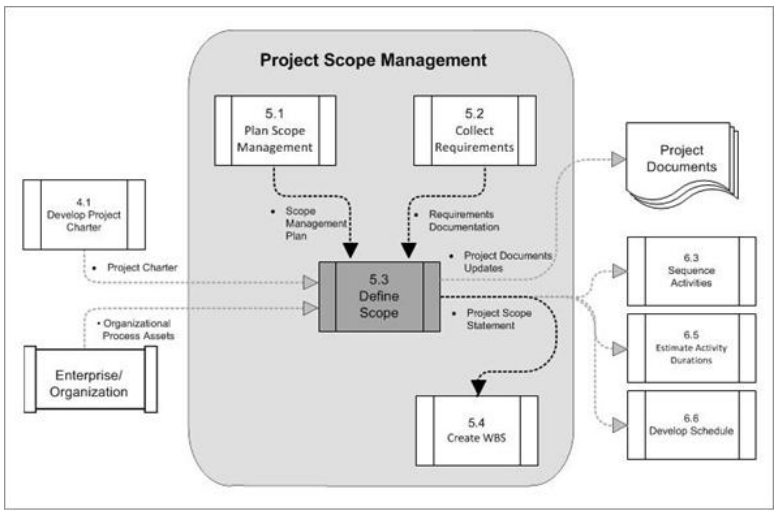


Figure 5-8. Define Scope Data Flow Diagram

The Define Scope process selects the product features/requirements from the requirements documentation delivered during the Collect Requirements process and then develops a detailed description of the project and product, service, or result. Since not all of the requirements identified in Collect Requirements will be included in the project, Define Scope involves choosing which requirements will be part of the project scope.

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. During planning, the project scope is defined and described with greater specificity as more information about the project is known. Existing risks, assumptions, and constraints are analyzed for completeness and added or updated as necessary.

5.3.1 Define Scope: Inputs

5.3.1.1 Scope Management Plan

Described in Section 5.1.3.1. The scope management plan provides the processes that will be used to define the detailed product and project scope.

5.3.1.2 Project Charter

Described in Section 4.1.3.1. The project charter provides the high-level project description and product characteristics. It also contains project approval requirements. If a project charter is not used in the performing organization, then comparable information needs to be acquired or developed, and used as a basis for the detailed project scope statement.

5.3.1.3 Requirements Documentation

Described in Section 5.2.3.1. The requirements documentation is used to select the features that will be included in the product scope.

5.3.1.4 Organizational Process Assets

Described in Section 2.1.4. Organizational process assets can influence how scope is defined. Examples include, but are not limited to:

- Policies, procedures, and templates for a project scope statement;
- Project files from previous projects; and
- Lessons learned from previous phases or projects.

5.3.2 Define Scope: Tools and Techniques

5.3.2.1 Expert Judgment

Expert judgment is often used to analyze the information needed to develop the project scope statement. Such judgment and expertise are applied to any technical detail. Such expertise is provided by any group or individual with specialized knowledge or training, and is available from many sources, including but not limited to:

- Other units within the organization;
- Consultants;
- Stakeholders, including customers or sponsors;
- Professional and technical associations;
- Industry groups; and
- Subject matter experts.

5.3.2.2 Product Analysis

For projects that have a product as a deliverable, as opposed to a service or result, product analysis can be an effective tool. Each application area has one or more generally accepted methods for translating high-level product descriptions into tangible deliverables. Product analysis includes techniques such as product breakdown, systems analysis, requirements analysis, systems engineering, value engineering, and value analysis.

5.3.2.3 Alternatives Generation

Alternatives generation is a technique used to develop as many potential options as possible in order to identify different approaches to execute and perform the work of the project. A variety of general management techniques can be used such as brainstorming, lateral thinking, pairwise comparisons, etc.

5.3.2.4 Facilitated Workshops

Described in Section 5.2.2.3. The participation of key players with a variety of expectations and/or fields of expertise in these intensive working sessions helps to reach a cross-functional and common understanding of the project objectives and its limits.

5.3.3 Define Scope: Outputs

5.3.3.1 Project Scope Statement

The project scope statement is the description of the project scope, major deliverables, assumptions, and constraints. The project scope statement describes, in detail, the project's deliverables and the work required to create those deliverables. It also provides a common understanding of the project scope among project stakeholders. It may contain explicit scope exclusions that can assist in managing stakeholder expectations. It 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 the work that

will be performed and the work that is excluded can determine how well the project management team can control the overall project scope. The detailed project scope statement, either directly, or by reference to other documents, includes the following:

- **Product scope description.** Progressively elaborates the characteristics of the product, service, or result described in the project charter and requirements documentation.
- **Acceptance criteria.** The set of conditions that must be met before deliverables are accepted.
- **Project deliverables.** Deliverables include any unique and verifiable product, result or capability to perform a service that must be produced to complete a process, phase, or project. They also include ancillary results, such as project management reports and documentation. These deliverables may be described at a summary level or in great detail.
- **Project exclusions.** Generally identifies what is excluded from the project. Explicitly stating what is out of scope for the project helps to manage stakeholders' expectations.
- **Project constraints.** Lists and describes the specific internal or external restrictions or limitations associated with the project scope that affect the execution of the project, for example, a predefined budget or any imposed dates or schedule milestones that are issued by the customer or performing organization. When a project is performed under an agreement, contractual provisions will generally be constraints. Information on constraints may be listed in the project scope statement or in a separate log.
- **Project assumptions.** Lists and describes the factors associated with the project scope that are considered to be true, real, or certain, without proof or demonstration, and describes the potential impact of those factors if they prove to be false. Project teams frequently identify, document, and validate assumptions as part of their planning process. Information on assumptions may be listed in the project scope statement or in a separate log.

Although the project charter and the project scope statement are sometimes perceived as containing a certain degree of redundancy, they are different in the level of detail contained in each. The project charter contains high-level information, while the project scope statement contains a detailed description of the scope elements. These elements are progressively elaborated throughout the project. Table 5-1 describes some of the key elements for each document.

Table 5-1. Elements of the Project Charter and Project Scope Statement

Project Charter	Project Scope Statement
Project purpose or justification	Product scope description (progressively elaborated)
Measurable project objectives and related success criteria	Product acceptance criteria
High-level requirements	Project deliverables
High-level project description, product characteristics	Project exclusions
Summary milestone schedule	Project constraints
Summary budget	Project assumptions
Project approval requirements (what constitutes success, who decides it, who signs off)	
Assigned project manager, responsibility and authority level	
Name and responsibility of the person(s) authorizing project charter	

5.3.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Stakeholder register,
- Requirements documentation, and
- Requirements traceability matrix.

5.4 Create WBS

Create WBS is the process of subdividing project deliverables and project work into smaller, more manageable components. The key benefit of this process is that it provides a structured vision of what has to be performed. The inputs, tools and techniques, and outputs of this process are depicted in Figure 5-9. Figure 5-10 depicts the data flow diagram of the process.

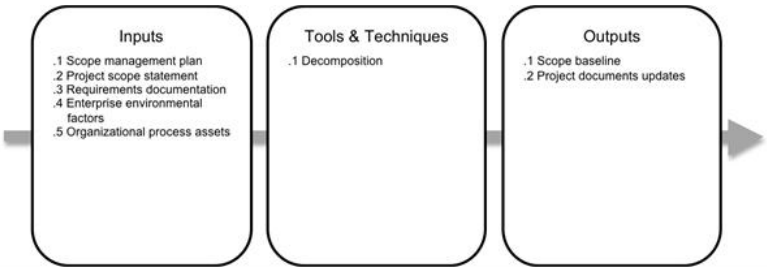


Figure 5-9. Create WBS: Inputs, Tools & Techniques, and Outputs

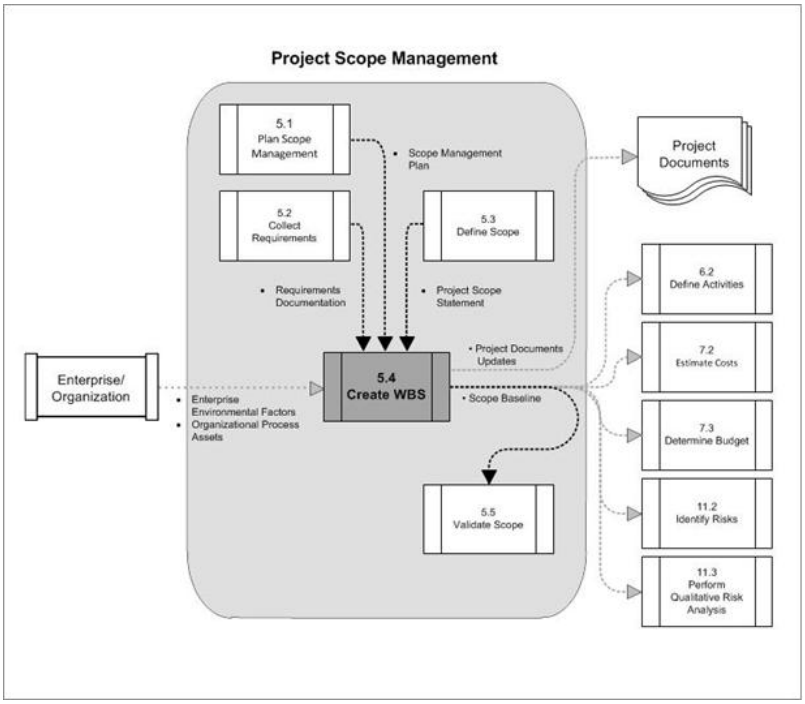


Figure 5-10. Create WBS Data Flow Diagram

The WBS is a hierarchical decomposition of the total scope of work to be carried out 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, and represents the work specified in the current approved project scope statement.
The planned work is contained within the lowest level WBS components, which are called work packages. A work package can be scheduled, cost estimated, monitored, and controlled. In the context of the WBS, work refers to work products or deliverables that are the result of activity and not to the activity itself.

5.4.1 Create WBS: Inputs

5.4.1.1 Scope Management Plan

Described in Section 5.1.3.1. The scope management plan specifies how to create the WBS from the detailed project scope statement and how the WBS will be maintained and approved.

5.4.1.2 Project Scope Statement

Described in Section 5.3.3.1. The project scope statement describes the work that will be performed and the work that is excluded. It also lists and describes the specific internal or external restrictions or limitations that may affect the execution of the project.

5.4.1.3 Requirements Documentation

Described in Section 5.2.3.1. Detailed requirements documentation is essential for understanding what needs to be produced as the result of the project and what needs to be done to deliver the project and its final products.

5.4.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. Industry specific WBS standards, relevant to the nature of the project, may serve as external reference sources for creation of the WBS. For example, engineering projects may reference ISO/IEC 15288 on Systems Engineering – System Life

Cycle Processes, to create a WBS for a new project.

5.4.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Create WBS process include, but are not limited to:

- Policies, procedures, and templates for the WBS;
- Project files from previous projects; and
- Lessons learned from previous projects.

5.4.2 Create WBS: Tools and Techniques

5.4.2.1 Decomposition

Decomposition is a technique used for dividing and subdividing the project scope and project deliverables into smaller, more manageable parts. The work package is the work defined at the lowest level of the WBS for which cost and duration can be estimated and managed. The level of detail for work packages will vary with the size and complexity of the project. Decomposition of the total project work into work packages generally involves the following activities:

- Identifying and analyzing 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; and
- Verifying that the degree of decomposition of the work is necessary and sufficient.

A portion of a WBS with some branches of the WBS decomposed down through the work package level is shown in Figure 5-11.

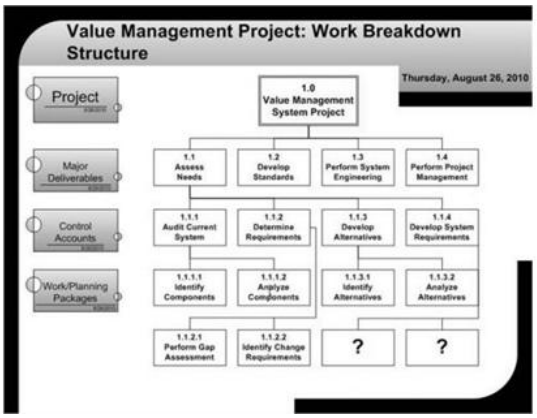


Figure 5-11. Sample WBS Decomposed Down Through Work Packages

A WBS structure may be created through various approaches. Some of the popular methods include: the top-down approach, the bottom-up approach, the use of organization-specific guidelines, and the use of WBS templates. The WBS structure can be represented in a number of forms, such as:

- Using phases of the project life cycle as the first level of decomposition, with the product and project deliverables inserted at the second level, as shown in Figure 5-12;
- Using major deliverables as the first level of decomposition, as shown in Figure 5-13; and
- Using subprojects which may be developed by organizations outside the project team, such as contracted work. The seller then develops the supporting contract WBS as part of the contracted work.

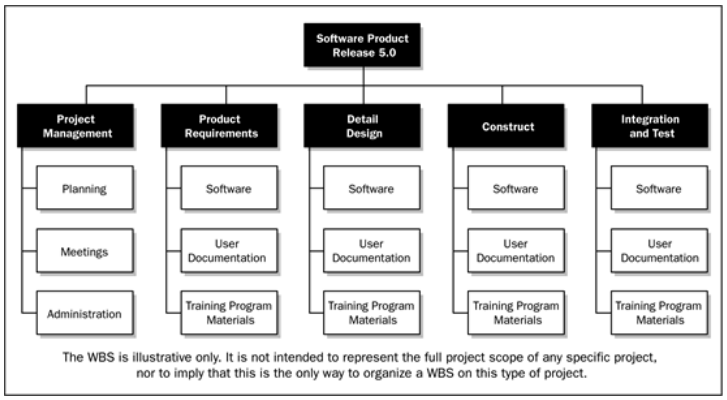


Figure 5-12. Sample WBS Organized by Phase

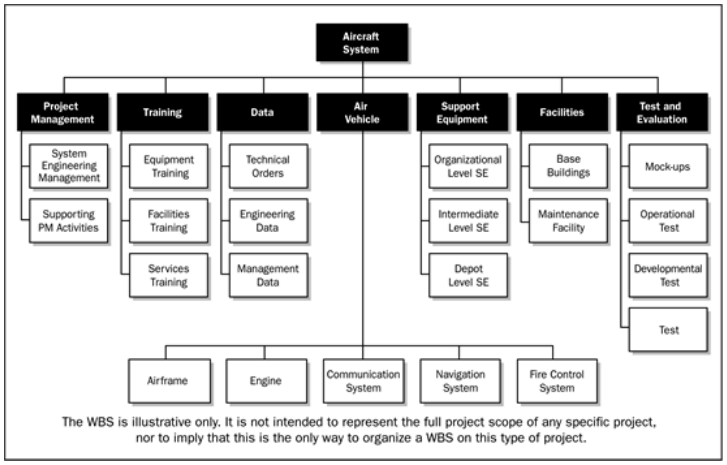


Figure 5-13. Sample WBS with Major Deliverables

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. The WBS can be structured as an outline, an organizational chart, a fishbone diagram, or using any other method. 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. Different deliverables can have different levels of decomposition. To arrive at a work package, the work for some deliverables needs to be decomposed only to the next level, while others need additional levels of decomposition. As the work is decomposed to greater levels of detail, the ability to plan, manage, and control the work is enhanced. However, excessive decomposition can lead to nonproductive management effort, inefficient use of resources, and decreased efficiency in performing the work.

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 agreed on, so the details of the WBS can be developed. This technique is sometimes referred to as rolling wave planning.

The WBS represents all product and project work, including the project management work. The total of the work at the lowest levels must roll up to the higher levels so that nothing is left out and no extra work is completed. This is sometimes called the 100 percent rule.

For specific information regarding the WBS, refer to the *Practice Standard for Work Breakdown Structures* – Second Edition. This standard contains industry-specific examples of WBS templates that can be tailored to specific projects in a particular application area.

5.4.3 Create WBS: Outputs

5.4.3.1 Scope Baseline

The scope baseline is the approved version of a scope statement, work breakdown structure (WBS), and its associated WBS dictionary, that can be changed only through formal change control procedures and is used as a basis for comparison. It is a component of the project management plan. Once approved, it is changed only through formal change control procedures. Components of the scope baseline include:

- **Project scope statement.** The project scope statement includes the description of the project scope, major deliverables, assumptions, and constraints.
- **WBS.** The WBS is a hierarchical decomposition of the total scope of work to be carried out by the project team to accomplish the project objectives and create the required deliverables, with each descending level of the WBS representing an increasingly detailed definition of the project work. The WBS is finalized by establishing control accounts for the work packages and a unique identifier from a code of accounts. These identifiers provide a structure for hierarchical summation of costs, schedule, and resource information. A control account is a management control point where scope, budget, actual cost, and schedule are integrated and compared to the earned value for performance measurement. Control accounts are placed at selected management points in the WBS. Each control account may include one or more work packages, but each of the work packages should be associated with only one control account.
- **WBS dictionary.** The WBS dictionary is a document that provides detailed deliverable, activity, and scheduling information about each component in the WBS. The WBS dictionary is a document that supports the WBS. Information in the WBS dictionary includes, but is not limited to:
  - Code of account identifier,
  - Description of work,
  - Assumptions and constraints,

- Responsible organization,
- List of schedule milestones,
- Associated schedule activities,
- Resources required,
- Cost estimates,
- Quality requirements,
- Acceptance criteria,
- Technical references, and
- Agreement information.

5.4.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to, requirements documentation. If approved change requests result from the Create WBS process, then the requirements documentation may need to be updated to include approved changes.

5.5 Validate Scope

Validate Scope is the process of formalizing acceptance of the completed project deliverables. The key benefit of this process is that it brings objectivity to the acceptance process. The inputs, tools and techniques, and outputs of this process are depicted in Figure 5-14. Figure 5-15 depicts the data flow diagram of the process.

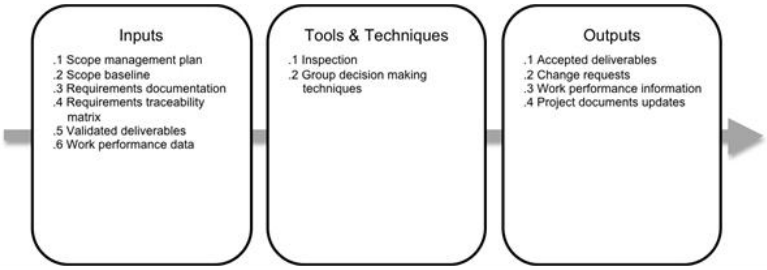


Figure 5-14. Validate Scope: Inputs, Tools & Techniques, and Outputs

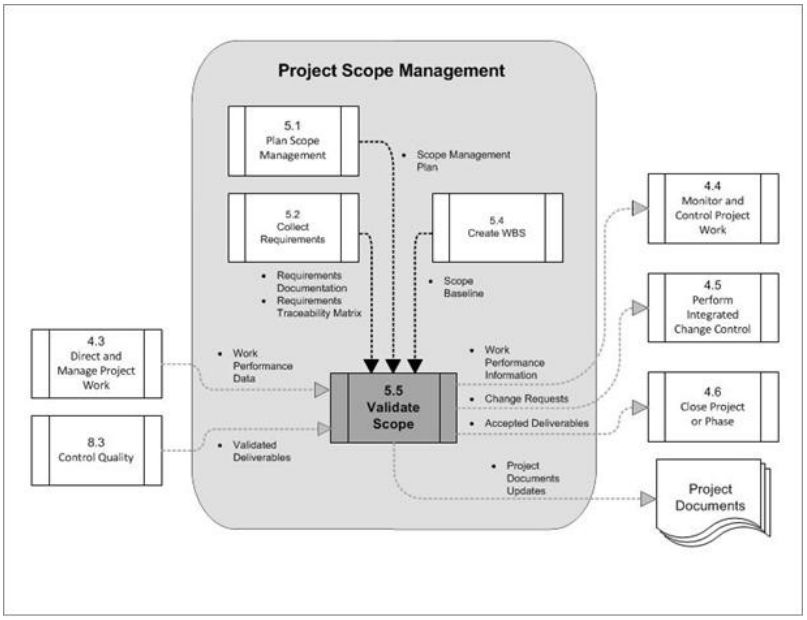


Figure 5-15. Validate Scope Data Flow Diagram

The validated deliverables obtained from the Control Quality process are reviewed with the customer or sponsor to ensure that they are completed satisfactorily and have received formal acceptance of the deliverables by the customer or sponsor. In this process, the outputs obtained as a result of the Planning processes in the Project Scope Management Knowledge Area, such as the requirements documentation or the scope baseline, as well as the work performance data obtained from the Execution processes in other Knowledge Areas, are the basis for performing the validation and for final acceptance.

Scope validation differs from quality control in that scope validation is primarily concerned with acceptance of the deliverables, while quality control is primarily concerned with correctness of the deliverables and meeting the quality requirements specified for the deliverables. Control Quality is generally performed before Validate Scope, although the two processes may be performed in parallel.

5.5.1 Validate Scope: Inputs

5.5.1.1 Scope Management Plan

Described in Section 5.1.3.1. The scope management plan specifies how formal acceptance of the completed project deliverables will be obtained.

5.5.1.2 Scope Baseline

Described in Section 5.4.3.1. The scope baseline includes the product scope description and the project deliverables, and also defines the process and criteria for accepting completed products, services, or results.

5.5.1.3 Requirements Documentation

Described in Section 5.2.3.1. The requirements documentation lists all the project, product, and other types of requirements that must be present for the project and product, along with their acceptance criteria.

5.5.1.4 Requirements Traceability Matrix

Described in Section 5.2.3.2. The requirements traceability matrix links requirements to their origin and tracks them throughout the project life cycle.

5.5.1.5 Validated Deliverables

Described in Section 8.3.3.3. Validated deliverables are completed and checked for correctness through the Control Quality process.

5.5.1.6 Work Performance Data

Described in Section 4.3.3.2. Work performance data can include the degree of compliance with requirements, number of nonconformities, severity of the nonconformities, or the number of validation cycles performed in a period of time.

5.5.2 Validate Scope: Tools and Techniques

5.5.2.1 Inspection

Inspection includes activities such as measuring, examining, and validating to determine whether work and deliverables meet requirements and product acceptance criteria. Inspections are sometimes called reviews, product reviews, audits, and walkthroughs. In some application areas, these different terms have unique and specific meanings.

5.5.2.2 Group Decision-Making Techniques

Described in Section 5.2.2.5. These techniques are used to reach a conclusion when the validation is performed by several persons.

5.5.3 Validate Scope: Outputs

5.5.3.1 Accepted Deliverables

Deliverables that meet the acceptance criteria are formally signed off and approved by the customer or sponsor. Formal documentation received from the customer or sponsor acknowledging formal stakeholder acceptance of the project's deliverables is forwarded to the Close Project or Phase process (Section 4.6).

5.5.3.2 Change Requests

The completed deliverables that have not been formally accepted are documented, along with the reasons for nonacceptance. Those deliverables may require a change request for defect repair. The change requests are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).

5.5.3.3 Work Performance Information

Work performance information includes information about project progress, such as which deliverables have started, their progress, and which deliverables have finished or which have been accepted. This information is documented and communicated to stakeholders as

described in Section 10.3.3.1.

5.5.3.4 Project Documents Updates

Project documents that may be updated as a result of the Validate Scope process include any documents that define the product or report status on product completion. Validated project documents may require approvals from the customer or sponsor in the form of signatures or signoffs.

5.6 Control Scope

Control Scope is the process of monitoring the status of the project and product scope and managing changes to the scope baseline. The key benefit of this process is that it allows the scope baseline to be maintained throughout the project. The inputs, tools and techniques, and outputs of this process are depicted in Figure 5-16. Figure 5-17 depicts the data flow diagram of the process.

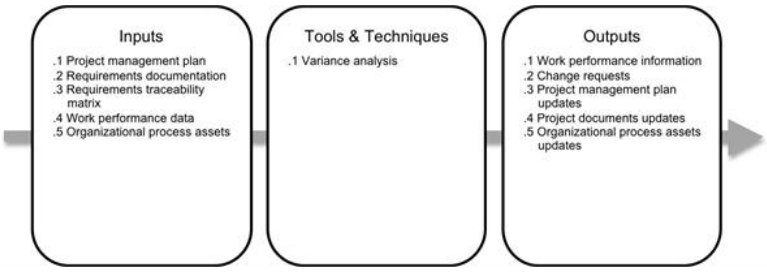


Figure 5-16. Control Scope: Inputs, Tools & Techniques, and Outputs

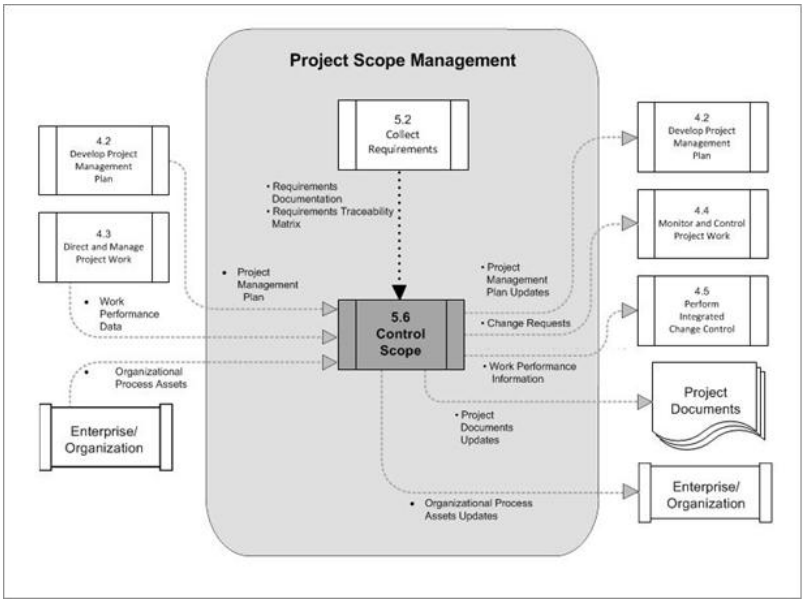


Figure 5-17. Control Scope Data Flow Diagram

Controlling the project scope ensures all requested changes and recommended corrective or preventive actions are processed through the Perform Integrated Change Control process (see Section 4.5). Control Scope is also used to manage the actual changes when they occur and is integrated with the other control processes. The uncontrolled expansion to product or project scope without adjustments to time, cost, and resources is often referred to as project scope creep. Change is inevitable, thereby mandating some type of change control process.

5.6.1 Control Scope: Inputs

5.6.1.1 Project Management Plan

Described in Section 4.2.3.1. The following information from the project management plan is used to control scope:

- **Scope baseline.** The scope baseline is compared to actual results to determine if a change, corrective action, or preventive action is necessary.
- **Scope management plan.** Sections from the scope management plan describe how the project scope will be monitored and controlled.
- **Change management plan.** The change management plan defines the process for managing change on the project.

- **Configuration management plan.** The configuration management plan defines those items that are configurable, those items that require formal change control, and the process for controlling changes to such items.
- **Requirements management plan.** This plan is a component of the project management plan that describes how the project requirements will be analyzed, documented, and managed.

5.6.1.2 Requirements Documentation

Described in Section 5.2.3.1. Requirements must be unambiguous (measurable and testable), traceable, complete, consistent, and acceptable to key stakeholders. Well-documented requirements make it easier to detect any deviation in the scope agreed for the project or product.

5.6.1.3 Requirements Traceability Matrix

Described in Section 5.2.3.2. The requirements traceability matrix helps to detect the impact of any change or deviation from the scope baseline on the project objectives.

5.6.1.4 Work Performance Data

Described in Section 4.3.3.2. Work performance data can include the number of change requests received, the number of requests accepted or the number of deliverables completed, etc.

5.6.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Control Scope process include but are not limited to:

- Existing formal and informal scope control-related policies, procedures, guidelines; and
- Monitoring and reporting methods to be used.

5.6.2 Control Scope: Tools and Techniques

5.6.2.1 Variance Analysis

Variance analysis is a technique for determining the cause and degree of difference between the baseline and actual performance. Project performance measurements are used to assess the magnitude of variation from the original scope baseline. Important aspects of project scope control include determining the cause and degree of variance relative to the scope baseline (Section 5.4.3.1) and deciding whether corrective or preventive action is required.

5.6.3 Control Scope: Outputs

5.6.3.1 Work Performance Information

Work performance information produced can include the categories of the changes received, their source, or how they can impact schedule or cost.

5.6.3.2 Change Requests

Analysis of scope performance can result in a change request to the scope baseline or other components of the project management plan. Change requests can include preventive or corrective actions, defect repairs, or enhancement requests. Change requests are processed for review and disposition according to the Perform Integrated Change Control process (Section 4.5).

5.6.3.3 Project Management Plan Updates

Project management plan updates may include, but are not limited to:

- **Scope Baseline Updates.** If the approved change requests have an effect on the project scope, then the scope statement, the WBS, and the WBS dictionary are revised and reissued to reflect the approved changes.
- **Other Baseline Updates.** If the approved change requests have an effect on the project aside from the project scope, then the corresponding cost baseline and schedule baselines are revised and reissued to reflect the approved changes.

5.6.3.4 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Requirements documentation, and

- Requirements traceability matrix.

5.6.3.5 Organizational Process Assets Updates

Organizational process assets that may be updated include, but are not limited to:

- Causes of variances,
- Corrective action chosen and the reasons, and
- Other types of lessons learned from project scope control.

CHAPTER 6

PROJECT TIME MANAGEMENT

Project Time Management includes the processes required to manage the timely completion of the project. Figure 6-1 provides an overview of the Project Time Management processes, which are as follows:

6.1 Plan Schedule Management—The process of establishing the policies, procedures, and documentation for planning, executing, and controlling the project schedule.

6.2 Define Activities—The process of identifying the specific actions to be performed to produce the project deliverables.

6.3 Sequence Activities—The process of identifying and documenting relationships among the project activities.

6.4 Estimate Activity Resources—The process of estimating the type and quantities of material, people, equipment, or supplies required to perform each activity.

6.5 Estimate Activity Durations—The process of estimating the number of work periods needed to complete individual activities with estimated resources.

6.6 Develop Schedule—The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model.

6.7 Control Schedule—The process of monitoring the status of the project to update project progress and managing changes to the schedule baseline.

These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.

Some practitioners distinguish the printed project schedule information (schedule) from the schedule data and calculations that produce the schedule, by referring to the scheduling engine populated with project data as the schedule model. A schedule model is a representation of the plan for executing the project's activities including durations, dependencies and other planning information, used to produce project schedules along with other scheduling artifacts. This text uses the terms schedule or schedule model, as appropriate.

On some projects, especially those of smaller scope, defining activities, sequencing activities, estimating activity resources, estimating activity durations, and developing the schedule model 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.

The work involved in performing Project Time Management begins with the planning effort by the project management team through the Develop Project Management Plan process (see Section 4.2). This planning effort is also part of the Plan Schedule Management process (Section 6.1). The schedule management plan identifies a scheduling methodology and scheduling tool, and sets the format and establishes criteria for developing and controlling the project schedule. A scheduling methodology defines the rules and approaches for the scheduling process. Some of the better known methodologies include critical path method (CPM) and critical chain method (CCM).

The Project Time Management processes and their associated tools and techniques are documented in the schedule management plan. The schedule management plan is a component of the project management plan, and may be formal or informal, highly detailed or broadly framed, based upon the needs of the project, and includes appropriate control thresholds.

Developing the project schedule model uses the outputs from the processes to define activities, sequence activities, estimate activity resources, and estimate activity durations in combination with the scheduling tool to produce the schedule model. The finalized and approved schedule is the baseline that will be used in the Control Schedule process (Section 6.7). As the project activities are being performed, the majority of effort in the Project Time Management Knowledge Area will occur in the Control Schedule process to ensure completion of project work in a timely manner. Figure 6-2 provides a scheduling overview that shows how the scheduling methodology, scheduling tool, and outputs from the Project Time Management processes interact to create a project schedule.

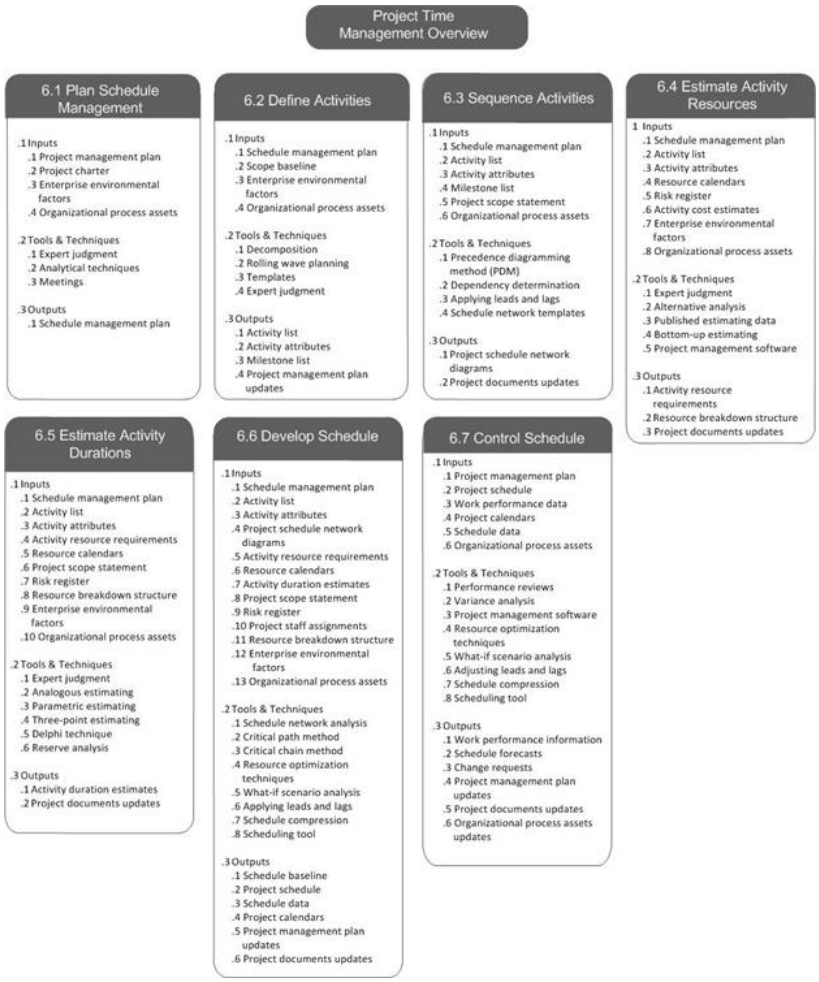


Figure 6-1. Project Time Management Overview

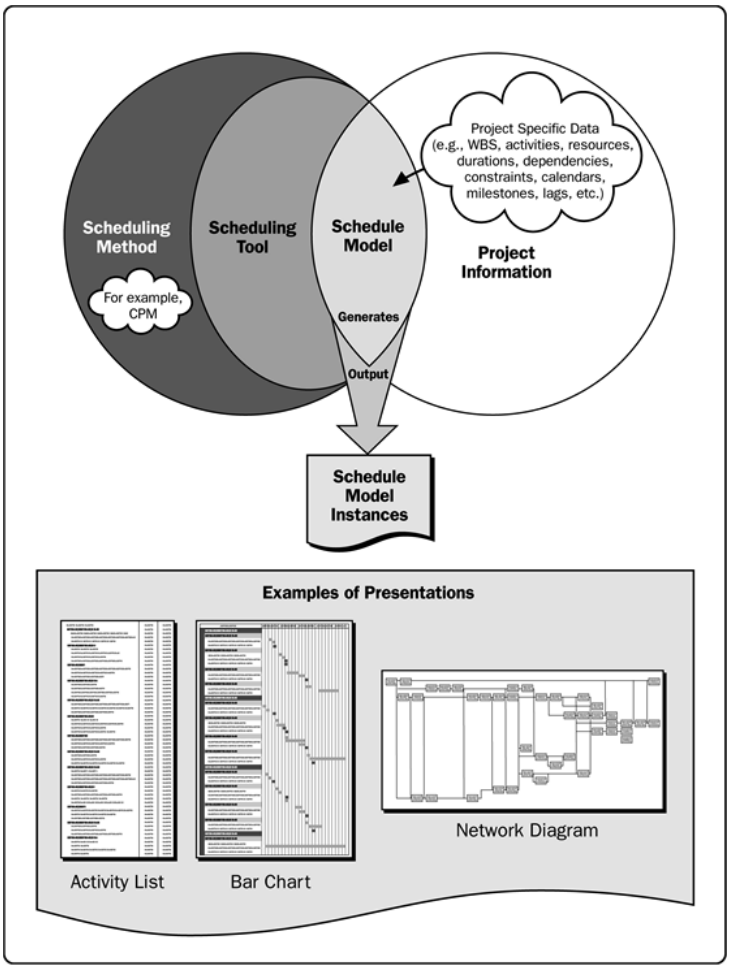


Figure 6-2. Scheduling Overview

6.1 Plan Schedule Management

Plan Schedule Management is the process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule. The key benefit of this process is that it ensures that the schedule management processes and their associated tools and techniques are documented. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-3. Figure 6-4 depicts the data flow diagram of the process.

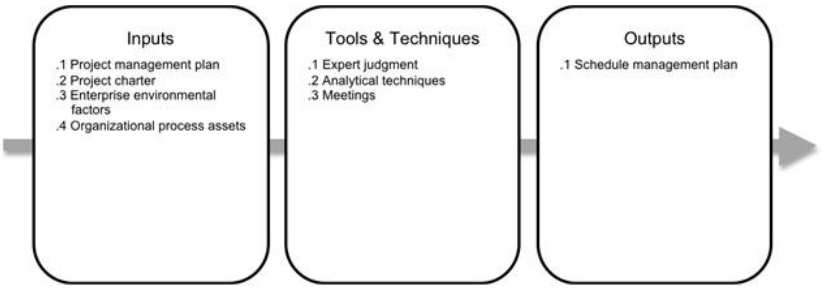


Figure 6-3. Plan Schedule Management: Inputs, Tools & Techniques, and Outputs

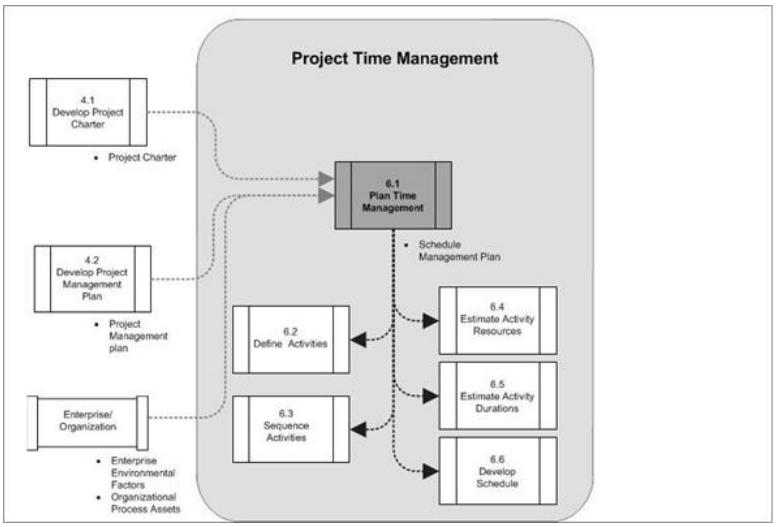


Figure 6-4. Plan Schedule Management Data Flow Diagram

The schedule management plan is a component of the project management plan. The schedule management plan may be formal or informal, highly detailed or broadly framed, based upon the needs of the project, and includes appropriate control thresholds. The schedule management plan defines how schedule contingencies will be reported and assessed. The schedule management plan may be updated to reflect a change in the way the schedule is managed.

6.1.1 Plan Schedule Management: Inputs

6.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan contains information used to develop the schedule management plan which includes, but is not limited to:

- **Scope baseline.** The scope baseline will define the work breakdown structure (WBS) detail for duration estimation and management; and
- **Other information.** Other scheduling related cost, risk, and communications decisions from the project management plan are used to develop the schedule.

6.1.1.2 Project Charter

Described in Section 4.1.3.1. The project charter defines the project approval requirements that will influence the management of the project schedule.

6.1.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that influence the Plan Schedule Management process include, but are not limited to:

- Organizational culture, structure, and processes can all influence schedule management;
- Resource availability and skills that may influence schedule planning;
- Published commercial information such as resource productivity information is often available from commercial databases that track; and
- Company work authorization systems.

6.1.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Plan Schedule Management process include, but are not limited to:

- Monitoring and reporting tools to be used;
- Historical information;
- Schedule control tools;
- Existing formal and informal schedule control related policies, procedures, and guidelines;
- Project management software provides the scheduling tool and alternative possibilities for managing the schedule;
- Templates;
- Project closure guidelines;
- Change control procedures; and
- Risk control procedures.

6.1.2 Plan Schedule Management: Tools and Techniques

6.1.2.1 Expert Judgment

Expert judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects. Expert judgment can also suggest whether to combine methods and how to reconcile differences between them. Judgment based upon expertise in an application area, Knowledge Area, discipline, industry, etc., as appropriate for the activity being performed, should be used in developing the schedule management plan.

6.1.2.2 Analytical Techniques

The Plan Schedule Management process may involve choosing strategic options to estimate and schedule the project such as: scheduling methodology, scheduling tools and techniques, estimating approaches, formats, and project management software. The schedule management plan may also detail ways to fast track or crash the project schedule such as undertaking work in parallel. These decisions, like other schedule decisions affecting the project, may affect project risks.
Organizational policies and procedures may influence which scheduling techniques are employed in these decisions. Techniques may include, but are not limited to, rolling wave planning, applying leads and lags, alternatives analysis, and variance analysis.

6.1.2.3 Meetings

Project teams may hold planning meetings to develop the schedule management plan. Participants at these meetings may include the project manager, the project sponsor, selected project team members, selected stakeholders, anyone with responsibility for schedule planning or execution, and others as needed.

6.1.3 Plan Schedule Management: Outputs

6.1.3.1 Schedule Management Plan

A component of the project management plan that establishes the criteria and the activities for developing, monitoring, and controlling the schedule. The schedule management plan may be formal or informal, highly detailed or broadly framed, based upon the needs of the project.
For example, the schedule management plan can establish the following:

- **Project schedule model development.** The scheduling methodology and the scheduling tool to be used in the development of the project schedule model;
- **Level of accuracy**. Activity duration estimates will adhere to a rounding of the data to a prescribed precision (e.g., one day), 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 (such as staff hours, staff days, or weeks. is defined for each of the resources;
- **Organizational procedures links.** The WBS (Section 5.4) provides the framework for the schedule management plan, allowing for consistency with the estimates and resulting schedules;
- **Control thresholds.** Variance thresholds for monitoring schedule performance may be specified to indicate an agreed-upon amount of variation to be allowed before some action needs to be taken. Thresholds are typically expressed as percentage deviations from the baseline plan;
- **Rules of performance measurement.** Earned value management (EVM) rules of performance measurement are set. For example, the schedule management plan may specify:
    - WBS points at which management of progress and schedule will be measured,
    - Earned value measurement techniques (e.g., baselines, fixed-formula, percent complete, etc.) to be employed (for more specific information, refer to the *Practice Standard for Earned Value Management*),
    - Schedule performance measurements such as schedule variance (SV) and schedule performance index (SPI) used to assess the magnitude of variation to the original schedule baseline.
- **Reporting formats.** The formats and frequency for the various schedule reports are defined; and
- **Process descriptions.** Descriptions of each of the other schedule management processes are documented.

6.2 Define Activities

Define Activities is the process of identifying the specific actions to be performed to produce the project deliverables. The key benefit of this process is that the defined activities provide a basis for estimating, scheduling, executing, monitoring, and

controlling the project work. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-5. Figure 6-6 depicts the data flow diagram of the process.

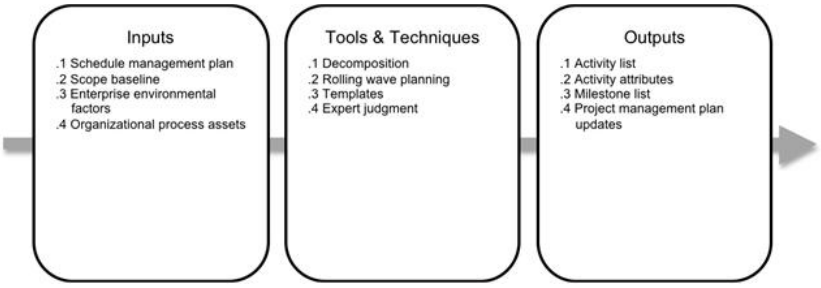


Figure 6-5. Define Activities: Inputs, Tools & Techniques, and Outputs

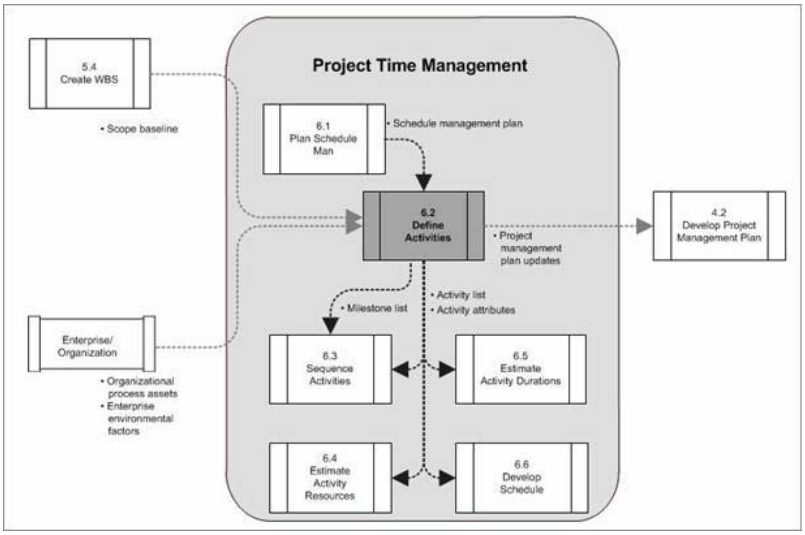


Figure 6-6. Define Activities Data Flow Diagram

Implicit in this process are defining and planning the schedule activities such that the project objectives will be met. The Create WBS process identifies the deliverables at the lowest level in the WBS—the work package. Work packages are typically decomposed into smaller components called activities that represent the work necessary to complete the work package.

6.2.1 Define Activities: Inputs

6.2.1.1 Schedule Management Plan

Described in Section 6.1.3.1. A key input from the schedule management plan is the prescribed level of detail necessary to manage the work.

6.2.1.2 Scope Baseline

Described in Section 5.4.3.1. The project deliverables, constraints, and assumptions documented in the project scope baseline are considered explicitly while defining activities.

6.2.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors that influence the Define Activities process include, but are not limited to:

- Project management information systems (PMIS);
- Organizational culture, structure, and processes;
- Published commercial information from commercial databases;
- Project Management Information Systems (PMIS); and
- Existing formal and informal activity planning-related policies, procedures, and guidelines, such as the scheduling methodology, that are considered in developing the activity definitions.

6.2.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the

Define Activities process include, but are not limited to: lessons learned knowledge base containing historical information regarding activities lists used by previous similar projects.

6.2.2 Define Activities: Tools and Techniques

6.2.2.1 Decomposition

Decomposition is a technique used for dividing and subdividing the project scope and project deliverables into smaller, more manageable parts. Activities represent the effort needed to complete a work package. The Define Activities process defines the final outputs as activities rather than deliverables, as done in the Create WBS process (Section 5.4). The activity list, WBS, and WBS dictionary can be developed either sequentially or concurrently, with the WBS and WBS dictionary as the basis for development of the final activity list. Each work package within the WBS is decomposed into the activities required to produce the work package deliverables. Involving team members in the decomposition can lead to better and more accurate results.

6.2.2.2 Rolling Wave Planning

Rolling wave planning is an iterative planning technique in which the work to be accomplished in the near term is planned in detail, while the work in the future is planned at a more general level. It is a form of progressive elaboration. Therefore, work can exist at various levels of detail depending on where it is in the project life cycle. For example, agile project management, originating in software development, uses iterative planning as a progression of rolling wave planning. The agile project team utilizes CPM scheduling for each development cycle (iteration). Agile project management focuses on shorter development cycles and tangible results for each iteration; the focus is on creating value instead of completing activities.
During early strategic planning, when information is less defined, work packages may be decomposed to the milestone level. As more is known about the upcoming events in the near term, it can be decomposed into activities.

6.2.2.3 Templates

A standard activity list or a portion of an activity list from a previous project is often usable as a template for a new project. The related activity attributes information in the templates can also contain other descriptive information useful in defining activities. Templates can also be used to identify typical schedule milestones.

6.2.2.4 Expert Judgment

Project team members or other experts, who are experienced and skilled in developing detailed project scope statements, the WBS, and project schedules, can provide expertise in defining activities.

6.2.3 Define Activities: Outputs

6.2.3.1 Activity List

The activity list is a comprehensive list that includes all schedule activities required on the project. The activity list also includes the activity identifier and a scope of work description for each activity in sufficient detail to ensure that project team members understand what work is required to be completed. Each activity should have a unique title that describes its place in the schedule, even if that activity is presented in another environment.

6.2.3.2 Activity Attributes

Activities, distinct from milestones, have durations, during which the work of that activity is performed, and may have resources and costs associated with that work. Activity attributes extend the description of the activity by identifying the multiple components associated with each activity. The components for each activity evolve over time. During the initial stages of the project, they include the activity identifier (ID), WBS ID, and activity label, and when completed, may include activity codes, activity description, predecessor activities, successor activities, logical relationships, leads and lags (Section 6.3.2.3), resource requirements, imposed dates, constraints, and assumptions. Activity attributes can be used to identify the person responsible for executing the work, geographic area, or place where the work has to be performed, and activity type such as level of effort (LOE), discrete effort, and apportioned effort (AE). Activity attributes are used for 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.

6.2.3.3 Milestone List

A milestone is a significant point or event in the project. A milestone does not have any duration, resources, or cost because it represents a moment in time. A milestone list identifies all milestones and indicates whether the milestone is mandatory, such as those required by contract, or optional, such as those based upon historical information. Milestones are similar to regular schedule activities, with the same structure and attributes, but they have zero duration.

6.2.3.4 Project Management Plan Updates

As a result of Define Activities, changes to scope or requirements may be discovered that will impact a number of elements of the project management plan. Updates to the project management plan may include changes to scope and cost baselines, risk management decisions, communications management plan, and stakeholder management.

6.3 Sequence Activities

Sequence Activities is the process of identifying and documenting relationships among the project activities. The key benefit of this process is that it documents the logical sequence of work to obtain the greatest efficiency given all project constraints. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-7. Figure 6-8 depicts the data flow diagram of the process.

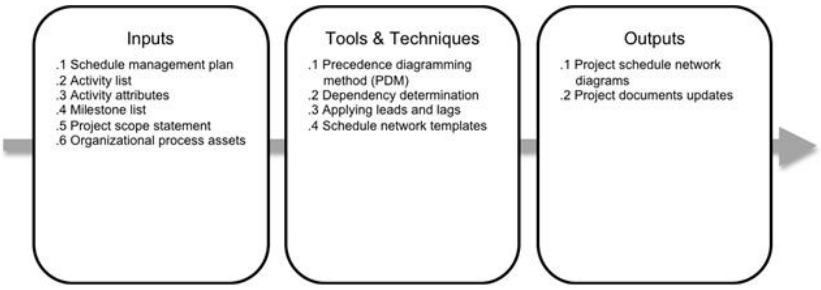


Figure 6-7. Sequence Activities: Inputs, Tools & Techniques, and Outputs

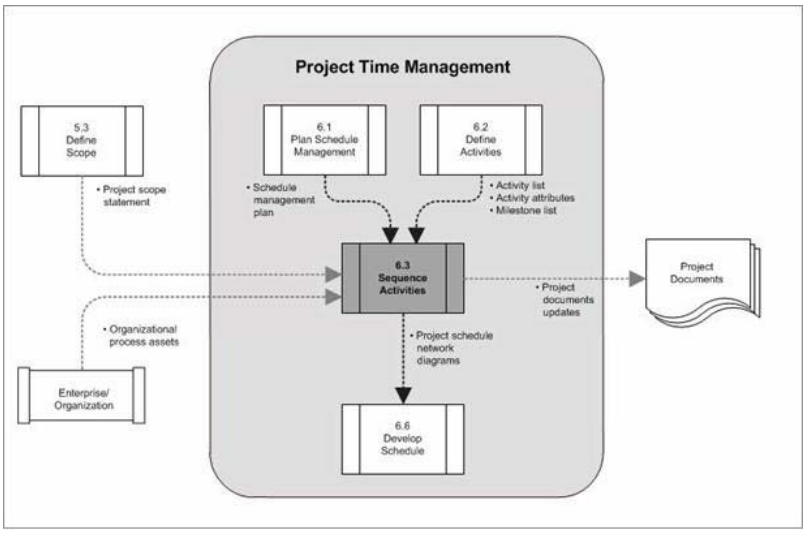


Figure 6-8. Sequence Activities Data Flow Diagram

Ideally, every activity and milestone except the first and last are connected to at least one predecessor and one successor. There may be milestones or deliverables that are set in a zone of the schedule for display purposes that do not need successors if their predecessors have the correct logic. It may be necessary to use lead or lag time between activities to support a realistic and achievable project schedule. Sequencing can be performed by using project management software or by using manual or automated techniques.

6.3.1 Sequence Activities: Inputs

6.3.1.1 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan identifies the scheduling method and tool to be used for the project, which will guide how the activities may be sequenced.

6.3.1.2 Activity List

Described in Section 6.2.3.1. The activity list contains all schedule activities required on the project, which must be sequenced.

6.3.1.3 Activity Attributes

Described in Section 6.2.3.2. Activity attributes may describe a necessary sequence of events or defined predecessor or successor relationships.

6.3.1.4 Milestone List

Described in Section 6.2.3.3. The milestone list may have scheduled dates for specific milestones, which may influence the way activities are sequenced.

6.3.1.5 Project Scope Statement

Described in Section 5.3.3.1. The project scope statement contains the product scope description, which includes product characteristics that may 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.

6.3.1.6 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Sequence Activities process include, but are not limited to, project files from the corporate knowledge base used for scheduling methodology.

6.3.2 Sequence Activities: Tools and Techniques

6.3.2.1 Precedence Diagramming Method

The precedence diagramming method is a technique used for constructing a schedule model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the sequence in which the activities are to be performed. This technique is also called activity-on-node (AON), and is the method used by most project management software packages. This process usually starts at the beginning of the project. Figure 6-9 shows the difference between different dependencies of the PDM. PDM includes four types of dependencies or logical relationships. A predecessor activity is an activity that logically comes before a dependent activity in a schedule. A successor activity is a dependent activity that logically comes after another activity in a schedule. These relationships are defined below and are illustrated in Figure 6-9:

- **Finish-to-start (FS).** A logical relationship in which a successor activity cannot start until a predecessor activity has finished. Example: A running race cannot commence (successor) until the referee signals (predecessor) the start.
- **Finish-to-finish (FF).** A logical relationship in which a successor activity cannot finish until a predecessor activity has finished. Example: While building a house, painting (predecessor) must finish before interior work can finish (successor).
- **Start-to-start (SS).** A logical relationship in which a successor activity cannot start until a predecessor activity has started. Example: Level concrete (successor) cannot begin until pour foundation (predecessor) begins.
- **Start-to-finish (SF).** A logical relationship in which a successor activity cannot finish until a predecessor activity has started. Example: Tickets to a concert can be sold (successor) until fixed concert day (predecessor).

In PDM, finish-to-start is the most commonly used type of precedence relationship. The start-to-finish relationship is very rarely used but is included here for a complete list of the PDM relationship types.

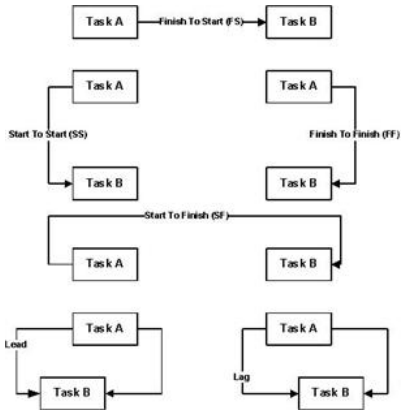


Figure 6-9. Precedence Diagramming Method (PDM) Relationship Types, Lead and Lag

6.3.2.2 Dependency Determination

Dependencies may be characterized by the following attributes: internal or external, mandatory or discretionary. Dependency has four attributes, but two can be applicable at the same time:

- **Mandatory dependencies.** Mandatory dependencies are those that are contractually required or inherent in the nature of the work. 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. Technical dependencies may not be mandatory. The project team determines which dependencies are mandatory during the process of sequencing the activities.
- **Discretionary dependencies.** Discretionary dependencies are sometimes referred to as preferred logic, preferential logic, or soft logic. Discretionary dependencies are 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 may be other acceptable sequences. Discretionary dependencies should be fully documented since they can create arbitrary total float values and can limit later scheduling options. When fast tracking techniques are employed, these discretionary dependencies should be reviewed and considered for modification or removal. The project team determines which dependencies are discretionary during the process of sequencing the activities.
- **External dependencies.** External dependencies involve a relationship between project activities and nonproject activities. These dependencies are usually outside the project team's control. For example, the testing activity in a software project may be dependent on the 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. The project management team determines which dependencies are external during the process of sequencing the activities.
- **Internal dependencies.** Internal dependencies involve a relationship that is internal to the company and/or project. These dependencies may be outside the project team's control. For example, if the team cannot test a machine until they put it together, this is an internal mandatory dependency. The project management team determines which dependencies are internal during the process of sequencing the activities.

6.3.2.3 Applying Leads and Lags

A lead is the amount of time whereby a successor activity can be advanced with respect to a predecessor activity. For example, on a project to construct a new office building, the landscaping could be scheduled to start two weeks prior to the scheduled punch list completion. This would be shown as a finish-to-start with a two-week lead. Lead is often represented as a negative value for lag in scheduling software.

A lag is the amount of time whereby a successor activity needs to be delayed with respect to a predecessor activity. For example, a technical writing team may begin editing the draft of a large document 15 days after they begin writing it. This can be shown as a start-to-start relationship with a 15-day lag.

The project management team determines the dependencies that may require a lead or a lag to accurately define the logical relationship. The use of leads and lags should not replace schedule logic. Activities and their related assumptions should be documented.

6.3.2.4 Schedule Network Templates

Standardized schedule network diagram templates are used to expedite the preparation of networks of project 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.

6.3.3 Sequence Activities: Outputs

6.3.3.1 Project Schedule Network Diagrams

A project schedule network diagram is a graphical representation of the logical relationships, also referred to as dependencies, among the project schedule activities. Figure 6-10 illustrates a project schedule network diagram. A project schedule network diagram is produced manually or by using project management software. It can include full project details, or have one or more summary activities. A summary narrative can accompany the diagram and describe the basic approach used to sequence the activities. Any unusual activity sequences within the network should be fully described within the narrative.

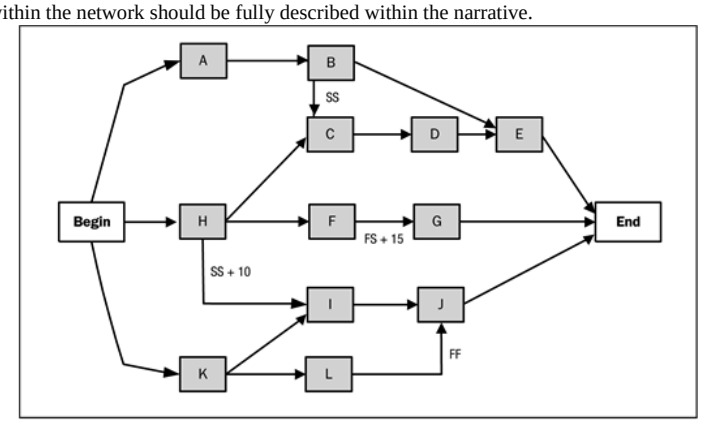


Figure 6-10. Project Schedule Network Diagram

6.3.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Activity lists,
- Activity attributes, and
- Risk register.

6.4 Estimate Activity Resources

Estimate Activity Resources is the process of estimating the type and quantities of material, people, equipment, or supplies required to perform each activity. The key benefit of this process is that it identifies the type, quantity, and characteristics of resources required to complete the activity which allows more accurate cost and duration estimates. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-11. Figure 6-12 depicts the data flow diagram of the process.

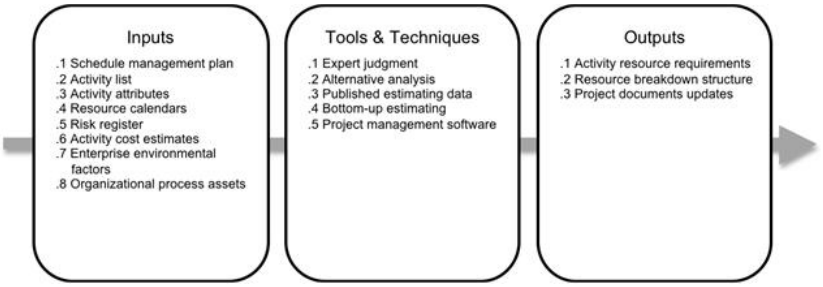


Figure 6-11. Estimate Activity Resources: Inputs, Tools & Techniques, and Outputs

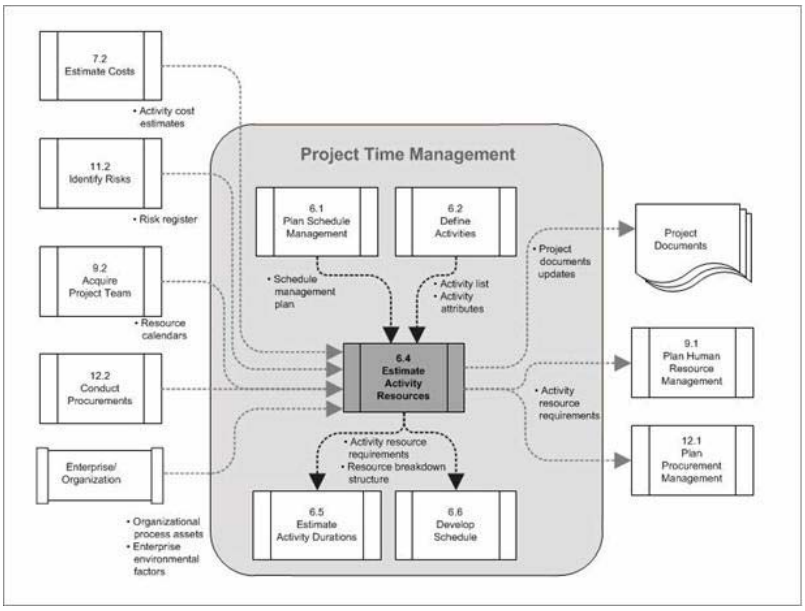


Figure 6-12. Estimate Activity Resources Data Flow Diagram

The Estimate Activity Resources process is closely coordinated with the Estimate Costs process (Section 7.2). 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 may 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.

6.4.1 Estimate Activity Resources: Inputs

6.4.1.1 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan identifies the level of accuracy and the units of measure for the resources to be estimated.

6.4.1.2 Activity List

Described in Section 6.2.3.1. The activity list identifies the activities which will need resources.

6.4.1.3 Activity Attributes

Described in Section 6.2.3.2. The activity attributes provide the primary data input for use in estimating those resources required for each activity in the activity list.

6.4.1.4 Resource Calendars

Described in Sections 9.2.3.2 and 12.2.3.3. A resource calendar is a calendar that identifies the working days and shifts on which each specific resource is available. Information on which resources (such as people, equipment, and material) are potentially available during a planned activity period, is used for estimating resource utilization. Resource calendars specify when and how long identified project resources will be available during the project. This information may be at the activity or project level. This knowledge includes consideration of attributes such as resource experience and/or skill level, as well as various geographical locations from which the resources originate and when they may be available.
The composite resource calendar includes the availability, capabilities, and skills of human resources (Section 9.2.3.2). For example, during the early phases of an engineering design project, the pool of resources may include junior and senior engineers in large numbers. During later phases of the same project, however, the pool may be limited to those individuals who are knowledgeable about the project as a result of having worked on the earlier phases of the project.

6.4.1.5 Risk Register

Described in Section 11.2.3.1. Risk events that may impact resource selection and availability.

6.4.1.6 Activity Cost Estimates

Described in Section 7.2.3.1. The cost of resources may impact resource selection.

6.4.1.7 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Estimate Activity Resources process include, but are not limited to, resource availability and skills.

6.4.1.8 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Estimate Activity Resources process include, but are not limited to:

- Policies and procedures regarding staffing,
- Policies and procedures relating to rental and purchase of supplies and equipment, and
- Historical information regarding types of resources used for similar work on previous projects.

6.4.2 Estimate Activity Resources: Tools and Techniques

6.4.2.1 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.

6.4.2.2 Alternative 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 rent-or-buy decisions regarding the resource (Section 12.2.3.3).

6.4.2.3 Published Estimating Data

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

6.4.2.4 Bottom-Up Estimating

Bottom-up estimating is a method of estimating project duration or cost by aggregating the estimates of the lower-level components of the WBS. When an activity cannot be estimated with a reasonable degree of confidence, the work within the activity is decomposed into more detail. The resource needs are estimated. These estimates are then aggregated into a total quantity for each of the activity's resources. Activities may or may not have dependencies between them that can affect the application and use of resources. If there are dependencies, this pattern of resource usage is reflected and documented in the estimated requirements of the activity.

6.4.2.5 Project Management Software

Project management software has the capability to help plan, organize, and manage resource pools and develop resource estimates. Depending on the sophistication of the software, resource breakdown structures, resource availability, resource rates and various resource calendars can be defined to assist in optimizing resource utilization.

6.4.3 Estimate Activity Resources: Outputs

6.4.3.1 Activity Resource Requirements

Estimate activity resource requirements identifies the types and quantities of resources required for each activity in a work package. These requirements then can be aggregated to determine the estimated resources for each work package and each work period. 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 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 quantities are used.

6.4.3.2 Resource Breakdown Structure

The resource breakdown structure is a hierarchical representation of resources by category and type. Examples of resource categories include labor, material, equipment, and supplies. Resource types may include the skill level, grade level, or other information as appropriate to the project. The resource breakdown structure is useful for organizing and reporting project schedule data with resource utilization information.

6.4.3.3 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Activity list,
- Activity attributes, and
- Resource calendars.

6.5 Estimate Activity Durations

Estimate Activity Durations is the process of approximating the number of work periods needed to complete the individual project activities utilizing the estimated resources. The key benefit of this process is that it provides the amount of time each activity will take to complete, which is a major input into the Develop Schedule process. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-13. Figure 6-14 depicts the data flow diagram of the process.

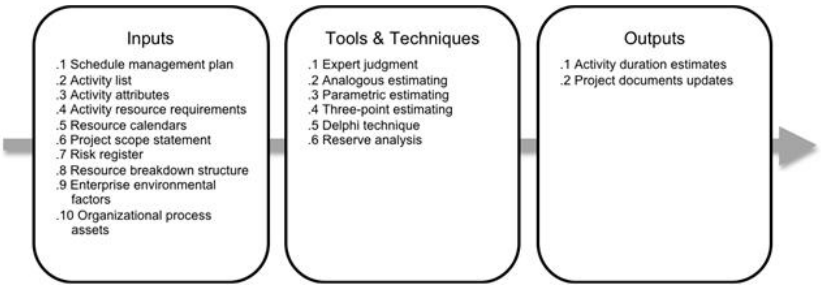


Figure 6-13. Estimate Activity Durations: Inputs, Tools & Techniques, and Outputs

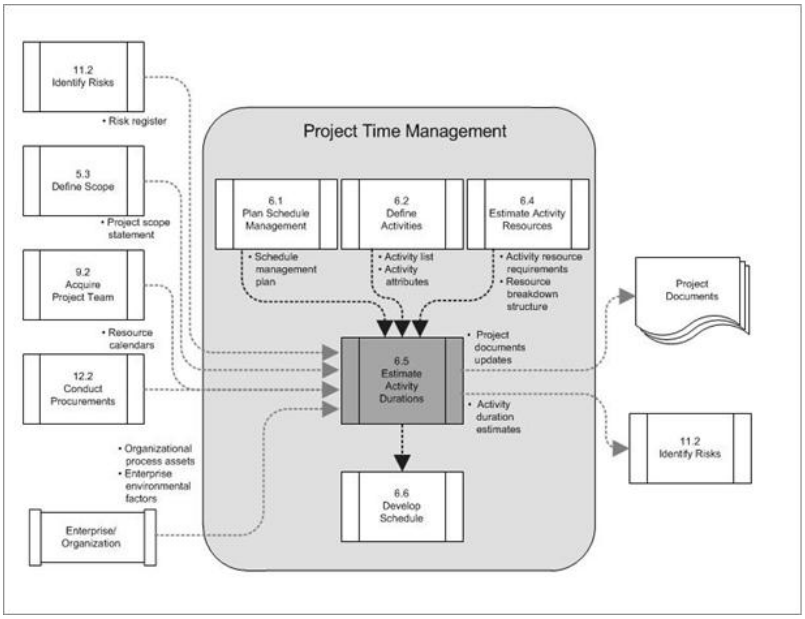


Figure 6-14. Estimate Activity Durations Data Flow Diagram

Estimating activity durations uses information on activity scope of work, required resource types, estimated resource quantities, and resource calendars. The inputs of the estimates of activity duration originate from the person or group on the project team who is most familiar with the nature of the work in the specific activity. The duration estimate is progressively elaborated, and the process considers the quality and availability of the input data. For example, as the project engineering and design work evolves, more detailed and precise data is available, and the accuracy of the duration estimates improves. Thus, the duration estimate can be assumed to be progressively more

accurate and of better quality.
The Estimate Activity Durations process requires that the amount of work effort required to complete the activity is estimated and the amount of resources available to be applied to complete the activity is estimated. These estimates are used to approximate the number of work periods (activity duration) needed to complete the activity. All data and assumptions that support duration estimating are documented for each estimate of activity duration.
Most project management software for scheduling handles this situation by using a project calendar and alternative work-period resource calendars, which are usually identified by the resources that require specific work periods. In addition to the sequencing logic, the activities will be performed according to the project calendar and the appropriate resource calendars.

6.5.1 Estimate Activity Durations: Inputs

6.5.1.1 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan defines the method used and the level of accuracy required to estimate activity durations.

6.5.1.2 Activity List

Described in Section 6.2.3.1. The activity list identifies the activities that will need duration estimates.

6.5.1.3 Activity Attributes

Described in Section 6.2.3.2. The activity attributes provide the primary data input for use in estimating durations required for each activity in the activity list.

6.5.1.4 Activity Resource Requirements

Described in Section 6.4.3.1. The estimated activity resource requirements will have an effect on the duration of the activity, since the resources assigned to the activity and the availability of those resources will significantly influence the duration of most activities. For example, if additional or lower-skilled resources are assigned to an activity, there may be reduced efficiency or productivity due to increased communication, training, and coordination needs leading to a longer duration estimate.

6.5.1.5 Resource Calendars

Described in Section 6.4.1.4. The resource calendars influence the duration of schedule activities. For example, when a senior and a junior staff member are assigned to a project on a full-time basis, a senior staff member can generally be expected to complete a given activity in less time than a junior staff member.

6.5.1.6 Project Scope Statement

Described in Section 5.3.3.1. The constraints and assumptions from the project scope statement are considered when estimating the activity durations. Examples of assumptions include, but are not limited to:

- Existing conditions,
- Availability of information, and
- Length of the reporting periods.

Examples of constraints include, but are not limited to:

- Available skilled resources, and
- Contract terms and requirements.

6.5.1.7 Risk Register

Described in Section 11.2.3.1. The risk register provides the list of risks, along with the results of risk analysis and risk response planning. Examples of information used includes:

- Risks,
- Assumptions, and
- Constraints.

6.5.1.8 Resource Breakdown Structure

Described in Section 6.4.3.2. The resource breakdown structure provides a hierarchical structure of the identified resources by resource category and resource type.

6.5.1.9 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Estimate Activity Durations process include, but are not limited to:

- Duration estimating databases and other reference data,
- Productivity metrics, and
- Published commercial information.

6.5.1.10 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Estimate Activity Durations process include, but are not limited to:

- Historical duration information,
- Project calendars,
- Scheduling methodology, and
- Lessons learned.

6.5.2 Estimate Activity Durations: Tools and Techniques

6.5.2.1 Expert Judgment

Expert judgment, guided by historical information, can provide duration estimate information or recommended maximum activity durations from prior similar projects. Expert judgment can also be used to determine whether to combine methods of estimating and how to reconcile differences between them.

6.5.2.2 Analogous Estimating

Analogous estimating is a technique for estimating the duration or cost of an activity or a project using historical data from a similar activity or project. Analogous estimating uses parameters from a previous, similar project, such as duration, budget, size, weight, and complexity, as the basis for estimating the same parameter or measure for a future project. When estimating durations, this technique relies on the actual duration of previous, similar projects as the basis for estimating the duration of the current project. It is a gross value estimating approach, sometimes adjusted for known differences in project complexity. Analogous duration estimating is frequently used to estimate project duration when there is a limited amount of detailed information about the project. Analogous estimating is generally less costly and time consuming than other techniques, but it is also less accurate. Analogous duration estimates can be applied to a total project or to segments of a project and may be used in conjunction with other estimating methods. Analogous 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.

6.5.2.3 Parametric Estimating

Parametric estimating is an estimating technique in which an algorithm is used to calculate cost or duration based on historical data and project parameters. Parametric estimating uses a statistical relationship between historical data and other variables (e.g., square footage in construction) to calculate an estimate for activity parameters, such as cost, budget, and duration.
Activity durations can be quantitatively determined by multiplying the quantity of work to be performed by labor hours per unit of work. For example, activity duration on a design project is estimated by the number of drawings multiplied by the number of labor hours per drawing, or on a cable installation, the meters of cable multiplied by the number of labor hours per meter. For example, if the assigned resource is capable of installing 25 meters of cable per hour, the duration required to install 1,000 meters is 40 hour. (1,000 meters divided by 25 meters per hour).
This technique can produce higher levels of accuracy depending upon the sophistication and underlying data built into the model. Parametric time estimates can be applied to a total project or to segments of a project, in conjunction with other estimating methods.

6.5.2.4 Three-Point Estimating

The accuracy of activity duration estimates may be improved by considering estimation uncertainty and risk. This concept originated with the program evaluation and review technique (PERT). PERT uses three estimates to define an approximate range for an activity's duration:

- **Most likely** (*tM*)**.** This estimate is based on the duration of the activity, given the resources likely to be assigned, their productivity, realistic expectations of availability for the activity, dependencies on other participants, and interruptions.
- **Optimistic** (*tO*). The activity duration is based on analysis of the best-case scenario for the activity.

• **Pessimistic** (*tP*). The activity duration is based on analysis of the worst-case scenario for the activity.

Duration estimates based on a simple average of the three points may provide more accuracy, and the three points clarify the range of uncertainty of the duration estimates. Common examples include, but are not limited to:

• **Simple Averaging.** Depending on the assumed distribution of values within the range, the expected time, *tE*, of the three estimates could be calculated using the following formula:

$tE = (tO + tM + tP) / 3$

• **Weighted Averaging.** PERT analysis calculates an Expected (*tE*) activity duration using a weighted average of these three estimates using the following formula:

$tE = (tO + 4tM + tP) / 6$

6.5.2.5 Delphi Technique

Team-based approaches, such as the Delphi technique, are useful for engaging team members to improve estimate accuracy and commitment to the emerging estimates. By involving people who are close to the technical execution of work in the estimation process, additional information is gained and more accurate estimates obtained. When people are involved in the estimation process, their commitment towards meeting the resulting estimates increases.

6.5.2.6 Reserve Analysis

Duration estimates may include contingency reserves, sometimes referred to as time reserves or buffers, into the overall project schedule to account for schedule uncertainty. Contingency reserves are the estimated duration within the schedule baseline, which is allocated for identified risks that are accepted and for which contingent or mitigation responses are developed. Contingency reserves may be estimated to account for this unknown amount of rework. Contingency reserves provide for a specific activity, for the whole project, or both. The contingency reserve may be a percentage of the estimated activity duration, a fixed number of work periods, or may be developed by using quantitative analysis methods such as Monte Carlo simulation (Section 11.4.2.2). As more precise information about the project becomes available, the contingency reserve may be used, reduced, or eliminated. Contingency should be clearly identified in schedule documentation.

Estimates may also be produced for the amount of management reserve of time for the project. Management reserves are a specified amount of the project duration withheld for management control purposes and are reserved for unforeseen work that is within scope of the project. Management reserves are intended to address the “unknown-unknowns” that can affect a project. Management reserve is not included in the schedule baseline, but it is part of the overall project duration requirements. Use of management reserves requires a change to the schedule baseline.

6.5.3 Estimate Activity Durations: Outputs

6.5.3.1 Activity Duration Estimates

Activity duration estimates are quantitative assessments of the likely number of work periods that are required to complete an activity. Duration estimates do not include any lags as described in Section 6.3.2.3. Activity duration estimates may include some indication of the range of possible results. For example:

• weeks ± 2 days, which indicates that the activity will take at least eight days and not more than twelve (assuming a five-day workweek); and

• 15 % probability of exceeding three weeks, which indicates a high probability—85 %—that the activity will take three weeks or less.

6.5.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to:

• Activity attributes; and

• Assumptions made in developing the activity duration estimate such as skill levels and availability.

6.6 Develop Schedule

Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model. The key benefit of this process is that it generates a schedule with planned dates for completing project activities by entering schedule activities, durations, resources, and their availabilities into the scheduling tool. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-15. Figure 6-16 depicts the data flow diagram of the process.

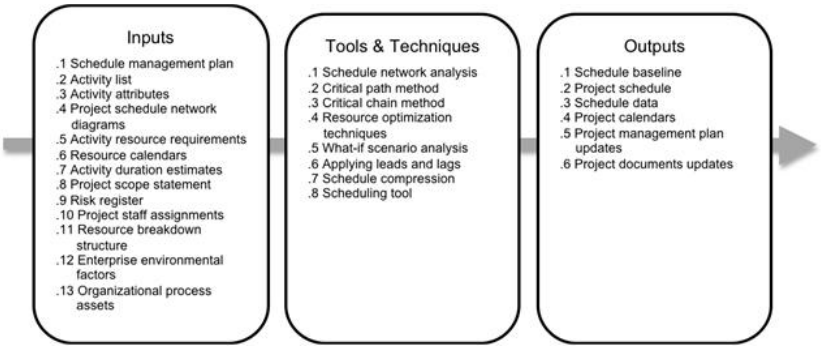


Figure 6-15 Develop Schedule: Inputs, Tools & Techniques, and Outputs

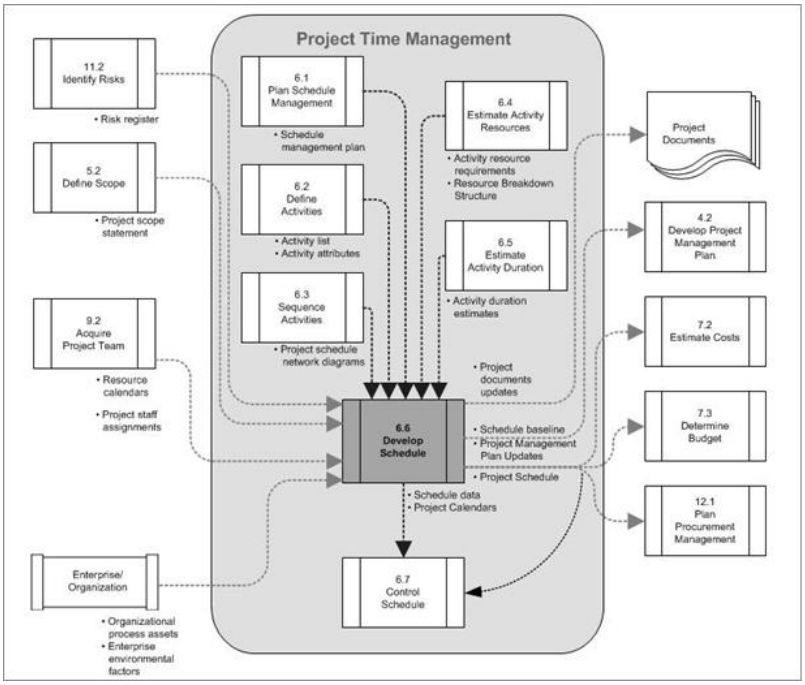


Figure 6-16. Develop Schedule Data Flow Diagram

Developing an acceptable project schedule is often an iterative process. It determines the planned start and finish dates for project activities and milestones, based on the accuracy of the inputs. Schedule development can require the review and revision of duration estimates and resource estimates to create the project schedule model to establish an approved project schedule that can serve as a baseline to track progress. Revising and maintaining the project schedule model to sustain a realistic schedule continue throughout the project as work progresses, the project management plan changes, and the nature of risk events evolves. For example, in an agile project management environment, the project team utilizes the project schedule model to develop schedules in each development cycle (iteration).

For more specific information regarding scheduling, refer to the *Practice Standard for Scheduling*.

6.6.1 Develop Schedule: Inputs

6.6.1.1 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan identifies the scheduling method and tool used to create the schedule, and how the schedule is to be calculated.

6.6.1.2 Activity List

Described in Section 6.2.3.1. The activity list identifies the activities that will be included in the schedule model.

6.6.1.3 Activity Attributes

Described in Section 6.2.3.2. The activity attributes provide the details used to build the schedule model.

6.6.1.4 Project Schedule Network Diagrams

Described in Section 6.3.3.1. The project schedule network diagrams contain the logical relationships of predecessors and successors that will be used to calculate the schedule.

6.6.1.5 Activity Resource Requirements

Described in Section 6.4.3.1. The activity resource requirements identify the types and quantities of resources required for each activity used to create the schedule model.

6.6.1.6 Resource Calendars

Described in Sections 9.2.3.2 and 12.2.3.3. The resource calendars contain information on the availability of resources during the project.

6.6.1.7 Activity Duration Estimates

Described in Section 6.5.3.1. The activity duration estimates contain the quantitative assessments of the likely number of work periods that will be required to complete an activity that will be used to calculate the schedule.

6.6.1.8 Project Scope Statement

Described in Section 5.3.3.1. The project scope statement contains assumptions and constraints that can impact the development of the project schedule.

6.6.1.9 Risk Register

Described in Section 11.2.3.1. The risk register provides the details of all identified risks and their characteristics that affect the schedule model.

6.6.1.10 Project Staff Assignments

Described in Section 9.2.3.1. The project staff assignments specify which resources are assigned to each activity.

6.6.1.11 Resource Breakdown Structure

Described in Section 6.4.3.2. The resource breakdown structure provides the details by which resource analysis and organizational reporting can be done.

6.6.1.12 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors include, but are not limited to:

- Standards,
- Communication channels, and
- Scheduling tool to be used in developing the schedule model.

6.6.1.13 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Develop Schedule process include, but are not limited to: scheduling methodology and project calendar.

6.6.2 Develop Schedule: Tools and Techniques

6.6.2.1 Schedule Network Analysis

Schedule network analysis is a technique that generates the project schedule model. It employs 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 for the uncompleted portions of project activities. 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.

6.6.2.2 Critical Path Method

The critical path method, as shown in Figure 6-17, is a method used to estimate the minimum project duration and determine the amount of scheduling flexibility on the logical network paths within the schedule model. The critical path is the sequence of activities that represents the longest path through a project, which determines the shortest possible

duration. The critical path method, which is a schedule network analysis technique, calculates the early start, early finish, late start, and late finish dates for all activities without regard for any resource limitations by performing a forward and backward pass analysis through the schedule network. The resulting early and late start and finish dates are not necessarily the project schedule, rather they indicate the time periods within which the activity could be scheduled, given activity durations, logical relationships, leads, lags, and other known constraints.
On any network path, the schedule flexibility is measured by the amount of time that a schedule activity can be delayed or extended from its early start date without delaying the project finish date or violating a schedule constraint, and is termed "total float." Critical paths have either a zero or negative total float, and any activity in the project schedule is called a critical path activity. Negative total float is caused when a constraint on the late dates is violated by duration and logic. A critical path is normally characterized by zero total float on the critical path, but could also be negative. Networks may have multiple near-critical paths. Many software packages allow the user to define "critical" activities. Adjustments to activity durations (if more resources or less scope can be arranged), logical relationships (if the relationships were discretionary to begin with), 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 has been calculated, then the free float, the amount of time that a schedule activity can be delayed without delaying the early start date of any successor or violating a schedule constraint, can also be determined.

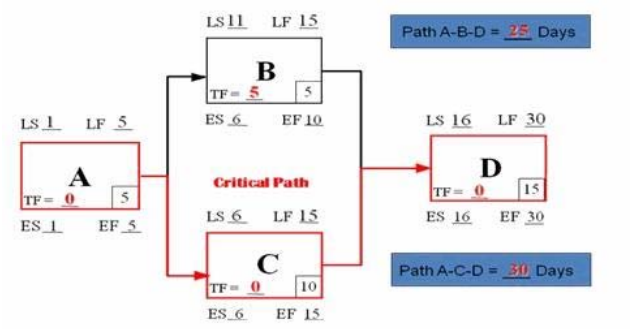


Figure 6-17. Critical Path Method

6.6.2.3 Critical Chain Method

The critical chain method is a schedule method that allows the project team to place buffers on any project schedule path to account for limited resources and project uncertainties. The critical chain method is developed from the critical path method. The critical chain method is developed from the critical path method approach and considers the effects of resource allocation, resource leveling, and activity duration uncertainty on the critical path determined using the critical path method. To do so, the critical chain method introduces the concept of buffers and buffer management.
The critical chain method adds duration buffers that are nonwork schedule activities to manage uncertainty. One buffer, as shown in Figure 6-18, placed at the end of the critical chain, is known as the project buffer and protects the target finish date from slippage along the critical chain. Additional buffers, known as feeding buffers, are placed at each point that a chain of dependent tasks not on the critical chain feeds into the critical chain. Feeding buffers thus protect the critical chain from slippage along the feeding chains. The size of each buffer should account for the uncertainty in the duration of the chain of dependent tasks leading up to that buffer. Once the buffer schedule activities are determined, the planned activities are scheduled to their latest possible planned start and finish dates. Consequently, instead of managing the total float of network paths, the critical chain method focuses on managing the remaining buffer durations against the remaining durations of task chains.

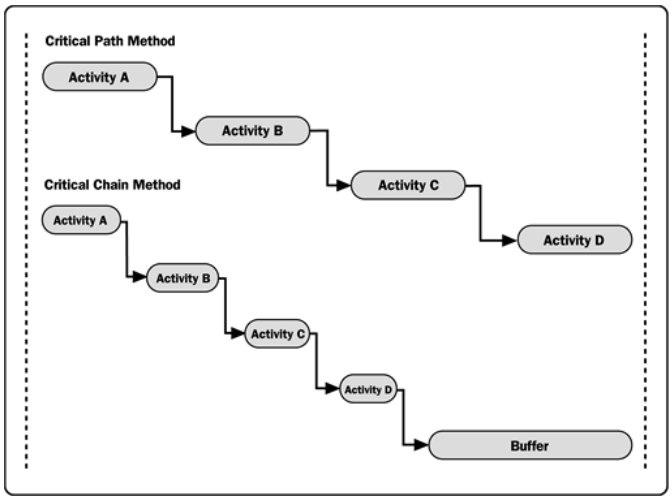


Figure 6-18. Comparison of Critical Path and Critical Chain Methods

6.6.2.4 Resource Optimization Techniques

Examples of resource optimization techniques that can be used to adjust the schedule model due to demand and supply of resources includes, but is not limited to:

- **Resource leveling.** A technique in which start and finish dates are adjusted based on resource constraints with the goal of balancing demand for resources with the available supply. Resource leveling can be used when shared or critical required resources are only available at certain times, or in limited quantities, or over-allocated, such as when a resource has been assigned to two or more activities during the same time period, or to keep resource usage at a constant level. Resource leveling can often cause the original critical path to change.

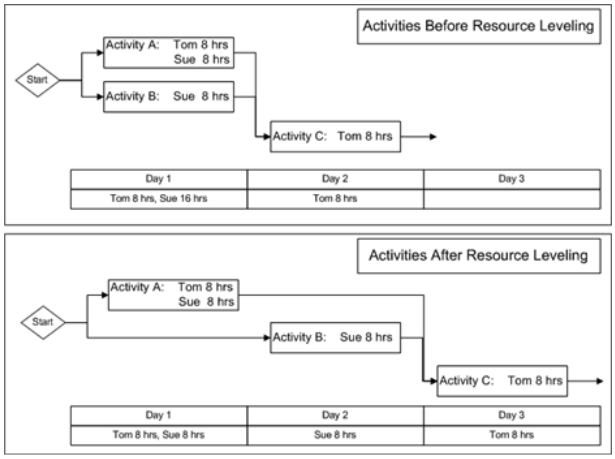


Figure 6-19. Resource Leveling

- **Resource Smoothing.** A technique that adjusts the activities of a schedule model such that the requirements for resources on the project do not exceed certain predefined resource limits. In resource smoothing, as opposed to resource leveling, the project critical path is not changed and the completion date may not be delayed. In other words, activities may only be delayed within their floats.

6.6.2.5 What-If Scenario Analysis

What-if scenario analysis is the process of evaluating scenarios in order to predict their effect, positively or negatively, on project objectives. 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 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, usually using probability distributions constructed from the three-point estimates (described in Section 6.5.2.4). 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 activity and used to calculate a distribution of possible outcomes for the total project.

6.6.2.6 Applying Leads and Lags

Described in Section 6.3.2.3. Leads and lags are refinements applied during network analysis to develop a viable schedule by adjusting the start time of the successor activities. Leads and lags are used in limited circumstances where processes require a set period of time to elapse between the predecessors and successors without work or resource impact.

6.6.2.7 Schedule Compression

Schedule compression techniques are used to shorten the schedule duration without reducing the project scope, in order to meet schedule constraints, imposed dates, or other schedule objectives. Schedule compression techniques include:

- **Crashing.** A technique used to shorten the schedule duration for the least incremental cost by adding resources. Examples of crashing include approving overtime, bringing in additional resources, or paying to expedite delivery to activities on the critical path. Crashing works only for activities on the critical path where additional resources will shorten the duration. Crashing does not always produce a viable alternative and may result in increased risk and/or cost.
- **Fast tracking.** A schedule compression technique in which activities or phases normally done in sequence are performed in parallel for at least a portion of their duration. An example is constructing the foundation for a building before completing all of the architectural drawings. Fast tracking may result in rework and increased risk. Fast tracking only works if activities can be overlapped to shorten the duration.

6.6.2.8 Scheduling Tool

Automated scheduling tools expedite the scheduling process by generating start and finish dates based on the inputs of activities, network diagrams, resources and activity durations. A scheduling tool can be used in conjunction with other project management software applications as well as manual methods.

6.6.3 Develop Schedule: Outputs

6.6.3.1 Schedule Baseline

A schedule baseline is the approved version of a schedule model that can be changed only through formal change control procedures and is used as a basis for comparison to actual results. It is accepted and approved by the project management team as the schedule baseline with baseline start dates and baseline finish dates. During monitoring and controlling, the baseline dates are comparing the actual start and finish dates to determine whether variances have occurred. The schedule baseline is a component of the project management plan.

6.6.3.2 Project Schedule

The outputs from a schedule model are called presentations. All of the examples listed below are classified as presentations. The project schedule is an output that presents linked activities, with planned dates, durations, milestones, and resources. At a minimum, the project schedule includes a planned start date and planned finish date for each activity. If resource planning is done at an early stage, then the project schedule remains preliminary until resource assignments have been confirmed and scheduled start and finish dates are established. This process usually occurs no later than the completion of the project management plan (Section 4.2.3.1). A target project schedule model may also be developed with a defined target start and target finish for each activity. The project schedule presentation may be presented in summary form, sometimes referred to as the master schedule or milestone schedule, or presented in detail. Although a project schedule model can be presented in tabular form, it is more often presented graphically, using one or more of the following formats:

- **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 6-20.
- **Bar charts.** These charts, also known as Gantt charts, represent schedule information where activities are listed on the vertical axis, dates are shown on the horizontal axis, and activity durations are shown as horizontal bars placed according to start and finish dates. Bar charts are relatively easy to read, and are frequently used in management presentations. For control and management communications, 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 6-20 that is presented in a WBS structured format.
- **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 6-10, 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 6-20. This example also shows how each work package is planned as a series of related activities.

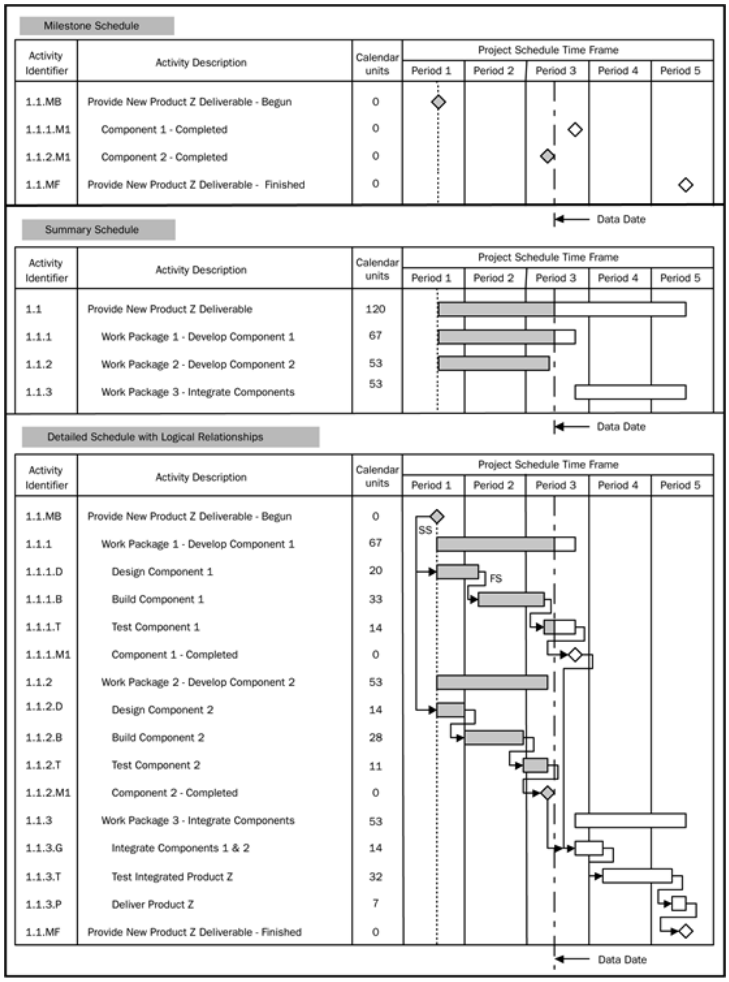


Figure 6-20. Project Schedule—Examples

Figure 6-20 shows the schedule for a sample project being executed, with the work in progress reported through the data date, a point in time when the status of the project is recorded, which is sometimes also called the as-of date or status date. For a simple project schedule model, Figure 6-20 reflects various presentations of a milestone schedule, a summary schedule, and a detailed schedule. Figure 6-20 also visually shows the relationships among the three different levels of schedule presentation.

6.6.3.3 Schedule Data

The schedule data for the project schedule model is the collection of information for describing and controlling the schedule. The schedule data 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, or resource-leveled, with or without imposed dates; and
- Scheduling of contingency reserves.

Schedule data could also include such items as resource histograms, cash-flow projections, and order and delivery schedules.

6.6.3.4 Project Calendars

A project calendar is a calendar that identifies working days and shifts that are available for scheduled activities. A schedule model may require more than one project calendar to allow for different work periods for some activities to calculate the project schedule. The project calendars may be updated.

6.6.3.5 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- Schedule baseline, and
- Schedule management plan.

6.6.3.6 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- **Activity resource requirements.** Resource leveling can have a significant effect on preliminary estimates for the types and quantities of resources required. If the resource-leveling analysis changes the project resource requirements, then the project resource requirements are updated.
- **Activity attributes.** Activity attributes (Section 6.2.3.2) are updated to include any revised resource requirements and any other revisions generated by the Develop Schedule process.
- **Calendars.** The calendar for each project may consist of multiple calendars, project calendars, individual resource calendars etc., as the basis for scheduling the project.
- **Risk register.** The risk register may need to be updated to reflect opportunities or threats perceived through scheduling assumptions.

6.7 Control Schedule

Control Schedule is the process of monitoring the status of project activities to update the project progress and managing changes to the schedule baseline. The key benefit of this process is that it provides the means to recognize variance from plan and take corrective action and thus minimize risk. The inputs, tools and techniques, and outputs of this process are depicted in Figure 6-21. Figure 6-22 depicts the data flow diagram of the process.

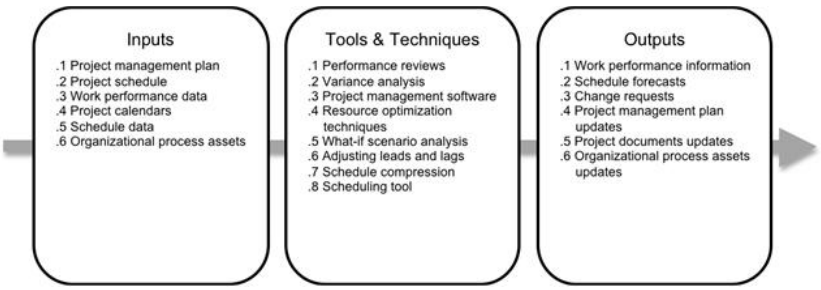


Figure 6-21. Control Schedule: Inputs, Tools & Techniques, and Outputs

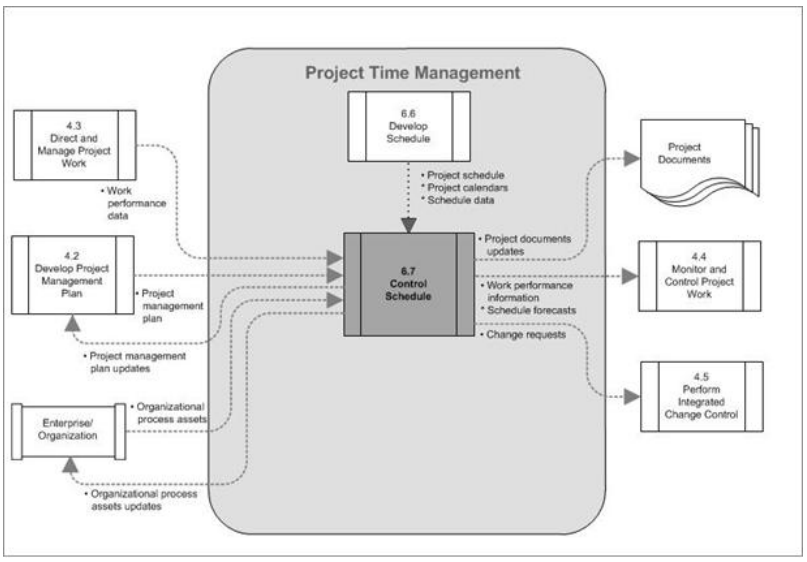


Figure 6-22. Control Schedule Data Flow Diagram

Control schedule is concerned with:

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

If an agile approach is utilized, control schedule is concerned with:

- Determining the current status of the project schedule by comparing the total amount of work delivered and accepted against predictions of work completed for the time elapsed,
- Conducting retrospective reviews (scheduled lessons learned reviews) for correcting processes and improving, if required,
- Reprioritizing the remaining work plan (backlog),
- Determining the rate of delivery (velocity) and acceptance of work per iteration (agreed work cycle duration, typically two weeks or one month),
- Determining that the project schedule has changed, and
- Managing the actual changes as they occur.

Control Schedule is a component of the Perform Integrated Change Control process (Section 4.5).

6.7.1 Control Schedule: Inputs

6.7.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan contains the schedule management plan and the schedule baseline. The schedule management plan describes how the schedule will be managed and controlled. The schedule baseline is used to compare with actual results to determine if a change, corrective action, or preventive action is necessary.

6.7.1.2 Project Schedule

Described in Section 6.6.3.2. Project schedule refers to the most recent version with notations to indicate updates, completed activities, and started activities as of the indicated data date.

6.7.1.3 Work Performance Data

Described in Section 4.3.3.2. Information about project progress such as which activities have started, their progress (actual duration and remaining duration), and which activities have finished.

6.7.1.4 Project Calendars

Described in Section 6.6.3.4. A schedule model may require more than one project calendar to allow for different work periods for some activities to calculate the schedule forecasts.

6.7.1.5 Schedule Data

Described in Section 6.6.3.3. Schedule data will be reviewed and updated in the Control Schedule process.

6.7.1.6 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Control Schedule process include, but are not limited to:

- Existing formal and informal schedule control-related policies, procedures, and guidelines;
- Schedule control tools; and
- Monitoring and reporting methods to be used.

6.7.2 Control Schedule: Tools and Techniques

6.7.2.1 Performance Reviews

Performance reviews measure, compare, and analyze schedule performance such as actual start and finish dates, percent complete, and remaining duration for work in progress. Various techniques may be used, among them:

- **Trend analysis.** Trend analysis examines project performance over time to determine if performance is improving or deteriorating. Graphical analysis techniques are valuable for understanding performance to date and for comparison to future performance goals in the form of completion dates.
- **Critical chain method (Section 6.6.2.3).** Comparing the amount of buffer remaining to the amount of buffer needed to protect the delivery date can help determine schedule status. The difference between the buffer needed and the buffer remaining can determine whether corrective action is appropriate.

6.7.2.2 Variance Analysis

Schedule performance measurements, such as schedule variance (SV) and schedule performance index (SPI), are used to assess the magnitude of variation to the original schedule baseline. The total float and early finish variances are also essential planning components to evaluate project time performance. Important aspects of schedule control include determining the cause and degree of variance relative to the schedule baseline (Section 6.6.3.1), estimating the implications of those variances for future work to completion, and deciding whether corrective or preventive action is required. For example, a major delay on any 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.

6.7.2.3 Project Management Software

Project management software for scheduling provides the ability to track planned dates versus actual dates, and to forecast the effects of changes to the project schedule model.

6.7.2.4 Resource Optimization Techniques

Described in Section 6.6.2.4. Resource optimization techniques involve the scheduling of activities and the resources required by those activities while taking into consideration both the resource availability and the project time.

6.7.2.5 What-if Scenario Analysis

Described in Section 6.6.2.5. What-if scenario analysis is used to review various scenarios to bring the schedule model into alignment with the plan.

6.7.2.6 Adjusting Leads and Lags

Adjusting leads and lags is used to find ways to bring project activities that are behind into alignment with the plan. For example, on a project to construct a new office building, the landscaping could be rescheduled to start before with the exterior work of the building is complete by increasing the lead time in the relationship. Or, a technical writing team can re-schedule the start of editing the draft of a large document immediately after the first section of the document is completed by eliminating lag.

6.7.2.7 Schedule Compression

Described in Section 6.6.2.7. Schedule compression techniques are used to find ways to bring project activities that are behind into alignment with the plan.

6.7.2.8 Scheduling Tool

Schedule data is updated and compiled into the schedule model to reflect actual progress of the project and remaining work to be completed. The scheduling tool (Section 6.6.2.8) and the supporting schedule data are used in conjunction with manual methods or other project management software to perform schedule network analysis to generate an updated project schedule.

6.7.3 Control Schedule: Outputs

6.7.3.1 Work Performance Information

The calculated SV and SPI values for WBS components, in particular the work packages and control accounts, are documented and communicated to stakeholders.

6.7.3.2 Schedule Forecasts

Schedule forecasts are 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. The information is based on the project's past performance and expected future performance, and includes information that could impact the project in the future, such as estimate at completion (EAC) and estimate to complete (ETC).

6.7.3.3 Change Requests

Schedule variance analysis, along with review of progress reports, results of performance measures, and modifications to the project schedule may result in change requests to the schedule baseline and/or to other components of the project management plan. Change

requests are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5). Preventive actions may include recommended changes to reduce the probability of negative schedule variances.

6.7.3.4 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- **Schedule baseline.** Changes to the schedule baseline are incorporated in response to approved change requests (Section 4.4.3.1) related to project scope changes, activity resources, or activity duration estimates.
- **Schedule management plan.** The schedule management plan may be updated to reflect a change in the way the schedule is managed.
- **Cost baseline.** The cost baseline may be updated to reflect changes caused by compression or crashing techniques.

6.7.3.5 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- **Schedule Data.** New project schedule network diagrams may be 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 forecasted start and finish dates is needed to provide realistic data for directing the work, and for measuring performance and progress.
- **Project Schedule.** An updated project schedule will be generated from the updated schedule model with updated schedule data to reflect the schedule changes and manage the project.

6.7.3.6 Organizational Process Assets Updates

Organizational process assets that may be updated include, but are not limited to:

- Causes of variances,
- Corrective action chosen and the reasons, and
- Other types of lessons learned from project schedule control.

CHAPTER 7

PROJECT COST MANAGEMENT

Project Cost Management includes the processes involved in estimating, budgeting, funding, managing, and controlling costs so that the project can be completed within the approved budget. Figure 7-1 provides an overview of the Project Cost Management processes that include the following:

7.1 Plan Cost Management—The process that establishes the policies, procedures, and documentation for planning, managing, executing, and controlling project costs.

7.2 Estimate Costs—The process of developing an approximation of the monetary resources needed to complete project activities.

7.3 Determine Budget—The process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline.

7.4 Control Costs—The process of monitoring the status of the project to update the project costs and managing changes to the cost baseline.

These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.

On some projects, especially ones of smaller scope, cost estimating and cost budgeting are tightly linked, and can be viewed as a single process that can be performed by a single person over a relatively short period of time. These 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, making early scope definition critical (Section 5.3).

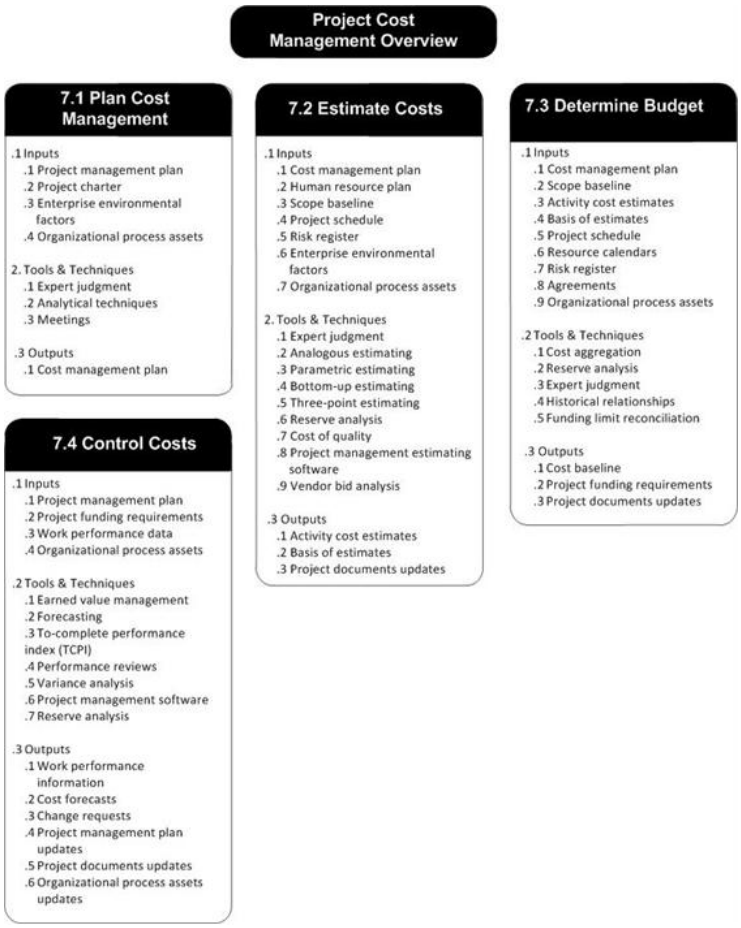


Figure 7-1. Project Cost Management Overview

Project Cost Management considers the stakeholder requirements for capturing costs. Different stakeholders will measure project costs in different ways and at different times. For example, the cost of an acquired item may be measured when the acquisition decision is made or committed, the order is placed, the item is delivered, or the actual cost is incurred or recorded for project accounting purposes.

Project Cost Management is primarily concerned with the cost of the resources needed to complete project activities. Project Cost Management should also consider the effect of project decisions on the subsequent recurring 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 but could do so by increasing the customer's operating costs.

In many organizations, predicting and analyzing the prospective financial performance of the project's product are 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 may address additional processes and numerous general financial management techniques such as return on investment, discounted cash flow, and investment payback analysis.

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.

7.1 Plan Cost Management

Plan Cost Management is a process that establishes the policies, procedures, and documentation for planning, managing, executing, and controlling project costs. The key benefit of this process is that it ensures that the cost management processes and their associated tools and techniques are documented. The inputs, tools and techniques, and outputs of this process are depicted in Figure 7-2. Figure 7-3 depicts the data flow diagram of the process.

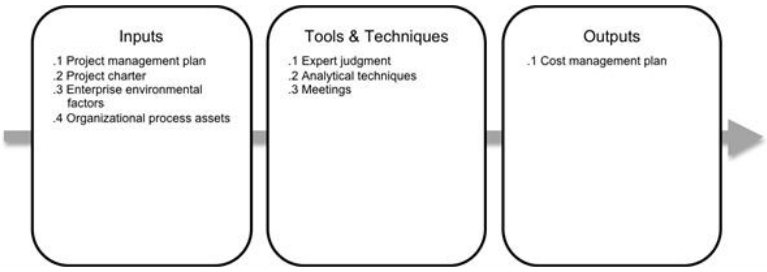


Figure 7-2. Plan Cost Management: Inputs, Tools & Techniques, and Outputs

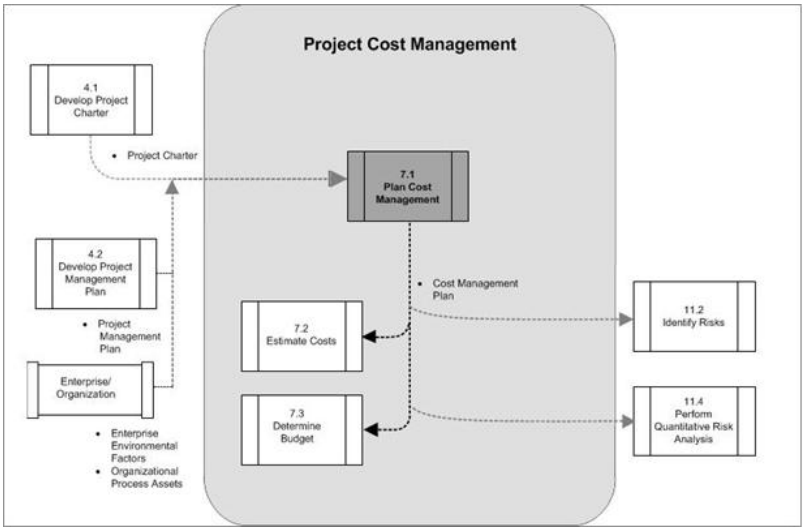


Figure 7-3. Plan Cost Management: Data Flow Diagram

The cost management processes and their associated tools and techniques are documented in the cost management plan. The cost management plan is a component of the project management plan.

7.1.1 Plan Cost Management: Inputs

7.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan contains information used to develop the cost management plan, which contains, but is not limited to:

- **Scope baseline.** The scope baseline will define the WBS detail for cost estimation and management.
- **Schedule baseline.** The schedule baseline defines when the project costs will be incurred.
- **Other information.** Other cost-related scheduling, risk, and communications decisions from the project management plan.

7.1.1.2 Project Charter

Described in Section 4.1.3.1. The project charter provides the summary budget from which the detailed project costs are developed. The project charter also defines the project approval requirements that will influence the management of the project costs.

7.1.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that influence the Plan Cost Management process include, but are not limited to:

- Organizational culture, structure, and processes can all influence cost management;
- Market conditions describe what products, services, and results are available in the regional and global market;
- Published commercial information such as 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 of information; and
- Project management information systems provide alternative possibilities for managing cost.

7.1.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Plan Cost Management process include, but are not limited to:

- Financial control procedures;
- Historical information;
- Financial databases; and
- Existing formal and informal cost budgeting-related policies, procedures, and guidelines.

7.1.2 Plan Cost Management: Tools and Techniques

7.1.2.1 Expert Judgment

Expert judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects. Expert judgment can also suggest whether to combine methods and how to reconcile differences between them. Judgment based upon expertise in an application area, Knowledge Area, discipline, industry, etc., as appropriate for the activity being performed should be used in developing the cost management plan.

7.1.2.2 Analytical Techniques

Developing the cost management plan may involve choosing strategic options to fund the project such as: self-funding, funding with equity, or funding with debt. The cost management plan may also detail ways to finance project resources such as purchasing, renting, or leasing. These decisions, like other financial decisions affecting the project, may affect project risks.
Organizational policies and procedures may influence which financial techniques are employed in these decisions. Techniques may include (but are not limited to): payback period, return on investment, internal rate of return, discounted cash flow, and net present value.

7.1.2.3 Meetings

Project teams may hold planning meetings to develop the cost management plan. Attendees at these meetings may include the project manager, the project sponsor, selected project team members, selected stakeholders, anyone with responsibility for cost planning or execution, and others as needed.

7.1.3 Plan Cost Management: Outputs

7.1.3.1 Cost Management Plan

The cost management plan is a component of a project management plan and describes how the project costs will be planned, structured, monitored, and controlled. The cost management processes and their associated tools and techniques are documented in the cost management plan.
For example, the cost management plan can establish the following:

- **Level of accuracy.** Activity cost estimates will adhere to a rounding of the data to a prescribed precision (e.g., US$100, US$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 (such as staff hours, staff days, weeks, or lump sum) is defined for each of the resources.
- **Organizational procedures links.** The work breakdown structure (WBS) (Section 5.4) provides the framework for the cost management plan, allowing for consistency with the estimates, budgets, and control of costs. The WBS component used for the project cost accounting is called the control account (CA). Each control account is assigned a unique code or account number(s) that links directly to the performing organization's accounting system.
- **Control thresholds.** Variance thresholds for monitoring cost performance may be specified to indicate an agreed-upon amount of variation to be allowed before some action needs to be taken. Thresholds are typically expressed as percentage deviations from the baseline plan.
- **Rules of performance measurement.** Earned value management (EVM) rules of performance measurement are set. For example, the cost management plan may:
    - Define the WBS and points at which measurement of control accounts will be performed;
    - Establish the earned value measurement techniques (e.g., weighted milestones, fixed-formula, percent complete, etc.) to be employed; and
    - Specify tracking methodologies and the earned value management computation equations for calculating projected estimate at completion (EAC) forecasts to provide a validity check on the bottom-up EAC.

  For more specific information regarding earned value management, refer to the *Practice Standard for Earned Value Management*.
- **Reporting formats.** The formats and frequency for the various cost reports are defined.
- **Process descriptions.** Descriptions of each of the other cost management processes are documented.
- **Additional details.** Additional details about cost activities. Details such as, but

not limited to:

- Description of strategic funding choices,
- Procedure for recording a cost, and
- Roles and responsibilities of persons who perform cost activities.

7.2 Estimate Costs

Estimate Costs is the process of developing an approximation of the monetary resources needed to complete project activities. The key benefit of this process is that it determines the amount of cost required to complete each activity. The inputs, tools and techniques, and outputs of this process are depicted in Figure 7-4. Figure 7-5 depicts the data flow diagram of the process.

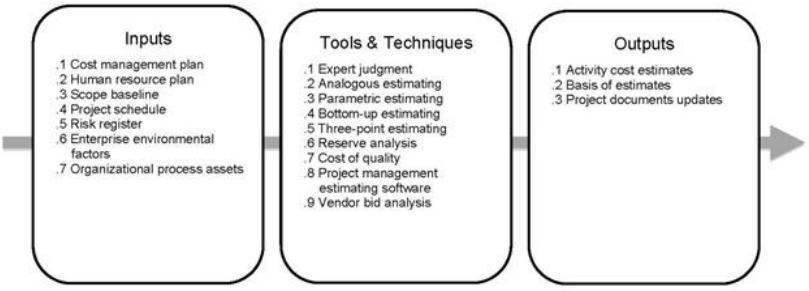


Figure 7-4. Estimate Costs: Inputs, Tools & Techniques, and Outputs

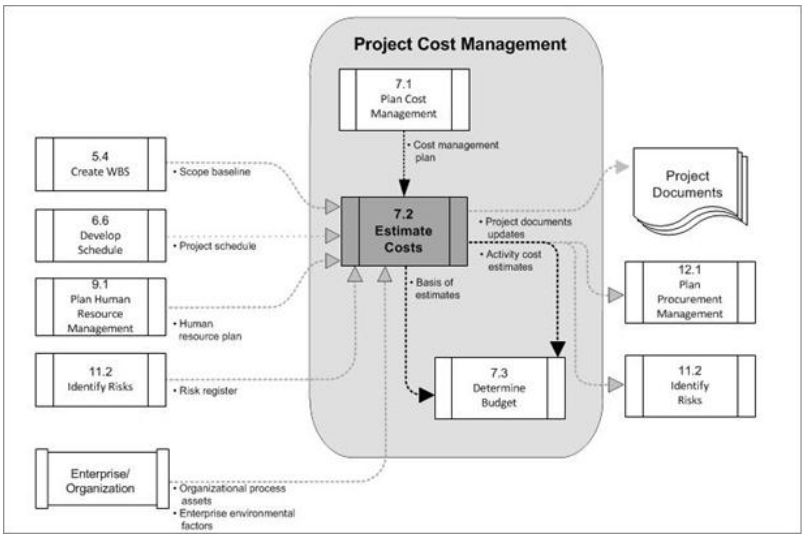


Figure 7-5. Estimate Costs Data Flow Diagram

Cost estimates are a prediction that is based on the information known at a given point in time. It includes the identification and consideration of costing alternatives to initiate and complete the project. Cost trade-offs and risks must be considered, such as make versus buy, buy versus lease, and the sharing of resources in order to achieve optimal costs for the project.

Cost estimates are generally expressed in units of some currency (i.e., dollars, euros, yen, etc.), although in some instances other units of measure, such as staff hours or staff days, are used to facilitate comparisons by eliminating the effects of currency fluctuations.

Cost estimates should be refined during the course of the project to reflect additional detail as it becomes available. The accuracy of a project estimate will increase as the project progresses through the project life cycle. Cost estimating is an iterative process from phase to phase. For example, a project in the initiation phase has a rough order of magnitude (ROM) estimate in the range of -25% to +75%. Later in the project, as more information is known, estimates could narrow to a range of ±10%. In some organizations, there are guidelines for when such refinements can be made and the degree of accuracy that is expected.

Sources of input information are derived from the outputs of processes in other Knowledge Areas. Once received, all of this information will remain available as inputs to all of the cost management processes.

Costs 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 contingency costs. A cost estimate is a quantitative assessment of the likely costs for resources required to complete the activity.

7.2.1 Estimate Costs: Inputs

7.2.1.1 Cost Management Plan

Described in Section 7.1.3.1. The cost management plan defines how project costs will be managed and controlled. It includes the method used and the level of accuracy required to estimate activity cost.

7.2.1.2 Human Resource Plan

Described in Section 9.1.3.1. The human resource plan provides project staffing attributes, personnel rates, and related rewards/recognition, which are necessary components for developing the project cost estimates.

7.2.1.3 Scope Baseline

The scope baseline is comprised of the following:

- **Project scope statement.** The project scope statement (Section 5.3.3.1) provides the product description, acceptance criteria, key deliverables, project boundaries, assumptions, and constraints about the project. One basic assumption that needs to be made when estimating project costs is whether the estimates will be limited to direct project costs only or whether the estimates will also include indirect costs. Indirect costs are those costs that cannot be directly traced to a specific project and therefore will be accumulated and allocated equitably over multiple projects by some approved and documented accounting procedure. One of the most common constraints for many projects is a limited project budget. Examples of other constraints are required delivery dates, available skilled resources, and organizational policies.
- **Work breakdown structure.** The WBS (Section 5.4) provides the relationships among all the components of the project and the project deliverables.
- **WBS dictionary.** The WBS dictionary (Section 5.4.3.1) 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.

Additional information that may be found in the scope baseline includes requirements with contractual and legal implications, such as health, safety, security, performance, environmental, insurance, intellectual property rights, licenses, and permits. All of this information should be considered when developing the cost estimates.

7.2.1.4 Project Schedule

Described in Section 6.6.3.2. The type and quantity of resources and the amount of time which those resources are applied to complete the work of the project are major factors in determining the project cost. Schedule activity resources and their respective durations are used as key inputs to this process. Estimate Activity Resources (Section 6.4) involves determining the availability and quantities required of staff and material needed to perform schedule activities. It is closely coordinated with cost estimating. Activity duration estimates (Section 6.5.3.1) will affect cost estimates on any project where the project budget includes an allowance for the cost of financing (including interest charges) and where resources are applied per unit of time for the duration of the activity. Activity duration estimates can also affect cost estimates that have time-sensitive costs included in them, such as union labor with regularly expiring collective bargaining agreements or materials with seasonal cost variations.

7.2.1.5 Risk Register

Described in Section 11.2.3.1. The risk register should be reviewed to consider risk response costs. Risks, which can be either threats or opportunities, typically have an impact on both activity and overall project costs. As a general rule, when the project experiences a negative risk event, the near-term cost of the project will usually increase, and there will sometimes be a delay in the project schedule.

7.2.1.6 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that influence the Estimate Costs process include, but are not limited to:

- **Market conditions.** These conditions describe what products, services, and results are available in the market, from whom, and under what terms and conditions. Regional and/or global supply and demand conditions greatly influence resource costs.
- **Published commercial information.** 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 of information.

7.2.1.7 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Estimate Costs process include, but are not limited to:

- Cost estimating policies,
- Cost estimating templates,
- Historical information, and
- Lessons learned.

7.2.2 Estimate Costs: Tools and Techniques

7.2.2.1 Expert Judgment

Expert judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects. Expert judgment can also be used to determine whether to combine methods of estimating and how to reconcile differences between them.

7.2.2.2 Analogous Estimating

Analogous cost estimating uses the values of parameters, such as scope, cost, budget, and duration or measures of scale such as size, weight, and complexity, from a previous, similar project as the basis for estimating the same parameter or measure for a current project. When estimating costs, this technique relies on the actual cost of previous, similar projects as the basis for estimating the cost of the current project. It is a gross value estimating approach, sometimes adjusted for known differences in project complexity.

Analogous cost estimating is frequently used to estimate a parameter when there is a limited amount of detailed information about the project, for example, in the early phases of a project. Analogous cost estimating uses historical information and expert judgment. Analogous cost estimating is generally less costly and time consuming than other techniques, but it is also generally less accurate. Analogous cost estimates can be applied to a total project or to segments of a project, used in conjunction with other estimating methods. Analogous estimating is most reliable when the previous projects are similar in fact and not just in appearance, and the project team members preparing the estimates have the needed expertise.

7.2.2.3 Parametric Estimating

Parametric estimating uses a statistical relationship between historical data and other variables (e.g., square footage in construction) to calculate an estimate for activity parameters, such as cost, budget, and duration. This technique can produce higher levels of accuracy depending upon the sophistication and underlying data built into the model. Parametric cost estimates can be applied to a total project or to segments of a project, in conjunction with other estimating methods.

7.2.2.4 Bottom-Up Estimating

Bottom-up estimating is a method of estimating a component of work. The cost of individual work packages or activities is estimated with the greatest level of specified detail. The detailed cost is then summarized or “rolled up” to higher levels for subsequent reporting and tracking purposes. The cost and accuracy of bottom-up cost estimating are typically influenced by the size and complexity of the individual activity or work package.

7.2.2.5 Three-Point Estimating

The accuracy of single-point activity cost estimates can be improved by considering estimation uncertainty and risk and using three estimates to define an approximate range for an activity’s cost:

- **Most likely** (*cM*). The cost of the activity, based on realistic effort assessment for the required work and any predicted expenses.
- **Optimistic** (*cO*). The activity cost based on analysis of the best-case scenario for the activity.
- **Pessimistic** (*cP*). The activity cost based on analysis of the worst-case scenario for the activity.

Cost estimates based on a simple average of the three points may provide more accuracy, and the three points clarify the range of uncertainty of the cost estimates. Common examples include, but are not limited to:

- **Simple Averaging.** Depending on the assumed distribution of values within the range, the expected cost, *cE*, of the three estimates can be calculated using the following formula:

$CE = (cO + cM + cP) / 3$

- **Weighted Averaging.** PERT analysis calculates an Expected (*cE*) activity cost using

a weighted average of the three estimates using the following formula:
$cE = (cO + 4cM + cP) / 6$
Cost estimates based on these distributions may provide more accuracy, and the three points clarify the range of uncertainty of the cost estimates.

7.2.2.6 Reserve Analysis

Cost estimates may include contingency reserves (sometimes called contingency allowances) to account for cost uncertainty. Contingency reserves are the budget within the cost baseline that is allocated for identified risks, which are accepted and for which contingent or mitigating responses are developed. Contingency reserves are often viewed as the part of the budget intended to address the “known unknowns” that can affect a project. For example, rework for some project deliverables could be anticipated, while the amount of this rework is unknown. Contingency reserves may be estimated to account for this unknown amount of rework. Contingency reserves can provide for a specific activity, for the whole project, or both. The contingency reserve may be a percentage of the estimated cost, a fixed number, or may be developed by using quantitative analysis methods. As more precise information about the project becomes available, the contingency reserve may be used, reduced, or eliminated. Contingency should be clearly identified in cost documentation. Contingency reserves are part of the cost baseline and the overall funding requirements for the project.
Estimates may also be produced for the amount of management reserve to be funded for the project. Management reserves are an amount of the project budget withheld for management control purposes and are reserved for unforeseen work that is within scope of the project. Management reserves are intended to address the “unknown unknowns” that can affect a project. The management reserve is not included in the cost baseline but is part of the overall project budget and funding requirements. Use of management reserves requires a change to the cost baseline.

7.2.2.7 Cost of Quality (COQ)

Assumptions about costs of quality (Section 8.1.2.2) may be used to prepare the activity cost estimate.

7.2.2.8 Project Management Estimating Software

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

7.2.2.9 Vendor Bid Analysis

Cost estimating methods may include analysis of what the project should cost, based on the responsive bids from qualified vendors. When projects are awarded to a vendor under competitive processes, additional cost estimating work may be required of the project team to examine the price of individual deliverables and to derive a cost that supports the final total project cost.

7.2.3 Estimate Costs: Outputs

7.2.3.1 Activity Cost Estimates

Activity cost estimates are quantitative assessments of the probable costs required to complete project work. Cost estimates 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, direct labor, materials, equipment, services, facilities, information technology, and special categories such as an inflation allowance or a cost contingency reserve. Indirect costs, if they are included in the project estimate, can be included at the activity level or at higher levels.

7.2.3.2 Basis of Estimates

The amount and type of additional details supporting the cost estimate vary by application area. Regardless of the level of detail, the supporting documentation should provide a clear and complete understanding of how the cost estimate was derived.
Supporting detail for activity cost estimates may include:

- Documentation of the basis of the estimate (i.e., how it was developed),
- Documentation of all assumptions made,
- Documentation of any known constraints,
- Indication of the range of possible estimates (e.g., US$10,000 (±10%) to indicate that the item is expected to cost between a range of values), and
- Indication of the confidence level of the final estimate.

7.2.3.3 Project Documents Updates

Project documents that may be updated include, but are not limited to, the risk register.

7.3 Determine Budget

Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline. The key benefit of this process is that it determines the cost baseline for which cost performance will be measured against and which future project performance can be monitored and controlled. The inputs, tools and techniques, and outputs of this process are depicted in Figure 7-6. Figure 7-7 depicts the data flow diagram of the process.

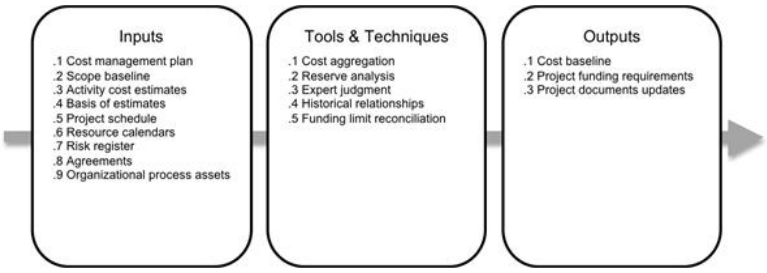


Figure 7-6. Determine Budget: Inputs, Tools & Techniques, and Outputs

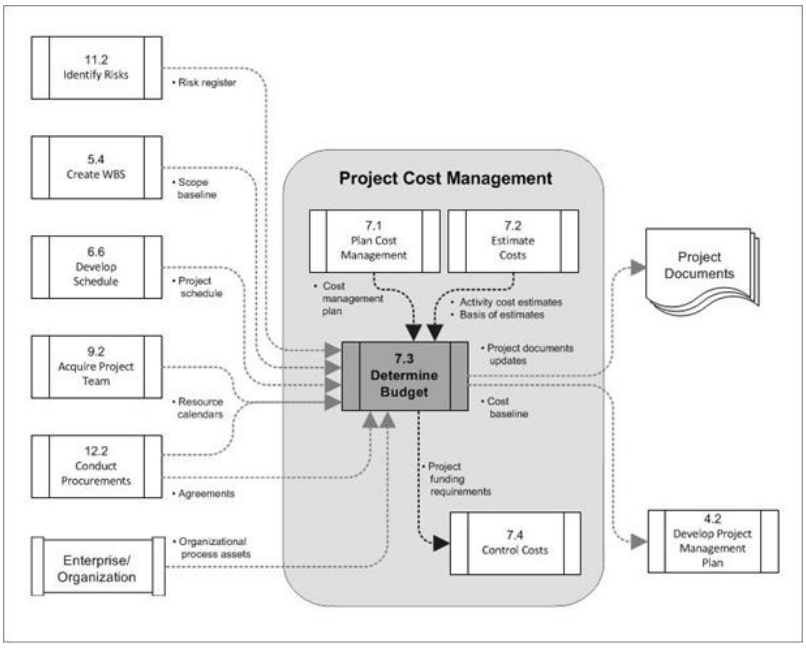


Figure 7-7. Determine Budget Data Flow Diagram

Project budgets constitute the funds authorized to execute the project. The cost baseline includes all authorized budgets, but excludes management reserves.

7.3.1 Determine Budget: Inputs

7.3.1.1 Cost Management Plan

Described in Section 7.1.3.1. The cost management plan describes how the project costs will be managed and controlled.

7.3.1.2 Scope Baseline

- **Project scope statement.** Formal limitations by period for the expenditure of project funds can be mandated by the organization, by contract (Section 12.2.3.2) or by other entities such as government agencies. These funding constraints are reflected in the project scope statement.
- **Work breakdown structure.** The WBS (Section 5.4) provides the relationships among all the project deliverables and their various components.
- **WBS dictionary.** The WBS dictionary (Section 5.4.3.1) 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.

7.3.1.3 Activity Cost Estimates

Described in Section 7.2.3.1. Cost estimates for each activity within a work package are aggregated to obtain a cost estimate for each work package.

7.3.1.4 Basis of Estimates

Described in Section 7.2.3.2. Supporting detail for cost estimates contained in the basis for estimates should specify any basic assumptions dealing with the inclusion or exclusion of indirect or other costs in the project budget that are specified in the basis of estimates.

7.3.1.5 Project Schedule

Described in Section 6.6.3.2. The project schedule includes planned start and finish dates for the project's activities, milestones, work packages, planning packages, and control accounts. This information can be used to aggregate costs to the calendar periods in which the costs are planned to be incurred.

7.3.1.6 Resource Calendars

Described in Sections 9.2.3.2 and 12.2.3.3. Resource calendars provide information on which resources are assigned to the project and when they are assigned. This information can be used to indicate resource costs over the duration of the project.

7.3.1.7 Risk Register

Described in Section 11.2.3.1. The risk register should be reviewed to consider how to aggregate the risk response costs.

7.3.1.8 Agreements

Described in Section 12.2.3.2. Applicable agreement information and costs relating to products, services, or results that have been purchased are included when determining the budget.

7.3.1.9 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Determine Budget process include, but are not limited to:

- Existing formal and informal cost budgeting-related policies, procedures, and guidelines;
- Cost budgeting tools; and
- Reporting methods.

7.3.2 Determine Budget: Tools and Techniques

7.3.2.1 Cost Aggregation

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.

7.3.2.2 Reserve Analysis

Budget reserve analysis can establish both the contingency reserves and the management reserves for the project. Management and contingency reserves are addressed in more detail in Section 7.2.2.6.

7.3.2.3 Expert Judgment

Judgment, guided by expertise in an application area, Knowledge Area, discipline, industry, or similar project, aids in determining the budget. Such expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training. Expert judgment is available from many sources, including, but not limited to:

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

7.3.2.4 Historical Relationships

Any historical relationships that result in parametric estimates or analogous estimates involve the use of project characteristics (parameters) to develop mathematical models to predict total project costs. Such models may be simple (e.g., residential home construction is based on a certain cost per square foot of space) or complex (e.g., one model of software development costing uses multiple separate adjustment factors, each of which has numerous points within it).
Both the cost and accuracy of analogous and parametric models can vary widely. They are most likely to be reliable when:

- Historical information used to develop the model is accurate,
- Parameters used in the model are readily quantifiable, and
- Models are scalable, such that they work for a large project, a small project, and phases of a project.

7.3.2.5 Funding Limit Reconciliation

The expenditure of funds should be reconciled with any funding limits on the commitment of funds for the project. A variance between the funding limits and the planned expenditures will sometimes necessitate the rescheduling of work to level out the rate of expenditures. This is accomplished by placing imposed date constraints for work into the project schedule.

7.3.3 Determine Budget: Outputs

7.3.3.1 Cost Baseline

The cost baseline is the approved version of the time-phased project budget, excluding any management reserves that can only be changed through formal change control procedures and is used as a basis for comparison to actual results. It is developed as a summation of the approved budgets for the different schedule activities.
Figure 7-8 illustrates the various components of the project budget and cost baseline. Cost estimates for the various project activities along with any contingency reserves for these activities are aggregated into their associated work package costs. The work package cost estimates, along with any contingency reserves estimated for the work packages, are aggregated into control accounts. The summation of the control accounts make up the cost baseline. Since the cost estimates that make up the cost baseline are directly tied to the schedule activities, this enables a time-phased view of the cost baseline, which is typically displayed in the form of an S-curve, as is illustrated in Figure 7-9.
Management reserves are added to the cost baseline to produce the project budget. As changes warranting the use of management reserves arise, the change control process is used to obtain approval to move the applicable management reserve funds into the cost baseline.

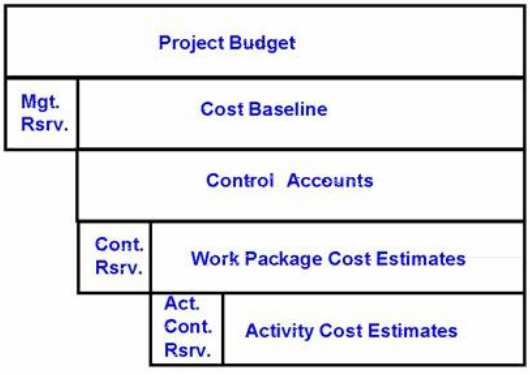


Figure 7-8. Project Budget Components

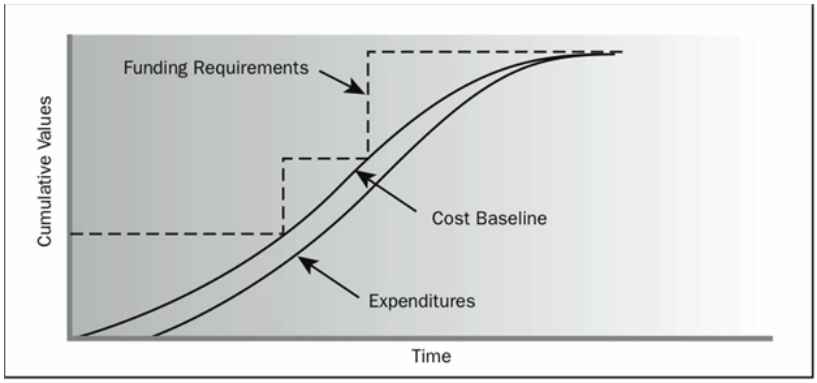


Figure 7-9. Cost Baseline, Expenditures, and Funding Requirements

7.3.3.2 Project Funding Requirements

Total funding requirements and periodic funding requirements (e.g., quarterly, annually) are derived from the cost baseline. The cost baseline will include projected expenditures plus anticipated liabilities. Funding often occurs in incremental amounts that are not continuous, which appear as steps as shown in Figure 7-9. The total funds required are those included in the cost baseline, plus management reserves, if any. Funding requirements may include the source(s) of the funding.

7.3.3.3 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Risk register,
- Cost estimates, and
- Project schedule.

7.4 Control Costs

Control Costs is the process of monitoring the status of the project to update the project budget and managing changes to the cost baseline. The key benefit of this process is that it provides the means to recognize variance from plan and take corrective action and thus minimize risk. The inputs, tools and techniques, and outputs of this process are depicted in Figure 7-10. Figure 7-11 depicts the data flow diagram of the process.

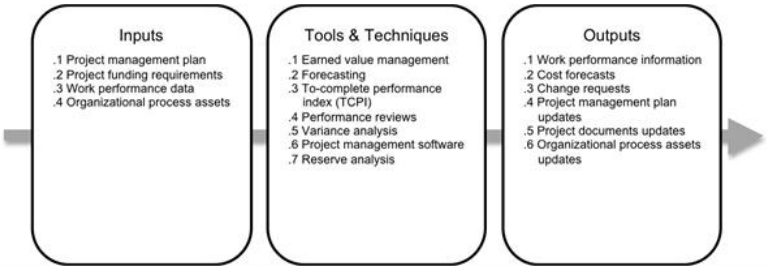


Figure 7-10. Control Costs: Inputs, Tools & Techniques, and Outputs

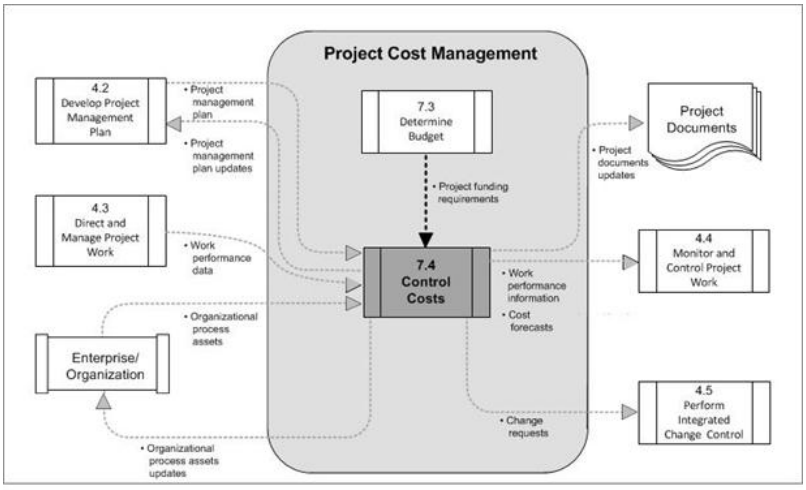


Figure 7-11. Control Costs Data Flow Diagram

Updating the budget requires knowing the actual costs spent to date. Any increase to the

authorized budget can only be approved through the Perform Integrated Change Control process (Section 4.5). Monitoring the expenditure of funds without regard to the value of work being accomplished for such expenditures has little value to the project, other than to allow the project team to stay within the authorized funding. Much of the effort of cost control involves analyzing the relationship between the consumption of project funds to the physical work being accomplished for such expenditures. The key to effective cost control is the management of the approved cost baseline and the changes to that baseline. Project cost control includes:

- Influencing the factors that create changes to the authorized cost baseline;
- Ensuring that all change requests are acted on in a timely manner;
- Managing the actual changes when and as they occur;
- Ensuring that cost expenditures do not exceed the authorized funding, by period and in total for the project;
- Monitoring cost performance to isolate and understand variances from the approved cost baseline;
- Monitoring work performance against funds expended;
- Preventing unapproved changes from being included in the reported cost or resource usage;
- Informing appropriate stakeholders of all approved changes and associated cost; and
- Bringing expected cost overruns within acceptable limits.

7.4.1 Control Costs: Inputs

7.4.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan contains the following information that is used to control cost:

- **Cost baseline.** The cost baseline is compared with actual results to determine if a change, corrective action, or preventive action is necessary.
- **Cost management plan.** The cost management plan describes how the project costs will be managed and controlled (Section 7.1.3.1).

7.4.1.2 Project Funding Requirements

Described in Section 7.3.3.2. The project funding requirements include projected expenditures plus anticipated liabilities.

7.4.1.3 Work Performance Data

Described in Section 4.3.3.2. Work performance data includes information about project progress, such as which activities have started, their progress, and which deliverables have finished. Information also includes costs that have been authorized and incurred, and estimates for completing project work.

7.4.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Control Costs process include, but are not limited to:

- Existing formal and informal cost control-related policies, procedures, and guidelines;
- Cost control tools; and
- Monitoring and reporting methods to be used.

7.4.2 Control Costs: Tools and Techniques

7.4.2.1 Earned Value Management

Earned value management (EVM) is a methodology that combines scope, schedule, and resource measurements to assess project performance and progress. It is a commonly used method of performance measurement for projects. It integrates the scope baseline with the cost baseline, along with the schedule baseline, to form the performance measurement baseline that helps the project management team assess and measure project performance and progress. It is a project management technique that requires the formation of an integrated baseline against which performance can be measured for the duration of the project. The principles of EVM can be applied to all projects in any industry. EVM develops and monitors three key dimensions for each work package and control account:

- **Planned value.** Planned value (PV) is the authorized budget assigned to scheduled work. It is the authorized budget planned for the work to be accomplished for an activity or work breakdown structure component. This budget is allocated by phase over the life of the program, but at a given moment, planned value defines the work that should have been accomplished. The total of the PV is sometimes referred to as the performance measurement baseline (PMB). The total planned value for the project is also known as budget at completion (BAC).
- **Earned value.** Earned value (EV) is a measure of work performed expressed in terms of the budget authorized for that work. It is the authorized work that has been completed,

plus the authorized budget for such completed work. The EV being measured must be related to the PMB, and the EV measured cannot be greater than the authorized PV budget for a component. The term EV is often used to describe the percentage completion of a project. Progress measurement criteria should be established for each WBS component to measure work in progress. Project managers monitor EV, both incrementally to determine current status and cumulatively to determine the long-term performance trends.

- **Actual cost.** Actual cost (AC) is the realized cost incurred for the work performed on an activity during a specific time period. It is the total cost incurred in accomplishing the work that the EV measured. The AC needs to correspond in definition to whatever was budgeted for in the PV and measured in the EV (e.g., direct hours only, direct costs only, or all costs including indirect costs). The AC will have no upper limit; whatever is spent to achieve the EV will be measured.

Variances from the approved baseline will also be monitored:

- **Schedule variance.** Schedule variance (SV) is the amount by which the project is ahead or behind the planned delivery date, at a given point in time, expressed as the difference between the earned value and the planned value. It is a measure of schedule performance on a project. It is equal to the earned value (EV) minus the planned value (PV). The EVM schedule variance is a useful metric in that it can indicate a project falling behind its baseline schedule. The EVM schedule variance will ultimately equal zero when the project is completed because all of the planned values will have been earned. Schedule variance is best used in conjunction with critical path methodology (CPM) scheduling and risk management. Equation: SV = EV - PV
- **Cost variance.** Cost variance (CV) is the amount of budget deficit or surplus at a given point in time, expressed as the difference between earned value and the actual cost. It is a measure of cost performance on a project. It is equal to the earned value (EV) minus the actual costs (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. The CV is particularly critical because it indicates the relationship of physical performance to the costs spent. Any negative CV is often nonrecoverable to the project. Equation: CV= EV - AC

The SV and CV values can be converted to efficiency indicators to reflect the cost and schedule performance of any project for comparison against all other projects or within a portfolio of projects. The variances and indices are useful for determining project status and providing a basis for estimating project cost and schedule outcome.

- **Schedule performance index.** The schedule performance index (SPI) is a measure of how efficiently the project team is using its time, expressed as the ratio of earned value to planned value. It is sometimes used in conjunction with the cost performance index (CPI) to forecast the final project completion estimates. An SPI value less than 1.0 indicates less work was completed than was planned. An SPI greater than 1.0 indicates that more work was completed than was planned. Since the SPI measures all project work, the performance on the critical path also needs to be analyzed to determine whether the project will finish ahead of or behind its planned finish date. The SPI is equal to the ratio of the EV to the PV. Equation: SPI = EV/PV
- **Cost performance index.** The cost performance index (CPI) is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost. It is considered the most critical EVM metric and measures the cost efficiency for the work completed. A CPI value of less than 1.0 indicates a cost overrun for work completed. A CPI value greater than 1.0 indicates a cost underrun of performance to date. The CPI is equal to the ratio of the EV to the AC. Equation: CPI = EV/AC

The three parameters of planned value, earned value, and actual cost can be monitored and reported on both a period-by-period basis (typically weekly or monthly) and on a cumulative basis. Figure 7-12 uses S-curves to display EV data for a project that is performing over budget and behind the work plan.

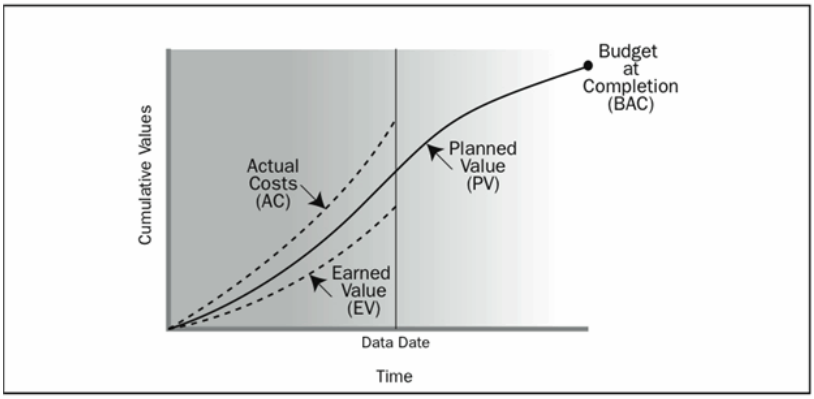


Figure 7-12. Earned Value, Planned Value, and Actual Costs

7.4.2.2 Forecasting

As the project progresses, the project team may develop a forecast for the estimate at completion (EAC) that may differ from the budget at completion (BAC) based on the project performance. If it becomes obvious that the BAC is no longer viable, the project manager

should develop a forecasted EAC. Forecasting the EAC involves making 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 generated, updated, and reissued based on work performance data (Section 4.3.3.2) provided as the project is executed. The work performance information covers the project's past performance and any information that could impact the project in the future.

EACs are typically based on the actual costs incurred for work completed, plus an estimate to complete (ETC) the remaining work. It is incumbent on the project team to predict what it may encounter to perform the ETC, based on its experience to date. The EVM method works well in conjunction with manual forecasts of the required EAC costs. The most common EAC forecasting approach is a manual, bottom-up summation by the project manager and project team.

The project manager's bottom-up EAC method builds upon the actual costs and experience incurred for the work completed, and requires a new estimate to complete the remaining project work. Equation: EAC = AC + bottom-up ETC.

The project manager's manual EAC is quickly compared with a range of calculated EACs representing various risk scenarios. While EVM data quickly provide many statistical EACs, only three of the more common methods are described as follows:

- **EAC forecast for ETC work performed at the budgeted rate.** This EAC method accepts the actual project performance to date (whether favorable or unfavorable) as represented by the actual costs, and predicts that all future ETC work will be accomplished at the budgeted rate. When actual performance is unfavorable, the assumption that future performance will improve should be accepted only when supported by project risk analysis. Equation: EAC = AC + BAC – EV
- **EAC forecast for ETC work performed at the present CPI.** This method assumes what the project has experienced to date can be expected to continue in the future. The ETC work is assumed to be performed at the same cumulative cost performance index (CPI) as that incurred by the project to date. Equation: EAC = BAC / cumulative CPI
- **EAC forecast for ETC work considering both SPI and CPI factors.** In this forecast, the ETC work will be performed at an efficiency rate that considers both the cost and schedule performance indices. It assumes both a negative cost performance to date, and a requirement to meet a firm schedule commitment by the project. This method is most useful when the project schedule is a factor impacting the ETC effort. Variations of this method weigh the CPI and SPI at different values (e.g., 80/20, 50/50, or some other ratio) according to the project manager's judgment. Equation: AC + [(BAC – EV) / (cumulative CPI × cumulative SPI)]

Each of these approaches are applicable for any given project and will provide the project management team with an "early warning" signal if the EAC forecasts are not within acceptable tolerances.

7.4.2.3 To-Complete Performance Index (TCPI)

The to-complete performance index (TCPI) is a measure of the cost performance that must be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the budget available. It is the calculated cost performance index that must be achieved on the remaining work to meet a specified management goal, such as the BAC or the EAC. If it becomes obvious that the BAC is no longer viable, the project manager develops a forecasted estimate at completion (EAC). Once approved, the EAC effectively supersedes the BAC as the cost performance goal. Equation for the TCPI based on the BAC: (BAC – EV) / (BAC – AC)

The TCPI is conceptually displayed in Figure 7-13. The equation for the TCPI is shown in the lower left as the work remaining (defined as the BAC minus the EV) divided by the funds remaining (which can be either the BAC minus the AC, or the EAC minus the AC). If the cumulative CPI falls below the baseline (as shown in Figure 7-13), all future work of the project will need to be performed immediately in the range of the TCPI (BAC) (as reflected in the top line of Figure 7-13) to stay within the authorized BAC. Whether this level of performance is achievable is a judgment call based on a number of considerations, including risks, schedule, and technical performance. Once management acknowledges that the BAC is no longer attainable, the project manager will prepare a new estimate at completion (EAC) for the work, and once approved, the project will work to the new EAC value. This level of performance is displayed as the TCPI (EAC) line. The equation for the TCPI based on the EAC: (BAC – EV) / (EAC – AC). The EVM formulas are provided in Figure 7-14.

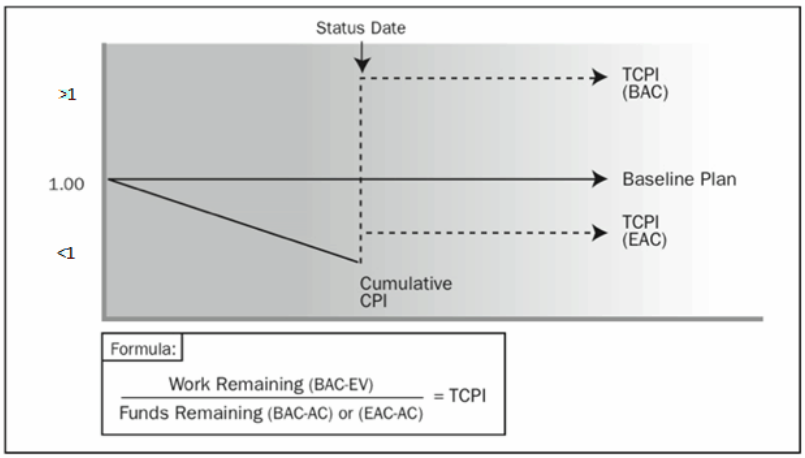


Figure 7-13. To-Complete Performance Index (TCPI)

7.4.2.4 Performance Reviews

Performance reviews compare cost performance over time, schedule activities or work packages overrunning and underrunning the budget, and estimated funds needed to complete work in progress. If EVM is being used, the following information is determined:

- Variance analysis. Variance analysis, as used in EVM, is the explanation (cause, impact, and corrective actions) for cost (EV – AC), schedule (EV – PV), and at completion (BAC – EAC) variances. Cost and schedule variances are the most frequently analyzed measurements.
- Trend analysis. Trend analysis examines project performance over time to determine if performance is improving or deteriorating. Graphical analysis techniques are valuable for understanding performance to date and for comparison to future performance goals in the form of BAC versus EAC and completion dates.
- Earned value performance. Earned value performance compares the performance measurement baseline to actual schedule and cost performance. If EVM is not being used, then the analysis of the cost baseline against actual costs for the work performed is used for cost performance comparisons.

EARNED VALUE ANALYSIS					
Abbrev Notes	Name	Lexicon Definition	How Used	Equation	Interpretation of Result
PV	Planned Value	The authorized budget assigned to scheduled work.	The value of the work planned to be completed to a point in time, usually the data date, or project completion.		
EV	Earned Value	The measure of work performed expressed in terms of the budget authorized for that work.	The planned value of all the work completed (earned) to a point in time, usually the data date, without reference to actual costs.	EV = sum of the planned value of completed work	
AC	Actual Cost	The actual cost incurred for the work performed on an activity during a specific time period.	The actual cost of all the work completed to a point in time, usually the data date.		
BAC	Budget at Completion	The sum of all budgets established for the work to be performed.	The value of total planned work, the project cost baseline.		
CV	Cost Variance	The amount of budget deficit or surplus at a given point in time, expressed as the difference between the earned value and the actual cost.	The difference between the value of work completed to a point in time, usually the data date, and the actual costs to the same point in time.	CV = EV – AC	Positive = "Under planned cost" Neutral = "On planned cost" Negative = "Over planned cost"
SV	Schedule Variance	The amount by which the project is ahead or behind the planned delivery date, at a given point in time, expressed as the difference between the earned value and the planned value.	The difference between the work completed to a point in time, usually the data date, and the work planned to be completed to the same point in time.	SV = EV – PV	Positive = "Ahead of Schedule" Neutral = "On schedule" Negative = "Behind Schedule"
CPI	Cost Performance Index	A measure of the cost efficiency of budgeted resources expressed as the ratio of earned value to actual cost.	A CPI of 1.00 means the project is exactly on budget, that the work actually done so far is exactly the same as the cost so far. Other values show the percentage of how much costs are over or under the budgeted amount for work accomplished.	CPI = EV / AC	Greater than 1.0 = "Under planned cost" Exactly 1.0 = "On planned cost" Less than 1.0 = "Over planned cost"
SPI	Schedule Performance Index	A measure of how efficiently the project is accomplishing its work expressed as the ratio of earned value to planned value.	An SPI of 1.0 means that the project is exactly on schedule, that the work actually done so far is exactly the same as the work planned to be done so far. Other values show the percentage of how much costs are over or under the budgeted amount for work planned.	SPI = EV / PV	Greater than 1.0 = "Ahead of schedule" Exactly 1.0 = "On schedule" Less than 1.0 = "Behind schedule"
EAC	Estimate At Completion	The expected total cost of completing all work expressed as the sum of the actual cost to date and the estimate to complete.	If the CPI is expected to be the same for the remainder of the project EAC can be calculated using:	EAC = BAC / CPI	
			If future work will be accomplished at the planned rate use:	EAC = AC + BAC – EV	
			If the initial plan is no longer valid use:	EAC = AC + bottom up ETC	
			If both the CPI and SPI influence the remaining work:	EAC = AC + [(BAC–EV)/(CPI x SPI)]	
ETC	Estimate to Complete	The expected cost to finish all the remaining project work.	Assuming work proceeds as per plan the cost of completing the remaining scheduled work can be calculated using:	ETC = EAC – AC	
			Re-estimate the remaining work from the bottom up.	ETC = Re-estimate	
TCPI	To Complete Performance Index	A measure of the cost performance that must be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the budget available.	The efficiency that must be maintained in order to complete as plan.	TCPI = [BAC – EV] / [BAC – AC]	Greater than 1.0 = Harder to complete Exactly 1.0 = Same to complete Less than 1.0 = Easier to complete
			The efficiency that must be maintained in order to complete the current EAC.	TCPI = [BAC – EV] / [EAC – AC]	Greater than 1.0 = Harder to complete Exactly 1.0 = Same to complete Less than 1.0 = Easier to complete

Figure 7-14. Earned Value Calculations Summary Table

7.4.2.5 Variance Analysis

Cost performance measurements are used to assess the magnitude of variation to the original cost baseline. Important aspects of project cost control include determining the cause and degree of variance relative to the cost baseline (Section 7.3.3.1) and deciding whether corrective or preventive action is required. The percentage range of acceptable variances will tend to decrease as more work is accomplished. The larger percentage variances allowed at the start of the project can decrease as the project nears completion.

7.4.2.6 Project Management Software

Project management software is often used to monitor the three EVM dimensions (PV, EV, and AC), to display graphical trends, and to forecast a range of possible final project results.

7.4.2.7 Reserve Analysis

During cost control, reserve analysis is used to monitor the status of contingency and management reserves for the project to determine if these reserves are still needed or if additional reserves need to be requested. As work on the project progresses, these reserves may be used as planned to cover the cost of risk mitigation events or other contingencies. Or, if the probable risk events do not occur, the unused contingency reserves may be removed from the project budget to free up resources for other projects or operations. Additional risk analysis during the project may reveal a need to request that additional reserves be added to the project budget. Management and contingency reserves are addressed in more detail in Section 7.2.2.6.

7.4.3 Control Costs: Outputs

7.4.3.1 Work Performance Information

The calculated CV, SV, CPI, SPI, TCPI, and VAC values for WBS components, in particular the work packages and control accounts, are documented and communicated to stakeholders.

7.4.3.2 Cost Forecasts

Either a calculated EAC value or a bottom-up EAC value is documented and communicated to stakeholders.

7.4.3.3 Change Requests

Analysis of project performance may result in a change request to the cost baseline or other components of the project management plan. Change requests may include preventive or corrective actions, and are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).

7.4.3.4 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- **Cost baseline.** Changes to the cost baseline are incorporated in response to approved changes in scope, activity resources, or cost estimates. In some cases, cost variances can be so severe that a revised cost baseline is needed to provide a realistic basis for performance measurement.
- **Cost management plan.** Changes to the cost management plan, such as changes to control thresholds or specified levels of accuracy required in managing the project's cost, are incorporated in response to feedback from relevant stakeholders.

7.4.3.5 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Cost estimates, and
- Basis of estimates.

7.4.3.6 Organizational Process Assets Updates

Organizational process assets that may be updated include, but are not limited to:

- Causes of variances,
- Corrective action chosen and the reasons,
- Financial databases, and
- Other types of lessons learned from project cost control.

CHAPTER 8

PROJECT QUALITY MANAGEMENT

Project Quality Management includes the processes and 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. Project Quality Management uses policies and procedures to implement, within the project's context, the organization's quality management system and, as appropriate, it supports continuous process improvement activities as undertaken on behalf of the performing organization. Project Quality Management works to ensure that the project requirements, including product requirements, are met and validated.
Figure 8-1 provides an overview of the Project Quality Management processes, which include:
8.1 Plan Quality Management—The process of identifying quality requirements and/or standards for the project and its deliverables and documenting how the project will demonstrate compliance with quality requirements.
8.2 Perform Quality Assurance—The process of auditing the quality requirements and the results from quality control measurements to ensure that appropriate quality standards and operational definitions are used.
8.3 Control Quality—The process of monitoring and recording results of executing the quality activities to assess performance and recommend necessary changes.
These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.

Project Quality Management addresses the management of the project and the deliverables of the project. It applies to all projects, regardless of the nature of their deliverables. Quality measures and techniques are specific to the type of deliverables being produced by the project. For example, the project quality management of software deliverables may use some different approaches and measures from those used when building a nuclear power plant. In either case, failure to meet the quality requirements can have serious, negative consequences for any or all of the project's stakeholders. For example:

- Meeting customer requirements by overworking the project team may result in decreased profits and increased project risks, employee attrition, errors, or rework.
- Meeting project schedule objectives by rushing planned quality inspections may result in undetected errors, decreased profits, and increased post-implementation risks.

Quality and *grade* are not the same concepts. Quality as a delivered performance or result is "the degree to which a set of inherent characteristics fulfill requirements **[x]**." Grade as a design intent is a category assigned to deliverables having the same functional use but different technical characteristics **[x]**. The project manager and the project management team are responsible for managing the tradeoffs associated with delivering the required levels of both quality and grade. While a quality level that fails to meet quality requirements is always a problem, a low grade of quality may not be a problem. For example:

- It may not be a problem if a suitable low-grade software product (one with a limited number of features) was of high quality (no obvious defects, readable manual). In this example, the product would be fit for its general purpose of use.
- It may be a problem if a high-grade software product (one with numerous features) was of low quality (many defects, poorly organized user documentation). In essence, its high-grade feature set would prove ineffective and/or inefficient due to its low quality.

The project management team must determine the appropriate levels of accuracy and precision for use in the quality management plan. *Precision* is a measure of exactness. For example, the magnitude for each increment on the measurement's number line is the interval that determines the measurement's precision. *Accuracy* is an assessment of correctness. For example, the measured value is very close to the true value of the characteristic that has been measured. Precise measurements are not necessarily accurate measurements and accurate measurements are not necessarily precise measurements.

The basic approach to project quality management as described in this section is intended to be compatible with that of the International Organization for Standardization (ISO). Every project should have a quality management plan. Project teams should follow the quality management plan and should have data to demonstrate compliance with the plan. In the context of achieving ISO compatibility, modern quality management approaches seek to minimize variation and to deliver results that meet defined requirements. These approaches recognize the importance of:

- **Customer satisfaction.** Understanding, evaluating, defining, and managing requirements so that customer expectations are met. This requires a combination of conformance to requirements (to ensure the project produces what it was created to produce) and fitness for use (the product or service must satisfy real needs).
- **Prevention over inspection.** Quality must be planned, designed, and built into—not inspected into the project's management or the project's deliverables. The cost of preventing mistakes is generally much less than the cost of correcting mistakes when they are found by inspection or during usage.
- **Continuous improvement.** The PDCA (plan-do-check-act) cycle is the basis for quality improvement as defined by Shewhart and modified by Deming. In addition, quality improvement initiatives such as Total Quality Management (TQM) and Lean Six Sigma should improve the quality of the project's management as well as the quality of the project's product. Commonly used process improvement models include Malcolm Baldrige, Organizational Project Management Maturity Model (OPM3®), and Capability Maturity Model Integrated (CMMI®).
- **Management responsibility.** Success requires the participation of all members of the project team. Nevertheless, management retains the responsibility to provide suitable resources at adequate capacities.

Cost of quality (COQ) refers to the total cost of the conformance work and the nonconformance work that must be done as a compensatory effort because some portion of the required work effort may be done or has been done incorrectly on the first attempt to perform that work. The costs for COQ work may be incurred throughout the deliverable's life cycle. For example, decisions made by the project team can impact the operational costs associated with using a completed deliverable. Post-project COQ costs might be incurred because of product returns, warranty claims, and recall campaigns. Therefore, because of the temporary nature of projects and the potential benefits that may be derived from reducing the post-project cost of quality, sponsoring organizations may choose to invest in product quality improvement. These investments would be made in the areas of conformance work that act to prevent defects or act to mitigate the costs of defects by inspecting out nonconforming units (Refer to Figure 8-2 and Section 8.1.2.2).

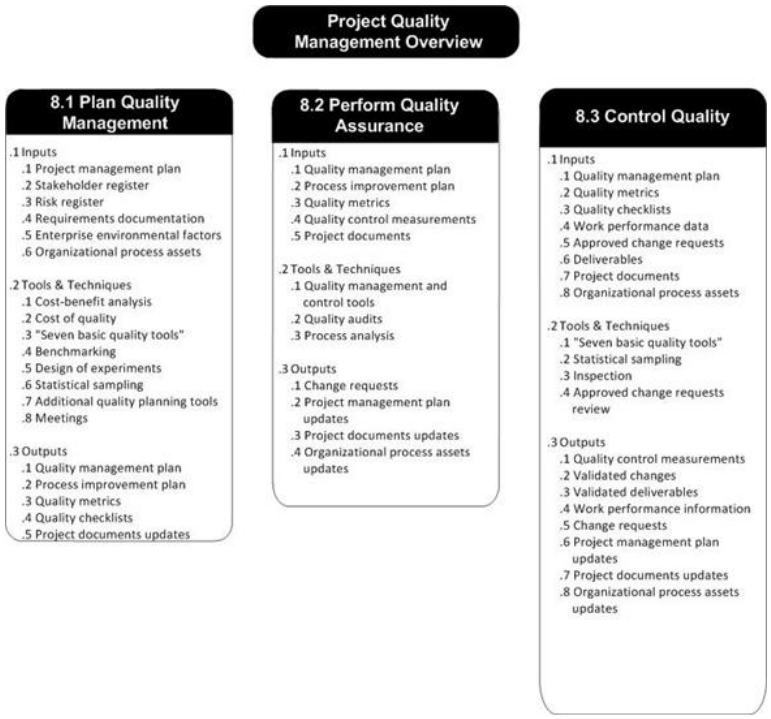


Figure 8-1. Project Quality Management Overview

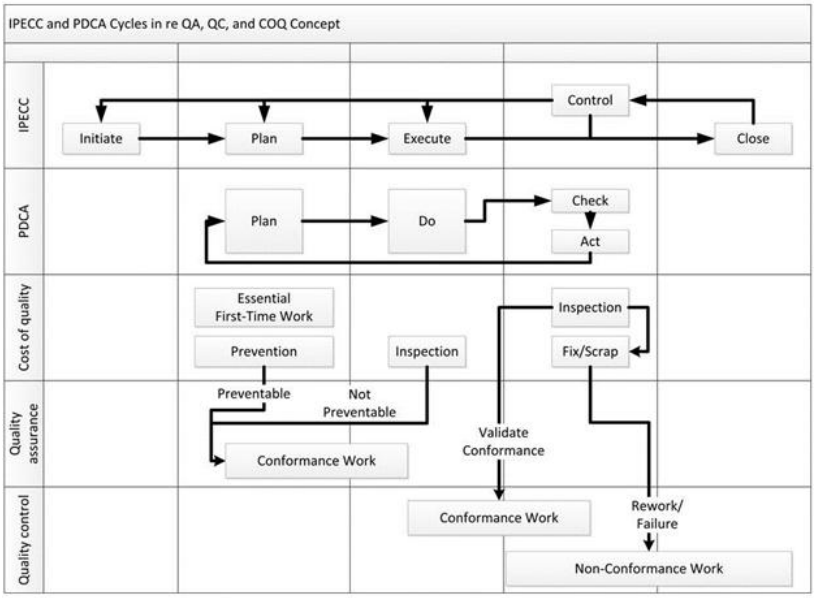


Figure 8-2. Fundamental Relationships of Quality Assurance and Quality Control to the IPECC, PDCA, and Cost of Quality Models

8.1 Plan Quality Management

Plan Quality Management is the process of identifying quality requirements and/or standards for the project and its deliverables, and documenting how the project will demonstrate compliance with relevant quality requirements. The key benefit of this process is that it provides guidance and direction on how quality will be managed and validated throughout the project. The inputs, tools and techniques, and outputs of this process are depicted in Figure 8-3. Figure 8-4 depicts the data flow diagram of the process.

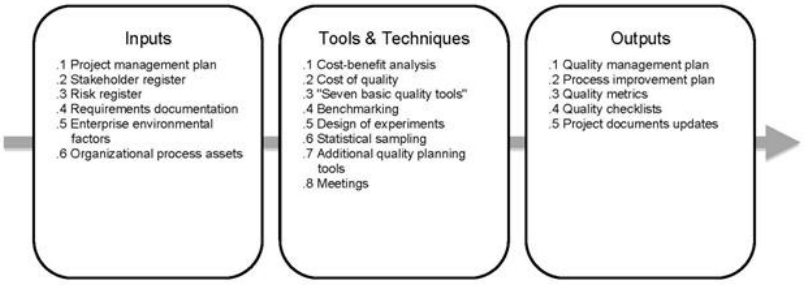


Figure 8-3. Plan Quality Management Inputs, Tools & Techniques, and Outputs

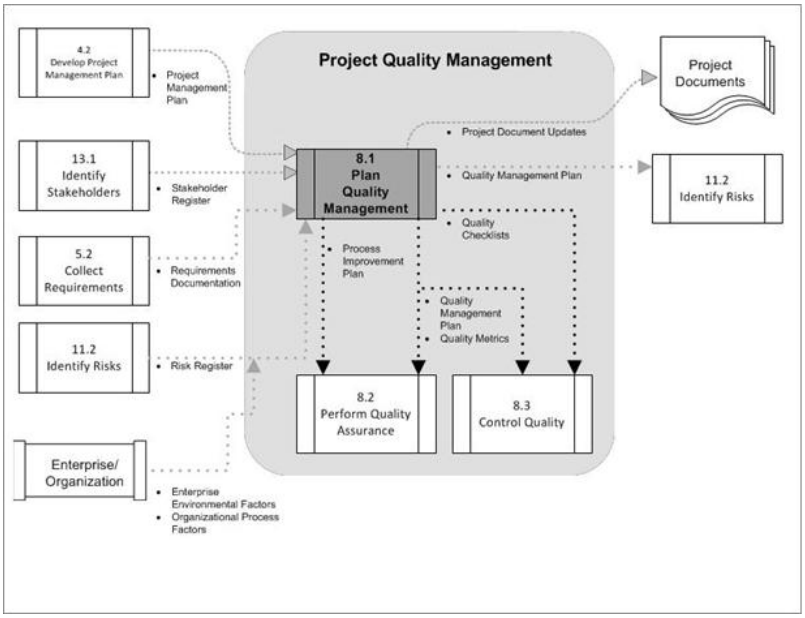


Figure 8-4. Plan Quality Management Data Flow Diagram

Quality planning should be performed in parallel with the other planning processes. For example, proposed changes in the deliverables to meet identified quality standards may require cost or schedule adjustments and a detailed risk analysis of the impact to plans. The quality planning techniques discussed here are those used most frequently on projects. There are many others that may be useful on certain projects or in some application areas.

8.1.1 Plan Quality Management: Inputs

8.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan is used to develop the quality management plan. The information used for the development of the quality management plan includes, but is not limited to:

- **Scope baseline.** The scope baseline (Section 5.4.3.1) includes:
  - *Project scope statement.* The project scope statement contains the project description, major project deliverables, and acceptance criteria. The product scope will often contain details of technical issues and other concerns that can affect quality planning and that should have been identified as a result of the planning processes in Scope Management. The definition of acceptance criteria may significantly increase or decrease quality costs and thus, project costs. Satisfying all acceptance criteria implies that the needs of the customer have been met.
  - *Work breakdown structure (WBS).* The WBS identifies the deliverables and the work packages used to measure project performance.
  - *WBS dictionary.* The WBS dictionary provides detailed information for WBS elements.
- **Schedule baseline.** The schedule baseline documents the accepted schedule performance measures, including start and finish dates (Section 6.6.3.1).
- **Cost baseline.** The cost baseline documents the accepted time interval being used to measure cost performance (Section 7.3.3.1).

8.1.1.2 Stakeholder Register

Described in Section 13.1.3.1. The stakeholder register aids in identifying those stakeholders possessing a particular interest in, or having an impact on, quality.

8.1.1.3 Risk Register

Described in Section 11.2.3.1. The risk register contains information on threats and opportunities that may impact quality requirements.

8.1.1.4 Requirements Documentation

Described in Section 5.2.3.1. Requirements documentation captures the requirements that the project shall meet pertaining to stakeholder expectations. The components of the requirements documentation include, but are not limited to project (including product) and quality requirements. The requirements are used by the project team to help plan how quality control will be implemented on the project.

8.1.1.5 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that influence the Plan Quality Management process include, but are not limited to:

- Governmental agency regulations;
- Rules, standards, and guidelines specific to the application area; and
- Working or operating conditions of the project or its deliverables that may affect project quality.

8.1.1.6 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Plan Quality Management process include, but are not limited to:

- Organizational quality policies, procedures, and guidelines. The performing organization's quality policy, as endorsed by senior management, sets the organization's intended direction on implementing its quality management approach.
- Historical databases; and
- Lessons learned from previous projects.

8.1.2 Plan Quality Management: Tools and Techniques

8.1.2.1 Cost-Benefit Analysis

The primary benefits of meeting quality requirements include less rework, higher productivity, lower costs, increased stakeholder satisfaction, and increased profitability. A business case for each quality activity compares the cost of the quality step to the expected benefit.

8.1.2.2 Cost of Quality (COQ)

Cost of quality includes all costs incurred over the life of the product by investment in preventing nonconformance to requirements, appraising the product or service for conformance to requirements, and failing to meet requirements (rework). Failure costs are often categorized into internal (found by the project) and external (found by the customer). Failure costs are also called cost of poor quality. Figure 8-5 provides some examples to consider in each area.

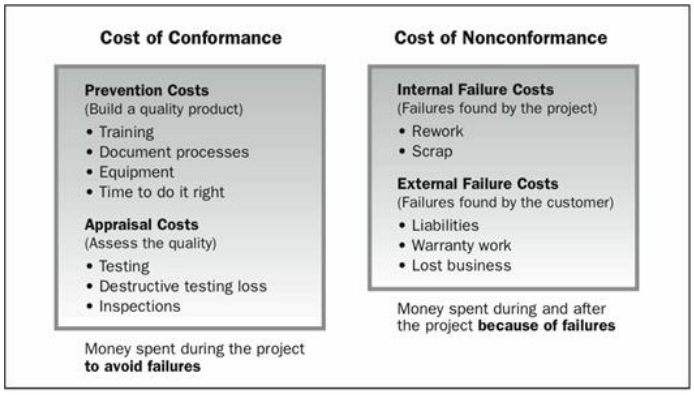


Figure 8-5. Cost of Quality

8.1.2.3 "Seven Basic Quality Tools"

The seven basic quality tools are used within the context of the PDCA to solve quality-related problems. As conceptually illustrated in Figure 8-7, the seven basic quality tools are:

- *Cause-and-effect diagrams,* which are also known as fishbone diagrams or as

Ishikawa diagrams. The problem statement placed at the head of the fishbone is used as a starting point to trace the problem's source back to its actionable root cause. The problem statement typically describes the problem as a gap to be closed or as an objective to be achieved. The causes are found by looking at the problem statement and asking "why" until the actionable root cause has been identified or until the reasonable possibilities on each fishbone have been exhausted. Fishbone diagrams often prove useful in linking the undesirable effects seen as special variation to the assignable cause on which project teams should implement corrective actions to eliminate the special variation detected in a control chart.

- *Flowcharts*, which are also referred to as process maps because they display the sequence of steps and the branching possibilities that exist for a process that transforms one or more inputs into one or more outputs. Flowcharts are often used to map the procedures that exist within a horizontal value chain using a SIPOC (Supplier, Input, Process, Output, Customer) model (Figure 8-6). Flowcharts may prove useful in understanding and estimating the cost of quality in a process. This is obtained by using the workflow branching logic and associated relative frequencies to estimate expected monetary value for the conformance and nonconformance work required to deliver the expected conforming output.

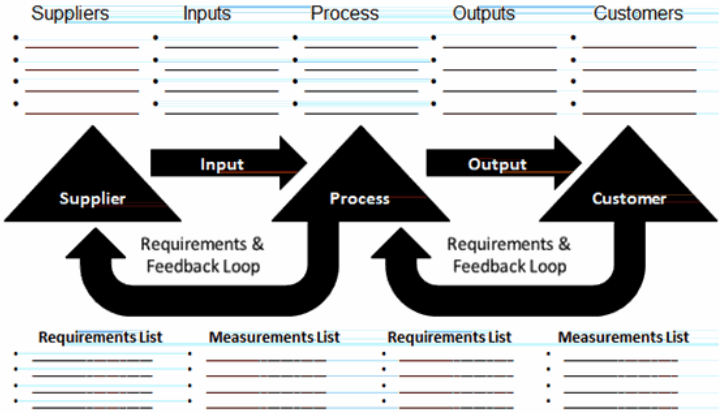


Figure 8-6. The SIPOC Model

- *Checksheets*, are also known as tally sheets and may be used as a checklist when gathering data. Checksheets are used to organize facts in a manner that will facilitate the effective collection of useful data about a potential quality problem. They are especially useful for gathering attributes data while performing inspections to identify defects. For example, data about the frequencies or consequences of defects collected in checksheets are often displayed using Pareto diagrams.
- *Pareto diagrams*, exist as a special form of vertical bar chart and are used to identify the vital few sources that are responsible for causing most of a problem's effects. The categories shown on the horizontal axis must exist as a valid probability distribution that accounts for 100% of the possible observations. The relative frequencies of each specified cause listed on the horizontal axis decrease in magnitude until the default source named "*other*" accounts for any nonspecified causes. Typically, the Pareto diagram will be organized into categories that measure either frequencies or consequences.
- *Histograms*, are a special form of bar chart and are used to describe the central tendency, dispersion, and shape of a statistical distribution. Unlike the control chart, the histogram does not consider the influence of time on the variation that exists within a distribution.
- *Control charts*, are used to determine whether or not a process is stable or has predictable performance. Upper and lower specification limits are based on requirements of the contract. They reflect the maximum and minimum values allowed. There may be penalties associated with exceeding the specification limits. Upper and lower control limits are set by the project manager and appropriate stakeholders to reflect the points at which corrective action will be taken to prevent exceeding specification limits. For repetitive processes, the control limits are generally ± 3s. A process is considered out of control when a data point exceeds a control limit or if seven consecutive points are above or below the mean.

Control charts can be used to monitor various types of output variables. Although used most frequently to track repetitive activities required for producing manufactured lots, control charts may also be used to monitor cost and schedule variances, volume, and frequency of scope changes, or other management results to help determine if the project management processes are in control.

- *Scatter diagrams*, exist as ordered pairs (X, Y) and are sometimes called correlation charts because they seek to explain a change in the dependent variable Y in relationship to a change observed in the corresponding independent variable X. The direction of correlation may be proportional (positive correlation), inverse (negative correlation), or a pattern of correlation may not exist (zero correlation). If correlation can be established, a regression line can be calculated and used to estimate how a change to the independent variable will influence the value of the dependent variable.

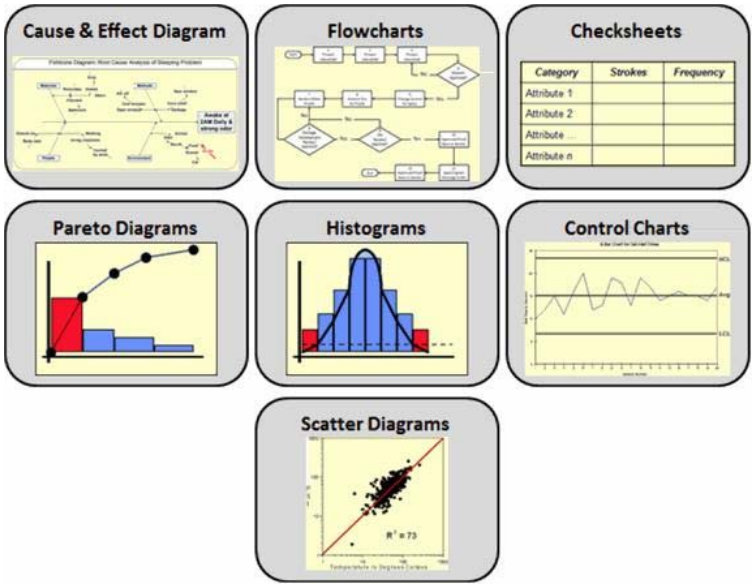


Figure 8-7. Storyboard Illustrating a Conceptual Example of Each of the Seven Basic Quality Tools

8.1.2.4 Benchmarking

Benchmarking involves comparing actual or planned project practices to those of comparable projects to identify best practices, generate ideas for improvement, and provide a basis for measuring performance.
Benchmarked projects may exist within the performing organization or outside of it, can be within the same application area or can make analogies from projects in a different application area.

8.1.2.5 Design of Experiments

Design of experiments (DOE) is a statistical method for identifying which factors may influence specific variables of a product or process under development or in production.
DOE may be used during the Plan Quality Management process to determine the number and type of tests and their impact on cost of quality.
DOE also plays a role in optimizing products or processes. DOE is used to reduce the sensitivity of product performance to sources of variations caused by environmental or manufacturing differences. One important aspect of this technique is that it provides a statistical framework for systematically changing all the important factors, rather than changing the factors one at a time. Analysis of the experimental data should provide the optimal conditions for the product or process, highlight the factors that influence the results, and reveal the presence of interactions and synergy 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.

8.1.2.6 Statistical Sampling

Statistical sampling involves choosing part of a population of interest for inspection (for example, selecting ten engineering drawings at random from a list of seventy-five).
Sample frequency and sizes should be determined during the Plan Quality Management process so the cost of quality will include the number of tests, expected scrap, etc.
There is a substantial body of knowledge on statistical sampling. In some application areas, it may be necessary for the project management team to be familiar with a variety of sampling techniques to assure the sample selected represents the population of interest.

8.1.2.7 Additional Quality Planning Tools

Other quality planning tools are used to define the quality requirements and to plan effective quality management activities. These include, but are not limited to:

- **Brainstorming.** This technique is used to generate ideas (defined in Section 11.2.2.2).
- **Force field analysis.** These are diagrams of the forces for and against change.
- **Nominal group techniques.** These techniques are used to allow ideas to be brainstormed in small groups and then reviewed by a larger group.
- **Quality management and control tools.** These tools are used to link and sequence the activities identified (defined in Section 8.2.2.1).

8.1.2.8 Meetings

Project teams may hold planning meetings to develop the quality management plan. Attendees at these meetings may include the project manager; the project sponsor; selected project team members; selected stakeholders; anyone with responsibility for Plan Quality Management, Perform Quality Assurance, or Control Quality; and others as needed.

8.1.3 Plan Quality Management: Outputs

8.1.3.1 Quality Management Plan

The quality management plan is a component of the project management plan that describes how the organization's quality policies will be implemented. It describes how the project management team plans to meet the quality requirements set for the project.
The quality management plan may be formal or informal, detailed, or broadly framed. The style and detail in the quality plan are determined by the requirements of the project.
The quality management plan should be reviewed early in the project to ensure that decisions are based on accurate information. The benefits of this review can include a sharper focus on the project's value proposition and reductions in costs and in the frequency of schedule overruns that were caused by rework.

8.1.3.2 Process Improvement Plan

The process improvement plan is a subsidiary of the project management plan (Section 4.2.3.1). The process improvement plan details the steps for analyzing processes to identify activities that enhance their value. Areas to consider include:

- **Process boundaries.** Describe the purpose of the process, the start and end of the process, its inputs and outputs, the required data, the process owner, and the stakeholders of the process.
- **Process configuration.** A graphical depiction of processes, with interfaces identified, used to facilitate analysis.
- **Process metrics.** Along with control limits, allows analysis of process efficiency.
- **Targets for improved performance.** Guide the process improvement activities.

8.1.3.3 Quality Metrics

A quality metric specifically describes a project or product attribute and how the control quality process will measure it. A measurement is an actual value. The tolerance defines the allowable variations to the metric. For example, if the quality objective is to stay within the approved budget by ± 10%, the specific quality metric is used to measure the cost of every deliverable and determine the percent variance from the approved budget for that deliverable. Quality metrics are used in the perform quality assurance and control quality processes. Some examples of quality metrics include on-time performance, cost control, defect frequency, failure rate, availability, reliability, and test coverage.

8.1.3.4 Quality Checklists

A checklist is a structured tool, usually component-specific, used to verify that a set of required steps has been performed. Based on the project's requirements and practices, checklists may be simple or complex. Many organizations have standardized checklists available to ensure consistency in frequently performed tasks. In some application areas, checklists are also available from professional associations or commercial service providers. Quality checklists should incorporate the acceptance criteria included in the scope baseline.

8.1.3.5 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Stakeholder register; and
- Responsibility assignment matrix (Section 9.1.2.1).

8.2 Perform Quality Assurance

Perform Quality Assurance is the process of auditing the quality requirements and the results from quality control measurements to ensure that appropriate quality standards and operational definitions are used. The key benefit of this process is it facilitates the improvement of quality processes. The inputs, tools and techniques, and outputs of this process are depicted in Figure 8-8. Figure 8-9 depicts the data flow diagram of the process.

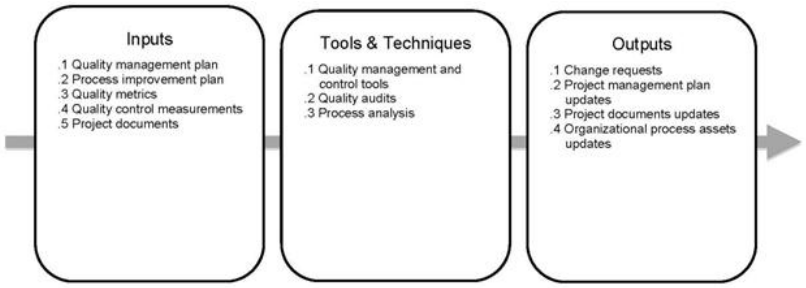


Figure 8-8. Perform Quality Assurance: Inputs, Tools & Techniques, and Outputs

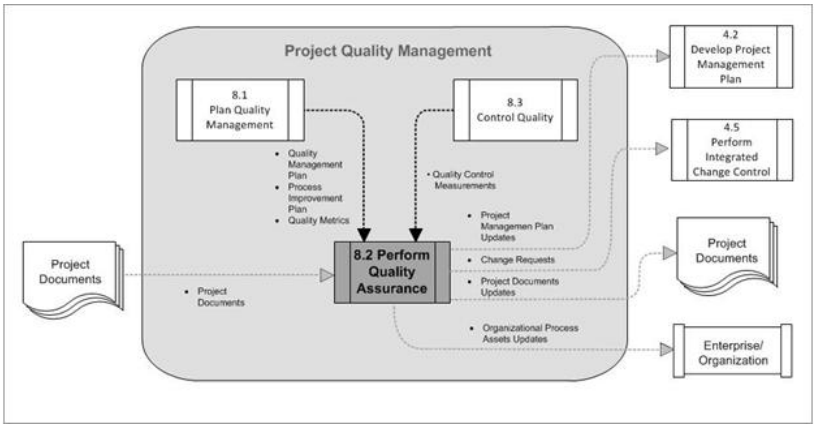


Figure 8-9. Perform Quality Assurance Data Flow Diagram

The quality assurance process implements a set of planned and systematic acts and processes defined within the project's quality management plan. Quality assurance seeks to build confidence that a future output or an unfinished output, also known as work in progress, will be completed in a manner that meets the specified requirements and expectations. Quality assurance contributes to the state of being certain about quality by preventing defects through the planning processes or by inspecting out defects during the work-in-progress stage of implementation. Perform Quality Assurance is an execution process that uses data created during Plan Quality Management (Section 8.1) and Control Quality (Section 8.3).

In project management, the prevention and inspection aspects of quality assurance should have a demonstrable influence on the project schedule. Quality assurance work will fall under the conformance work category in the cost of quality framework.

A quality assurance department, or similar organization, often oversees quality assurance activities. Quality assurance support, regardless of the unit's title, may be provided to the project team, the management of the performing organization, the customer or sponsor, as well as other stakeholders not actively involved in the work of the project.

Perform Quality Assurance also provides an umbrella for continuous process improvement, which is an iterative means for improving the quality of all processes. Continuous process improvement reduces waste and eliminates activities that do not add value. This allows processes to operate at increased levels of efficiency and effectiveness.

8.2.1 Perform Quality Assurance: Inputs

8.2.1.1 Quality Management Plan

Described in Section 8.1.3.1. The quality management plan describes the quality assurance and continuous process improvement approaches for the project.

8.2.1.2 Process Improvement Plan

Described in Section 8.1.3.2. The project's quality assurance activities must be supportive of and consistent with the performing organization's process improvement plans.

8.2.1.3 Quality Metrics

Described in Section 8.1.3.3. The quality metrics provide the variables that should be measured and the allowable variations.

8.2.1.4 Quality Control Measurements

Described in Section 8.3.3.1. Quality control measurements are the results of control quality activities. They are used to analyze and evaluate the quality standards and processes of the performing organization.

8.2.1.5 Project Documents

Project documents may influence quality assurance work and must be monitored within the context of a system for configuration management.

8.2.2 Perform Quality Assurance: Tools and Techniques

8.2.2.1 Quality Management and Control Tools

The Perform Quality Assurance processes uses the tools and techniques of the Plan Quality Management and Control Quality processes. In addition, other tools that are available include (see also Figure 8-10):

- **Affinity diagrams.** Also known as KJ Methods. The affinity diagram is similar to mind-mapping techniques in that they are used to generate ideas that can be linked to form organized patterns of thought about a problem. In project management, the creation of the WBS may be enhanced by using the affinity diagram to give structure to the decomposition of scope.
- **Process decision program charts (PDPC)**. Used to understand a goal in relation to the steps for getting to the goal. The PDPC is useful as a method for contingency planning because it aids teams in anticipating intermediate steps that could derail achievement of the goal.
- **Interrelationship digraphs.** An adaptation of relationship diagrams. The interrelationship digraphs provide a process for creative problem-solving in moderately complex scenarios that possess intertwined logical relationships up to 50 relevant items. The interrelationship digraph may be developed from data generated in other tools such as the affinity diagram, the tree diagram, or the fishbone diagram.
- **Tree diagrams.** Also known as systematic diagrams and may be used to represent decomposition hierarchies such as the WBS, RBS (risk breakdown structure), and OBS (objectives breakdown structure). In project management, tree diagrams are useful in visualizing the parent-to-child relationships in any decomposition hierarchy that uses a systematic set of rules that define a nesting relationship. Because tree diagrams permit the creation of nested branches that terminate into a single decision point, they are useful as decision trees for establishing an expected value for a limited number of dependent relationships that have been diagramed systematically.
- **Prioritization matrices.** Identify the key issues and the suitable alternatives to be prioritized as a set of decisions for implementation. Criteria are prioritized and weighted before being applied to all available alternatives to obtain a mathematical score that ranks the options.
- **Activity network diagrams**. Previously known as arrow diagrams. They have been expanded to include both the AOA (Activity on Arrow) and the AON (Activity on Node) formats of a network diagram. Activity network diagrams are used with project scheduling methodologies such as PERT, CPM, and PDM.
- **Matrix diagrams**. Used to perform data analysis within the organizational structure created in the matrix. The matrix diagram seeks to show the strength of relationships that exist between the rows and columns that form the matrix. Matrix diagrams exist in many formats that include the two-dimensional L-Type, T-Type, and X-Type matrices as well as the three-dimensional C-Type.

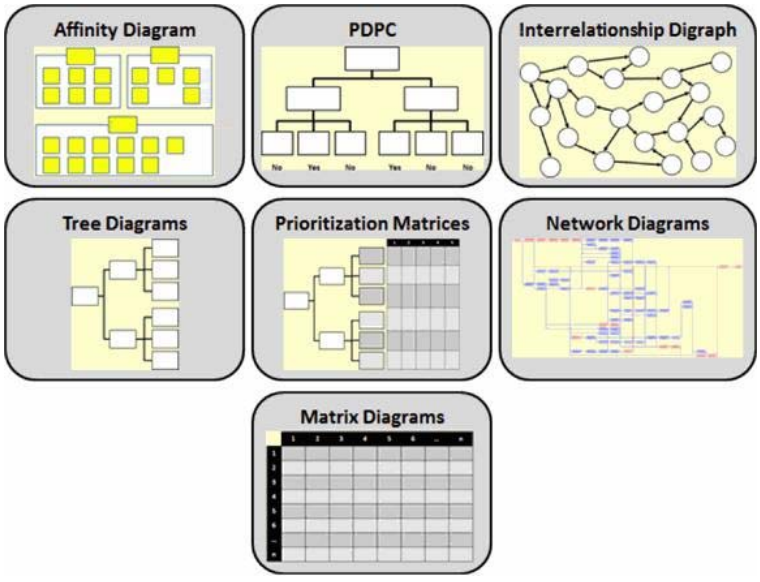


Figure 8-10. Storyboard.

8.2.2.2 Quality Audits

A quality audit is a structured, independent process to determine if project activities comply with organizational and project policies, processes, and procedures. The objectives of a quality audit are:

- Identify all good and best practices being implemented,
- Identify all gaps and shortcomings,
- Share good practices introduced or implemented in similar projects in the organization and/or industry.
- Proactively offer assistance in a positive manner to improve implementation of processes to help the team raise productivity.
- Highlight contributions of each audit in the lessons learned repository of the organization.

The subsequent effort to correct any deficiencies should result in a reduced cost of quality and an increase in sponsor or customer acceptance of the project's product. Quality audits may be scheduled or random, and may be conducted by internal or external auditors.
Quality audits can confirm the implementation of approved change requests including corrective actions, defect repairs, and preventive actions.

8.2.2.3 Process Analysis

Process analysis follows the steps outlined in the process improvement plan to identify needed improvements. This analysis also examines problems experienced, constraints experienced, and nonvalue-added activities identified during process operation. Process analysis includes root cause analysis—a specific technique used to identify a problem, discover the underlying causes that lead to it, and develop preventive actions.

8.2.3 Perform Quality Assurance: Outputs

8.2.3.1 Change Requests

Change requests are created and used as input into the Perform Integrated Change Control process (Section 4.5) process to allow full consideration of the recommended improvements. Change requests are used to take corrective action, preventive action, or to perform defect repair.

8.2.3.2 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- Quality management plan,
- Schedule management plan, and
- Cost management plan.

8.2.3.3 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Quality audit reports,
- Training plans, and
- Process documentation.

8.2.3.4 Organizational Process Assets Updates

Elements of the organizational process assets that may be updated include, but are not limited to, quality standards.

8.3 Control Quality

Control Quality is the process of monitoring and recording results of executing the quality activities to assess performance and recommend necessary changes. The key benefits of this process include: identifying the causes of poor process or product quality and recommending and/or taking action to eliminate them and validating that project deliverables and work meet the requirements specified by key stakeholders necessary for final acceptance. The inputs, tools and techniques, and outputs of this process are depicted in Figure 8-11. Figure 8-12 depicts the data flow diagram of the process.

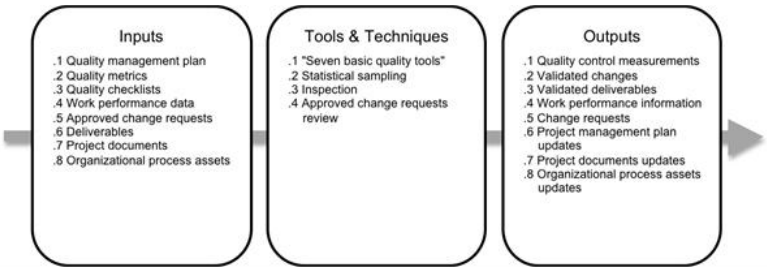


Figure 8-11. Control Quality: Inputs, Tools & Techniques, and Outputs

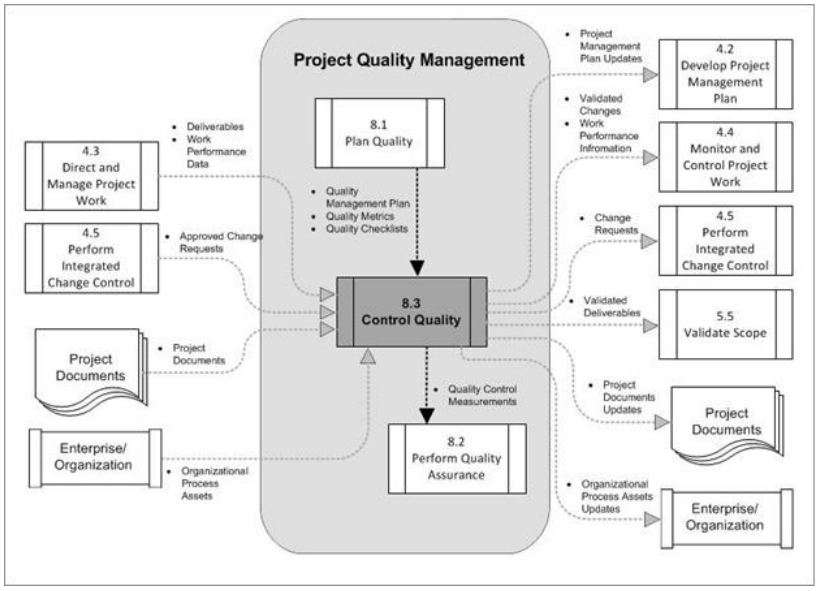


Figure 8-12. Control Quality Data Flow Diagram

The Control Quality process uses a set of operational techniques and tasks to validate that the delivered output will meet the requirements and expectations. Quality assurance should be used during the project's planning and implementation phase to provide confidence that the stakeholder's expectations will be met and quality control should be used during the project implementation and closeout phases to formally demonstrate, with reliable data, that the customer's acceptance criteria have been met.

The project management team should have a working knowledge of statistical control processes to evaluate data contained in the control quality outputs. Among other subjects, the team may find it useful to know the differences between the following pairs of terms:

- Prevention (keeping errors out of the process) and inspection (keeping errors out of the hands of the customer).
- Attribute sampling (the result either conforms or does not conform) and variables sampling (the result is rated on a continuous scale that measures the degree of conformity). See also Figures 8-2 and 8-7.
- Tolerances (specified range of acceptable results) and control limits (that identify the boundaries of common variation in a statistically stable performance).

8.3.1 Control Quality: Inputs

8.3.1.1 Quality Management Plan

Described in Section 8.1.3.1. The project management plan contains the quality management plan, which is used to control quality. The quality management plan describes how quality control will be performed within the project.

8.3.1.2 Quality Metrics

Described in Section 8.1.3.3. A quality metric describes a project or product attribute and how it will be measured. Some examples of quality metrics include: function points, mean time between failure (MTBF), mean time to repair (MTTR).

8.3.1.3 Quality Checklists

Described in Section 8.1.3.4. Quality checklists are structured lists that help to verify that the work of the project and its deliverables fulfill a set of requirements.

8.3.1.4 Work Performance Data

Described in Section 4.3.3.2. Work performance data can include:

- Planned versus actual technical performance,
- Planned versus actual schedule performance, and
- Planned versus actual cost performance.

8.3.1.5 Approved Change Requests

As part of the Perform Integrated Change Control process, a change control status update indicates that some changes are approved and some are not. Approved change requests may include modifications such as defect repairs, revised work methods, and revised schedule. The timely implementation of approved changes needs to be verified.

8.3.1.6 Deliverables

Described in Section 4.3.3.1. A deliverable is any unique and verifiable product, result, or capability that results in a validated deliverable required by the project.

8.3.1.7 Project Documents

Project documents may include, but are not limited to:

- Agreements.
- Quality audit reports and corrective action plans.
- Training plans and assessments of effectiveness.
- Process documentation such as those obtained using either the seven basic quality tools or the quality management and control tools shown in Figures 8-7 and 8-10.

8.3.1.8 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Control Quality process include, but are not limited to:

- Quality standards and policies,
- Standard work guidelines, and
- Issue and defect reporting procedures and communication policies.

8.3.2 Control Quality: Tools and Techniques

8.3.2.1 “Seven Basic Quality Tools”

Described in Section 8.1.2.3. The seven basic quality tools are illustrated conceptually in Figure 8-7.

8.3.2.2 Statistical Sampling

Described in Section 8.1.2.6. Samples are selected and tested as defined in the quality management plan.

8.3.2.3 Inspection

An inspection is the examination of a work product to determine if it conforms to documented standards. The results of an inspection generally include measurements and may be conducted at any level. For example, the results of a single activity can be inspected, or the final product of the project can be inspected. Inspections may be called reviews, peer reviews, audits, or walkthroughs. In some application areas, these terms have narrow and specific meanings. Inspections also are used to validate defect repairs.

8.3.2.4 Approved Change Requests Review

All approved change requests should be reviewed to verify that they were implemented as approved.

8.3.3 Control Quality: Outputs

8.3.3.1 Quality Control Measurements

Quality control measurements are the documented results of control quality activities. They should be captured in the format that was specified during quality planning.

8.3.3.2 Validated Changes

Any changed or repaired items are inspected and will be either accepted or rejected before notification of the decision is provided. Rejected items may require rework.

8.3.3.3 Validated Deliverables

A goal of Control Quality is to determine the correctness of deliverables. The results of executing the Control Quality process are validated deliverables. Validated deliverables are an input to Validate Scope (5.5.1.5) for formalized acceptance.

8.3.3.4 Work Performance Information

Work performance information is the performance data collected from various controlling processes, analyzed in context and integrated based on relationships across areas. Examples include information about the project requirements fulfillment such as causes for rejections, rework required, or the need for process adjustments.

8.3.3.5 Change Requests

If the recommended corrective or preventive actions or a defect repair requires a change to the project management plan, a change request (Section 4.4.3.1) should be initiated in accordance with the defined Perform Integrated Change Control (4.5) process.

8.3.3.6 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- Quality management plan (Section 8.1.3.1), and
- Process improvement plan (Section 8.1.3.2).

8.3.3.7 Project Documents Updates

Project documents that may be updated include, but are not limited to,

- Quality standards;
- Contracts;
- Quality audit reports and corrective action plans;
- Training plans and assessments of effectiveness; and
- Process documentation, such as information obtained using the seven basic quality tools or the quality management and control tools.

8.3.3.8 Organizational Process Assets Updates

Elements of the organizational process assets that may be updated include, but are not limited to:

- **Completed checklists.** When checklists are used, the completed checklists become part of the project's records (Section 4.1.1.5).
- **Lessons learned documentation.** The causes of variances, the reasoning behind the corrective action chosen, and other types of lessons learned from control quality are documented so they become part of the historical database for both the project and the performing organization.

CHAPTER 9

PROJECT HUMAN RESOURCE MANAGEMENT

Project Human Resource Management includes the processes that organize, manage, and lead the project team. The project team is comprised of the people with assigned roles and responsibilities for completing the project. The type and number of project team members can change frequently as the project progresses. Project team members may also be referred to as the project's staff. While the specific roles and responsibilities for the project team members are assigned, the involvement of all team members in project planning and decision making can be beneficial. Early involvement and participation of team members adds their expertise during the planning process and strengthens their commitment to the project.

Figure 9-1 provides an overview of the Project Human Resource Management processes, which are as follows:

9.1 Plan Human Resource Management—The process of identifying and documenting project roles, responsibilities, and required skills, reporting relationships, and creating a staffing management plan.

9.2 Acquire Project Team—The process of confirming human resource availability and obtaining the team necessary to complete project assignments.
9.3 Develop Project Team—The process of improving the competencies, team interaction, and the overall team environment to enhance project performance.
9.4 Manage Project Team—The process of tracking team member performance, providing feedback, resolving issues, and managing changes to optimize project performance.
These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.
Examples of interactions that require additional planning include the following situations:

- After initial team members create a work breakdown structure, additional team members may need to be acquired.
- As additional team members are acquired, their experience levels, or lack thereof, could increase or decrease project risk, creating the need for additional risk planning updates.
- When activity durations are estimated, budgeted, scoped, or planned prior to identifying all project team members and their competency levels, the activity durations may be subject to change.

The project management team is a subset of the project team and is responsible for the project management and leadership activities such as initiating, planning, executing, monitoring, controlling, and closing the various project phases. This group can also be referred to as the core, executive, or leadership team. For smaller projects, the project management responsibilities may be shared by the entire team or administered solely by the project manager. The project sponsor works with the project management team, typically assisting with matters such as project funding, clarifying scope, monitoring progress, and influencing others in both the requesting and performing organization in order to benefit the project.
Managing and leading the project team include, but are not limited to:

- **Influencing the project team.** The project manager needs to be aware of and influence, when possible, those human resource factors that may impact the project. This includes team environment, geographical locations of team members, communications among stakeholders, internal and external politics, cultural issues, organizational uniqueness, and other people factors that may alter the project performance.
- **Professional and ethical behavior.** The project management team should be aware of, subscribe to, and ensure that all team members follow ethical behavior.

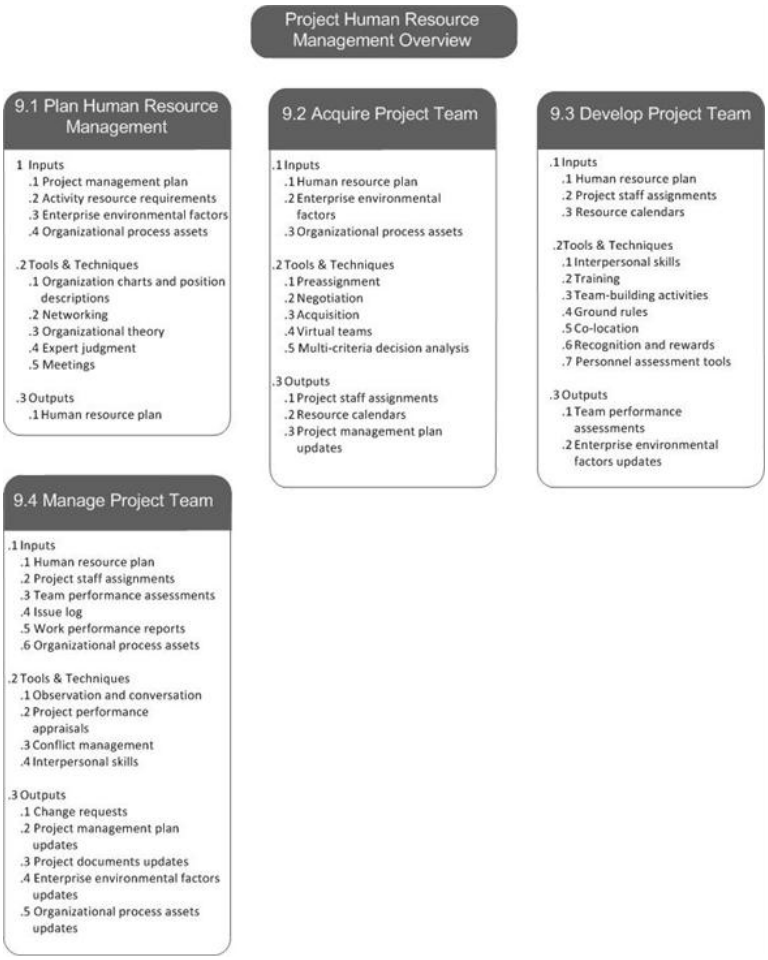


Figure 9-1. Project Human Resource Management Overview

9.1 Plan Human Resource Management

Plan Human Resource Management is the process of identifying and documenting project roles, responsibilities, and required skills, reporting relationships, and creating a staffing management plan. The key benefit of this process is that it documents project roles and responsibilities, project organization charts, and the staffing management plan including the timetable for staff acquisition and release. The inputs, tools and techniques, and outputs of this process are depicted in Figure 9-2. Figure 9-3 depicts the data flow diagram of the process.

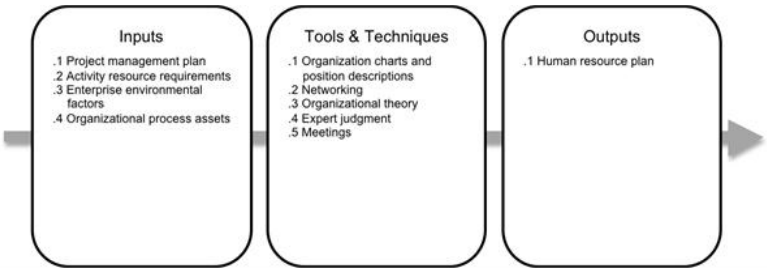


Figure 9-2. Plan Human Resource Management: Inputs, Tools & Techniques, and Outputs

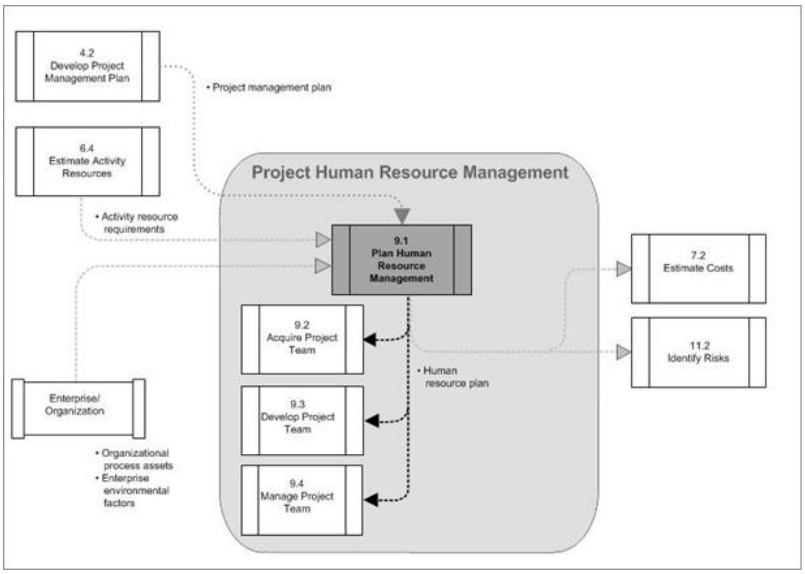


Figure 9-3. Plan Human Resource Management Data Flow Diagram

Human resource planning is used to determine and identify human resources with the necessary skills required for project success. The human resource plan describes how the roles and responsibilities, reporting relationships, and staff management will be addressed and structured within a project. It may also contain the staff management plan including timetables for staff acquisition and release, identification of training needs, team-building strategies, plans for recognition and rewards programs, compliance considerations, safety issues, and the impact of the staffing management plan on the organization.

Effective human resource planning should consider and plan for the availability of or competition for scarce or limited human resources. Project roles can be designated for persons or groups. Those persons or groups can be from inside or outside the organization performing the project. Other projects may be competing for human resources with the same competencies or skill sets. Given these factors, project costs, schedules, risks, quality, and other areas may be significantly affected.

9.1.1 Plan Human Resource Management: Inputs

9.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan is used to develop the human resource plan as described in Section 9.1.3.1. The information used for the development of the human resource plan includes, but is not limited to:

- The project life cycle selected and the processes that will be applied to each phase;
- How work will be executed to accomplish the project objectives;
- How human resources requirements will be met and how roles and responsibilities, reporting relationships, and staffing management will be addressed and structured for the project;

- A change management plan that documents how changes will be monitored and controlled;
- A configuration management plan that documents how configuration management will be performed;
- How integrity of the performance measurement baselines will be maintained; and
- Needs and techniques for communication among stakeholders.

9.1.1.2 Activity Resource Requirements

Described in Section 6.4.3.1. Human resource planning uses activity resource requirements to determine the human resource needs for the project. The preliminary requirements regarding the required people and competencies for the project team members are progressively elaborated as part of the human resource planning process.

9.1.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Plan Human Resource Management process include, but are not limited to:

- Organizational culture and structure;
- Existing human resources;
- Personnel administration policies; and
- Marketplace conditions.

9.1.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Plan Human Resource Management process include, but are not limited to:

- Organizational standard processes, policies, and standardized role descriptions;
- Templates for organizational charts and position descriptions;
- Historical information on organizational structures that have worked in previous projects; and
- Escalation procedures for handling issues within the team and within the performing organization.

9.1.2 Plan Human Resource Management: Tools and Techniques

9.1.2.1 Organization Charts and Position Descriptions

Various formats exist to document team member roles and responsibilities. Most of the formats fall into one of three types (Figure 9-4): hierarchical, matrix, and text-oriented. Additionally, some project assignments are listed in subsidiary plans, such as the risk, quality, or communications management plans. Regardless of the method utilized, the objective is to ensure that each work package has an unambiguous owner and that all team members have a clear understanding of their roles and responsibilities.

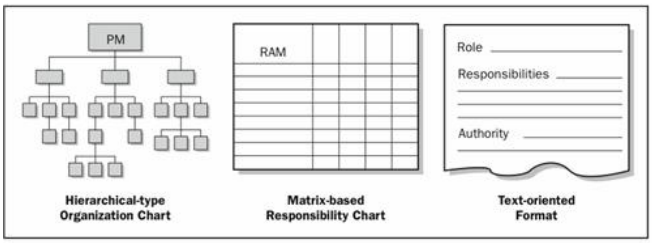


Figure 9-4. Roles and Responsibility Definition Formats

- **Hierarchical-type charts.** The traditional organization chart structure can be used to show positions and relationships in a graphical, top-down format. Work breakdown structures (WBS) designed to show how project deliverables are broken down into work packages provide a way of showing high-level areas of responsibility. While the WBS shows a breakdown of project deliverables, the organizational breakdown structure (OBS) is arranged according to an organization's existing departments, units, or teams with the project activities or work packages listed under each department. An operational department such as information technology or purchasing can see all of its project responsibilities by looking at its portion of the OBS. The resource breakdown structure is another hierarchical chart used to break down the project by types of resources. For example, a resource breakdown structure can depict all of the welders and welding equipment being used in different areas of a ship even though they can be scattered among different branches of the OBS and WBS. The resource breakdown structure is helpful in tracking project costs and can be aligned with the organization's accounting system. It can contain resource categories other than human resources.
- **Matrix-based charts.** A responsibility assignment matrix (RAM) is a grid that shows the project resources assigned to each work package. It is used to illustrate the connections between work packages or activities and project team members. On larger projects, RAMs can be developed at various levels. For example, a high-level RAM can

define what a project team group or unit is responsible for within each component of the WBS, while lower-level RAMs are used within the group to designate roles, responsibilities, and levels of authority for specific activities. The matrix format shows all activities associated with one person and all people associated with one activity. This also ensures that there is only one person accountable for any one task to avoid confusion. One example of a RAM is a RACI (responsible, accountable, consult, and inform) chart, shown in Figure 9-5. The sample chart shows the work to be done in the left column as activities. The assigned resources can be shown as individuals or groups. The RACI is just one type of RAM; the project manager can select other options such as "lead" and "resource" designations or others as appropriate for the project. The RACI is particularly important when the team consists of internal and external resources to ensure clear divisions of roles and expectations.

RACI Chart	Person				
Activity	Ann	Ben	Carlos	Dina	Ed
Define	A	R	I	I	I
Design	I	A	R	C	C
Develop	I	A	R	C	C
Test	A	I	I	R	I

R = Responsible A = Accountable C = Consult I = Inform

Figure 9-5. Responsibility Assignment Matrix (RAM) Using a RACI Format

- **Text-oriented formats.** Team member responsibilities that require detailed descriptions can be specified in text-oriented formats. Usually in outline form, the documents provide information such as responsibilities, authority, competencies, and qualifications. The documents are known by various names including position descriptions and role-responsibility-authority forms. These documents can be used as templates for future projects, especially when the information is updated throughout the current project by applying lessons learned.

9.1.2.2 Networking

Networking is the formal and informal interaction with others in an organization, industry, or professional environment. It is a constructive way to understand political and interpersonal factors that will impact the effectiveness of various staffing management options. Examples of human resources networking activities include proactive correspondence, luncheon meetings, informal conversations including meetings and events, trade conferences, and symposia. Networking can be a useful technique at the beginning of a project. It can also be an effective way to enhance project management professional development during the project and after the project ends.

9.1.2.3 Organizational Theory

Organizational theory provides information regarding the way in which people, teams, and organizational units behave. Effective use of this information can shorten the amount of time, cost, and effort needed to create the human resource planning outputs and improve the likelihood that the planning will be effective. It is important to recognize that different organizational structures have different individual response, individual performance, and personal relationship characteristics.

9.1.2.4 Expert Judgment

When developing the human resource plan, expert judgment is used to:

- List the preliminary requirements for the required skills;
- Assess the roles required for the project based on standardized role descriptions within the organization;
- Determine reporting relationships needed based on the organizational culture and lessons learned on staffing provide guidelines on lead time required for staffing based on market conditions;
- Identify risks associated with staff acquisition, retention, and release plans; and
- Identify and recommend programs for complying with applicable government and union contracts.

9.1.2.5 Meetings

When planning human resource management of the project, the planning team will hold meetings.

9.1.3 Plan Human Resource Management: Outputs

9.1.3.1 Human Resource Plan

The human resource plan, a part of the project management plan, provides guidance on how project human resources should be defined, staffed, managed, controlled, and eventually released. The human resource plan includes, but is not limited to, the following:

- **Roles and responsibilities.** The following should be addressed when listing the roles and responsibilities needed to complete a project:
  - *Role.* The function assumed by or assigned to a person in the project. Examples of project roles are civil engineer, court liaison, business analyst, and testing coordinator. Role clarity concerning authority, responsibilities, and boundaries should also be documented.
  - *Authority.* The right to apply project resources, make decisions, sign approvals and influence others to carry out the work of the project. Examples of decisions that need clear authority include the selection of a method for completing an activity, quality acceptance, and how to respond to project variances. Team members operate best when their individual levels of authority match their individual responsibilities.
  - *Responsibility.* The assigned duties and work that a project team member is expected to perform in order to complete the project's activities.
  - *Competency.* The skill and capacity required to complete project activities. If project team members do not possess required competencies, performance can be jeopardized. When such mismatches are identified, proactive responses such as training, hiring, schedule changes, or scope changes are initiated.
- **Project organization charts.** A project organization chart is a graphic display of project team members and their reporting relationships. It can be formal or informal, highly detailed or broadly framed, based on the needs of the project. For example, the project organization chart for a 3,000-person disaster response team will have greater detail than a project organization chart for an internal, twenty-person project.
- **Staffing management plan.** The staffing management plan is a component of the human resource plan that describes when and how project team members will be acquired and how long they will be needed. It describes how human resource requirements will be met. The staffing management plan can be formal or informal, highly detailed or broadly framed, depending upon the needs of the project. The plan is updated continually during the project to direct ongoing team member acquisition and development actions. Information in the staffing management plan varies by application area and project size, but items to consider include:
  - *Staff acquisition.* A number of questions arise when planning the acquisition of project team members. For example, whether the human resources come from within the organization or from external, contracted sources; whether the team members need to work in a central location or may work from distant locations; costs associated with each level of expertise needed for the project; and level of assistance that the organization's human resource department and functional managers are able to provide to the project management team.
  - *Resource calendars.* Calendars that identify the working days and shifts on which each specific resource is available. The staffing management plan describes necessary time frames for project team members, either individually or collectively, as well as when acquisition activities such as recruiting should start. One tool for charting human resources is a resource histogram. This bar chart illustrates the number of hours a person, department, or entire project team that will be needed each week or month over the course of the project. The chart can include a horizontal line that represents the maximum number of hours available from a particular resource. Bars that extend beyond the maximum available hours identify the need for a resource leveling strategy, such as adding more resources or modifying the schedule. An example of a resource histogram is illustrated in Figure 9-6.

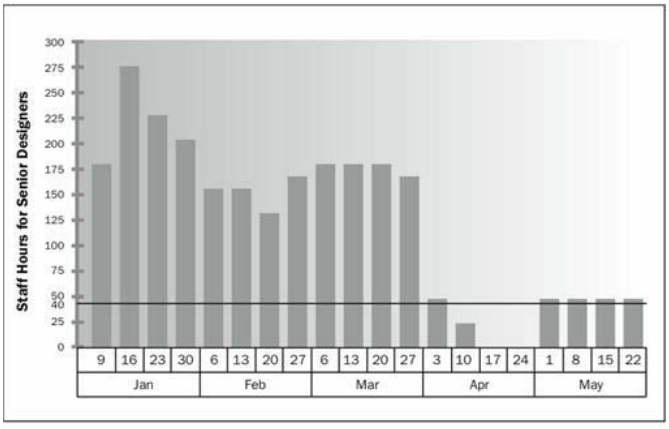


Figure 9-6. Illustrative Resource Histogram

• *Staff release plan.* Determining the method and timing of releasing team members benefits both the project and team members. When team members are released from a project, the costs associated with those resources are no longer charged to the project, thus reducing project costs. Morale is improved when smooth transitions to upcoming projects are already planned. A staff release plan also helps mitigate human resource risks that may occur during or at the end of a project.

• *Training needs.* If it is expected that the team members to be assigned will not have the required competencies, a training plan can be developed as part of the project. The plan can also include ways to help team members obtain certifications that would support their ability to benefit the project.

• *Recognition and rewards.* Clear criteria for rewards and a planned system for their use help promote and reinforce desired behaviors. To be effective, recognition and rewards should be based on activities and performance under a person's control. For example, a team member who is to be rewarded for meeting cost objectives should have an appropriate level of control over decisions that affect expenses. Creating a plan with established times for distribution of rewards ensures that recognition takes place and is not forgotten. Recognition and rewards are part of the Develop Project Team process (Section 9.3).

• *Compliance.* The staffing management plan can include strategies for complying with applicable government regulations, union contracts, and other established human resource policies.

• *Safety.* Policies and procedures that protect team members from safety hazards can be included in the staffing management plan as well as in the risk register.

9.2 Acquire Project Team

Acquire Project Team is the process of confirming human resource availability and obtaining the team necessary to complete project assignments. The key benefit of this process is that it outlines and guides the process of team selection, responsibility, and assignment for implementation of a successful team. The inputs, tools and techniques, and outputs of this process are depicted in Figure 9-7. Figure 9-8 depicts the data flow diagram of the process.

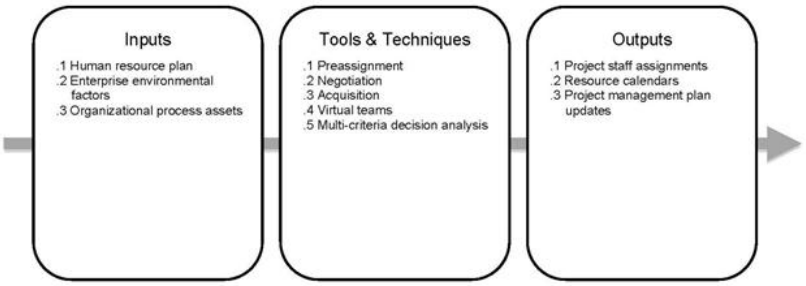


Figure 9-7. Acquire Project Team: Inputs, Tools & Techniques, and Outputs

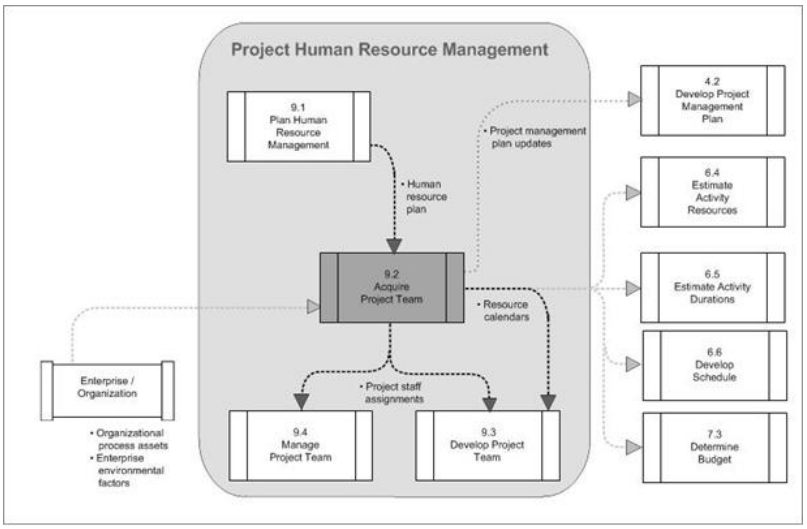


Figure 9-8. Acquire Project Team Data Flow Diagram

The project management team may or may not have direct control over team member selection because of collective bargaining agreements, use of subcontractor personnel, matrix project environment, internal or external reporting relationships, or other various reasons. It is important that the following factors are considered during the process of acquiring the project team:

• The project manager or project management team should effectively negotiate and

influence others who are in a position to provide the required human resources for the project.

- Failure to acquire the necessary human resources for the project may affect project schedules, budgets, customer satisfaction, quality, and risks. It could decrease the probability of success and ultimately result in project cancellation.
- If the human resources are not available due to constraints, economic factors, or previous assignments to other projects, the project manager or project team may be required to assign alternative resources, perhaps with lower competencies, provided there is no violation of legal, regulatory, mandatory, or other specific criteria.

These factors should be considered and planned for in the planning stages of the project. The project manager or project management team will be required to reflect the impact of any unavailability of required human resources in the project schedule, project budget, project risks, project quality, training plans, and the other project management plans as required.

9.2.1 Acquire Project Team: Inputs

9.2.1.1 Human Resource Plan

Described in Section 9.1.3.1. The human resource plan provides guidance on how project human resources should be identified, staffed, managed, controlled, and eventually released. It includes:

- Roles and responsibilities defining the positions, skills, and competencies that the project demands;
- Project organization charts indicating the number of people needed for the project; and
- Staffing management plan delineating the time periods each project team member will be needed and other information important to acquiring the project team.

9.2.1.2 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that influence the Acquire Project Team process include, but are not limited to:

- Existing information for human resources including availability, competency levels, prior experience, interest in working on the project and their cost rate;
- Personnel administration policies such as those that affect outsourcing;
- Organizational structure as described in Section 2.3.1; and
- Location or multiple locations.

9.2.1.3 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Acquire Project Team process include, but are not limited to, organization standard policies, processes, and procedures.

9.2.2 Acquire Project Team: Tools and Techniques

9.2.2.1 Preassignment

When project team members are selected in advance they are considered preassigned. This situation can occur if the project is the result of specific people being promised as part of a competitive proposal, if the project is dependent upon the expertise of particular persons, or if some staff assignments are defined within the project charter.

9.2.2.2 Negotiation

Staff assignments are negotiated on many projects. For example, the project management team may need to negotiate with:

- Functional managers to ensure that the project receives appropriately competent staff in the required time frame, and that the project team members will be able, willing, and authorized to work on the project until their responsibilities are completed;
- Other project management teams within the performing organization to appropriately assign scarce or specialized human resources; and
- External organizations, vendors, suppliers, contractors, etc., for appropriate, scarce, specialized, qualified, certified, or other such specified human resources. Special consideration should be given to external negotiating policies, practices, processes, guidelines, legal, and other such criteria.

The project management team's ability to influence others plays an important role in negotiating staff assignments, as do the politics of the organizations involved. For example, a functional manager will weigh the benefits and visibility of competing projects when determining where to assign exceptional performers requested by various project teams.

9.2.2.3 Acquisition

When the performing organization lacks the in-house staff needed to complete a project, the required services may be acquired from outside sources. This can involve hiring individual consultants or subcontracting work to another organization.

9.2.2.4 Virtual Teams

The use of virtual teams creates new possibilities when acquiring project team members. Virtual teams can be defined as groups of people with a shared goal who fulfill their roles with little or no time spent meeting face to face. The availability of electronic communication such as e-mail, audio conferencing, web-based meetings and video conferencing has made such teams feasible. The virtual team format makes it possible to:

- Form teams of people from the same company who live in widespread geographic areas,
- Add special expertise to a project team even though the expert is not in the same geographic area,
- Incorporate employees who work from home offices,
- Form teams of people who work different shifts or hours,
- Include people with mobility limitations or disabilities, and
- Move forward with projects that would have been ignored due to travel expenses.

Communication planning becomes increasingly important in a virtual team environment. Additional time may be needed to set clear expectations, facilitate communications, develop protocols for resolving conflict, include people in decision making, understand cultural differences, and share credit in successes.

9.2.2.5 Multi-Criteria Decision Analysis

Selection criteria are often used as a part of acquiring the project team. By use of a multi-criteria decision analysis tool, criteria are developed and used to rate or score potential team members. The criteria are weighted according to the relative importance of the needs within the team. Some examples of selection criteria that can be used to score team members are shown below:

- **Availability.** Whether the team member is available to work on the project within the time period needed. If there are there any concerns for availability during the project timeline.
- **Cost.** If the cost of adding the team member is within the prescribed budget.
- **Experience.** If the member has the relevant experience that will contribute to the project success.
- **Ability.** Whether the team member has the competencies needed by the project.
- **Knowledge.** If the member has relevant knowledge of the customer, similar implemented projects, and nuances of the project environment.
- **Skills.** Whether the member has the relevant skills to use a project tool, implementation, or training.

9.2.3 Acquire Project Team: Outputs

9.2.3.1 Project Staff Assignments

The project is staffed when appropriate people have been assigned through the previously described methods. The documentation of these assignments can include a project team directory, memos to team members, and names inserted into other parts of the project management plan, such as project organization charts and schedules.

9.2.3.2 Resource Calendars

Resource calendars document the time periods that each project team member can work on the project. Creating a reliable schedule (Section 6.6.3.1) depends on having a good understanding of each person’s schedule conflicts, including vacation time and commitments to other projects, to accurately document team member availability.

9.2.3.3 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to, the human resource plan. For example, when specific people are assigned to project roles and responsibilities, there may not be an exact fit between the staffing requirements indicated in the human resource plan and the individual.

9.3 Develop Project Team

Develop Project Team is the process of improving the competencies, team interaction, and the overall team environment to enhance project performance. The key benefit of this process is that it results in improved teamwork, enhanced people skills and competencies,

motivated employees, reduced staff turnover rates and improved overall project performance. The inputs, tools and techniques, and outputs of this process are depicted in Figure 9-9. Figure 9-10 depicts the data flow diagram of the process.

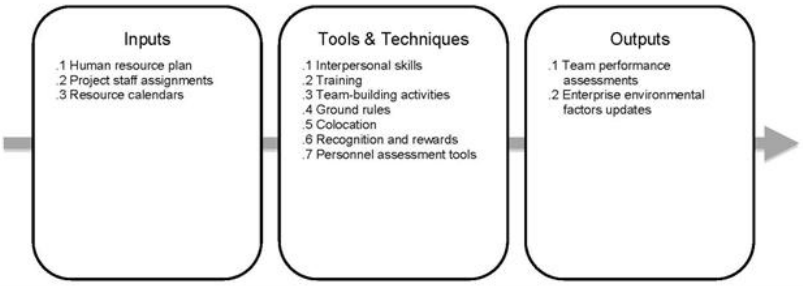


Figure 9-9. Develop Project Team: Inputs, Tools & Techniques, and Outputs

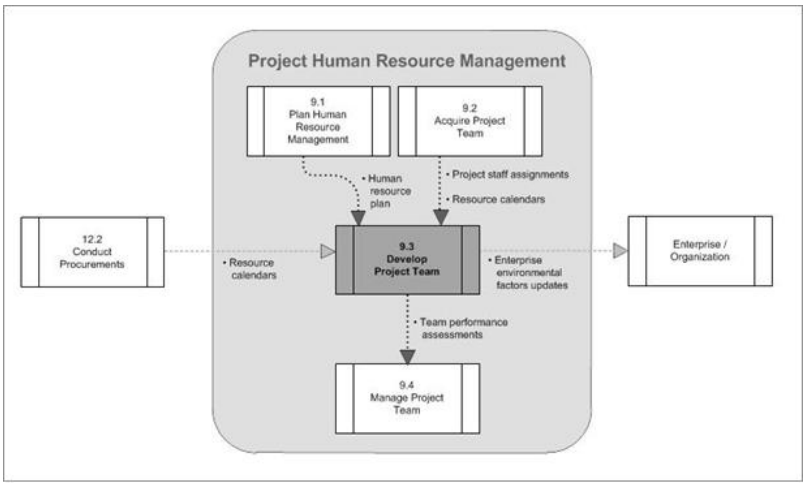


Figure 9-10. Develop Project Team Data Flow Diagram

Project managers should acquire skills to identify, build, maintain, motivate, lead, and inspire project teams to achieve high team performance and to meet the project's objectives. Teamwork is a critical factor for project success, and developing effective project teams is one of the primary responsibilities of the project manager. Project managers should create an environment that facilitates teamwork. Project managers should continually motivate their team by providing challenges and opportunities, by providing timely feedback and support as needed, and by recognizing and rewarding good performance. High team performance can be achieved by using open and effective communication, developing trust among team members, managing conflicts in a constructive manner, and encouraging collaborative problem-solving and decision-making. The project manager should request management support and/or influence the appropriate stakeholders to acquire the resources needed to develop effective project teams.

Project managers operate in a global environment and work on projects characterized by cultural diversity. Team members often have diverse industry experience, multiple languages, and sometimes operate in the "team language" that is a different language or norm than their native one. The project management team should capitalize on cultural differences, focus on developing and sustaining the project team throughout the project life cycle, and promote working together interdependently in a climate of mutual trust. Developing the project team improves the people skills, technical competencies, and overall team environment and project performance. It requires clear, timely, effective, and efficient communication between team members throughout the life of the project. Objectives of developing a project team include, but are not limited to:

- Improving knowledge and skills of team members in order to increase their ability to complete project deliverables, while lowering costs, reducing schedules, and improving quality;
- Improving feelings of trust and agreement among team members in order to raise morale, lower conflict, and increase team work; and
- Creating a dynamic and cohesive team culture to improve both individual and team productivity, team spirit, and cooperation, and to allow cross training and mentoring between team members to share knowledge and expertise.

9.3.1 Develop Project Team: Inputs

9.3.1.1 Human Resource Plan

Described in Section 9.1.3.1. The human resource plan provides guidance on how project human resources should be defined, staffed, managed, controlled, and eventually released.

It identifies training strategies and plans for developing the project team. Items such as rewards, feedback, additional training, and disciplinary actions can be added to the plan as a result of ongoing team performance assessments and other forms of project team management.

9.3.1.2 Project Staff Assignments

Described in Section 9.2.3.1. Team development starts with a list of the project team members. Project staff assignment documents identify the people who are on the team.

9.3.1.3 Resource Calendars

Described in Section 9.2.3.2. Resource calendars identify times when the project team members can participate in team development activities.

9.3.2 Develop Project Team: Tools and Techniques

9.3.2.1 Interpersonal Skills

Interpersonal skills are sometimes known as “soft skills” or “emotional intelligence,” and are particularly important to team development. The project management team can greatly reduce problems and increase cooperation by understanding the sentiments of project team members, anticipating their actions, acknowledging their concerns, and following up on their issues. Skills such as empathy, influence, creativity, and group facilitation are valuable assets when managing the project team.

9.3.2.2 Training

Training includes all activities designed to enhance the competencies of the project team members. Training can be formal or informal. Examples of training methods include classroom, online, computer-based, on-the-job training from another project team member, mentoring, and coaching. If project team members lack the necessary management or technical skills, such skills can be developed as part of the project work. Scheduled training takes place as stated in the human resource plan. Unplanned training takes place as a result of observation, conversation, and project performance appraisals conducted during the controlling process of managing the project team.

9.3.2.3 Team-Building Activities

Team-building activities can vary from a 5-minute agenda item in a status review meeting to an off-site, professionally facilitated experience designed to improve interpersonal relationships. The objective of team-building activities is to help individual team members work together effectively. Team-building strategies are particularly valuable when team members operate from remote locations without the benefit of face-to-face contact. Informal communication and activities can help in building trust and establishing good working relationships.

As an ongoing process, team building is crucial to project success. While team building is essential during the front end of a project, it is a never-ending process. Changes in a project environment are inevitable, and to manage them effectively, a continued or a renewed team-building effort should be applied. The project manager should continually monitor team functioning and performance to determine if any actions are needed to prevent or correct various team problems.

One of the models used to describe team development is the Tuckman ladder, which includes five stages of development that teams may go through. Although it’s common for these stages to occur in order, it’s not uncommon for a team to get stuck in a particular stage or slip to an earlier stage. Projects with team members who worked together in the past may skip a stage.

- **Forming.** This phase is where the team meets and learns about the project and their formal roles and responsibilities. Team members tend to be independent and not as open in this phase.
- **Storming.** During this phase, the team begins to address the project work, technical decisions, and the project management approach. If team members are not collaborative and open to differing ideas and perspectives, the environment can become counterproductive.
- **Norming.** In the norming phase, team members begin to work together and adjust their work habits and behaviors to support the team. The team learns to trust each other.
- **Performing.** Teams that reach the performing stage function as a well-organized unit. They are interdependent and work through issues smoothly and effectively.
- **Adjourning.** In the adjourning phase, the team completes the work and moves on from the project.

The duration of a particular stage depends upon team dynamics, team size, and team leadership. Project managers should have a good understanding of team dynamics in order to move their team members through all stages in an effective manner.

9.3.2.4 Ground Rules

Ground rules establish clear expectations regarding acceptable behavior by project team members. Early commitment to clear guidelines decreases misunderstandings and increases productivity. Discussing ground rules allows team members to discover values that are important to one another. All project team members share responsibility for enforcing the rules once they are established.

9.3.2.5 Colocation

Colocation involves placing many or all of the most active project team members in the same physical location to enhance their ability to perform as a team. Colocation can be temporary, such as at strategically important times during the project, or for the entire project. Colocation strategies can include a team meeting room, places to post schedules, and other conveniences that enhance communication and a sense of community. While colocation is considered a good strategy, the use of virtual teams is sometimes unavoidable.

9.3.2.6 Recognition and Rewards

Part of the team development process involves recognizing and rewarding desirable behavior. The original plans concerning ways in which to reward people are developed during the Plan Human Resource Management process. It is important to recognize that a particular reward given to any individual will only be effective if it satisfies a need which is valued by that individual. Award decisions are made, formally or informally, during the process of managing the project team through project performance appraisals (Section 9.4.2.2). Cultural differences should be considered when determining recognition and rewards.
People are motivated if they feel they are valued in the organization and this value is demonstrated by the rewards given to them. Generally, money is viewed by most as a very tangible aspect of any reward system, but other intangible rewards are also effective. Most project team members are motivated by an opportunity to grow, accomplish, and apply their professional skills to meet new challenges. Public recognition of good performance creates positive reinforcement. A good strategy for project managers is to give the team all possible recognition during the life cycle of the project rather than after the project is completed.

9.3.2.7 Personnel Assessment Tools

Personnel assessment tools give the project manager and the project team insight into areas of strength and weakness. These tools help project managers assess the team preferences and how they process and organize information, how they tend to make decisions and how they prefer to interact with people.
These tools can provide improved understanding, trust, and communications among team members, and facilitate more productive teams throughout the project.

9.3.3 Develop Project Team: Outputs

9.3.3.1 Team Performance Assessments

As project team development efforts such as training, team building, and colocation are implemented, the project management team makes formal or informal assessments of the project team's effectiveness. Effective team development strategies and activities are expected to increase the team's performance, which increases the likelihood of meeting project objectives. Team performance assessment criteria should be determined by all appropriate parties and incorporated in the Develop Project Team inputs.
The performance of a successful team is measured in terms of technical success according to agreed-upon project objectives, performance on project schedule (finished on time), and performance on budget (finished within financial constraints). High-performance teams are characterized by these task-oriented and results-oriented outcomes.
The evaluation of a team's effectiveness may include indicators such as:

- Improvements in skills that allow individuals to perform assignments more effectively,
- Improvements in competencies that help the team perform better as a team,
- Reduced staff turnover rate, and
- Increased team cohesiveness where team members share information and experiences openly and help each other to improve the overall project performance.

As a result of conducting an evaluation of the team's overall performance, the project management team can identify the specific training, coaching, mentoring, assistance, or changes required to improve the team's performance. This should also include identification of the appropriate or required resources necessary to achieve and implement the improvements identified in the assessment. These resources and recommendations for team improvement should be well documented and forwarded to the relevant parties.

9.3.3.2 Enterprise Environmental Factors Updates

The enterprise environmental factors that may be updated as a result of the Develop Project Team process include, but are not limited to, personnel administration, employee training records and skill assessments.

9.4 Manage Project Team

Manage Project Team is the process of tracking team member performance, providing feedback, resolving issues, and managing changes to optimize project performance. The key benefit of this process is that it observes team behavior, manages conflict, resolves issues, and appraises team member performance. The inputs, tools and techniques, and outputs of this process are depicted in Figure 9-11. Figure 9-12 depicts the data flow diagram of the process.

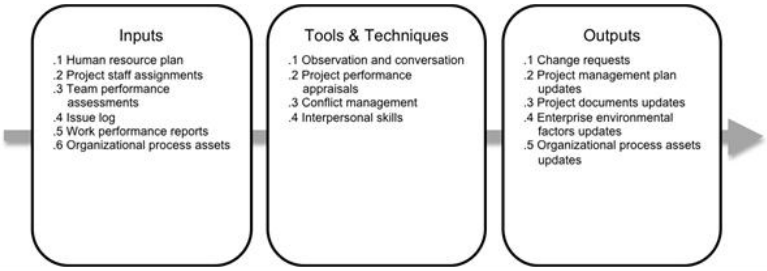


Figure 9-11. Manage Project Team: Inputs, Tools & Techniques, and Outputs

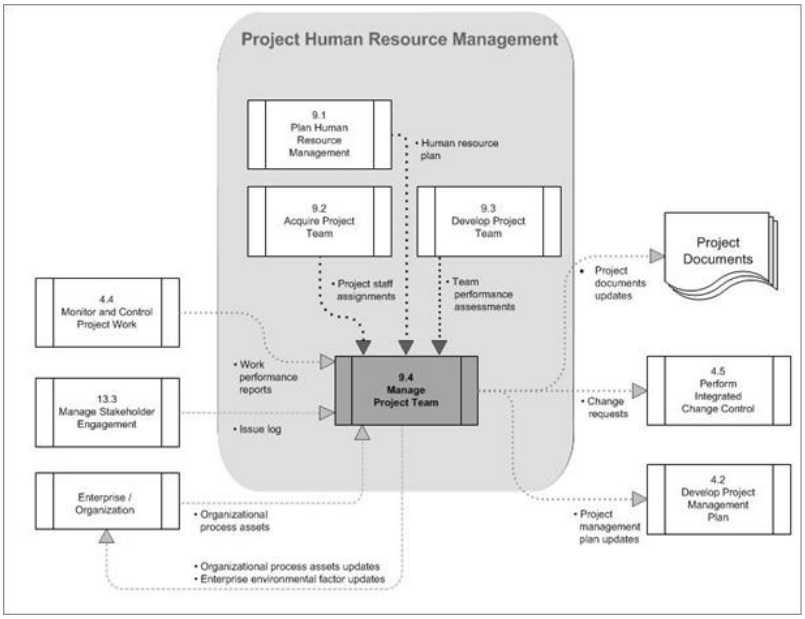


Figure 9-12. Manage Project Team Data Flow Diagram

As a result of managing the project team, change requests are submitted, the human resource plan is updated, issues are resolved, input is provided for performance appraisals, and lessons learned are added to the organization's database.

Managing the project team requires a variety of management skills for fostering teamwork and integrating the efforts of team members to create high-performance teams. Team management involves a combination of skills with special emphasis on communication, conflict management, negotiation, and leadership. Project managers should provide challenging assignments to team members and provide recognition for high performance.

9.4.1 Manage Project Team: Inputs

9.4.1.1 Human Resource Plan

Described in Section 9.1.3.1. The human resource plan provides guidance on how project human resources should be defined, staffed, managed, controlled, and eventually released. It includes, but is not limited to:

- Roles and responsibilities,
- Project organization, and
- The staffing management plan.

9.4.1.2 Project Staff Assignments

Described in Section 9.2.3.1. Project staff assignments provide documentation, which includes the list of project team members.

9.4.1.3 Team Performance Assessments

Described in Section 9.3.3.1. The project management team makes ongoing formal or informal assessments of the project team's performance. By continually assessing the project team's performance, actions can be taken to resolve issues, modify communication, address conflict, and improve team interaction.

9.4.1.4 Issue Log

Described in Section 4.4.3.4. Issues arise in the course of managing the project team. An issue log or action item log can be used to document and monitor who is responsible for resolving specific issues by a target date.

9.4.1.5 Work Performance Reports

Described in Section 4.4.3.2. Work performance reports provide documentation about the current project status compared to project forecasts. Performance areas that can help with project team management include results from schedule control, cost control, quality control, and scope validation. The information from performance reports and related forecasts assists in determining future human resource requirements, recognition and rewards, and updates to the staffing management plan.

9.4.1.6 Organizational Process Assets

Described in Section 2.1.4.
The organizational process assets that can influence the Manage Project Team process include, but are not limited to:

- Certificates of appreciation,
- Newsletters,
- Websites,
- Bonus structures,
- Corporate apparel, and
- Other organizational perquisites.

9.4.2 Manage Project Team: Tools and Techniques

9.4.2.1 Observation and Conversation

Observation and conversation are used to stay in touch with the work and attitudes of project team members. The project management team monitors progress toward project deliverables, accomplishments that are a source of pride for team members, and interpersonal issues.

9.4.2.2 Project Performance Appraisals

Objectives for conducting performance appraisals during the course of a project can include clarification of roles and responsibilities, constructive feedback to team members, discovery of unknown or unresolved issues, development of individual training plans, and the establishment of specific goals for future time periods.
The need for formal or informal project performance appraisals depends on the length of the project, complexity of the project, organizational policy, labor contract requirements, and the amount and quality of regular communication.

9.4.2.3 Conflict Management

Conflict is inevitable in a project environment. Sources of conflict include scarce resources, scheduling priorities, and personal work styles. Team ground rules, group norms, and solid project management practices, like communication planning and role definition, reduce the amount of conflict.
Successful conflict management results in greater productivity and positive working relationships. When managed properly, differences of opinion can lead to increased creativity and better decision making. If the differences become a negative factor, project team members are initially responsible for their resolution. If conflict escalates, the project manager should help facilitate a satisfactory resolution. Conflict should be addressed early and usually in private, using a direct, collaborative approach. If disruptive conflict continues, formal procedures may be used, including disciplinary actions.
The success of project managers in managing their project teams often depends a great deal

on their ability to resolve conflict. Different project managers may have different conflict resolution styles. Factors that influence conflict resolution methods include:

- Relative importance and intensity of the conflict,
- Time pressure for resolving the conflict,
- Position taken by players involved, and
- Motivation to resolve conflict on a long-term or a short-term basis.

There are six general techniques for resolving conflict. As each one has its place and use, these are not given in any particular order:

- **Withdrawing/Avoiding.** Retreating from an actual or potential conflict situation.
- **Smoothing/Accommodating.** Emphasizing areas of agreement rather than areas of difference.
- **Compromising.** Searching for solutions that bring some degree of satisfaction to all parties.
- **Forcing.** Pushing one's viewpoint at the expense of others; offers only win-lose solutions.
- **Collaborating.** Incorporating multiple viewpoints and insights from differing perspectives; leads to consensus and commitment.
- **Confronting/Problem Solving.** Treating conflict as a problem to be solved by examining alternatives; requires a give-and-take attitude and open dialogue.

9.4.2.4 Interpersonal Skills

Project managers use a combination of technical, personal, and conceptual skills to analyze situations and interact appropriately with team members. Using appropriate interpersonal skills allows project managers to capitalize on the strengths of all team members.

Examples of interpersonal skills that a project manager uses most often include:

- **Leadership.** Successful projects require strong leadership skills. Leadership is important through all phases of the project life cycle. It is especially important to communicate the vision and inspire the project team to achieve high performance.
- **Influencing.** Because project managers often have little or no direct authority over their team members in a matrix environment, their ability to influence stakeholders on a timely basis is critical to project success. Key influencing skills include:
    - Ability to be persuasive and clearly articulate points and positions;
    - High levels of active and effective listening skills;
    - Awareness of, and consideration for the various perspectives in any situation; and
    - Gathering relevant and critical information to address important issues and reach agreements while maintaining mutual trust.
- **Effective decision making.** This involves the ability to negotiate and influence the organization and the project management team. Some guidelines for decision making include:
    - Focus on goals to be served,
    - Follow a decision-making process,
    - Study the environmental factors,
    - Develop personal qualities of the team members,
    - Stimulate team creativity, and
    - Manage risk.

9.4.3 Manage Project Team: Outputs

9.4.3.1 Change Requests

Staffing changes, whether by choice or by uncontrollable events, can affect the rest of the project management plan. When staffing issues disrupt the project team from adhering to the project management plan such as causing the schedule to be extended or the budget to be exceeded, a change request can be processed through the Perform Integrated Change Control process. Staffing changes may include moving people to different assignments, outsourcing some of the work, and replacing team members who leave.

Preventive actions are those actions that are developed to reduce the probability and/or impact of problems before they occur. These actions may include cross-training to reduce problems during project team member absences and additional role clarification to ensure all responsibilities are fulfilled.

9.4.3.2 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to, the human resource plan.

9.4.3.3 Project Documents Updates

Project documents that may indirectly be updated include, but are not limited to:

- Issue log, and
- Role description and assignments.

9.4.3.4 Enterprise Environmental Factors Updates

Enterprise environmental factors that may require updates as a result of the Manage Project Team process include, but are not limited to:

- Input to organizational performance appraisals, and
- Personnel skill updates.

9.4.3.5 Organizational Process Assets Updates

Organizational process assets that may require updates as a result of the Manage Project Team process include, but are not limited to:

- Historical information and lessons learned documentation,
- Templates, and
- Organizational standard processes.

CHAPTER 10

PROJECT COMMUNICATIONS MANAGEMENT

Project Communications Management includes the processes that are required to ensure timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and the ultimate disposition of project information. Project managers spend the majority of their time communicating with team members and other project stakeholders, whether they are internal (at all organizational levels) or external to the organization. Effective communication creates a bridge between diverse stakeholders by connecting various cultural and organizational backgrounds, different levels of expertise, and various perspectives and interests that impact or have an influence upon the project execution or outcome.

Figure 10-1 provides an overview of the Project Communications Management processes, which are as follows:

10.1 Plan Communications Management—The process of gathering and analyzing project stakeholder information and requirements to develop an appropriate communications approach for the project.

10.2 Manage Communications—The process of gathering project information for communications creation, distribution, storage, retrieval and ultimate disposition in accordance to the Communications Management Plan.

10.3 Control Communications—The process of monitoring and controlling communications throughout the entire project life cycle to ensure the information needs of the project stakeholders are met.

These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.

The communication activities involved in these processes may often have many potential dimensions that need to be considered, including but not limited to:

- Internal (within the project) and external (customer, vendors, other projects, organizations, the public),
- Formal (reports, memos, briefings) and informal (emails, ad-hoc discussions),
- Vertical (up and down the organization) and horizontal (with peers),
- Official (newsletters, annual report) and unofficial (off the record communications),
- Written and oral, and
- Verbal and nonverbal (voice inflections, body language).

Most communication skills are common for both general management and project management, such as, but not limited to:

- Listening actively and effectively,
- Questioning of probing ideas and situations to ensure better understanding,
- Educating to increase team's knowledge so that they can be more effective,
- Fact-finding to identify or confirm information,
- Setting and managing expectations,
- Persuading a person, a team, or an organization to perform an action,
- Motivating to provide encouragement or reassurance,
- Coaching to improve performance and achieve desired results,
- Negotiating to achieve mutually acceptable agreements between parties,
- Resolving conflict to prevent disruptive impacts, and
- Summarizing, recapping, and identifying the next steps.

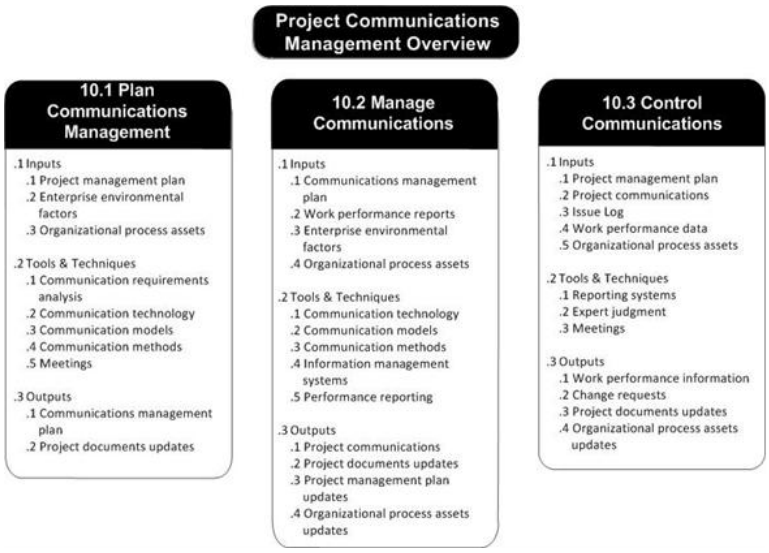


Figure 10-1. Project Communications Management Overview

10.1 Plan Communications Management

Plan Communications Management is the process of gathering and analyzing the project stakeholder's information and requirements to develop an appropriate communications approach for the project. The key benefit of this process is that it documents the approach to communicate most effectively and efficiently with stakeholders. The inputs, tools and techniques, and outputs of this process are depicted in Figure 10-2. Figure 10-3 depicts the data flow diagram of the Plan Communications Management process.

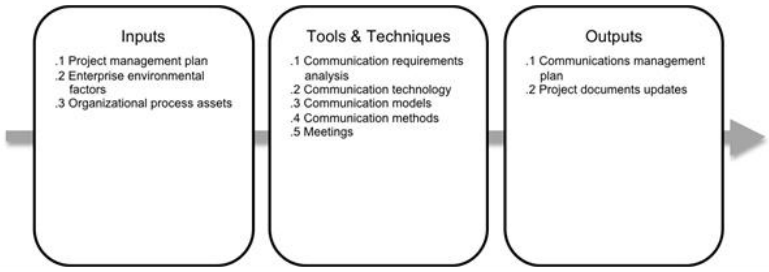


Figure 10-2. Plan Communications Management: Inputs, Tools & Techniques, and Outputs

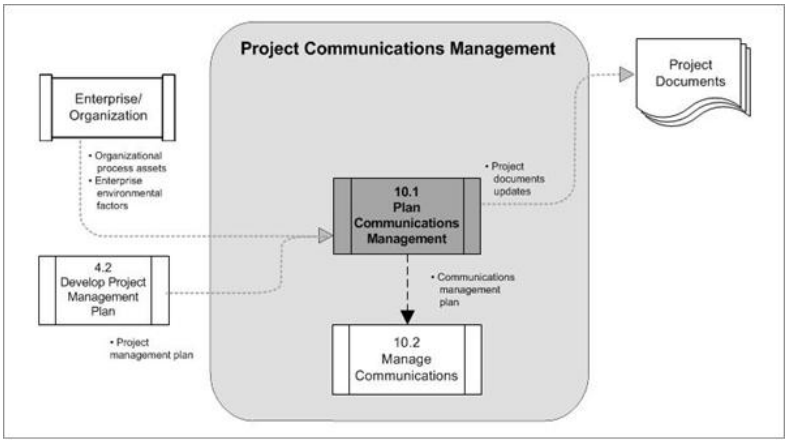


Figure 10-3. Plan Communications Management Data Flow Diagram

These considerations are important to the ultimate success of any project. Inadequate communications planning may lead to problems such as delay in message delivery, communication of information to the wrong audience, or insufficient communication to the stakeholders and misunderstanding or misinterpretation of the message communicated. On most projects, communication planning is done very early, such as during project management plan development. This allows appropriate resources, such as time and budget, to be allocated to communication activities. Effective communication means that the information is provided in the right format, at the right time, to the right audience, and with the right impact. Efficient communication means providing only the information that is needed.

While all projects share the need to communicate project information, the information needs and methods of distribution may vary widely. In addition, the methods of storage,

retrieval, and ultimate disposition of the project information need to be considered during this process. Important considerations that may need to be taken into account include, but are not limited to:

- Who needs what information and who is authorized to access that information,
- When they will need the information,
- Where the information should be stored,
- What format the information should be stored in,
- How the information can be retrieved, and
- Whether time zone, language barriers, and cross-cultural considerations need to be taken into account.

The results of the Plan Communications Management process should be reviewed regularly throughout the project and revised as needed to ensure continued applicability.

10.1.1 Plan Communications Management: Inputs

10.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan provides information on how the project will be executed, monitored, controlled, and closed.

10.1.1.2 Enterprise Environmental Factors

Described in Section 2.1.5. The Plan Communications Management process is tightly linked with enterprise environmental factors, since the structure of an organization will have a major effect on the project's communications requirements. All enterprise environmental factors described in Section 2.1.5 are used as inputs for this process, since communications must be adapted to the project environment.

10.1.1.3 Organizational Process Assets

Described in Section 2.1.4. All organizational process assets described in Section 2.1.4 are used as inputs to the Plan Communications Management process. Of these, lessons learned and historical information are of particular importance because they can provide insights on both the decisions taken regarding communications issues and the results of those decisions in previous similar projects. These can be used as guiding information to plan the communication activities for the current project.

10.1.2 Plan Communications Management: Tools and Techniques

10.1.2.1 Communication Requirements Analysis

The analysis of the communication requirements determines the information needs of the project stakeholders. These requirements are defined by combining the type and format of information needed with an analysis of the value of that information. Project resources should be expended only on communicating information that contributes to the success of the project or where a lack of communication can lead to failure.

The project manager should also consider the number of potential communication channels or paths as an indicator of the complexity of a project's communications. The total number of potential communication channels is $n(n – 1)/2$, where n represents the number of stakeholders. In this example, a project with 10 stakeholders has $10(10 – 1)/2 = 45$ potential communication channels. As a result, a key component of planning the project's actual communications is to determine and limit who will communicate with whom and who will receive what information.

Sources of information typically used to identify and define project communication requirements include, but are not limited to:

- Organizational charts,
- Project organization and stakeholder responsibility relationships,
- Disciplines, departments, and specialties involved in the project,
- Logistics of how many persons will be involved with the project and at which locations,
- Internal information needs (e.g., when communicating within organizations),
- External information needs (e.g., when communicating with the media, public, or contractors), and
- Stakeholder information from within the stakeholder register.

10.1.2.2 Communication Technology

The methods used to transfer information among project stakeholders may vary significantly. For example, a project team may use techniques from brief conversations to extended meetings, or from simple written documents to extensive materials (e.g., schedules and databases), which are accessible online as methods of communication.

Factors that can affect the choice of communication technology include:

- **Urgency of the need for information.** There is a need to consider the urgency, frequency, and format of the information to be communicated as they may vary from project

to project and also within different stages of a project.

- **Availability of technology.** There is a need to ensure that the technology that is required to facilitate communication is compatible, available, and accessible for all stakeholders throughout the life of the project.
- **Ease of Use.** There is a need to ensure that the choice of communication technologies is suitable for project participants and that appropriate training events are planned for, where appropriate.
- **Project environment.** There is a need to determine if the team will meet and operate on a face-to-face basis or in a virtual environment; whether they will be located in one or multiple time zones; whether they will use multiple languages for communication; and finally, whether there are any other project environmental factors, such as culture, which may affect communications.
- **Sensitivity and confidentiality of the information.** There is a need to determine if the information to be communicated is sensitive or confidential and whether or not additional security measures need to be taken. Also, the most appropriate way to communicate the information should be considered.

10.1.2.3 Communication Models

The communication models used to facilitate communications and the exchange of information may vary from project to project and also within different stages of the same project. A basic communication model, shown in Figure 10-4, consists of two parties, defined as the sender and receiver. Components of the model are:

- **Encode.** Thoughts or ideas are translated (encoded) into language by the sender.
- **Transmit Message.** This information is then sent using communication technology (medium) by the sender. The transmission of this message may be compromised by various factors (e.g., distance, unfamiliar technology, inadequate infrastructure, cultural difference, and lack of background information). These factors are collectively termed as noise.
- **Decode.** The message is translated by the receiver back into meaningful thoughts or ideas.
- **Acknowledge.** Upon receipt of a message, the receiver may signal (acknowledge) receipt of the message but this does not necessarily mean agreement with or comprehension of the message.
- **Feedback/Response:** When the received message has been decoded and understood, the receiver encodes their thoughts and ideas into a message and then transmits this message to the original sender.

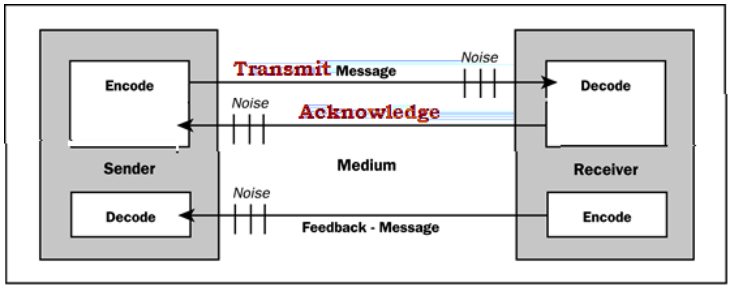


Figure 10-4. Basic Communication Model

The components of the basic communication model need to be considered when project communications are discussed. As part of the communications process, the sender is responsible for the transmission of the message and making sure that the information being communicated is clear and complete. The receiver is responsible for ensuring that the information is received in its entirety, understood correctly, and acknowledged appropriately.

There are many challenges in using these components to effectively communicate with project stakeholders, such as in a highly technical, multinational project team. Successful communication of a technical concept from one team member to another team member in a different country could involve encoding the message in the appropriate language, sending the message using a variety of technologies, and having the receiver decode the message into his or her native language and then reply or provide feedback. Any noise introduced along the way may compromise the original meaning of the message. In this example, there are multiple factors that may lead to the intended meaning of the message being misunderstood or misinterpreted.

10.1.2.4 Communication Methods

There are several communication methods that are used to share information among project stakeholders. These methods are broadly classified as follows:

- **Interactive communication.** Between two or more parties performing a multidirectional exchange of information. It is the most efficient way to ensure a common understanding by all participants on specified topics, and includes meetings, phone calls, and video conferencing, etc.
- **Push communication.** Sent to specific recipients who need to receive the information. This ensures that the information is distributed but does not ensure that it

actually reached or was understood by the intended audience. Push communications includes letters, memos, reports, emails, faxes, voice mails, press releases, etc.

- **Pull communication.** Used for very large volumes of information, or for very large audiences, and requires the recipients to access the communication content at their own discretion. These methods include intranet sites, e-learning, and knowledge repositories, etc.

The choices of communication methods that are used for a project need to be based on the communication requirements and may need to be discussed and agreed upon by the project stakeholders

10.1.2.5 Meetings

Described in Section 4.3.2.3. The Plan Communications Management process requires discussion and dialogue with the project team to determine the most appropriate way to update and communicate project information, and to respond to requests from various stakeholders for that information. These discussions and dialogue are commonly facilitated through meetings, which may be conducted face to face or online and in different locations, such as the project site or the customer's site.

There are several types of project-related meetings where project communications may occur. Most project meetings consist of stakeholders coming together for the purpose of resolving problems or making decisions. Although casual discussions may be construed as a meeting, most project meetings are more formal with a prearranged time, place, and agenda. Typical meetings begin with a defined list of issues to be discussed, which are circulated in advance with minutes and other information documented specifically for the meeting. This information is then disseminated to other appropriate stakeholders on an as-needed basis.

10.1.3 Plan Communications Management: Outputs

10.1.3.1 Communications Management Plan

The communications management plan is a component of the project management plan that describes how project communications will be planned, structured, monitored, and controlled. The plan contains the following information:

- Stakeholder communication requirements;
- Information to be communicated, including language, format, content, and level of detail;
- Reason for the distribution of that information;
- Time frame and frequency for the distribution of required information;
- Person responsible for communicating the information;
- Person responsible for authorizing release of confidential information;
- Person or groups who will receive the information;
- Methods or technologies used to convey the information, such as memos, e-mail, and/or press releases;
- Resources allocated for communication activities, including time and budget;
- Escalation process identifying time frames and the management chain (names) for escalation of issues that cannot be resolved at a lower staff level;
- Method for updating and refining the communications management plan as the project progresses and develops;
- Glossary of common terminology;
- Flow charts of the information flow in the project, workflows with possible sequence of authorization, list of reports, and meeting plans, etc.; and
- Communication constraints usually derived from specific legislation or regulation, technology, and organizational policies, etc.

The communications management plan can also include guidelines and templates for project status meetings, project team meetings, e-meetings, and e-mail messages. The use of a project website and project management software can also be included if these are to be used in the project.

10.1.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Project schedule, and
- Stakeholder register.

10.2 Manage Communications

Manage Communications is the process of gathering project information for communications creation, distribution, storage, retrieval, and ultimate disposition in accordance with the communications management plan. The key benefit of this process is that it enables an efficient communications flow between project stakeholders. The inputs, tools and techniques, and outputs of this process are depicted in Figure 10-5. Figure 10-6 depicts the data flow diagram of the Manage Communications process.

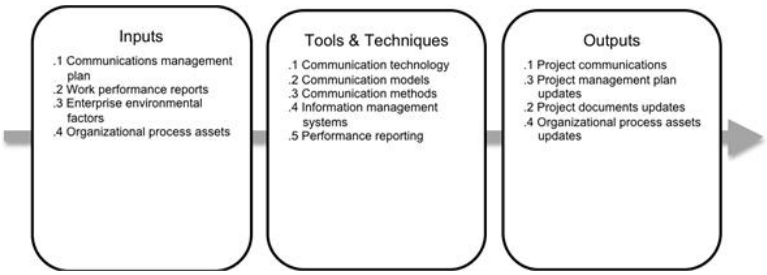


Figure 10-5. Manage Communications: Inputs, Tools & Techniques, and Outputs

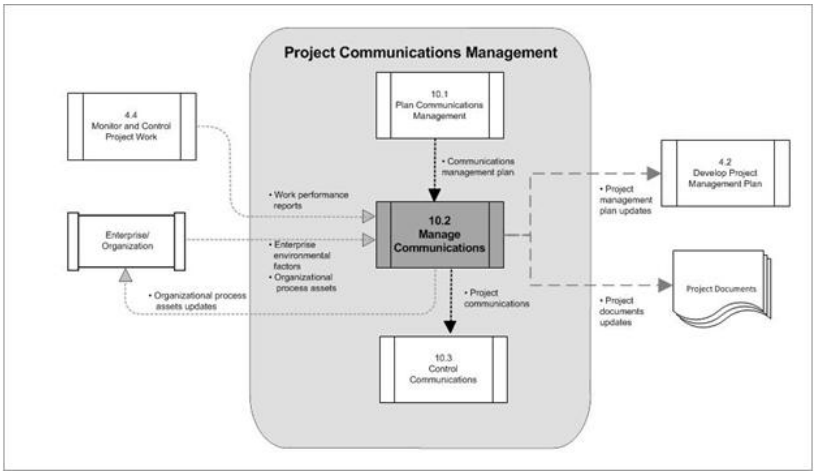


Figure 10-6. Manage Communications Data Flow Diagram

Management of this process goes beyond the distribution of relevant information and seeks to ensure that the information being communicated to project stakeholders has been received and understood. It also provides opportunities for stakeholders to make requests for further information, clarification, and discussion. Techniques and considerations for effective communications management include, but are not limited to, the following:

- **Sender-receiver models.** Incorporating feedback loops to provide opportunities for interaction/participation and remove barriers to communication.
- **Choice of media.** Situation specifics as to when to communicate in writing versus orally, when to prepare an informal memo versus a formal report, and when to communicate face-to-face versus by e-mail.
- **Writing style.** Appropriate use of active versus passive voice, sentence structure, and word choice.
- **Meeting management techniques.** Preparing an agenda and dealing with conflicts.
- **Presentation techniques.** Awareness of the impact of body language and design of visual aids.
- **Facilitation techniques.** Building consensus and overcoming obstacles.
- **Listening techniques.** Listening actively and removal of barriers that adversely affect comprehension

10.2.1 Manage Communications: Inputs

10.2.1.1 Communications Management Plan

Described in Section 10.1.3.1. The communications management plan describes how project communications will be planned, structured, monitored, and controlled.

10.2.1.2 Work Performance Reports

Described in Section 4.4.3.2. Work performance reports are a collection of project performance and status information that may be used to facilitate discussion and to create communications. To optimize this process, it is important that reports be comprehensive, accurate, and available in a timely manner.

10.2.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. Specific enterprise environmental factors that can influence the Manage Communications process include, but are not limited to:

- Organizational culture, structure, and processes;
- Government or industry standards; and
- Project management information systems.

10.2.1.4 Organizational Process Assets

Described in Section 2.1.4. Organizational process assets that can influence the Manage Communications process include, but are not limited to:

- Policies, procedures, and guidelines regarding communications management;
- Templates; and
- Historical information and lessons learned.

10.2.2 Manage Communications: Tools and Techniques

10.2.2.1 Communication Technology

Described in Section 10.1.2.2. The choice of communication technology is an important consideration in the Manage Communications process. As this can vary significantly from project to project and also throughout the life of a project, the focus is to ensure that the choice is appropriate for the information that is being communicated.

10.2.2.2 Communication Models

Described in Section 10.1.2.3. The choice of communication models is an important consideration in this process. As the components in the communications all contribute toward an effective and efficient communications process, the focus is to ensure that the choice of the communication model is appropriate for the project that is undertaken and that any barriers (noise) are identified and managed.

10.2.2.3 Communication Methods

Described in Section 10.1.2.4. The choice of communication methods is an important consideration in this process. As there can be many potential barriers and challenges during this process, the focus is to ensure that the information that has been created and distributed has been received and understood to enable response and feedback.

10.2.2.4 Information Management Systems

Project information is managed and distributed using a variety of tools, including:

- Hard-copy document management, letters, memos, reports, press releases;
- Electronic communications management: e-mail, fax, voice mail, telephone, video and web conferencing, websites, and web publishing; and
- Electronic project management tools, such as web interfaces to scheduling and project management software, meeting and virtual office support software, portals, and collaborative work management tools.

10.2.2.5 Performance Reporting

Performance reporting is the act of collecting and distributing performance information, including status reports, progress measurements, and forecasts. Performance reporting involves the periodic collection and analysis of baseline versus actual data to understand and communicate the project progress and performance as well as to forecast the project results.

Performance reporting needs to provide information at an appropriate level for each audience. The format may range from a simple status report to more elaborate reports and may be prepared regularly or on an exception basis. A simple status report might show performance information, such as percent complete, or status dashboards for each area (i.e., scope, schedule, cost, and quality). More elaborate reports may include:

- Analysis of past performance,
- Analysis of project forecasts (including time and cost),
- Current status of risks and issues,
- Work completed during the period,
- Work to be completed in the next period,
- Summary of changes approved in the period, and
- Other relevant information, which must be reviewed and discussed.

10.2.3 Manage Communications: Outputs

10.2.3.1 Project Communications

The Manage Communications process involves the activities that are required for information to be created, distributed, received, acknowledged, and understood. Project communications can vary significantly and are influenced by factors such as, but not limited to, the urgency and impact of the message, its method of delivery, and level of confidentiality.

10.2.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Issue log,
- Project schedule, and
- Project budget.

10.2.3.3 Project Management Plan Updates

The project management plan provides information on project baselines, communications management, and stakeholder management. Each of these areas may require updates based upon the current performance of the project against the performance measurement baseline. The performance measurement baseline is an approved plan for the project work to which the project execution is compared, and deviations are measured for management control. The performance measurement baseline typically integrates scope, schedule, and cost parameters of a project, but may also include technical and quality parameters.

10.2.3.4 Organizational Process Assets Updates

The organizational process assets, which may be updated include, but are not limited to:

- **Stakeholder notifications.** Information may be provided to stakeholders about resolved issues, approved changes, and general project status.
- **Project reports.** Formal and informal project reports describe project status and include lessons learned, issue logs, project closure reports, and outputs from other Knowledge Areas (Chapters 4-13).
- **Project presentations.** The project team provides information formally or informally to any or all of the project stakeholders. The information and presentation method should be relevant to the needs of the audience.
- **Project records.** Project records may include correspondence, memos, meeting minutes, and other documents describing the project. This information should, to the extent possible and appropriate, be maintained in an organized manner. Project team members can also maintain records in a project notebook or register, which could be physical or electronic.
- **Feedback from stakeholders.** Information received from stakeholders concerning project operations is distributed and used to modify or improve future performance of the project.
- **Lessons learned documentation.** Documentation includes the causes of issues, reasoning behind the corrective action chosen, and other types of lessons learned about communications management. Lessons learned need to be documented and distributed so that it becomes part of the historical database for both the project and the performing organization.

10.3 Control Communications

Control Communications is the process of monitoring and controlling of communications throughout the entire project life cycle to ensure the information needs of project stakeholders are met. The key benefit of this process is that it ensures an optimal information flow between all communication participants, at any moment in time. The inputs, tools and techniques, and outputs of this process are depicted in Figure 10-7. Figure 10-8 depicts the data flow diagram of the Control Communications process.

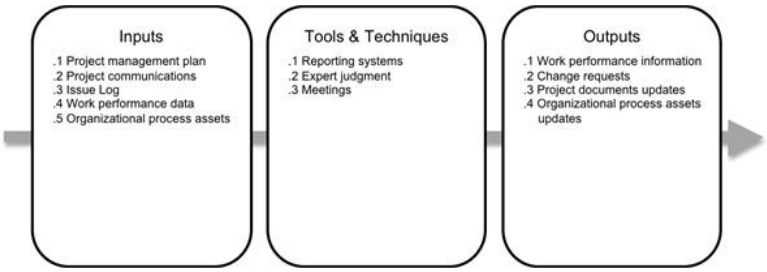


Figure 10-7. Control Communications: Inputs, Tools & Techniques, and Outputs

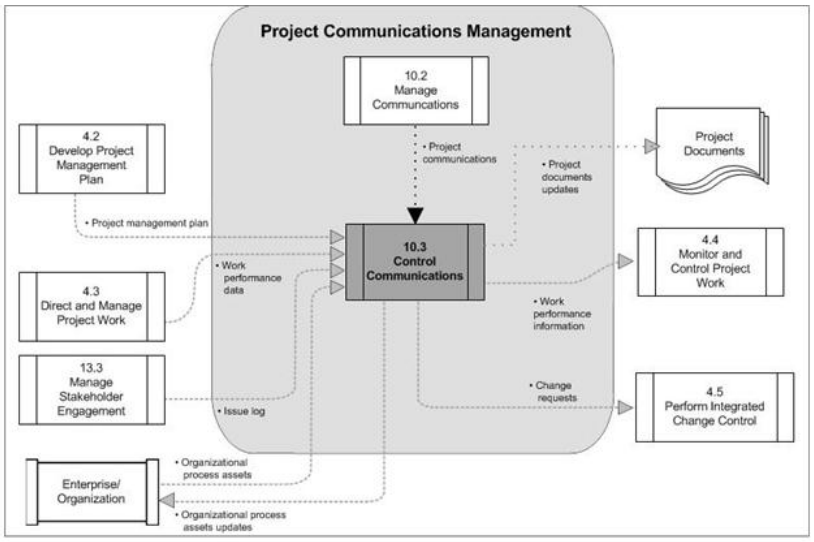


Figure 10-8. Monitor and Control Communications Data Flow Diagram

The Control Communications process can trigger an iteration of the Plan Communications Management and/or Manage Communications processes, thus illustrating the continuous nature of the Project Communications Management processes. Specific communication elements, such as issues or key performance indicators (such as actual vs. planned schedule, cost, and quality), may trigger an immediate revision, while others may be cumulated. The impact and repercussions of project communications should be carefully evaluated and controlled to ensure that the right message is delivered to the right audience at the right time.

10.3.1 Control Communications: Inputs

10.3.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan describes how the project will be executed, monitored, controlled, and closed. It provides valuable information for the Control Communications process such as, but not limited to:

- Stakeholder communication requirements,
- Reason for the distribution of the information,
- Timeframe and frequency for the distribution of required information,
- Individual or group responsible for communication of the information, and
- Individual or group receiving the information.

10.3.1.2 Project Communications

Described in Section 10.2.3.1. The Control Communications process involves the activities that are required for information and communications to be monitored, acted upon, and released to stakeholders. Project communications come from multiple sources and may vary significantly in their format, level of detail, degree of formality and confidentiality. Project communications may include but are not limited to:

- Performance reports,
- Deliverables status,
- Schedule progress, and
- Costs incurred.

10.3.1.3 Issue Log

Described in Section 13.3.3.1. An issue log or action item log is used to document and monitor the resolution of issues. It may be used to facilitate communication and ensure a common understanding of issues. A written log documents and helps monitor who is responsible for resolving specific issues by a target date. Issue resolution addresses obstacles that can block the team from achieving its goals. This information is important to the Control Communications process as it provides both a repository for what has already happened in the project and a platform for subsequent communications to be delivered.

10.3.1.4 Work Performance Data

Described in Section 4.3.3.2. Work performance data organize and summarize the information gathered, and present the results of comparative analysis to the performance measurement baseline.

10.3.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that may influence the Control Communications process include, but are not limited to:

- Report templates;
- Policies, standards, and procedures that define communications;
- Specific communication technologies available ;
- Allowed communication media;
- Record retention policies; and
- Security requirements.

10.3.2 Control Communications: Tools and Techniques

10.3.2.1 Reporting Systems

A reporting system provides a standard tool for the project manager to capture, store, and distribute information to stakeholders about the project's costs incurred, schedule progress, and performance. Some software packages allow the project manager to consolidate reports from several systems and facilitate report distribution to the project stakeholders. Examples of distribution formats may include table reporting, spreadsheet analysis, and presentations. Graphic capabilities can be used to create visual representations of project performance information.

10.3.2.2 Expert Judgment

Expert judgment is often relied upon by the project team to assess the impact of the project communications, need for action or intervention, actions that should be taken, responsibility for taking such actions, and the timeframe for taking action. Expert judgment may need to be applied to technical and/or management details and may be provided by any group or individual with specialized knowledge or training, such as:

- Other units within the organization,
- Consultants,
- Stakeholders, including customers or sponsors,
- Professional and technical associations,
- Industry groups,
- Subject matter experts, and
- Project management office (PMO).

The project manager, in collaboration with the project team, then determines the actions required to ensure that the right message is communicated to the right audience at the right time.

10.3.2.3 Meetings

The Control Communications process requires discussion and dialogue with the project team to determine the most appropriate way to update and communicate project performance, and to respond to requests from stakeholders for information. These discussions and dialogues are commonly facilitated through meetings, which may be conducted face to face or online and in different locations, such as the project site or the client's site.

10.3.3 Control Communications: Outputs

10.3.3.1 Work Performance Information

Work performance information organizes and summarizes the performance data gathered. This performance data typically provides status and progress information on the project at the level of detail required by the various stakeholders. This information is then communicated to stakeholders in need of this information.

10.3.3.2 Change Requests

Described in Section 4.3.3.3. The Control Communications process often results in the need for adjustment, action, and intervention. As a result, change requests will be generated as an output. These change requests are processed through the Perform Integrated Change Control process (Section 4.5) and may result in:

- New or revised cost estimates, activity sequences, schedule dates, resource requirements, and analysis of risk response alternatives;
- Adjustments to the project management plan and documents;
- Recommendations of corrective actions that may bring the expected future performance of the project back in line with the project management plan; and
- Recommendations of preventive actions that may reduce the probability of incurring future negative project performance.

10.3.3.3 Project Documents Updates

Project documents may be updated as a result of the Control Communications process. These updates may include, but are not limited to:

- Forecasts,
- Performance reports, and
- Issue log.

10.3.3.4 Organizational Process Assets Updates

The organizational process assets that may be updated include, but are not limited to, report formats and lessons learned documentation. This documentation may become part of the historical database for both this project and the performing organization and may include the causes of issues, reasons behind the corrective action chosen, and other types of lessons learned during the project.

CHAPTER 11

PROJECT RISK MANAGEMENT

Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, and controlling risk on a project. The objectives of Project Risk Management are to increase the probability and impact of positive events, and decrease the probability and impact of negative events in the project.

Figure 11-1 provides an overview of the Project Risk Management processes, which are as follows:

11.1 Plan Risk Management—The process of defining how to conduct risk management activities for a project.

11.2 Identify Risks—The process of determining which risks may affect the project and documenting their characteristics.

11.3 Perform Qualitative Risk Analysis—The process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact.

11.4 Perform Quantitative Risk Analysis—The process of numerically analyzing the effect of identified risks on overall project objectives.

11.5 Plan Risk Responses—The process of developing options and actions to enhance opportunities and to reduce threats to project objectives.

11.6 Control Risks—The process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project.

These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.

Project risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and quality. A risk may have one or more causes and, if it occurs, it may have one or more impacts. A cause may be a given or potential requirement, assumption, constraint, or condition that creates the possibility of negative or positive outcomes. For example, causes could include the requirement of an environmental permit to do work, or having limited personnel assigned to design the project. The risk is that the permitting agency may take longer than planned to issue a permit, or, in the case of an opportunity, additional development personnel may become available who can participate in design and they can be assigned to the project. If either of these uncertain events occurs, there may be an impact on the project cost, schedule, or performance. Risk conditions may include aspects of the project's or organization's environment that contribute to project risk, such as immature project management practices, lack of integrated management systems, concurrent multiple projects, or dependency on external participants who cannot be controlled.

Project risk has its origins in the uncertainty present in all projects. Known risks are those that have been identified and analyzed, making it possible to plan responses for those risks. Specific unknown risks cannot be managed proactively, which suggests that the project team should have a contingency and management reserve. A project risk that has occurred is considered an issue.

Individual project risks are different from overall project risk. Overall project risk represents the effect of uncertainty on the project as a whole. It is more than the sum of the individual risks within a project, since it includes all sources of project uncertainty. It represents the exposure of stakeholders to the implications of variations in project outcome, both positive and negative.

Organizations perceive risk as the effect of uncertainty on projects and organizational objectives. Organizations and stakeholders are willing to accept varying degrees of risk depending on their risk attitude. The risk attitudes of both the organization and the stakeholders may be influenced by a number of factors, which are broadly classified into

two themes. One is risk appetite, which is the degree of uncertainty an entity is willing to take on, in anticipation of a reward. The other is risk tolerance, which is the maximum acceptable deviation an entity is willing to accept on the project or business objectives as the potential impact. The term risk threshold may refer to measures along the level of uncertainty or the level of impact at which a stakeholder may have a specific interest. For example, a threshold may be a measure of risk appetite that is unacceptable for a stakeholder or organization, or it may be a measure of risk tolerance at which point an entity may select a different risk response.

Risks that represent both positive and negative risks are commonly referred to as opportunities and threats. The project may be accepted if the risks are within tolerances and are in balance with the rewards that may be gained by taking the risks. Positive risks that offer opportunities within the limits of risk tolerances may be pursued in order to generate enhanced value. For example, adopting an aggressive resource optimization technique is a risk taken in anticipation of a reward for using fewer resources.

Individuals and groups adopt attitudes toward risk that influence the way they respond. These risk attitudes are driven by perception, tolerances, and other biases, which should be made explicit wherever possible. A consistent approach to risk should be developed for each project, and communication about risk and its handling should be open and honest. Risk responses reflect an organization's perceived balance between risk taking and risk avoidance.

To be successful, an organization should be committed to address risk management proactively and consistently throughout the project. A conscious choice should be made at all levels of the organization to actively identify and pursue effective risk management during the life of the project. Project risk could exist at the moment a project is initiated. Moving forward on a project without a proactive focus on risk management is likely to lead to more problems or issues arising from unmanaged threats, as well as less value or fewer benefits due to missed opportunities.

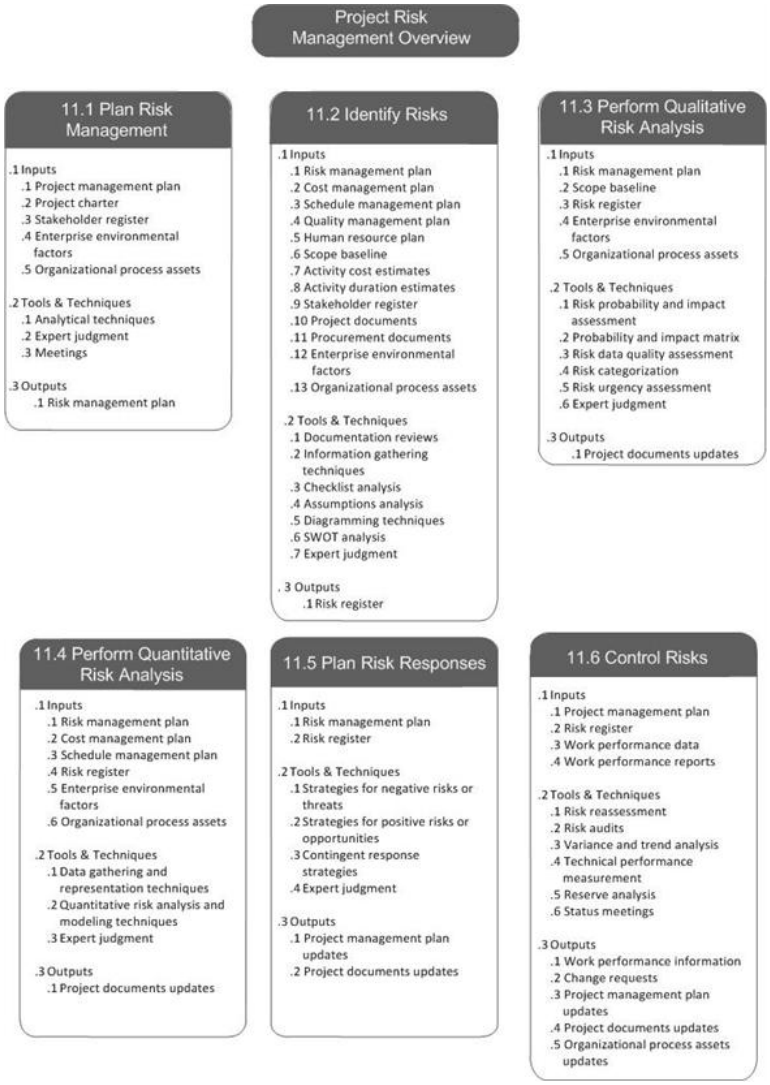


Figure 11-1. Project Risk Management Overview

11.1 Plan Risk Management

Plan Risk Management is the process of defining how to conduct risk management activities

for a project. The key benefit of this process is that it ensures that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-2. Figure 11-3 depicts the data flow diagram of the process.

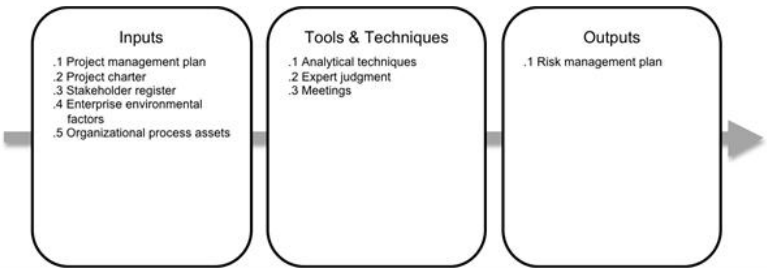


Figure 11-2. Develop Risk Management Plan: Inputs, Tools & Techniques, and Outputs

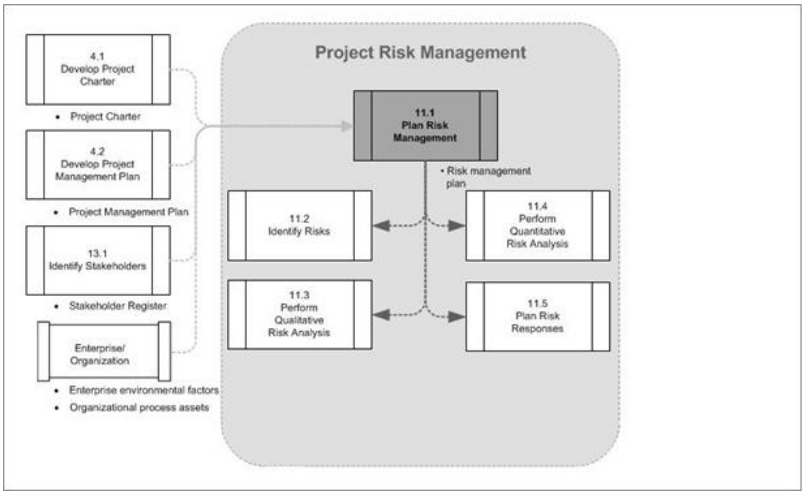


Figure 11-3. Plan Risk Management Data Flow Diagram

Careful and explicit planning enhances the probability of success for other risk management processes. Planning is also important to provide sufficient resources and time for risk management activities and to establish an agreed-upon basis for evaluating risks. The Plan Risk Management process should begin when a project is conceived and should be completed early during project planning.

11.1.1 Plan Risk Management: Inputs

11.1.1.1 Project Management Plan

In planning risk management, all approved subsidiary management plans and baselines should be taken into consideration in order to make the risk management plan consistent with them. The risk management plan is also a component of the project management plan.

11.1.1.2 Project Charter

Described in Section 4.1.3.1. The project charter can provide various inputs such as high-level risks, high-level project descriptions, and high-level requirements.

11.1.1.3 Stakeholder Register

Described in Section 13.1.3.1. The stakeholder register, which contains all details related to the project's stakeholders, provides an overview of their roles.

11.1.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Plan Risk Management process include, but are not limited to, risk attitudes and tolerances that describe the degree of risk that an organization will withstand.

11.1.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Plan Risk Management process include, but are not limited to:

- Risk categories,

- Common definitions of concepts and terms,
- Risk statement formats,
- Standard templates,
- Roles and responsibilities,
- Authority levels for decision making, and
- Lessons learned.

11.1.2 Plan Risk Management: Tools and Techniques

11.1.2.1 Analytical Techniques

Analytical techniques are used to understand and define the overall risk management context of the project. Risk management context is a combination of stakeholder risk attitudes and the strategic risk exposure of a given project based on the overall project context. For example, a stakeholder risk profile analysis may be performed to grade and qualify the project stakeholder risk appetite and tolerance. Other techniques, such as the use of strategic risk scoring sheets, are used to provide a high-level assessment of the risk exposure of the project based on the overall project context. Depending on these assessments, the project team can allocate appropriate resources and focus on the risk management plan.

11.1.2.2 Expert Judgment

To ensure a comprehensive establishment of the risk management plan, judgment and expertise should be considered from groups or individuals with specialized training or knowledge on the subject area, such as:

- Senior management,
- Project stakeholders,
- Project managers who have worked on projects in the same area (directly or through lessons learned),
- Subject matter experts (SMEs) in business or project area,
- Industry groups and consultants, and
- Professional and technical associations.

11.1.2.3 Meetings

Project teams hold planning meetings to develop the risk management plan. Attendees at these meetings may include the project manager, selected project team members and stakeholders, anyone in the organization with responsibility to manage the risk planning and execution activities, and others, as needed.
High-level plans for conducting the risk management activities are defined in these meetings. Risk management cost elements and schedule activities may be developed for inclusion in the project budget and schedule, respectively. Risk contingency reserve application approaches may be established or reviewed. Risk management responsibilities should be assigned. General organizational templates for risk categories and definitions of terms such as levels of risk, probability by type of risk, impact by type of objectives, and the probability and impact matrix will be tailored to the specific project. If templates for other steps in the process do not exist, they may be generated in these meetings. The outputs of these activities are summarized in the risk management plan.

11.1.3 Plan Risk Management: Outputs

11.1.3.1 Risk Management Plan

The risk management plan is a component of the project management plan and describes how risk management activities will be structured and performed on the project. The risk management plan includes the following:

- **Methodology.** Defines the approaches, tools, and data sources that will be used to perform risk management on the project.
- **Roles and responsibilities.** Define the lead, support, and risk management team members for each type of activity in the risk management plan, and clarify their responsibilities.
- **Budgeting.** Assigns resources, estimates funds needed for risk management for inclusion in the cost performance baseline, and establishes protocols for application of contingency reserve.
- **Timing.** Defines when and how often the risk management process will be performed throughout the project life cycle, establishes protocols for application of schedule contingency reserves, and establishes risk management activities for inclusion in the project schedule.
- **Risk categories.** Provides a structure that ensures a comprehensive process of systematically identifying risks to a consistent level of detail and contributes to the effectiveness and quality of the Identify Risks process. An organization can use a

previously prepared custom categorization framework, which may take the form of a simple list of categories or might be structured into a risk breakdown structure (RBS). The RBS is a hierarchical representation of risk categories. An example is shown in Figure 11-4.

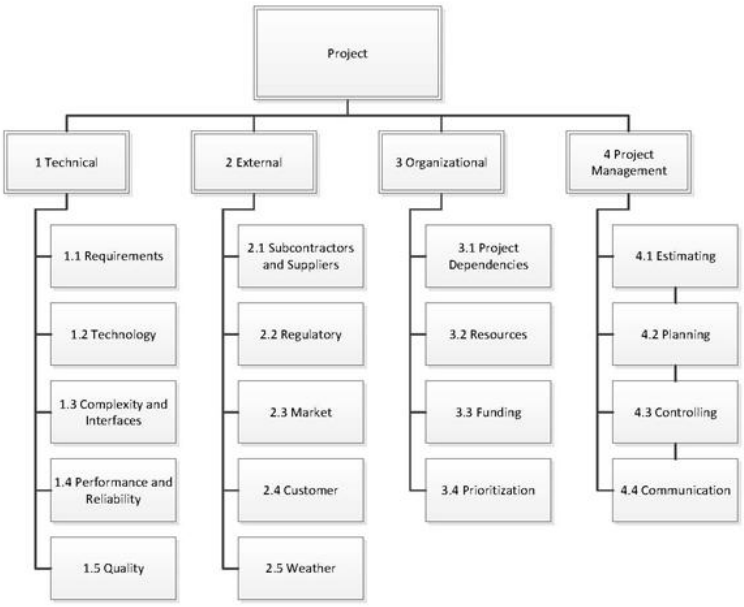


Figure 11-4. Example of a Risk Breakdown Structure (RBS)

• **Definitions of risk probability and impact.** The quality and credibility of the risk analysis requires that different levels of risk probability and impact be defined that are specific to the project context. General definitions of probability levels and impact levels are tailored to the individual project during the plan risk management process for use in subsequent processes. Figure 11-5 is an example of definitions of negative impacts that could be used in evaluating risk impacts related to four project objectives. (Similar tables may be established with a positive impact perspective). Figure 11-5 illustrates both relative and numerical (in this case, nonlinear) approaches.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives
(Examples are shown for negative impacts only)

	Relative or numerical scales are shown				
Project Objective	Very low /.05	Low /.10	Moderate /.20	High /.40	Very high /.80
Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase
Time	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time increase	>20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

This table presents examples of risk impact definitions for four different project objectives. They should be tailored in the Risk Management Planning process to the individual project and to the organization's risk thresholds. Impact definitions can be developed for opportunities in a similar way.

Figure 11-5. Definition of Impact Scales for Four Project Objectives

• **Probability and impact matrix.** A probability and impact matrix is a grid for rating each risk, based on the probability of its occurrence and the impact on the project objectives if that risk occurs. Risks are prioritized according to their potential implications for having an effect on the project's objectives. A typical approach to prioritizing risks is to use a look-up table or a probability and impact matrix. The specific combinations of probability and impact that lead to a risk being rated as "high," "moderate," or "low" importance are usually set by the organization.

• **Revised stakeholders' tolerances.** Stakeholders' tolerances, as they apply to the specific project, may be revised in the Plan Risk Management process.

• **Reporting formats.** Defines how the outcomes of the risk management process will be documented, analyzed, and communicated. It describes the content and format of the risk register as well as any other risk reports required.

• **Tracking.** Documents how risk activities will be recorded for the benefit of the current project and how risk management processes will be audited.

11.2 Identify Risks

Identify Risks is the process of determining which risks may affect the project and documenting their characteristics. The key benefit of this process is the documentation of

existing risks and the knowledge and ability it provides to the project team to anticipate events. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-6. Figure 11-7 depicts the data flow diagram of the process.

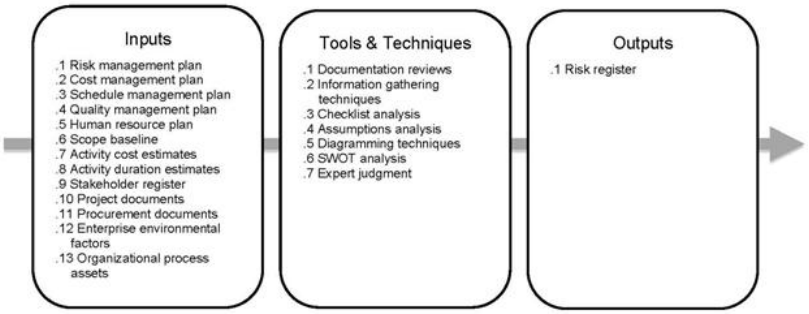


Figure 11-6. Identify Risks: Inputs, Tools & Techniques, and Outputs

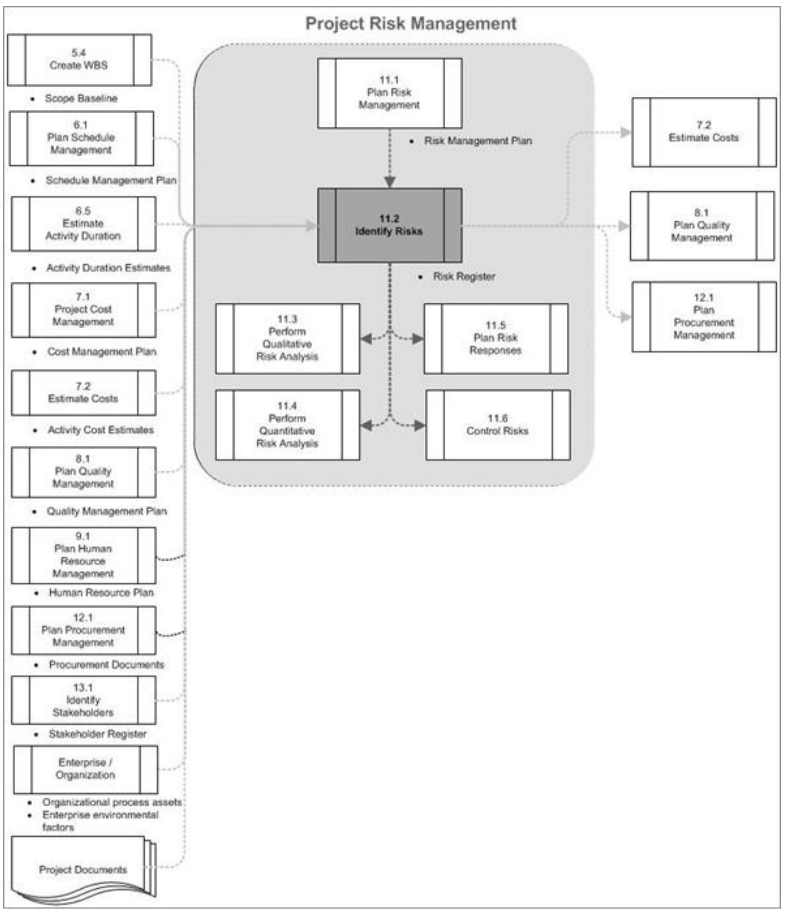


Figure 11-7. Identify Risks Data Flow Diagram

Participants in risk identification activities may include the following: project manager, project team members, risk management team (if assigned), customers, subject matter experts from outside the project team, end users, other project managers, stakeholders, and risk management experts. While these personnel are often key participants for risk identification, all project personnel should be encouraged to identify risks.

Identify risks is an iterative process, because new risks may evolve or become known as the project progresses through its life cycle. The frequency of iteration and participation in each cycle will vary by situation. The format of the risk statements should be consistent to ensure that each risk is understood clearly and unambiguously in order to support effective analysis and response development. The risk statement should support the ability to compare the relative effect of one risk against others on the project The process should involve the project team so they can develop and maintain a sense of ownership and responsibility for the risks and associated risk response actions. Stakeholders outside the project team may provide additional objective information.

11.2.1 Identify Risks: Inputs

11.2.1.1 Risk Management Plan

Described in Section 11.1.3.1. Key elements of the risk management plan that contribute to the Identify Risks process are the assignments of roles and responsibilities, provision for risk management activities in the budget and schedule, and categories of risk, which are sometimes expressed as a risk breakdown structure (Figure 11-4).

11.2.1.2 Cost Management Plan

Described in Section 7.1.3.1. The cost management plan provides processes and controls that can be used to help identify risks across the project.

11.2.1.3 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan contains the processes and procedures to maintain the project schedule.

11.2.1.4 Quality Management Plan

Described in Section 8.1.3.1. The quality management plan provides an overview of how quality measures and metrics are to be documented.

11.2.1.5 Human Resource Plan

Described in Section 9.1.3.1. The human resource plan provides guidance on how project human resources should be defined, staffed, managed, and eventually released. It can also contain roles and responsibilities, project organization charts, staffing management plan, which form a key input to identify risk process.

11.2.1.6 Scope Baseline

Described in Section 5.4.3.1. Project assumptions are found in the project scope statement. Uncertainty in project assumptions should be evaluated as potential causes of project risk.
The WBS is a critical input to identifying risks as it facilitates an understanding of the potential risks at both the micro and macro levels. Risks can be identified and subsequently tracked at summary, control account, and/or work package levels.

11.2.1.7 Activity Cost Estimates

Described in Section 7.2.3.1. Activity cost estimate reviews are useful in identifying risk as they provide a quantitative assessment of the likely cost to complete scheduled activities and ideally are expressed as a range, with the width of the range indicating the degree(s) of risk. The review may result in projections indicating the estimate is either sufficient or insufficient to complete the activity (and hence pose a risk to the project).

11.2.1.8 Activity Duration Estimates

Described in Section 6.5.3.1. Activity duration estimate reviews are useful in identifying risks related to the time allowances for the activities or project as a whole, again with the width of the range of such estimates indicating the relative degree(s) of risk.

11.2.1.9 Stakeholder Register

Described in Section 13.1.3.1. Information about the stakeholders is useful for soliciting inputs to identify risks, as this will ensure that key stakeholders, especially the customer, are interviewed or otherwise participate during the Identify Risks process.

11.2.1.10 Project Documents

Project documents include, but are not limited to:

- Assumptions log,
- Work performance reports,
- Earned value reports,
- Network diagrams, and
- Other project information proven to be valuable in identifying risks.

11.2.1.11 Procurement Documents

Defined in Section 12.1.3.3. If the project requires external procurement of resources, procurement documents become a key input to the Identify Risks process. The complexity and the level of detail of the procurement documents should be consistent with the value of, and risks associated with, planned procurement.

11.2.1.12 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors that can influence the Identify Risks process include, but are not limited to:

- Published information, including commercial databases,
- Academic studies,
- Published checklists,
- Benchmarking,
- Industry studies, and
- Risk attitudes.

11.2.1.13 Organizational Process Assets

Described in Section 2.1.4. Organizational process assets that can influence the identify risks process include, but are not limited to:

- Project files, including actual data,
- Organizational and project process controls,
- Risk statement templates, and
- Lessons learned.

11.2.2 Identify Risks: Tools and Techniques

11.2.2.1 Documentation Reviews

A structured review may be performed of the project documentation, including plans, assumptions, previous project files, contracts, and other information. The quality of the plans, as well as consistency between those plans and the project requirements and assumptions, may be indicators of risk in the project.

11.2.2.2 Information Gathering Techniques

Examples of information gathering techniques used in identifying risks can include:

- **Brainstorming.** The goal of brainstorming is to obtain a comprehensive list of project risks. The project team usually performs brainstorming, often with a multidisciplinary set of experts who are not part of the team. Ideas about project risk are generated under the leadership of a facilitator, either in a traditional free-form brainstorm session with ideas contributed by participants using methods such as de Bono Six Thinking Hats® or structured mass interviewing techniques such as the nominal group technique. Categories of risk, such as risk breakdown structure, can be used as a framework. Risks are then identified and categorized by type of risk and their definitions are refined.
- **Delphi technique.** The Delphi technique is a way to reach a consensus of experts. Project risk experts participate in this technique anonymously. A facilitator uses a questionnaire to solicit ideas about the important project risks. The responses are summarized and are then recirculated to the experts for further comment. Consensus may be reached in a few rounds of this process. The Delphi technique helps reduce bias in the data and keeps any one person from having undue influence on the outcome.
- **Interviewing.** Interviewing experienced project participants, stakeholders, and subject matter experts helps to identify risks.
- **Root cause analysis.** Root cause analysis is a specific technique used to identify a problem, discover the underlying causes that lead to it, and develop preventive action.

11.2.2.3 Checklist Analysis

Risk identification checklists are developed based on historical information and knowledge that has been accumulated from previous similar projects and from other sources of information. The lowest level of the RBS can also be used as a risk checklist. While a checklist may be quick and simple, it is impossible to build an exhaustive one, and care must be taken to ensure the checklist is not used to avoid the effort of proper risk identification. The team should also make sure to explore items that do not appear on the checklist. Additionally, the checklist should be pruned from time to time to remove or archive related items. The checklist should be reviewed during project closure to incorporate new lessons learned and improve it for use on future projects.

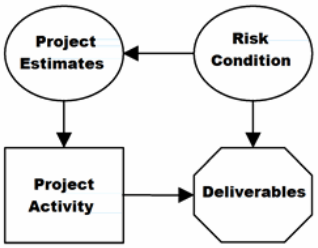
11.2.2.4 Assumptions Analysis

Every project and its plan is conceived and developed based on a set of hypotheses, scenarios, or assumptions. Assumptions analysis explores the validity of assumptions as they apply to the project. It identifies risks to the project from inaccuracy, instability, inconsistency, or incompleteness of assumptions.

11.2.2.5 Diagramming Techniques

Risk diagramming techniques may include:

- **Cause and effect diagrams.** These are also known as Ishikawa or fishbone diagrams and are useful for identifying causes of risks.
- **System or process flow charts.** These show how various elements of a system interrelate and the mechanism of causation.
- **Influence diagrams.** These are graphical representations of situations showing causal influences, time ordering of events, and other relationships among variables and outcomes, as shown in Figure 11-8.



- **Figure 11-8.** Influence Diagram

11.2.2.6 SWOT Analysis

This technique examines the project from each of the strengths, weaknesses, opportunities, and threats (SWOT) perspectives to increase the breadth of identified risks by including internally generated risks. The technique starts with identification of strengths and weaknesses of the organization, focusing on either the project, organization, or the business area in general. SWOT analysis then identifies any opportunities for the project that arise from organizational strengths, and any threats arising from organizational weaknesses. The analysis also examines the degree to which organizational strengths offset threats, as well as identifying opportunities that may serve to overcome weaknesses.

11.2.2.7 Expert Judgment

Risks may be identified directly by experts with relevant experience with similar projects or business areas. Such experts should be identified by the project manager and invited to consider all aspects of the project and suggest possible risks based on their previous experience and areas of expertise. The experts' bias should be taken into account in this process.

11.2.3 Identify Risks: Outputs

11.2.3.1 Risk Register

The primary output from Identify Risks is the initial entry into the risk register. The risk register is a document in which risks are recorded together with the results of risk analysis and risk response planning. It contains the outcomes of the other risk management processes as they are conducted, resulting in an increase in the level and type of information contained in the risk register over time. The preparation of the risk register begins in the Identify Risks process with the following information, and then becomes available to other project management and risk management processes.

- **List of identified risks**. The identified risks are described in as much detail as is reasonable. A simple structure for risks in the list may be applied, such as EVENT may occur, causing IMPACT, or IF CAUSE, EVENT may occur, leading to EFFECT. In addition to the list of identified risks, the root causes of those risks may become more evident. These are the fundamental conditions or events that may give rise to one or more identified risks. They should be recorded and used to support future risk identification for this and other projects.
- **List of potential responses.** Potential responses to a risk may sometimes be identified during the Identify Risks process. These responses, if identified in this process, should be used as inputs to the Plan Risk Responses process.

11.3 Perform Qualitative Risk Analysis

Perform Qualitative Risk Analysis is the process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact. The key benefit of this process is that it enables organizations to reduce the level of uncertainty and to focus on high-priority risks. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-9. Figure 11-10 depicts the data flow diagram of the process.

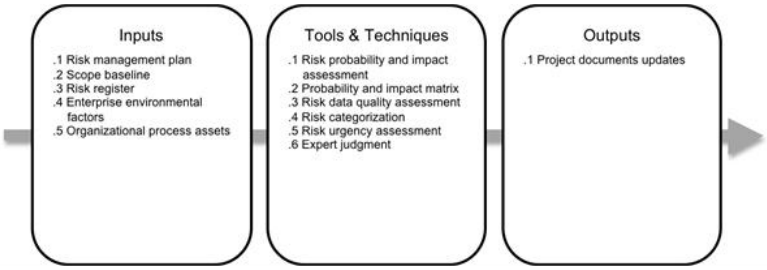


Figure 11-9. Perform Qualitative Risk Assessment: Inputs, Tools & Techniques, and Outputs

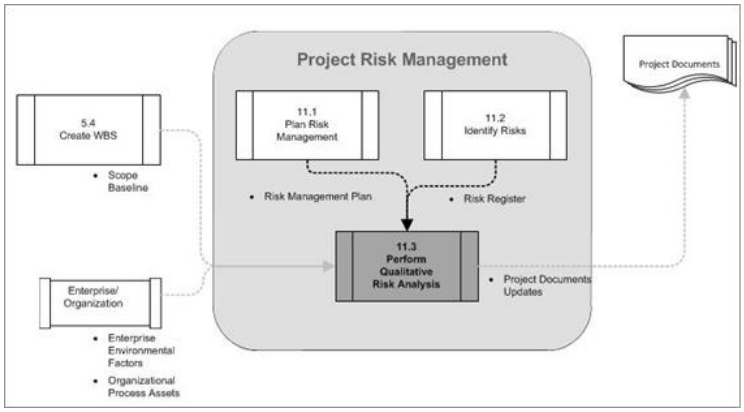


Figure 11-10. Perform Qualitative Risk Analysis Data Flow Diagram

Perform Qualitative Risk Analysis assesses the priority of identified risks using their relative probability or likelihood of occurrence, the corresponding impact on project objectives if the risks occur, as well as other factors such as the time frame for response and the organization's risk tolerance associated with the project constraints of cost, schedule, scope, and quality. Such assessments reflect the risk attitude of the project team and other stakeholders. Effective assessment therefore requires explicit identification and management of the risk attitudes of key participants in the Perform Qualitative Risk Analysis process. Where these risk attitudes introduce bias into the assessment of identified risks, attention should be paid to identifying bias and correcting for it.

Establishing definitions of the levels of probability and impact can reduce the influence of bias. The time criticality of risk-related actions may magnify the importance of a risk. An evaluation of the quality of the available information on project risks also helps to clarify the assessment of the risk's importance to the project.

Perform Qualitative Risk Analysis is usually a rapid and cost-effective means of establishing priorities for Plan Risk Responses and lays the foundation for Perform Quantitative Risk Analysis, if required. The Perform Qualitative Risk Analysis process should be revisited during the project life cycle to stay current with changes in the project risks. This process can lead into Perform Quantitative Risk Analysis or directly into Plan Risk Responses.

11.3.1 Perform Qualitative Risk Assessment: Inputs

11.3.1.1 Risk Management Plan

Described in Section 11.1.3.1. Key elements of the risk management plan used in the Perform Qualitative Risk Analysis process include roles and responsibilities for conducting risk management, budgets, schedule activities for risk management, risk categories, definitions of probability and impact, the probability and impact matrix, and revised stakeholders' risk tolerances. These inputs are usually tailored to the project during the Plan Risk Management process. If they are not available, they may be developed during the Perform Qualitative Risk Analysis process.

11.3.1.2 Scope Baseline

Described in Section 5.4.3.1. Projects of a common or recurrent type tend to have more well-understood risks. Projects using state-of-the-art or first-of-its-kind technology, and highly complex projects, tend to have more uncertainty. This can be evaluated by examining the scope baseline.

11.3.1.3 Risk Register

Described in Section 11.2.3.1. The risk register contains the information that will be used to assess and prioritize risks.

11.3.1.4 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors may provide insight and context to the risk assessment, such as:

- Industry studies of similar projects by risk specialists, and
- Risk databases that may be available from industry or proprietary sources.

11.3.1.5 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Perform Qualitative Risk Analysis process include information on prior, similar completed projects.

11.3.2 Perform Qualitative Risk Assessment: Tools and Techniques

11.3.2.1 Risk Probability and Impact Assessment

Risk probability assessment investigates the likelihood that each specific risk will occur. Risk impact assessment investigates the potential effect on a project objective such as schedule, cost, quality, or performance, including both negative effects for threats and positive effects for opportunities.
Probability and impact are assessed for each identified risk. Risks can be assessed in interviews or meetings with participants selected for their familiarity with the risk categories on the agenda. Project team members and knowledgeable persons external to the project are included.
The level of probability for each risk and its impact on each objective is evaluated during the interview or meeting. Explanatory detail, including assumptions justifying the levels assigned, are also recorded. Risk probabilities and impacts are rated according to the definitions given in the risk management plan. Risks with low ratings of probability and impact will be included on a watch list for future monitoring.

11.3.2.2 Probability and Impact Matrix

Risks can be prioritized for further quantitative analysis and planning risk responses based on their risk rating. Ratings are assigned to risks based on their assessed probability and impact. Evaluation of each risk's importance and priority for attention is typically conducted using a look-up table or a probability and impact matrix. Such a matrix specifies combinations of probability and impact that lead to rating the risks as low, moderate, or high priority. Descriptive terms or numeric values can be used depending on organizational preference.
The organization should determine which combinations of probability and impact result in a classification of high risk, moderate risk, and low risk. In a black-and-white matrix, these conditions are denoted using different shades of gray. Specifically in Figure 11-11, the dark gray area (with the largest numbers) represents high risk: the medium gray area (with the smallest numbers) represents low risk, and the light gray area (with in-between numbers) represents moderate risk. Usually, these risk-rating rules are specified by the organization in advance of the project and included in organizational process assets. Risk rating rules can be tailored in the Plan Risk Management process to the specific project.

Probability and Impact Matrix										
Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05 / Very Low	0.10 / Low	0.20 / Moderate	0.40 / High	0.80/ Very High	0.80 / Very High	0.40 / High	0.20 / Moderate	0.10 / Low	0.05 / Very Low

Figure 11-11 Probability and Impact Matrix

As illustrated in Figure 11-11, an organization can rate a risk separately for each

objective (e.g. , cost, time, and scope). In addition, it may develop ways to determine one overall rating for each risk. Finally, opportunities and risks are handled in the same matrix using definitions of the different levels of impact that are appropriate for each. The risk score helps guide risk responses. For example, risks that have a negative impact on objectives, if they occur and that are in the high-risk (dark gray) zone of the matrix, may require priority action and aggressive response strategies. Risks in the low-risk (medium gray) zone may not require proactive management action beyond being placed on a watch list or adding a contingency reserve. Similarly for opportunities, those in the high-risk (dark gray) zone that may be obtained most easily and offer the greatest benefit should, therefore, should be targeted first. Opportunities in the low-risk (medium gray) zone should be monitored.

11.3.2.3 Risk Data Quality Assessment

Risk data quality assessment is a technique to evaluate the degree to which the data about risks is useful for risk management. It involves examining the degree to which the risk is understood and the accuracy, quality, reliability, and integrity of the data about the risk.
The use of low-quality risk data may lead to a qualitative risk analysis of little use to the project. If data quality is unacceptable, it may be necessary to gather better data. Often, the collection of information about risks is difficult, and consumes time and resources beyond that originally planned.

11.3.2.4 Risk Categorization

Risks to the project can be categorized by sources of risk (e.g., using the RBS), the area of the project affected (e.g., using the WBS), or other useful category (e.g., project phase) to determine the areas of the project most exposed to the effects of uncertainty. Grouping risks by common root causes can lead to developing effective risk responses.

11.3.2.5 Risk Urgency Assessment

Risks requiring near-term responses may be considered more urgent to address. Indicators of priority may include time to affect a risk response, symptoms and warning signs, and the risk rating. In some qualitative analyses, the assessment of risk urgency is combined with the risk ranking that is determined from the probability and impact matrix to give a final risk severity rating.

11.3.2.6 Expert Judgment

Expert judgment is required to assess the probability and impact of each risk to determine its location in the matrix shown in Figure 11-11. Experts generally are those having experience with similar, recent projects. Gathering expert judgment is often accomplished with the use of risk facilitation workshops or interviews. The experts' bias should be taken into account in this process.

11.3.3 Perform Qualitative Risk Analysis: Outputs

11.3.3.1 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- **Risk register updates.** As new information becomes available through the qualitative risk assessment, the risk register must be updated. Updates to the risk register may include assessments of probability and impacts for each risk, risk ranking or scores, risk urgency information or risk categorization.
- **Assumptions log updates.** As new information becomes available through the qualitative risk assessment, assumptions could change. The assumptions log needs to be revisited to accommodate this new information. Assumptions may be incorporated into the project scope statement or in a separate assumptions log.

11.4 Perform Quantitative Risk Analysis

Perform Quantitative Risk Analysis is the process of numerically analyzing the effect of identified risks on overall project objectives. The key benefit of this process is that it produces quantitative risk information to support decision making in order to reduce project uncertainty. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-12. Figure 11-13 depicts the data flow diagram of the process.

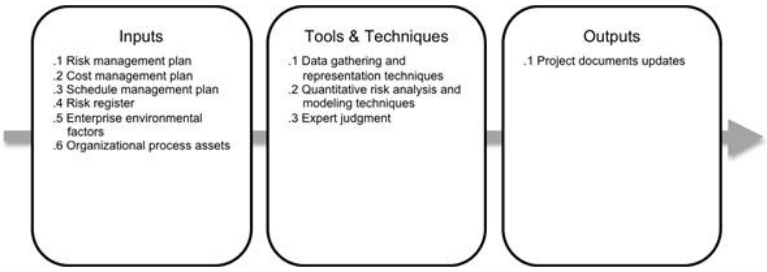


Figure 11-12. Perform Quantitative Risk Analysis: Inputs, Tools & Techniques, and Outputs

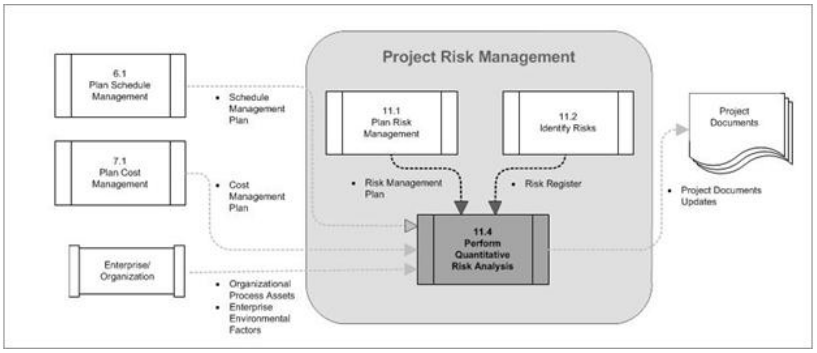


Figure 11-13. Perform Quantitative Risk Analysis Data Flow Diagram

Perform Quantitative Risk Analysis is performed on risks that have been prioritized by the Perform Qualitative Risk Analysis process as potentially and substantially impacting the project's competing demands. The Perform Quantitative Risk Analysis process analyzes the effect of those risks on project objectives. It is used mostly to evaluate the aggregate effect of all risks affecting the project. When the risks drive the quantitative analysis, the process may be used to assign a numerical priority rating to those risks individually. Perform Quantitative Risk Analysis generally follows the Perform Qualitative Risk Analysis process. In some cases, it may not be possible to execute the Perform Quantitative Risk Analysis process due to lack of sufficient data to develop appropriate models. The project manager should exercise expert judgment to determine the need for and the viability of quantitative risk analysis. The availability of time and budget, and the need for qualitative or quantitative statements about risk and impacts, will determine which method(s) to use on any particular project. Perform Quantitative Risk Analysis should be repeated, as needed, as part of the Control Risks process to determine if the overall project risk has been satisfactorily decreased. Trends may indicate the need for more or less risk management action.

11.4.1 Perform Quantitative Risk Analysis: Inputs

11.4.1.1 Risk Management Plan

Described in Section 11.1.3.1. The risk management plan provides guidelines, methods, and tools to be used in quantitative risk analysis.

11.4.1.2 Cost Management Plan

Described in Section 7.1.3.1. The cost management plan provides guidelines on establishing and managing risk reserves.

11.4.1.3 Schedule Management Plan

Described in Section 6.1.3.1. The schedule management plan provides guidelines on establishing and managing risk reserves.

11.4.1.4 Risk Register

Described in Section 11.2.3.1 The risk register is used as a reference point for performing quantitative risk analysis.

11.4.1.5 Enterprise Environmental Factors

Described in Section 2.1.5. Enterprise environmental factors may provide insight and context to the risk analysis, such as:

- Industry studies of similar projects by risk specialists, and
- Risk databases that may be available from industry or proprietary sources.

11.4.1.6 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Perform Quantitative Risk Analysis process include information on prior, similar completed projects.

11.4.2 Perform Quantitative Risk Analysis: Tools and Techniques

11.4.2.1 Data Gathering and Representation Techniques

• **Interviewing.** Interviewing techniques draw on experience and historical data to quantify the probability and impact of risks on project objectives. The information needed depends upon the type of probability distributions that will be used. For instance, information would be gathered on the optimistic (low), pessimistic (high), and most likely scenarios for some commonly used distributions. Examples of three-point estimates for cost are shown in Figure 11-14. Additional information on three point estimates appears in Estimate Activity Durations (Section 6.5) and Estimate Costs (Section 7.2). Documenting the rationale of the risk ranges and the assumptions behind them are important components of the risk interview because they can provide insight on the reliability and credibility of the analysis.

Range of Project Cost Estimates

WBS Element	Low	Most Likely	High
Design	$4M	$6M	$10M
Build	$16M	$20M	$35M
Test	$11M	$15M	$23M

Interviewing relevant stakeholders helps determine the three-point estimates for each WBS element for triangular, beta or other distributions. In this example, the likelihood of completing the project at or below the most likely estimate of $41 million is relatively small as shown in the simulation results in Figure 11-16 (Cost Risk Simulation Results).

Figure 11-14. Range of Project Cost Estimates Collected During the Risk Interview

• **Probability distributions.** Continuous probability distributions, which are used extensively in modeling and simulation, represent the uncertainty in values such as durations of schedule activities and costs of project components. Discrete distributions can be used to represent uncertain events, such as the outcome of a test or a possible scenario in a decision tree. Two examples of widely used continuous distributions are shown in Figure 11-15. These distributions depict shapes that are compatible with the data typically developed during the quantitative risk analysis. Uniform distributions can be used if there is no obvious value that is more likely than any other between specified high and low bounds, such as in the early concept stage of design.

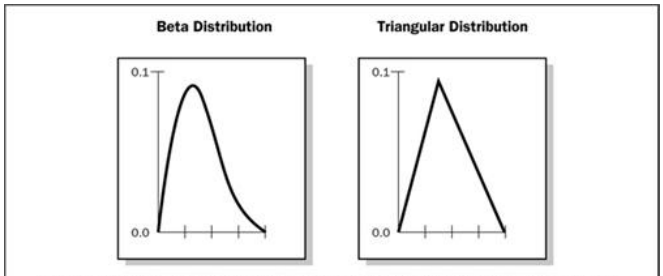


Figure 11-15. Examples of Commonly Used Probability Distributions

11.4.2.2 Quantitative Risk Analysis and Modeling Techniques

Commonly used techniques use both event-oriented and project-oriented analysis approaches, including:

• **Sensitivity analysis.** Sensitivity analysis helps to determine which risks have the most potential impact on the project. It helps to understand how the variations in project's objectives correlate with variations in different uncertainties. Conversely, it examines the extent to which the uncertainty of each project element affects the objective being studied when all other uncertain elements are held at their baseline values. One typical display of sensitivity analysis is the tornado diagram (Figure 11-16), which is useful for comparing relative importance and impact of variables that have a high degree of uncertainty to those that are more stable. A tornado diagram is a type of bar-chart where the Y-axis contains each type of uncertainty at base values, and the X-axis contains the spread or correlation of the uncertainty to the studied output. In this figure, each uncertainty contains a horizontal bar and is ordered vertically to show uncertainties with

a decreasing spread from the base values.

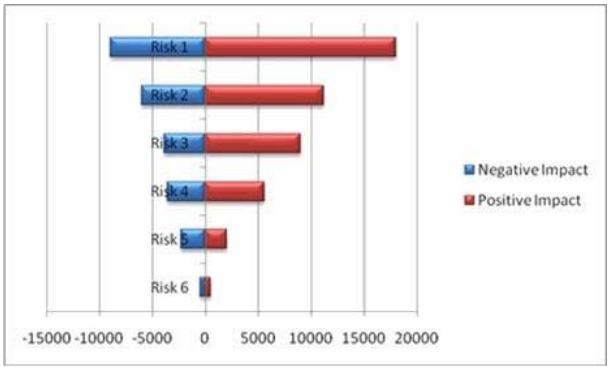


Figure 11-16. Example of Tornado Diagram

- **Expected monetary value analysis.** Expected monetary value (EMV) analysis is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen (i.e., analysis under uncertainty). The EMV of opportunities are generally expressed as positive values, while those of threats are expressed as negative values. EMV requires a risk-neutral assumption, neither risk averse nor risk seeking. EMV for a project is calculated by multiplying the value of each possible outcome by its probability of occurrence and adding the products together. A common use of this type of analysis is a decision tree analysis (Figure 11-17).

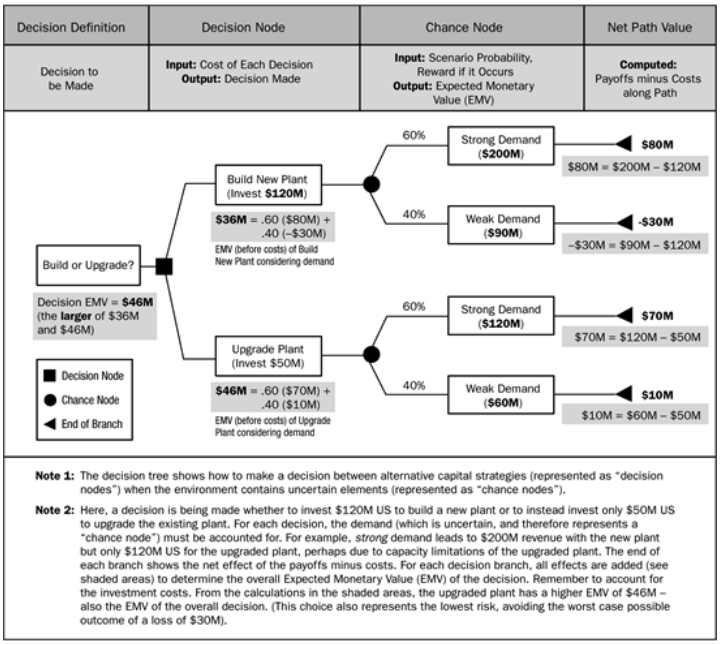


Figure 11-17. Decision Tree Diagram

- **Modeling and simulation.** A project simulation uses a model that translates the specified detailed uncertainties of the project into their potential impact on project objectives. Simulations are typically performed using the Monte Carlo technique. In a simulation, the project model is computed many times (iterated), with the input values (e.g., cost estimates or activity durations) chosen at random for each iteration from the probability distributions of these variables. A histogram (e.g., total cost or completion date) is calculated from the iterations. For a cost risk analysis, a simulation uses cost estimates. For a schedule risk analysis, the schedule network diagram and duration estimates are used. The output from a cost risk simulation using the 3-element model and risk ranges is shown in Figure 11-18. It illustrates the respective likelihood of achieving specific cost targets. Similar curves can be developed for other project objectives.

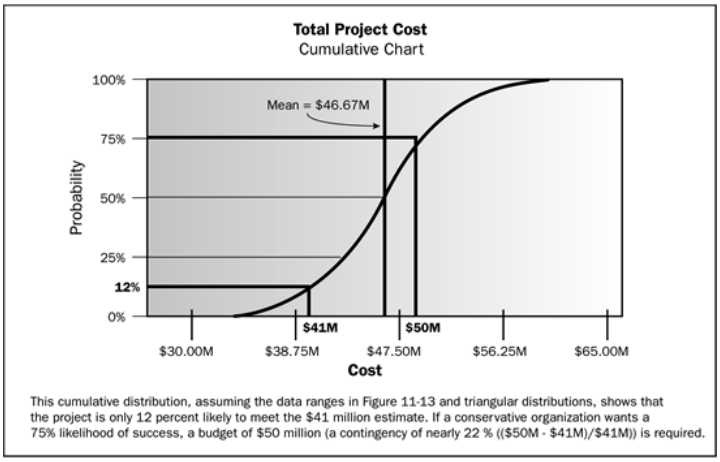


Figure 11-18. Cost Risk Simulation Results

11.4.2.3 Expert Judgment

Expert judgment (ideally using experts with relevant, recent experience) is required to identify potential cost and schedule impacts, to evaluate probability, and to define inputs such as probability distributions into the tools.
Expert judgment also comes into play in the interpretation of the data. Experts should be able to identify the weaknesses of the tools as well as their strengths. Experts may determine when a specific tool may or may not be more appropriate given the organization's capabilities and culture.

11.4.3 Perform Quantitative Risk Analysis: Outputs

11.4.3.1 Project Documents Updates

Project documents are updated with information resulting from quantitative risk analysis. For example, risk register updates could include:

- **Probabilistic analysis of the project.** Estimates are made of potential project schedule and cost outcomes listing the possible completion dates and costs with their associated confidence levels. This output, often expressed as a cumulative frequency distribution, is used with stakeholder risk tolerances to permit quantification of the cost and time contingency reserves. Such contingency reserves are needed to bring the risk of overrunning stated project objectives to a level acceptable to the organization.
- **Probability of achieving cost and time objectives.** With the risks facing the project, the probability of achieving project objectives under the current plan can be estimated using quantitative risk analysis results. For instance, in Figure 11-18, the likelihood of achieving the cost estimate of US$41million is about 12%.
- **Prioritized list of quantified risks.** This list includes those risks that pose the greatest threat or present the greatest opportunity to the project. These include the risks that may have the greatest effect on cost contingency and those that are most likely to influence the critical path. These risks may be evaluated, in some cases, through a tornado diagram generated as a result of the simulation analyses.
- **Trends in quantitative risk analysis results.** As the analysis is repeated, a trend may become apparent that leads to conclusions affecting risk responses. Organizational historical information on project schedule, cost, quality, and performance should reflect new insights gained through the Perform Quantitative Risk Analysis process. Such history may take the form of a quantitative risk analysis report. This report may be separate from, or linked to, the risk register.

11.5 Plan Risk Responses

Plan Risk Responses is the process of developing options and actions to enhance opportunities and to reduce threats to project objectives. The key benefit of this process is that it addresses the risks by their priority, inserting resources and activities into the budget, schedule and project management plan as needed. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-19. Figure 11-20 depicts the data flow diagram of the process.

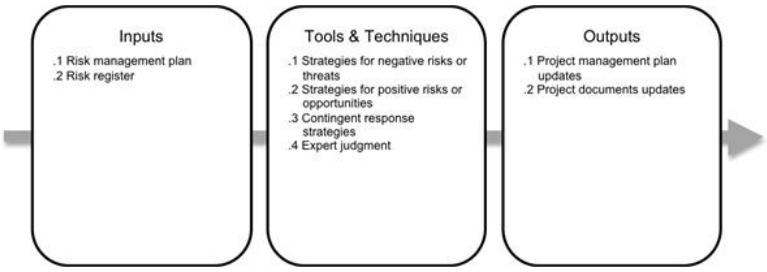


Figure 11-19. Plan Risk Responses: Inputs, Tools & Techniques, and Outputs

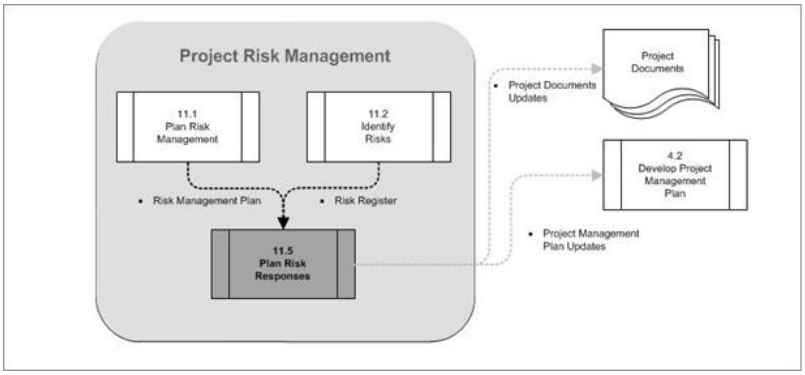


Figure 11-20. Plan Risk Responses Data Flow Diagram

The Plan Risk Responses process follows the Perform Qualitative Risk Analysis process and the Perform Quantitative Risk Analysis process (if used). It includes the identification and assignment of one person (an owner for risk response) to take responsibility for each agreed-to and funded risk response. Plan Risk Responses should be appropriate for the significance of the risk, cost effective in meeting the challenge, realistic within the project context, agreed upon by all parties involved, and owned by a responsible person. Selecting the best risk response from several options is often required.
The Plan Risk Responses process presents commonly used approaches to planning responses to the risks. Risks include threats and opportunities that can affect project success, and responses are discussed for each.

11.5.1 Plan Risk Responses: Inputs

11.5.1.1 Risk Management Plan

Important components of the risk management plan include roles and responsibilities, risk analysis definitions, timing for reviews (and for eliminating risks from review), and risk thresholds for low, moderate, and high risks. Risk thresholds help identify those risks for which specific responses are needed.

11.5.1.2 Risk Register

The risk register refers to identified risks, root causes of risks, lists of potential responses, risk owners, symptoms and warning signs, the relative rating or priority list of project risks, risks requiring response in the near term, risks for additional analysis and response, trends in qualitative analysis results, and a watch list of low-priority risks.

11.5.2 Plan Risk Responses: Tools and Techniques

Several risk response strategies are available. The strategy or mix of strategies most likely to be effective should be selected for each risk. Risk analysis tools, such as decision tree analysis (Section 11.4.2.2), can be used to choose the most appropriate responses. Specific actions are developed to implement that strategy, including primary and backup strategies, as necessary. A fallback plan can be developed for implementation if the selected strategy turns out not to be fully effective or if an accepted risk occurs. Secondary risks should also be reviewed. Secondary risks are risks that arise as a direct result of implementing a risk response. A contingency reserve is often allocated for time or cost. If developed, it may include identification of the conditions that trigger its use.

11.5.2.1 Strategies for Negative Risks or Threats

Three of the following strategies typically deal with threats or risks that may have negative impacts on project objectives if they occur. The fourth strategy, *accept*, can be used for negative risks or threats as well as positive risks or opportunities. These

strategies, described below, are to avoid, transfer, mitigate, and accept.

- **Avoid.** Risk avoidance is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact. It usually involves changing the project management plan to eliminate the threat entirely. The project manager may also isolate the project objectives from the risk's impact or change the objective that is in jeopardy. Examples of this include extending the schedule, changing the strategy, or reducing scope. The most radical avoidance strategy is to shut down the project entirely. Some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise.
- **Transfer.** Risk transference is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response. Transferring the risk simply gives another party responsibility for its management—it does not eliminate it. Transferring does not mean disowning the risk by transferring it to a later project or another person without his or her knowledge or agreement. Risk transference nearly always involves payment of a risk premium to the party taking on the risk. Transferring liability for risk is most effective in dealing with financial risk exposure. Transference tools can be quite diverse and include, but are not limited to, the use of insurance, performance bonds, warranties, guarantees, etc. Contracts may be used to transfer liability for specified risks to another party. For example, when a buyer has capabilities that the seller does not possess, it may be prudent to transfer some work and its concurrent risk contractually back to the buyer. In many cases, use of a cost-plus contract may transfer the cost risk to the buyer, while a fixed-price contract may transfer risk to the seller.
- **Mitigate.** Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a threat. It implies a reduction in the probability and/or impact of an adverse risk to be within acceptable threshold limits. Taking early action to reduce the probability and/or impact of a risk occurring on the project is often more effective than trying to repair the damage after the risk has occurred. Adopting less complex processes, conducting more tests, or choosing a more stable supplier are examples of mitigation actions. Mitigation may require prototype development to reduce the risk of scaling up from a bench-scale model of a process or product. Where it is not possible to reduce probability, a mitigation response might address the risk impact by targeting linkages that determine the severity. For example, designing redundancy into a system may reduce the impact from a failure of the original component.
- **Accept.** Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs. This strategy is adopted where it is not possible or cost-effective to address a specific risk in any other way. This strategy indicates that the project team has decided not to change the project management plan to deal with a risk, or is unable to identify any other suitable response strategy. This strategy can be either passive or active. Passive acceptance requires no action except to document the strategy, leaving the project team to deal with the risks as they occur, and to periodically review the threat to ensure that it does not change significantly. The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to handle the risks.

11.5.2.2 Strategies for Positive Risks or Opportunities

Three of the four responses are suggested to deal with risks with potentially positive impacts on project objectives. The fourth strategy, *accept*, can be used for negative risks or threats as well as positive risks or opportunities. These strategies, described below, are to exploit, share, enhance, and accept.

- **Exploit.** The exploit strategy may be selected for risks with positive impacts where the organization wishes to ensure that the opportunity is realized. This strategy seeks to eliminate the uncertainty associated with a particular upside risk by ensuring the opportunity definitely happens. Examples of directly exploiting responses include assigning an organization's most talented resources to the project to reduce the time to completion or to provide lower cost than originally planned.
- **Share.** Sharing a positive risk involves allocating some or all of the ownership of the opportunity to a third party who is best able to capture the opportunity for the benefit of the project. Examples of sharing actions include forming risk-sharing partnerships, teams, special-purpose companies, or joint ventures, which can be established with the express purpose of taking advantage of the opportunity so that all parties gain from their actions.
- **Enhance.** The enhance strategy is used to increase the probability and/or the positive impacts of an opportunity. Identifying and maximizing key drivers of these positive-impact risks may increase the probability of their occurrence. Examples of enhancing opportunities include adding more resources to an activity to finish early.
- **Accept.** Accepting an opportunity is being willing to take advantage of it if it comes along, but not actively pursuing it.

11.5.2.3 Contingent Response Strategies

Some responses are designed for use only if certain events occur. For some risks, it is appropriate for the project team to make a response plan that will only be executed under certain predefined conditions, if it is believed that there will be sufficient warning to

implement the plan. Events that trigger the contingency response, such as missing intermediate milestones or gaining higher priority with a supplier, should be defined and tracked.

11.5.2.4 Expert Judgment

Expert judgment is input from knowledgeable parties pertaining to the actions to be taken on a specific and defined risk. Expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training in establishing risk responses.

11.5.3 Plan Risk Responses: Outputs

11.5.3.1 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- **Schedule management plan.** The schedule management plan is updated to reflect changes in process and practice driven by the risk responses. This may include changes in tolerance or behavior related to resource loading and leveling, as well as updates to the schedule strategy.
- **Cost management plan.** The cost management plan is updated to reflect changes in process and practice driven by the risk responses. This may include changes in tolerance or behavior related to cost accounting, tracking, and reports, as well as updates to the budget strategy and how contingency reserves are consumed.
- **Quality management plan.** The quality management plan is updated to reflect changes in process and practice driven by the risk responses. This may include changes in tolerance or behavior related to requirements, quality assurance, or quality control, as well as updates to the requirements documentation.
- **Procurement management plan.** The procurement management plan may be updated to reflect changes in strategy, such as alterations in the make-or-buy decision or contract type(s) driven by the risk responses.
- **Human resource plan.** The staffing management plan, part of the human resource plan, is updated to reflect changes in project organizational structure and resource applications driven by the risk responses. This may include changes in tolerance or behavior related to staff allocation, as well as updates to the resource loading.
- **Scope baseline.** Because of new work (or omitted work) generated by the risk responses, the scope baseline may be updated to reflect those changes.
- **Schedule baseline.** Because of new work (or omitted work) generated by the risk responses, the schedule baseline may be updated to reflect those changes.
- **Cost baseline.** Because of new work (or omitted work) generated by the risk responses, the cost baseline may be updated to reflect those changes.

11.5.3.2 Project Documents Updates

In the Plan Risk Responses process, several project documents are updated as needed. For example when appropriate risk responses are chosen and agreed upon, they are included in the risk register. The risk register should be written to a level of detail that corresponds with the priority ranking and the planned response. Often, the high and moderate risks are addressed in detail. Risks judged to be of low priority are included in a watch list for periodic monitoring. Updates to the risk register can include, but are not limited to:

- Risk owners and assigned responsibilities,
- Agreed-upon response strategies,
- Specific actions to implement the chosen response strategy,
- Triggers, symptoms, and warning signs of a risk occurrence,
- Budget and schedule activities required to implement the chosen responses,
- Contingency plans and triggers that call for their execution,
- Fallback plans for use as a reaction to a risk that has occurred and the primary response proves to be inadequate,
- Residual risks that are expected to remain after planned responses have been taken, as well as those that have been deliberately accepted,
- Secondary risks that arise as a direct outcome of implementing a risk response, and
- Contingency reserves that are calculated based on the quantitative risk analysis of the project and the organization’s risk thresholds.

Other project documents updated could include:

- **Assumptions log updates.** As new information becomes available through the application of risk responses, assumptions could change. The assumptions log needs to be revisited to accommodate this new information.
- **Technical documentation updates.** As new information becomes available through the application of risk responses, technical approaches and physical deliverables may change. Any supporting documentation must be revisited to accommodate this new information.

11.6 Control Risks

Control Risks is the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project. The key benefit of this process is that it improves efficiency of the risk approach throughout the project life cycle to continuously optimize risk responses. The inputs, tools and techniques, and outputs of this process are depicted in Figure 11-21. Figure 11-22 depicts the data flow diagram of the process.

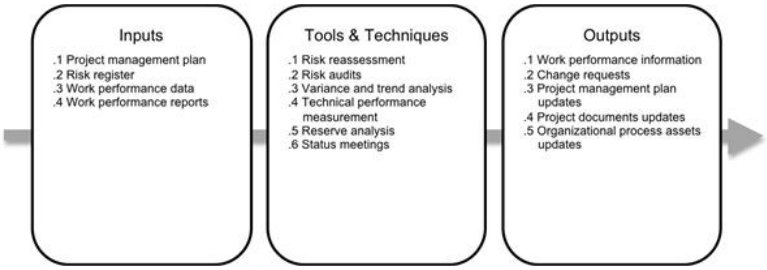


Figure 11-21. Control Risks: Inputs, Tools & Techniques, and Outputs

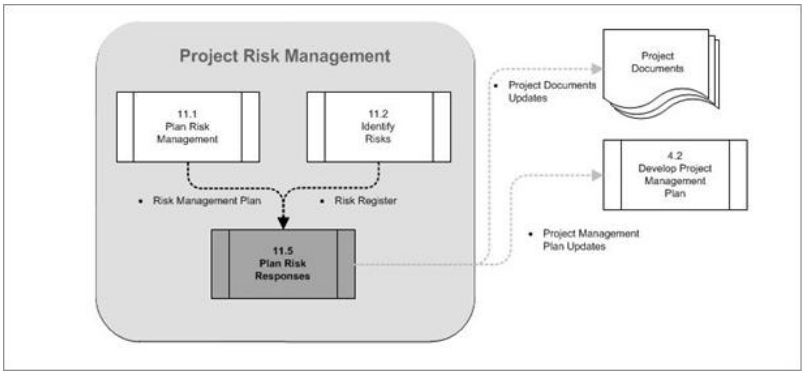


Figure 11-22. Control Risks Data Flow Diagram

Planned risk responses that are included in the risk register are executed during the life cycle of the project, but the project work should be continuously monitored for new, changing, and outdated risks.

The Control Risks process applies techniques, such as variance and trend analysis, which require the use of performance information generated during project execution. Other purposes of the Control Risks process are to determine if:

- Project assumptions are still valid,
- Analysis shows an assessed risk has changed or can be retired,
- Risk management policies and procedures are being followed, and
- Contingency reserves of cost or schedule should be modified in alignment with the current risk assessment.

Control Risks can involve choosing alternative strategies, executing a contingency or fallback plan, taking corrective action, and modifying the project management plan. The risk response owner reports periodically to the project manager on the effectiveness of the plan, any unanticipated effects, and any correction needed to handle the risk appropriately. Control Risks also includes updating the organizational process assets, including project lessons learned databases and risk management templates, for the benefit of future projects.

11.6.1 Control Risks: Inputs

11.6.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan, which includes the risk management plan, provides guidance for risk monitoring and controlling.

11.6.1.2 Risk Register

The risk register has key inputs that include identified risks and risk owners, agreed-upon risk responses, specific implementation actions, symptoms and warning signs of risk, residual and secondary risks, a watch list of low-priority risks, and the time and cost contingency reserves.

11.6.1.3 Work Performance Data

Described in Section 4.3.3.2. Work performance data related to various performance results

includes, but is not limited to:

- Deliverable status,
- Schedule progress, and
- Costs incurred.

11.6.1.4 Work Performance Reports

Described in Section 4.4.3.2. Work performance reports take information from performance measurements and analyze it to provide project work performance information including variance analysis, earned value data, and forecasting data.

11.6.2 Control Risks: Tools and Techniques

11.6.2.1 Risk Reassessment

Control Risks often results in identification of new risks, reassessment of current risks, and the closing of risks that are outdated. Project risk reassessments should be regularly scheduled. The amount and detail of repetition that are appropriate depends on how the project progresses relative to its objectives.

11.6.2.2 Risk Audits

Risk audits examine and document the effectiveness of risk responses in dealing with identified risks and their root causes, as well as the effectiveness of the risk management process. The project manager is responsible for ensuring that risk audits are performed at an appropriate frequency, as defined in the project's risk management plan. Risk audits may be included during routine project review meetings, or separate risk audit meetings may be held. The format for the audit and its objectives should be clearly defined before the audit is conducted.

11.6.2.3 Variance and Trend Analysis

Many control processes employ variance analysis to compare the planned results to the actual results. For the purposes of controlling risks, trends in the project's execution should be reviewed using performance information. Earned value analysis and other methods of project variance and trend analysis may be used for monitoring overall project performance. Outcomes from these analyses may forecast potential deviation of the project at completion from cost and schedule targets. Deviation from the baseline plan may indicate the potential impact of threats or opportunities.

11.6.2.4 Technical Performance Measurement

Technical performance measurement compares technical accomplishments during project execution to the schedule of technical achievement. It requires the definition of objective quantifiable measures of technical performance, which can be used to compare actual results against targets. Such technical performance measures may include weight, transaction times, number of delivered defects, storage capacity, etc. Deviation, such as demonstrating more or less functionality than planned at a milestone, can help to forecast the degree of success in achieving the project's scope.

11.6.2.5 Reserve Analysis

Throughout execution of the project, some risks may occur with positive or negative impacts on budget or schedule contingency reserves. Reserve analysis compares the amount of the contingency reserves remaining to the amount of risk remaining at any time in the project in order to determine if the remaining reserve is adequate.

11.6.2.6 Status Meetings

Project risk management should be an agenda item at periodic status meetings. The amount of time required for that item will vary, depending upon the risks that have been identified, their priority, and difficulty of response. Risk management becomes easier the more often it is practiced. Frequent discussions about risk make it more likely that people will identify risks and opportunities.

11.6.3 Control Risks: Outputs

11.6.3.1 Work Performance Information

Work performance information, from the Control Risks output, provides a mechanism to communicate and support project decision making.

11.6.3.2 Change Requests

Implementing contingency plans or workarounds sometimes results in a change request. Change requests are prepared and submitted to the Perform Integrated Change Control process (Section 4.5). Change requests can include recommended corrective and preventive actions as well.

- **Recommended corrective actions.** These are activities that realign the performance of the project work with the project management plan. They include contingency plans and workarounds. The latter are responses that were not initially planned, but are required to deal with emerging risks that were previously unidentified or accepted passively.
- **Recommended preventive actions.** These are activities that ensure that future performance of the project work is aligned with the project management plan.

11.6.3.3 Project Management Plan Updates

If the approved change requests have an effect on the risk management processes, the corresponding component documents of the project management plan are revised and reissued to reflect the approved changes. The elements of the project management plan that may be updated are the same as those in the Plan Risk Responses process.

11.6.3.4 Project Documents Updates

Project documents that may be updated as a result of the Control Risk process include, but are not limited to the risk register. Risk register updates may include:

- **Outcomes of risk reassessments, risk audits, and periodic risk reviews.** These outcomes may include identification of new risks, updates to probability, impact, priority, response plans, ownership, and other elements of the risk register. Outcomes can also include closing risks that are no longer applicable and releasing their associated reserves.
- **Actual outcomes of the project's risks and of the risk responses.** This information can help project managers to plan for risk throughout their organizations, as well as on future projects.

11.6.3.5 Organizational Process Assets Updates

The risk management processes produce information that may be used for future projects, and should be captured in the organizational process assets. The organizational process assets that may be updated include, but are not limited to:

- Templates for the risk management plan, including the probability and impact matrix, and risk register,
- Risk breakdown structure, and
- Lessons learned from the project risk management activities.

These documents should be updated as needed and at project closure. Final versions of the risk register and the risk management plan templates, checklists, and risk breakdown structure are included.

CHAPTER 12

PROJECT PROCUREMENT MANAGEMENT

Project Procurement Management includes the processes necessary to purchase or acquire products, services, or results needed from outside the project team. The organization can be either the buyer or seller of the products, services, or results of a project.
Project Procurement Management includes the contract management and change control processes required to develop and administer contracts or purchase orders issued by authorized project team members.
Project Procurement Management also includes administering any contract issued by an outside organization (the buyer) that is acquiring the project from the performing organization (the seller), and administering contractual obligations placed on the project team by the contract.
Figure 12-1 provides an overview of the Project Procurement Management processes which include the following:
12.1 Plan Procurement Management—The process of documenting project purchasing decisions, specifying the approach, and identifying potential sellers.
12.2 Conduct Procurements—The process of obtaining seller responses, selecting a seller, and awarding a contract.
12.3 Control Procurements—The process of managing procurement relationships, monitoring contract performance, and making changes and corrections as needed.
12.4 Close Procurements—The process of completing each project procurement.
These processes interact with each other and with processes in the other Knowledge Areas

as described in detail in Chapter 3.

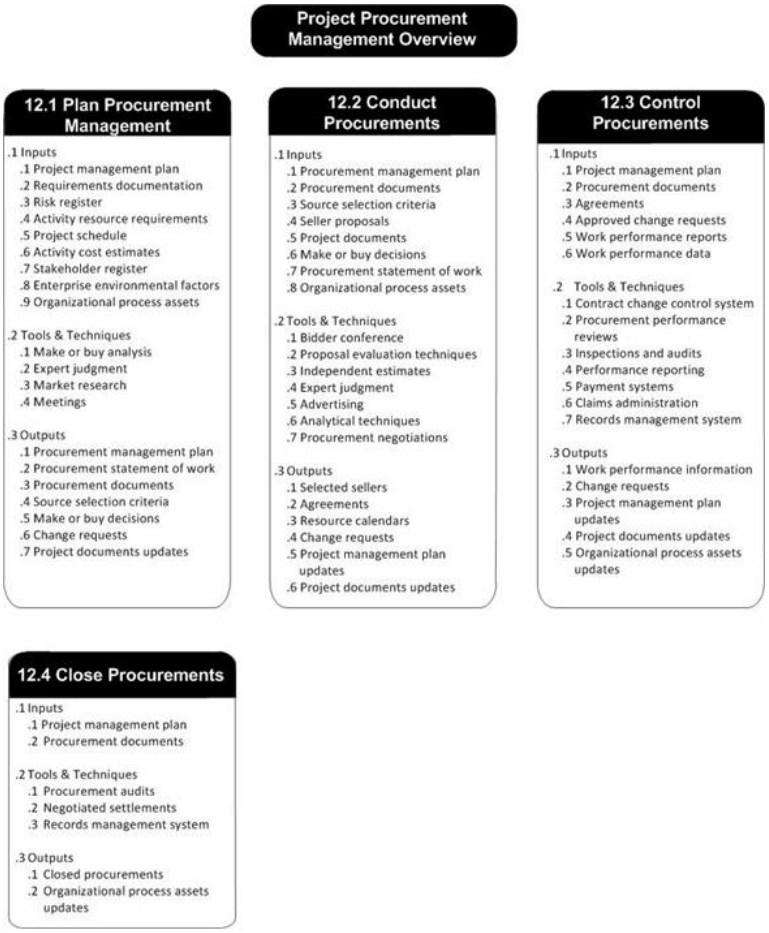


Figure 12-1. Project Procurement Management Overview

The Project Procurement Management processes involve agreements including contracts that are legal documents between a buyer and a seller. A contract represents a mutually binding agreement that obligates the seller to provide the specified products, services, or results, and obligates the buyer to provide monetary or other valuable consideration. The agreement can be simple or complex, and may reflect the simplicity or complexity of the deliverables and required effort.

A procurement contract includes terms and conditions, and may incorporate other items that the buyer specifies what the seller is to perform or provide. It is the project management team's responsibility to make certain that all procurements meet the specific needs of the project while adhering to organizational procurement policies. Depending upon the application area, a contract can also be called an agreement, an understanding, a subcontract, or a purchase order. Most organizations document policies and procedures specifically defining the procurement rules and specifying who has authority to sign and administer such agreements on behalf of the organization.

Although all project documents are subject to some form of review and approval, the legally binding nature of a contract usually means that it will be subjected to a more extensive approval process. In all cases, the primary focus of the review and approval process is to ensure that the contract language describes the products, services, or results that will satisfy the identified project need.

The project management team may seek support early from specialists in contracting, purchasing, law, and technical disciplines. Such involvement can be mandated by an organization's policies.

The various activities involved in the Project Procurement Management processes form the life cycle of a contract. By actively managing the contract life cycle and carefully wording the terms and conditions of the procurements, some identifiable project risks can be avoided, mitigated, or transferred to a seller. Entering into a contract for products or services is one method of allocating the responsibility for managing or sharing potential risks.

A complex project can involve managing multiple contracts or subcontracts simultaneously or in sequence. In such cases, each contract life cycle can end during any phase of the project life cycle. Project Procurement Management is discussed within the perspective of the buyer-seller relationship. The buyer-seller relationship can exist at many levels on any one project, and between organizations internal to and external to the acquiring organization.

Depending on the application area, the seller can be called a contractor, subcontractor, vendor, service provider, or supplier. Depending on the buyer's position in the project

acquisition cycle, the buyer can be called a client, customer, prime contractor, contractor, acquiring organization, governmental agency, service requestor, or purchaser. The seller can be viewed during the contract life cycle first as a bidder, then as the selected source, and then as the contracted supplier or vendor.

The seller will typically manage the work as a project if the acquisition is not just for shelf material, goods, or common products. In such cases:

- The buyer becomes the customer, and is thus a key project stakeholder for the seller.
- The seller's project management team is concerned with all the processes of project management, not just with those of this Knowledge Area.
- Terms and conditions of the contract become key inputs to many of the seller's management processes. The contract can actually contain the inputs (e.g., major deliverables, key milestones, cost objectives), or it can limit the project team's options (e.g., buyer approval of staffing decisions is often required on design projects).

In this section, it is assumed that the buyer of items for the project is assigned to the project team and that the sellers are organizationally external to the project team. It it also assumed that a formal contractual relationship will be developed and exists between the buyer and the seller. However, most of the discussion in this section is equally applicable to noncontractual work entered into with other units of the project team's organization.

12.1 Plan Procurement Management

Plan Procurement Management is the process of documenting project purchasing decisions, specifying the approach, and identifying potential sellers. The key benefit of this process is that it determines whether to acquire outside support, and if so, what to acquire, how to acquire it, how much is needed, and when to acquire it. The inputs, tools and techniques, and outputs of this process are depicted in Figure 12-2. Figure 12-3 depicts the data flow diagram of the process.

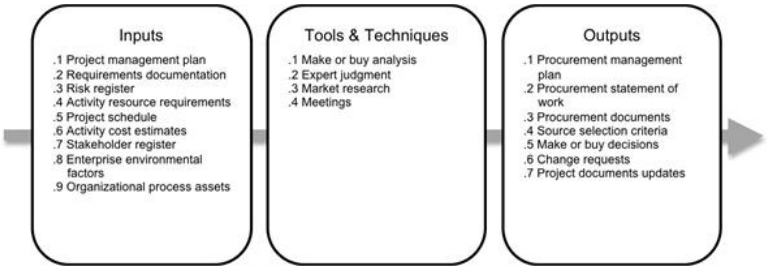


Figure 12-2. Plan Procurements: Inputs, Tools & Techniques, and Outputs

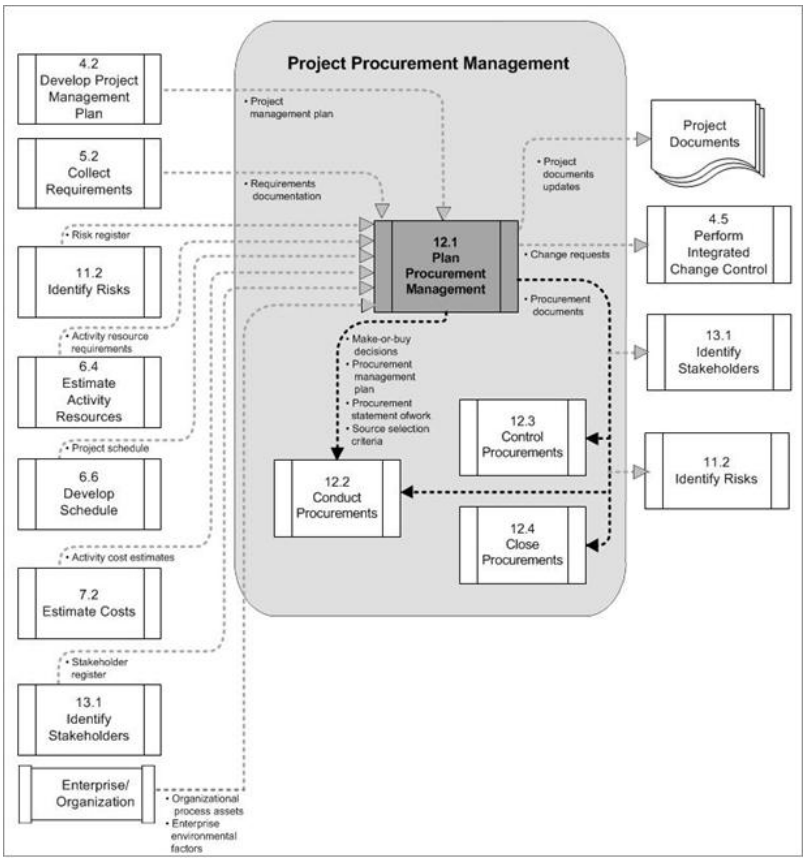


Figure 12-3. Plan Procurement Management Data Flow Diagram

Plan Procurement Management identifies those project needs that can best be, or must be met by acquiring products, services, or results outside of the project organization, versus those project needs which can be accomplished by the project team. When the project obtains products, services, and results required for project performance from outside of the performing organization, the processes from Plan Procurement Management through Close Procurements are performed for each item to be acquired.
The Plan Procurement Management process also includes consideration of potential sellers, particularly if the buyer wishes to exercise some degree of influence or control over acquisition decisions. Consideration should also be given to who is responsible for obtaining or holding any relevant permits and professional licenses that may be required by legislation, regulation, or organizational policy in executing the project.
The requirements of the project schedule can significantly influence the strategy during the Plan Procurement Management process. Decisions made in developing the procurement management plan can also influence the project schedule and are integrated with Develop Schedule, Estimate Activity Resources, and make-or-buy analysis.
The Plan Procurement Management process includes consideration of the risks involved with each make-or-buy analysis. It also includes reviewing the type of contract planned to be used with respect to mitigating risks, sometimes transferring risks to the seller.

12.1.1 Plan Procurement Management: Inputs

12.1.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan describes the need, justification, requirements, and current boundaries for the project. It includes but is not limited to:

- **Project scope statement.** The project scope statement contains the product scope description, service description and result description, the list of deliverables, and acceptance criteria, as well as important information regarding technical issues or concerns that could impact cost estimating. Identified constraints may include required delivery dates, available skilled resources, and organizational policies.
- **WBS.** The work breakdown structure (WBS) contains the components of work that may be resourced externally.
- **WBS dictionary**. The WBS dictionary 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.

12.1.1.2 Requirements Documentation

Described in Section 5.2.3.1. Requirements documentation may include:

- Important information about project requirements that is considered during planning for procurements, and
- Requirements with contractual and legal implications that may include health, safety, security, performance, environmental, insurance, intellectual property rights, equal employment opportunity, licenses, and permits—all of which are considered when planning for procurements.

12.1.1.3 Risk Register

Described in Section 11.2.3.1. The risk register includes risk-related information such as the identified risks, risk owners, and risk responses.

12.1.1.4 Activity Resource Requirements

Described in Section 6.4.3.1. Activity resource requirements contain information on specific needs such as people, equipment, or location.

12.1.1.5 Project Schedule

Described in Section 6.6.3.2. Project schedule contains information on required timelines or mandated deliverable dates.

12.1.1.6 Activity Cost Estimates

Described in Section 7.2.3.1. Cost estimates developed by the procuring activity are used to evaluate the reasonableness of the bids or proposals received from potential sellers.

12.1.1.7 Stakeholder Register

Described in Section 13.1.3.1. The stakeholder register provides details on the project participants and their interests in the project.

12.1.1.8 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Plan Procurement Management process include, but are not limited to:

- Marketplace conditions;
- Products, services, and results that are available in the marketplace;
- Suppliers, including past performance or reputation;
- Typical terms and conditions for products, services, and results or for the specific industry; and
- Unique local requirements.

12.1.1.9 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that influence the Plan Procurement Management process include, but are not limited to:

- Formal procurement policies, procedures, and guidelines. Most organizations have formal procurement policies and buying organizations. When such procurement support is not available, the project team should supply both the resources and the expertise to perform such procurement activities.
- Management systems that are considered in developing the procurement management plan and selecting the contractual relationships to be used.
- An established multi-tier supplier system of pre-qualified sellers based on prior experience.

All legal contractual relationships generally fall into one of two broad families: either fixed-price or cost reimbursable. Also, there is a third hybrid-type commonly in use called the time and materials contract. The more popular of the contract types in use are discussed below as discrete types, but in practice it is not unusual to combine one or more types into a single procurement.

- **Fixed-price contracts.** This category of contracts involves setting a fixed total price for a defined product or service to be provided. Fixed-price contracts may also incorporate financial incentives for achieving or exceeding selected project objectives, such as schedule delivery dates, cost and technical performance, or anything that can be quantified and subsequently measured. Sellers under fixed-price contracts are legally obligated to complete such contracts, with possible financial damages if they do not. Under the fixed-price arrangement, buyers need to precisely specify the product or services being procured. Changes in scope may be accommodated, but generally at an increase in contract price.
    - *Firm Fixed Price Contracts (FFP)*. The most commonly used contract type is the FFP. It is favored by most buying organizations because the price for goods is set at the outset and not subject to change unless the scope of work changes. Any cost increase due to adverse performance is the responsibility of the seller, who is obligated to complete the effort. Under the FFP contract, the buyer must precisely specify the product or services to be procured, and any changes to the procurement specification can increase the costs to the buyer.
    - *Fixed Price Incentive Fee Contracts (FPIF)*. This fixed-price arrangement gives the buyer and seller some flexibility in that it allows for deviation from performance, with financial incentives tied to achieving agreed to metrics. Typically such financial incentives are related to cost, schedule, or technical performance of the seller. Performance targets are established at the outset, and the final contract price is determined after completion of all work based on the seller's performance. Under FPIF contracts, a price ceiling is set, and all costs above the price ceiling are the responsibility of the seller, who is obligated to complete the work.
    - *Fixed Price with Economic Price Adjustment Contracts (FP-EPA)*. This contract type is used whenever the seller's performance period spans a considerable period of years, as is desired with many long-term relationships. It is a fixed-price contract, but with a special provision allowing for pre-defined final adjustments to the contract price due to changed conditions, such as inflation changes, or cost increases (or decreases) for specific commodities. The EPA clause must relate to some reliable financial index, which is used to precisely adjust the final price. The FP-EPA contract is intended to protect both buyer and seller from external conditions beyond their control.
- **Cost-reimbursable contracts.** This category of contract involves payments (cost reimbursements) to the seller for all legitimate actual costs incurred for completed work, plus a fee representing seller profit. Cost-reimbursable contracts may also include financial incentive clauses whenever the seller exceeds, or falls below, defined objectives such as costs, schedule, or technical performance targets. Three of the more common types of cost-reimbursable contracts in use are Cost Plus Fixed Fee (CPFF), Cost Plus Incentive Fee (CPIF), and Cost Plus Award Fee (CPAF).A cost-reimbursable contract provides the project flexibility to redirect a seller whenever the scope of work cannot be precisely defined at the start and needs to be altered, or when high risks may exist in the effort.
    - *Cost Plus Fixed Fee Contracts (CPFF).* The seller is reimbursed for all allowable costs for performing the contract work, and receives a fixed-fee payment calculated as a percentage of the initial estimated project costs. Fee is paid only for completed work and does not change due to seller performance. Fee amounts do not change unless the project scope changes.

- *Cost Plus Incentive Fee Contracts (CPIF).* The seller is reimbursed for all allowable costs for performing the contract work and receives a predetermined incentive fee based upon achieving certain performance objectives as set forth in the contract. In CPIF contracts, if the final costs are less or greater than the original estimated costs, then both the buyer and seller share costs from the departures based upon a prenegotiated cost-sharing formula, for example, an 80/20 split over/under target costs based on the actual performance of the seller.
- *Cost Plus Award Fee Contracts (CPAF).* The seller is reimbursed for all legitimate costs, but the majority of the fee is earned only based on the satisfaction of certain broad subjective performance criteria defined and incorporated into the contract. The determination of fee is based solely on the subjective determination of seller performance by the buyer, and is generally not subject to appeals.

- **Time and Material Contracts (T&M).** Time and material contracts are a hybrid type of contractual arrangement that contain aspects of both cost-reimbursable and fixed-price contracts. They are often used for staff augmentation, acquisition of experts, and any outside support when a precise statement of work cannot be quickly prescribed. These types of contracts resemble cost-reimbursable contracts in that they can be left open ended and may be subject to a cost increase for the buyer. The full value of the agreement and the exact quantity of items to be delivered may not be defined by the buyer at the time of the contract award. Thus, T&M contracts can increase in contract value as if they were cost-reimbursable contracts. Many organizations require not-to-exceed values and time limits placed in all T&M contracts to prevent unlimited cost growth. Conversely, T&M contracts can also resemble fixed unit price arrangements when certain parameters are specified in the contract. Unit labor or material rates can be preset by the buyer and seller, including seller profit, when both parties agree on the values for specific resource categories, such as senior engineers at specified rates per hour, or categories of materials at specified rates per unit.

12.1.2 Plan Procurement Management: Tools and Techniques

12.1.2.1 Make-or-Buy Analysis

A make-or-buy analysis is a general management technique used to determine whether particular work can best be accomplished by the project team or must be purchased from outside sources. Sometimes a capability may exist within the project organization, but may be committed to working on other projects, in which case, the project may need to source such effort from outside the organization in order to meet its schedule commitments. Budget constraints may influence make-or-buy decisions. If a buy decision is to be made, then a further decision of whether to purchase or lease is also made. A make-or-buy analysis should consider all related costs—both direct costs as well as indirect support costs. For example, the buy-side of the analysis includes both the actual out-of-pocket costs to purchase the product, as well as the indirect costs of supporting the purchasing process and purchased item.
Available contract types are also considered during the buy analysis. The risk sharing between the buyer and seller determines the suitable contract types, while the specific contract terms and conditions formalize the degree of risk being assumed by the buyer and seller.

12.1.2.2 Expert Judgment

Expert judgment is often used to assess the inputs to and outputs from this process. Expert purchasing judgment can also be used to develop or modify the criteria that will be used to evaluate seller proposals. Expert legal judgment may involve the services of legal staff to assist with unique procurement issues, terms, and conditions. Such judgment, including business and technical expertise, can be applied to both the technical details of the acquired products, services, or results and to various aspects of the procurement management processes.

12.1.2.3 Market Research

Market research includes examination of industry and specific vendor capabilities. Procurement teams may leverage information gained at conferences, online reviews and a variety of sources to identify market capabilities. The team may also refine particular procurement objectives to leverage maturing technologies while balancing risks associated with the breadth of vendors who can provide the materials or services desired.

12.1.2.4 Meetings

Research alone may not provide specific information to formulate a procurement strategy without additional interchange meetings with potential bidders. By collaborating with potential bidders, the company purchasing the material or service may benefit while the supplier can influence a mutually beneficial approach or product.

12.1.3 Plan Procurement Management: Outputs

12.1.3.1 Procurement Management Plan

The procurement management plan is a component of the project management plan that describes how a project team will acquire goods and services from outside the performing organization. It describes how the procurement processes will be managed from developing procurement documents through contract closure. The procurement management plan can include guidance for:

- Types of contracts to be used;
- Risk management issues;
- Whether independent estimates will be used and whether they are needed as evaluation criteria;
- Those actions the project management team can take unilaterally, if the performing organization has a prescribed procurement, contracting, or purchasing department;
- Standardized procurement documents, if needed;
- Managing multiple suppliers;
- Coordinating procurement with other project aspects, such as scheduling and performance reporting;
- Any constraints and assumptions that could affect planned procurements;
- Handling the required lead times to purchase items from sellers and coordinating them with the project schedule development;
- Handling the make-or-buy decisions and linking them into the Estimate Activity Resource and Develop Schedule processes;
- Setting the scheduled dates in each contract for the contract deliverables and coordinating with the schedule development and control processes;
- Identifying requirements for performance bonds or insurance contracts to mitigate some forms of project risk;
- Establishing the direction to be provided to the sellers on developing and maintaining a work breakdown structure (WBS);
- Establishing the form and format to be used for the procurement/contract statements of work;
- Identifying prequalified sellers, if any, to be used; and
- Procurement metrics to be used to manage contracts and evaluate sellers.

A procurement management plan can be formal or informal, can be highly detailed or broadly framed, and is based upon the needs of each project. The procurement management plan is a subsidiary component of the project management plan.

12.1.3.2 Procurement Statement of Work

The statement of work (SOW) for each procurement is developed from the project scope baseline and defines only that portion of the project scope that is to be included within the related contract. The procurement SOW describes the procurement item in sufficient detail to allow prospective sellers to determine if they are capable of providing the products, services, or results. Sufficient detail can vary based on the nature of the item, the needs of the buyer, or the expected contract form. Information included in a SOW can include specifications, quantity desired, quality levels, performance data, period of performance, work location, and other requirements.

The procurement SOW is written to be clear, complete, and concise. It includes a description of any collateral services required, such as performance reporting or post-project operational support for the procured item. In some application areas, there are specific content and format requirements for a procurement SOW. Each individual procurement item requires a SOW; however, multiple products or services can be grouped as one procurement item within a single SOW.

The procurement SOW can be revised and refined as required as it moves through the procurement process until incorporated into a signed contract award.

12.1.3.3 Procurement Documents

Procurement documents are used to solicit proposals from prospective sellers. Terms such as bid, tender, or quotation are generally used when the seller selection decision will be based on price (as when buying commercial or standard items), while a term such as proposal is generally used when other considerations, such as technical capability or technical approach are paramount. Common terms are in use for different types of procurement documents and may include request for information (RFI), invitation for bid (IFB), request for proposal (RFP), request for quotation (RFQ), tender notice, invitation for negotiation, and invitation for seller's initial response. Specific procurement terminology used may vary by industry and location of the procurement.

The buyer structures procurement documents to facilitate an accurate and complete response from each prospective seller and to facilitate easy evaluation of the responses. These documents include a description of the desired form of the response, the relevant procurement statement of work (SOW) and any required contractual provisions. With government contracting, some or all of the content and structure of procurement documents

may be defined by regulation.
The complexity and level of detail of the procurement documents should be consistent with the value of, and risks associated with, the planned procurement. Procurement documents must be sufficient to ensure consistent, appropriate responses, but flexible enough to allow consideration of any seller suggestions for better ways to satisfy the same requirements.
Issuing a procurement request to potential sellers to submit a proposal or bid is normally done in accordance with the policies of the buyer's organization, which can include publication of the request in public newspapers, in trade journals, in public registries, or on the internet.

12.1.3.4 Source Selection Criteria

Selection criteria are often included as a part of the procurement documents. Such criteria are developed and used to rate or score seller proposals, and can be objective or subjective.
Selection criteria may be limited to purchase price if the procurement item is readily available from a number of acceptable sellers. Purchase price in this context includes both the cost of the item and all ancillary expenses such as delivery.
Other selection criteria can be identified and documented to support an assessment for more complex products, services, or results. Some considerations are provided below.

- **Understanding of need.** How well does the seller's proposal address the procurement statement of work?
- **Overall or life-cycle cost.** Will the selected seller produce the lowest total cost of ownership (purchase cost plus operating cost)?
- **Technical capability.** Does the seller have, or can the seller be reasonably expected to acquire, the technical skills and knowledge needed?
- **Risk.** How much risk is embedded in the statement of work, how much risk will be assigned to the selected seller and how does the seller mitigate risk?
- **Management approach.** Does the seller have, or can the seller be reasonably expected to develop, management processes and procedures to ensure a successful project?
- **Technical approach.** Do the seller's proposed technical methodologies, techniques, solutions, and services meet the procurement documents requirements or are they likely to provide more or less than the expected results?
- **Warranty.** What does the seller propose to warrant for the final product, and through what time period?
- **Financial capacity.** Does the seller have, or can the seller reasonably be expected to obtain, the necessary financial resources?
- **Production capacity and interest.** Does the seller have the capacity and interest to meet potential future requirements?
- **Business size and type.** Does the seller's enterprise meet a specific category of business such as small, women-owned, or disadvantaged small business, as defined by the buyer or established by governmental agency and set forth as a condition of the contract award?
- **Past performance of sellers.** What has been the past experience with selected sellers?
- **References.** Can the seller provide references from prior customers verifying the seller's work experience and compliance with contractual requirements?
- **Intellectual property rights.** Does the seller assert intellectual property rights in the work processes or services they will use or in the products they will produce for the project?
- **Proprietary rights.** Does the seller assert proprietary rights in the work processes or services they will use or in the products they will produce for the project?

12.1.3.5 Make-or-Buy Decisions

A make-or-buy analysis results in a decision of whether particular work can best be accomplished by the project team or must be purchased from outside sources. If the decision is to make the item, then the procurement plan may define processes and agreements internal to the organization. A buy decision drives a similar process of reaching agreement with a supplier for the product or services.

12.1.3.6 Change Requests

Changes to the project management plan, its subsidiary plans, and other components may result in change requests. Change requests are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).

12.1.3.7 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Project scope,
- Requirements documentation,
- Requirements traceability documentation, and
- Risk register.

12.2 Conduct Procurements

Conduct Procurements is the process of obtaining seller responses, selecting a seller, and awarding a contract. The key benefit of this process is that it provides alignment of internal and external stakeholder expectations through established agreements. The inputs, tools and techniques, and outputs of this process are depicted in Figure 12-4. Figure 12-5 depicts the data flow diagram of the process.

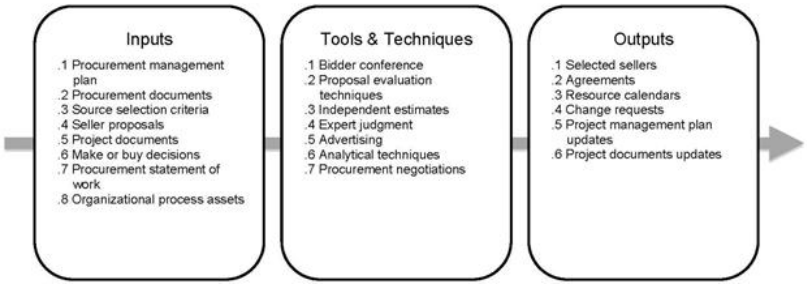


Figure 12-4. Conduct Procurements: Inputs, Tools & Techniques, and Outputs

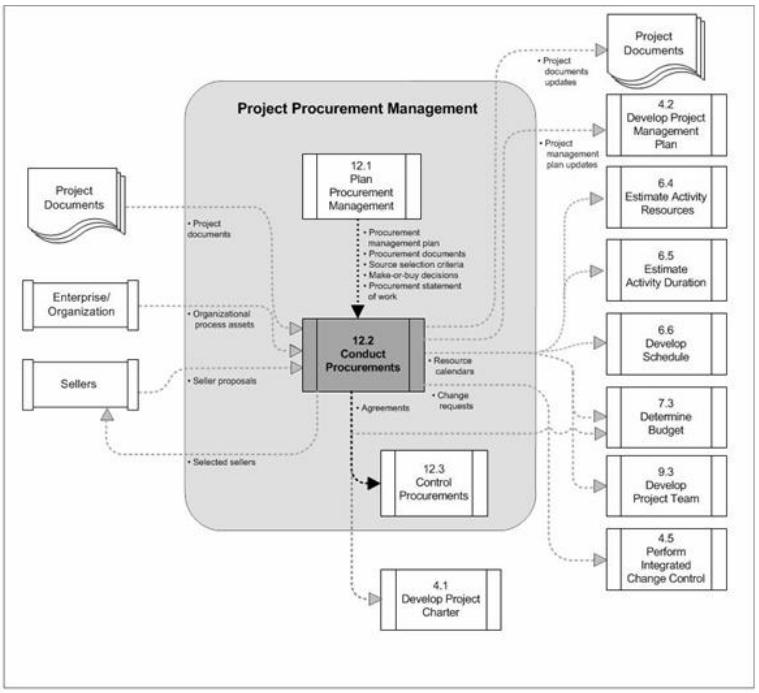


Figure 12-5. Conduct Procurements Data Flow Diagram

During the Conduct Procurements process, the team will receive bids or proposals and will apply previously defined selection criteria to select one or more sellers who are qualified to perform the work and acceptable as a seller.

On major procurement items, the overall process of requesting responses from sellers and evaluating those responses can be repeated. A short list of qualified sellers can be established based on a preliminary proposal. A more detailed evaluation can then be conducted based on a more specific and comprehensive requirements document requested from the sellers on the short list. In addition, tools and techniques described here may be used alone or in combination with select sellers. For example, a weighting system can be used to:

- Select a single seller that will be asked to sign a standard contract; and
- Establish a negotiating sequence by ranking all proposals by the weighted evaluation scores assigned to each proposal.

12.2.1 Conduct Procurements: Inputs

12.2.1.1 Procurement Management Plan

Described in Section 4.2.3.1. The procurement management plan describes how the procurement processes will be managed from developing procurement documentation through contract closure.

12.2.1.2 Procurement Documents

Described in Section 12.1.3.3. Procurement documents provide an audit trail for contracts and other agreements.

12.2.1.3 Source Selection Criteria

Described in Section 12.1.3.4.
Source selection criteria can include information on the supplier's required capabilities, capacity, delivery dates, product cost, life-cycle cost, technical expertise, and the approach to the contract.

12.2.1.4 Seller Proposals

Seller proposals, prepared in response to a procurement document package, form the basic information that will be used by an evaluation body to select one or more successful bidders (sellers).

12.2.1.5 Project Documents

Described in Section 11.5.3.2. Project documents that are often considered include the risk-related contract decisions included within the risk register.

12.2.1.6 Make-or-Buy Decisions

Described in Section 12.1.3.5. Companies procuring goods or services analyze the need, identify resources, and then compare procurement strategies when deciding to buy. Organizations also evaluate the need of buying products versus making the items themselves. Factors that influence make-or-buy decisions may include:

- Core capabilities of the organization,
- Value delivered by vendors meeting the need,
- Risks associated with meeting the need in a cost effective manner, and
- Capability internally compared with the vendor community.

12.2.1.7 Procurement Statement of Work

Described in Section 12.1.2. The procurement statement of work provides suppliers with a clearly stated set of goals, requirements and outcomes from which they can provide a quantifiable response. The statement of work is a critical component of the procurement process which can be modified as needed through the process until a final agreement is in place.

12.2.1.8 Organizational Process Assets

Described in Section 2.1.4. Elements of the organizational process assets that can influence the Conduct Procurements process include, but are not limited to:

- Listings of prospective and previously qualified sellers, and
- Information on relevant past experience with sellers, both good and bad.

Whenever a prior agreement is in place, the buyer and seller roles will have already been decided by executive management. In some cases the seller may already be working under a contract funded by the buyer or jointly by both parties. The effort of the buyer and seller in this process is to collectively prepare a procurement statement of work that will satisfy the requirements of the project. The parties will then negotiate a final contract for award.

12.2.2 Conduct Procurements: Tools and Techniques

12.2.2.1 Bidder Conferences

Bidder conferences (sometimes called contractor conferences, vendor conferences, and pre-bid conferences) are meetings between the buyer and all prospective sellers prior to submittal of a bid or proposal. They are used to ensure that all prospective sellers have a clear and common understanding of the procurement (both technical and contractual requirements), and that no bidders receive preferential treatment. Responses to questions can be incorporated into the procurement documents as amendments. To be fair, buyers must take great care to ensure that all prospective sellers hear every question from any individual prospective seller and every answer from the buyer.

12.2.2.2 Proposal Evaluation Techniques

On complex procurements, where source selection will be made based on seller responses to previously defined weighted criteria, a formal evaluation review process will be defined

by the buyer's procurement policies. The evaluation committee will make their selection for approval by management prior to the award.

12.2.2.3 Independent Estimates

For many procurement items, the procuring organization may elect to either prepare its own independent estimate, or have an estimate of costs prepared by an outside professional estimator, to serve as a benchmark on proposed responses. Significant differences in cost estimates can be an indication that the procurement statement of work was deficient, ambiguous, and/or that the prospective sellers either misunderstood or failed to respond fully to the procurement statement of work.

12.2.2.4 Expert Judgment

Expert judgment may be used in evaluating seller proposals. The evaluation of proposals may be accomplished by a multi-discipline review team with expertise in each of the areas covered by the procurement documents and proposed contract. This can include expertise from functional disciplines such as contracting, legal, finance, accounting, engineering, design, research, development, sales, and manufacturing.

12.2.2.5 Advertising

Existing lists of potential sellers often can be expanded by placing advertisements in general circulation publications such as selected newspapers or in specialty trade publications. Some organizations use online resources to communicate solicitations to the vendor community. Some government jurisdictions require public advertising of certain types of procurement items, and most government jurisdictions require public advertising or online posting of pending government contracts.

12.2.2.6 Analytical Techniques

Procurements involve defining a need in such a way that vendors can bring value through their offerings. To ensure that the need can be and is met, analytical techniques can help organizations identify the readiness of the vendor to provide the desired end state, determine the cost expected to support budgeting, and avoid cost overruns due to changes. By examining past performance information, teams may identify areas that may have more risk and that need to be monitored closely to ensure success of the project.

12.2.2.7 Procurement Negotiations

Negotiations clarify the structure, requirements and other terms of the purchases so that mutual agreement can be reached prior to signing the contract. Final contract language reflects all agreements reached. Subjects covered should include responsibilities, authority to make changes, applicable terms and governing law, technical and business management approaches, proprietary rights, contract financing, technical solutions, overall schedule, payments, and price. Negotiations conclude with a contract document that can be executed by both buyer and seller.
For complex procurement items, contract negotiation can be an independent process with inputs (e.g., issues or an open items listing) and outputs (e.g., documented decisions) of its own. For simple procurement items, the terms and conditions of the contract can be previously set and nonnegotiable, and only need to be accepted by the seller.
The project manager may not be the lead negotiator on procurements. The project manager and other members of the project management team may be present during negotiations to provide assistance, and if needed to add clarification of the project's technical, quality, and management requirements.

12.2.3 Conduct Procurements: Outputs

12.2.3.1 Selected Sellers

The selected sellers are those who have been judged to be in a competitive range based upon the outcome of the proposal or bid evaluation, and who have negotiated a draft contract that will become the actual contract when an award is made. Final approval of all complex, high-value, high-risk procurements will generally require organizational senior management approval prior to award.

12.2.3.2 Agreements

A procurement agreement is established with each selected supplying organization. External organizations require establishment of a contract between the organizations. The contract can be in the form of simple purchase order or a complex document. Regardless of the document's complexity, a contract is a mutually binding legal agreement that obligates the seller to provide the specified products, services, or results, and obligates the buyer to compensate the seller. A contract is a legal relationship subject to remedy in the courts.

The major components in an agreement document will vary, but may include the following:

- Statement of work or deliverables,
- Schedule baseline,
- Performance reporting,
- Period of performance,
- Roles and responsibilities,
- Seller's place of performance,
- Pricing,
- Payment terms,
- Place of delivery,
- Inspection and acceptance criteria,
- Warranty,
- Product support,
- Limitation of liability,
- Fees and retainer,
- Penalties,
- Incentives,
- Insurance and performance bonds,
- Subordinate subcontractor approvals,
- Change request handling, and
- Termination and alternative dispute resolution (ADR) mechanisms. The ADR method can be decided in advance as a part of the procurement award.

12.2.3.3 Resource Calendar

The quantity and availability of contracted resources and those dates on which each specific resource can be active or idle are documented.

12.2.3.4 Change Requests

Change requests to the project management plan, its subsidiary plans, and other components are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).

12.2.3.5 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- Cost baseline,
- Scope baseline,
- Schedule baseline, and
- Procurement management plan.

12.2.3.6 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Requirements documentation,
- Requirements traceability documentation, and
- Risk register.

12.3 Control Procurements

Control Procurements is the process of managing procurement relationships, monitoring contract performance, and making changes and corrections as needed. The key benefit of this process is that it ensures that the seller's performance meets procurement requirements and that the buyer performs according to the terms of the legal contract. The inputs, tools and techniques, and outputs of this process are depicted in Figure 12-6. Figure 12-7 depicts the data flow diagram of the process.

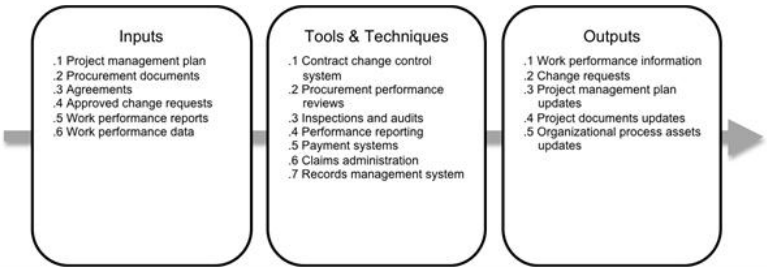


Figure 12-6. Control Procurements: Inputs, Tools & Techniques, and Outputs

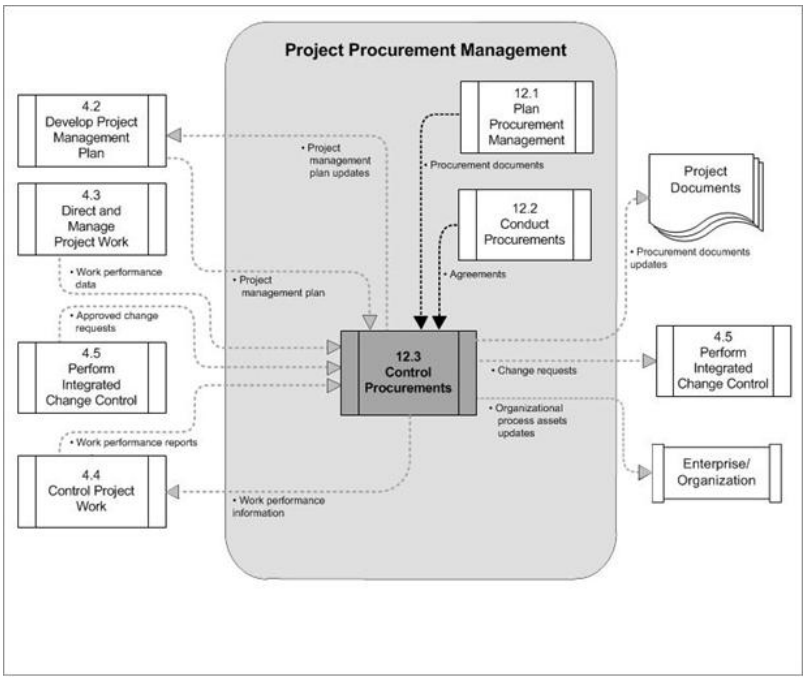


Figure 12-7. Control Procurements Data Flow Diagram

Both the buyer and the seller will administer the procurement contract for similar purposes. Each must ensure that both parties meet their contractual obligations and that their own legal rights are protected. The legal nature of the contractual relationship makes it imperative that the project management team is aware of the legal implications of actions taken when controlling any procurement. On larger projects with multiple providers, a key aspect of contract administration is managing interfaces among the various providers.

Due to varying organizational structures, many organizations treat contract administration as an administrative function separate from the project organization. While a procurement administrator may be on the project team, this individual typically reports to a supervisor from a different department. This is usually true if the performing organization is also the seller of the project to an external customer.

Control Procurements includes application of the appropriate project management processes to the contractual relationship(s) and integration of the outputs from these processes into the overall management of the project. This integration will often occur at multiple levels when there are multiple sellers and multiple products, services, or results involved. The project management processes that are applied may include, but are not limited to:

- **Direct and Manage Project Work.** To authorize the seller's work at the appropriate time.
- **Control Quality.** To inspect and verify the adequacy of the seller's product.
- **Perform Integrated Change Control.** To assure that changes are properly approved and that all those with a need to know are aware of such changes.
- **Control Risks.** To ensure that risks are mitigated.

Conduct Procurements also has a financial management component that involves monitoring payments to the seller. This ensures that payment terms defined within the contract are met and that seller compensation is linked to seller progress, as defined in the contract. One of the principal concerns when making payments to suppliers is that there is a close relationship of payments made to the work accomplished.

The Control Procurements process reviews and documents how well a seller is performing or has performed based on the contract and establishes corrective actions when needed. This performance review may be used as a measure of the seller's competency for performing similar work on future projects. Similar evaluations are also carried out when it is necessary to confirm that a seller is not meeting the seller's contractual obligations and when the buyer contemplates corrective actions. Control Procurements includes managing any early terminations of the contracted work (for cause, convenience, or default) in accordance with the termination clause of the contract.

Agreements can be amended at any time prior to contract closure by mutual consent, in accordance with the change control terms of the contract. Such amendments may not always be equally beneficial to both the seller and the buyer.

12.3.1 Control Procurements: Inputs

12.3.1.1 Project Management Plan

Described in Section 4.2.3.1. The procurement management plan describes how the procurement processes will be managed from developing procurement documentation through contract closure.

12.3.1.2 Procurement Documents

Described in Section 12.1.3.3. Procurement documents contain complete supporting records for administration of the procurement processes; this includes procurement contract awards and the statement of work.

12.3.1.3 Agreements

Described in Section 12.2.3.2. Agreements are understandings between parties, including understanding of the duties of each party.

12.3.1.4 Approved Change Requests

Approved change requests can include modifications to the terms and conditions of the contract, including the procurement statement of work, pricing, and descriptions of the products, services, or results to be provided. All procurement-related changes are formally documented in writing and approved before being implemented through the Control Procurements process.

12.3.1.5 Work Performance Reports

Described in Section 4.4.3.2. Seller performance-related documentation includes:

- **Technical documentation.** Seller-developed technical documentation and other deliverable information are provided in accordance with the terms of the contract.
- **Work performance information.** The seller's performance reports indicate which deliverables have been completed and which have not.

12.3.1.6 Work Performance Data

Described in Section 4.3.3.2. Work performance data includes the extent to which quality standards are being satisfied, what costs have been incurred or committed, and which seller invoices have been paid—are all collected as part of project execution.

12.3.2 Control Procurements: Tools and Techniques

12.3.2.1 Contract Change Control System

A contract change control system defines the process by which the procurement can be modified. It includes the paperwork, tracking systems, dispute resolution procedures, and approval levels necessary for authorizing changes. The contract change control system is integrated with the integrated change control system.

12.3.2.2 Procurement Performance Reviews

A procurement performance review is a structured review of the seller's progress to deliver project scope and quality, within cost and on schedule, as compared to the contract. It can include a review of seller-prepared documentation and buyer inspections, as well as quality audits conducted during seller's execution of the work. The objective of a performance review is to identify performance successes or failures, progress with respect to the procurement statement of work, and contract noncompliance, which allow the buyer to quantify the seller's demonstrated ability or inability to perform work. Such reviews may take place as a part of project status reviews, which would include key suppliers.

12.3.2.3 Inspections and Audits

Inspections and audits required by the buyer and supported by the seller, as specified in the procurement contract, can be conducted during execution of the project to verify compliance in the seller's work processes or deliverables. If authorized by contract, some inspection and audit teams can include buyer procurement personnel.

12.3.2.4 Performance Reporting

Performance reporting provides management with information about how effectively the seller is achieving the contractual objectives.

12.3.2.5 Payment Systems

Payments to the seller are typically processed by the accounts payable system of the buyer after certification of satisfactory work by an authorized person on the project team. All payments should be made and documented in strict accordance with the terms of the contract.

12.3.2.6 Claims Administration

Contested changes and potential constructive changes are those requested changes where the buyer and seller cannot reach an agreement on compensation for the change, or cannot agree that a change has occurred. These contested changes are variously called claims, disputes, or appeals. Claims are documented, processed, monitored, and managed throughout the contract life cycle, usually in accordance with the terms of the contract. If the parties themselves do not resolve a claim, it may have to be handled in accordance with alternative dispute resolution (ADR) typically following procedures established in the contract. Settlement of all claims and disputes through negotiation is the preferred method.

12.3.2.7 Records Management System

A records management system is used by the project manager to manage contract and procurement documentation and records. It consists of a specific set of processes, related control functions, and automation tools that are consolidated and combined as part of the project management information system (Section 4.4.2.3). The system contains a retrievable archive of contract documents and correspondence.

12.3.3 Control Procurements: Outputs

12.3.3.1 Work Performance Information

Work performance information provides a basis for identification of current or potential problems to support later claims or new procurements. By reporting on the performance of a vendor the organization increases knowledge of the performance of the procurement supporting improved forecasting, risk management and decision making. Performance reports also assist in the event there is a dispute with the vendor.
Work performance information includes reporting compliance of contracts, which provides procuring organizations a mechanism to track specific deliverables expected and received from vendors. Contract compliance reports support improved communications with vendors so that potential issues are addressed promptly to the satisfaction of all parties.

12.3.3.2 Change Requests

Change requests to the project management plan, its subsidiary plans and other components, such as the cost baseline, schedule baseline, and procurement management plan, may result from the Control Procurements process. Change requests are processed for review and approval through the Perform Integrated Change Control process.
Requested but unresolved changes can include direction provided by the buyer, or actions taken by the seller, that the other party considers a constructive change to the contract. Since any of these constructive changes may be disputed by one party and can lead to a claim against the other party, such changes are uniquely identified and documented by project correspondence.

12.3.3.3 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to:

- **Procurement management plan.** The procurement management plan is updated to reflect any approved change requests that affect procurement management, including impacts to costs or schedules.
- **Schedule baseline.** If there are slippages that impact overall project performance, the schedule baseline may need to be updated to reflect the current expectations.

12.3.3.4 Project Documents Updates

Project documents that may be updated include, but are not limited to procurement documentation. Procurement documentation may include the procurement contract with all supporting schedules, requested unapproved contract changes, and approved change requests. Procurement documentation also includes any seller-developed technical documentation and other work performance information such as deliverables, seller performance reports, and warranties, financial documents including invoices and payment records, and the results of contract-related inspections.

12.3.3.5 Organizational Process Assets Updates

Elements of the organizational process assets that may be updated include, but are not limited to:

- **Correspondence.** Contract terms and conditions often require written documentation of certain aspects of buyer/seller communications, such as the need for warnings of unsatisfactory performance and requests for contract changes or clarification. This can

include the reported results of buyer audits and inspections that indicate weaknesses the seller needs to correct. In addition to specific contract requirements for documentation, a complete and accurate written record of all written and oral contract communications, as well as actions taken and decisions made, are maintained by both parties.

- **Payment schedules and requests.** All payments should be made in accordance with the procurement contract terms and conditions.
- **Seller performance evaluation documentation.** Seller performance evaluation documentation is prepared by the buyer. Such performance evaluations document the seller's ability to continue to perform work on the current contract, indicate if the seller can be allowed to perform work on future projects, or rate how well the seller is performing the project work. These documents may form the basis for early termination of the seller's contract or determine how contract penalties, fees, or incentives are administered. The results of these performance evaluations can also be included in the appropriate qualified seller lists.

12.4 Close Procurements

Close Procurements is the process of completing each procurement. The key benefit of this process is that it documents agreements and related documentation for future reference. The inputs, tools and techniques, and outputs of this process are depicted in Figure 12-8. Figure 12-9 depicts the data flow diagram of the process.

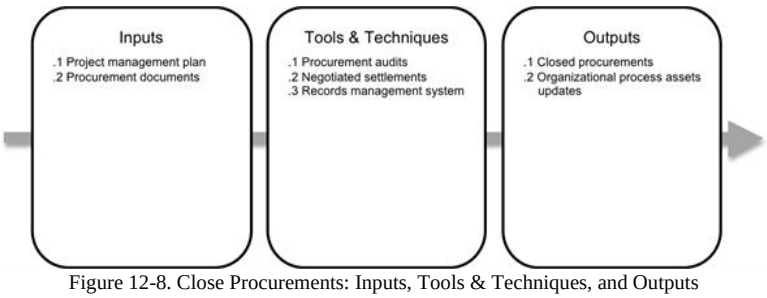


Figure 12-8. Close Procurements: Inputs, Tools & Techniques, and Outputs

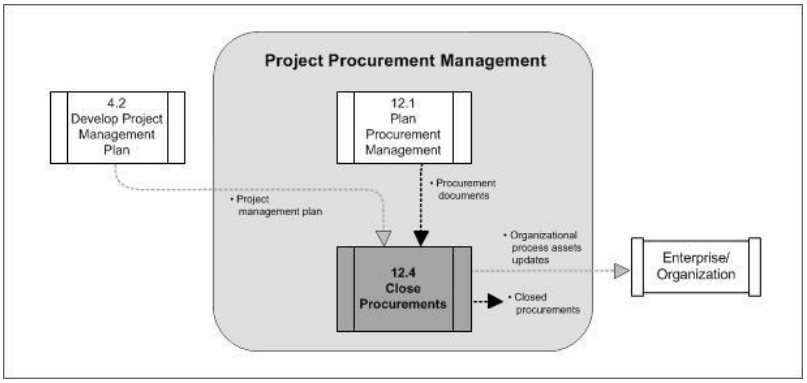


Figure 12-9. Close Procurements Data Flow Diagram

The Close Procurements process also involves administrative activities such as finalizing open claims, updating records to reflect final results, and archiving such information for future use. Close Procurements addresses each contract applicable to the project or a project phase. In multiphase projects, the term of a contract may only be applicable to a given phase of the project. In these cases, the Close Procurements process closes the procurement(s) applicable to that phase of the project. Unresolved claims may be subject to litigation after closure. The contract terms and conditions can prescribe specific procedures for contract closure.

Early termination of a contract is a special case of procurement closure that can result from a mutual agreement by both parties, from the default of one party, or for convenience of the buyer if provided for in the contract. The rights and responsibilities of the parties in the event of an early termination are contained in a terminations clause of the contract. Based upon those procurement terms and conditions, the buyer may have the right to terminate the whole contract or a portion of the contract, at any time, for cause or convenience. However, based upon those contract terms and conditions, the buyer may have to compensate the seller for seller's preparations and for any completed and accepted work related to the terminated part of the contract.

12.4.1 Close Procurements: Inputs

12.4.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan contains the procurement management plan, which provides the details and guidelines for closing out procurements.

12.4.1.2 Procurement Documents

To close the contract, all procurement documentation is collected, indexed, and filed. Information on contract schedule, scope, quality, and cost performance along with all contract change documentation, payment records, and inspection results are cataloged. This information can be used for lessons learned information and as a basis for evaluating contractors for future contracts.

12.4.2 Close Procurements: Tools and Techniques

12.4.2.1 Procurement Audits

A procurement audit is a structured review of the procurement process originating from the Plan Procurement Management process through Control Procurements. The objective of a procurement audit is to identify successes and failures that warrant recognition in the preparation or administration of other procurement contracts on the project, or on other projects within the performing organization.

12.4.2.2 Negotiated Settlements

In all procurement relationships, the final equitable settlement of all outstanding issues, claims, and disputes by negotiation is a primary goal. Whenever settlement cannot be achieved through direct negotiation, some form of alternative dispute resolution (ADR) including mediation or arbitration may be explored. When all else fails, litigation in the courts is the least desirable option.

12.4.2.3 Records Management System

Described in Section 12.3.2.7. A records management system is used by the project manager to manage contract and procurement documentation and records. Contract documents and correspondence are archived through the records management system as part of the Close Procurements process.

12.4.3 Close Procurements: Outputs

12.4.3.1 Closed Procurements

The buyer, usually through its authorized procurement administrator, provides the seller with formal written notice that the contract has been completed. Requirements for formal procurement closure are usually defined in the terms and conditions of the contract and are included in the procurement management plan.

12.4.3.2 Organizational Process Assets Updates

Elements of the organizational process assets that may be updated include, but are not limited to:

- **Procurement file.** A complete set of indexed contract documentation, including the closed contract, is prepared for inclusion with the final project files.
- **Deliverable acceptance.** The buyer, usually through its authorized procurement administrator, provides the seller with formal written notice that the deliverables have been accepted or rejected. Requirements for formal deliverable acceptance and how to address nonconforming deliverables are usually defined in the contract.
- **Lessons learned documentation.** Lessons learned, what has been experienced, and process improvement recommendations, should be developed for the project file to improve future procurements.

CHAPTER 13

PROJECT STAKEHOLDER MANAGEMENT

Project Stakeholder Management includes the processes required to identify all people or organizations impacted by the project, analyzing stakeholder expectations and impact on the project, and developing appropriate management strategies for effectively engaging stakeholders in project decisions and execution. Stakeholder management also focuses on continuous dialogue with stakeholders to meet their needs and expectations, addressing issues as they occur, and fostering appropriate stakeholder engagement in project decisions and activities. Stakeholder satisfaction must be managed as a key project deliverable.

Figure 13-1 provides an overview of the Project Stakeholder Management processes that include the following:

13.1 Identify Stakeholders—The process of identifying all relevant people or organizations impacted by the project, analyzing and documenting relevant information regarding their interests, involvement, interdependencies, and potential impact on project success.

13.2 Plan Stakeholder Management—The process of developing appropriate management strategies to effectively engage stakeholders in project decisions and execution based on the analysis of their needs, interests, and potential impact.

13.3 Manage Stakeholder Engagement—The process of communicating and working with stakeholders to meet their needs/expectations, address issues as they occur, and foster appropriate stakeholder engagement in project decisions and activities.

13.4 Control Stakeholder Engagement—The process of controlling overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders.

These processes interact with each other and with processes in the other Knowledge Areas as described in detail in Chapter 3.

Every project will have stakeholders who are impacted in a positive or negative way by the project. While some stakeholders may have a limited ability to influence the project, others may be powerful and have the ability to directly or indirectly influence the project. The ability of the project manager to correctly identify and manage these stakeholders in an appropriate manner can mean the difference between success and failure.

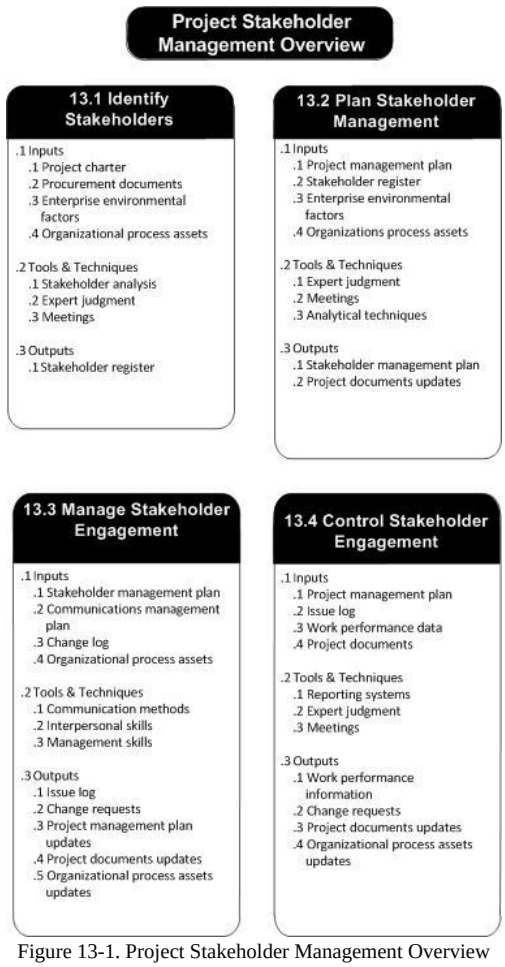


Figure 13-1. Project Stakeholder Management Overview

13.1 Identify Stakeholders

Identify Stakeholders is the process of identifying all relevant people or organizations impacted by the project, analyzing and documenting relevant information regarding their interests, involvement, interdependencies, and potential impact on project success. The key benefit of this process is that it allows the project manager to identify the appropriate level of focus necessary for each stakeholder or group of stakeholders. The inputs, tools and techniques, and outputs of this process are depicted in Figure 13-2. Figure 13-3 depicts the data flow diagram of the process.

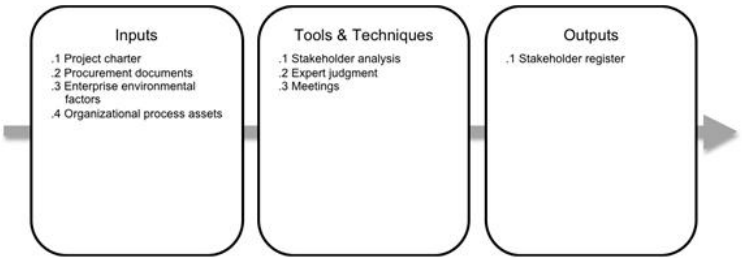


Figure 13-2. Identify Stakeholders: Inputs, Tools & Techniques, and Outputs

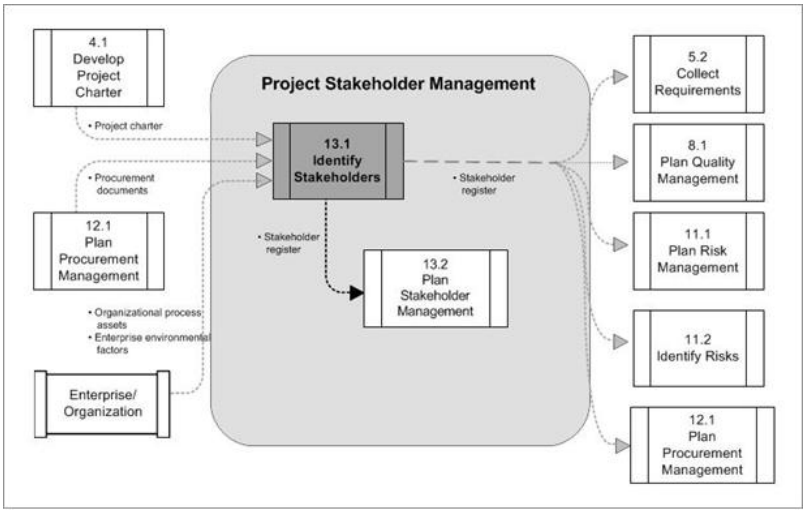


Figure 13-3. Identify Stakeholders Data Flow Diagram

Project stakeholders are individuals, groups, or organizations who may affect, be affected by, or perceive themselves to be affected by a decision, activity, or outcome of a project. They are comprised of persons and organizations such as customers, sponsors, the performing organization, and the public who are actively involved in the project, or whose interests may be positively or negatively affected by the execution or completion of the project. They may also exert influence over the project and its deliverables. Stakeholders may be at different levels within the organization and may possess different authority levels, or may be external to the performing organization for the project. Section 13.1.2.1 identifies various types of project stakeholders.

It is critical for project success to identify the stakeholders early in the project or phase, and to analyze their levels of interest, their individual expectations, as well as their importance and influence. Most projects will have a large number of stakeholders. While the project manager's time is limited and should be used as efficiently as possible, these stakeholders should be classified according to their interest, influence, and involvement in the project. This enables the project manager to focus on the relationships necessary to ensure the success of the project.

13.1.1 Identify Stakeholders: Inputs

13.1.1.1 Project Charter

Described in Section 4.1.3.1. The project charter can provide information about internal and external parties related with the project and affected by the result or the execution of the project, such as project sponsor(s), customers, team members, groups and departments participating in the project, and other people or organizations affected by the project.

13.1.1.2 Procurement Documents

Described in Section 12.1.3.3. If a project is the result of a procurement activity or is based on an established contract, the parties in that contract are key project stakeholders. Other relevant parties, such as suppliers, should also be considered as part of the project stakeholder list.

13.1.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. The enterprise environmental factors that can influence the Identify Stakeholders process include, but are not limited to:

- Organizational or company culture and structure;
- Governmental or industry standards (e.g., regulations, product standards); and
- Global, regional or local trends, and practices or habits.

13.1.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Identify Stakeholders process include, but are not limited to:

- Stakeholder register templates,
- Lessons learned from previous projects, and
- Stakeholder registers from previous projects.

13.1.2 Identify Stakeholders: Tools and Techniques

13.1.2.1 Stakeholder Analysis

Stakeholder analysis is a technique of systematically gathering and analyzing quantitative and qualitative information to determine whose interests should be taken into account throughout the project. It identifies the interests, expectations, and influence of the stakeholders and relates them to the purpose of the project. It also helps identify stakeholder relationships that can be leveraged to build coalitions and potential partnerships to enhance the project's chance of success.

Stakeholder analysis generally follows the steps described below:

- Identify all potential project stakeholders and relevant information, such as their roles, departments, interests, knowledge levels, expectations, and influence levels. Key stakeholders are usually easy to identify. They include anyone in a decision-making or management role who is impacted by the project outcome, such as the sponsor, the project manager, and the primary customer. Identifying other stakeholders is usually done by interviewing identified stakeholders and expanding the list until all potential stakeholders are included.
- Analyze the potential impact or support each stakeholder could generate, and classify them so as to define an approach strategy. In large stakeholder communities, it is important to prioritize the key stakeholders to ensure the efficient use of effort to communicate and manage their expectations.
- Assess how key stakeholders are likely to react or respond in various situations, in order to plan how to influence them to enhance their support and mitigate potential negative impacts.

There are multiple classification models used for stakeholders analysis, such as:

- *Power/interest grid*, grouping the stakeholders based on their level of authority ("power") and their level or concern ("interest") regarding the project outcomes;
- *Power/influence grid*, grouping the stakeholders based on their level of authority ("power") and their active involvement ("influence") in the project;
- *Influence/impact grid*, grouping the stakeholders based on their active involvement ("influence") in the project and their ability to effect changes to the project's planning or execution ("impact"); and
- *Salience model*, describing classes of stakeholders based on their power (ability to impose their will), urgency (need for immediate attention), and legitimacy (their involvement is appropriate).

Figure 13-4 presents an example of a power/interest grid with A-H representing the placement of generic stakeholders.

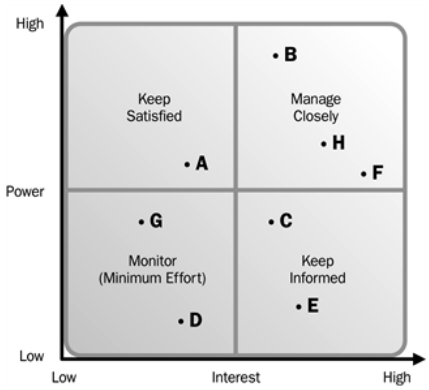


Figure 13-4. Example Power/Interest Grid with Stakeholders

13.1.2.2 Expert Judgment

To ensure comprehensive identification and listing of stakeholders, judgment and expertise should be sought from groups or individuals with specialized training or subject matter expertise, such as:

- Senior management;
- Other units within the organization;
- Identified key stakeholders;
- Project managers who have worked on projects in the same area (directly or through lessons learned);

- Subject matter experts (SMEs) in business or project area;
- Industry groups and consultants; and
- Professional and technical associations, regulatory bodies, and nongovernmental organizations (NGOs).

Expert judgment can be obtained through individual consultations (one-on-one meetings, interviews, etc.) or through a panel format (focus groups, surveys, etc.).

13.1.2.3 Meetings

Profile analysis meetings can be used to exchange and analyze information about roles, interests, knowledge, and the overall position of each stakeholder facing the project.

13.1.3 Identify Stakeholders: Outputs

13.1.3.1 Stakeholder Register

The main output of the Identify Stakeholders process is the stakeholder register. This contains all details related to the identified stakeholders including, but not limited to:

- **Identification information**. Name, organizational position, location, role in the project, contact information;
- **Assessment information.** Major requirements, main expectations, potential influence in the project, phase in the life cycle with the most interest; and
- **Stakeholder classification:** Internal/external, supporter/neutral/resistor, etc.

The stakeholder register should be consulted and updated on a regular basis, as stakeholders may change—or new ones identified—throughout the life cycle of the project.

13.2 Plan Stakeholder Management

Plan Stakeholder Management is the process of developing appropriate management strategies to effectively engage stakeholders in project decisions and execution based on the analysis of their needs, interests and potential impact. The key benefit of this process is that it provides a clear, actionable plan to interact with project stakeholders to support the project's interests. The inputs, tools and techniques, and outputs of this process are depicted in Figure 13-5. Figure 13-6 depicts the data flow diagram of the process.

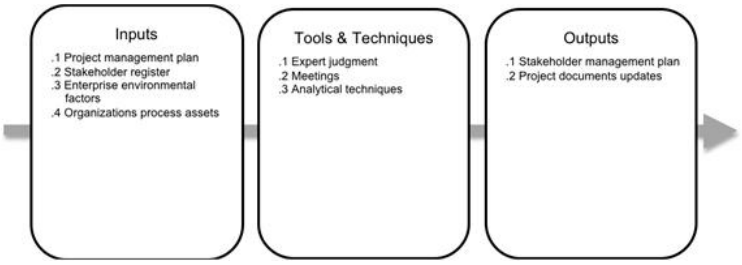


Figure 13-5. Plan Stakeholder Management: Inputs, Tools & Techniques, and Outputs

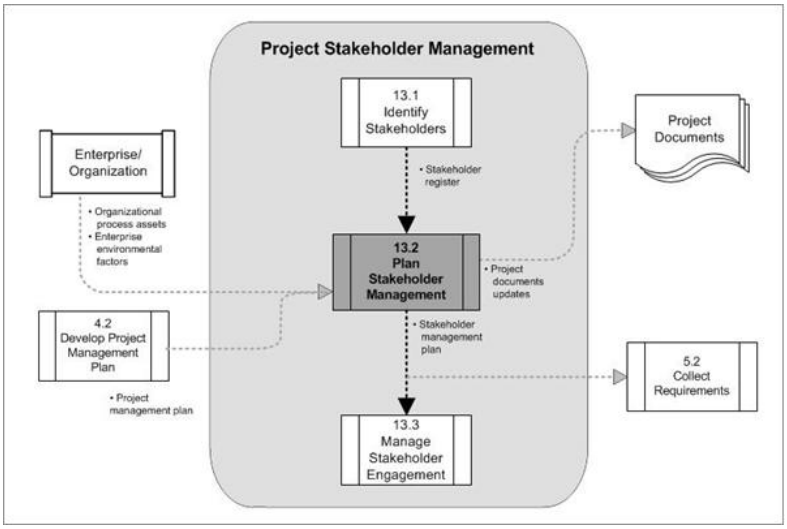


Figure 13-6. Plan Stakeholder Management Data Flow Diagram

Plan Stakeholder Management identifies how the project will affect stakeholders, which then allows the project team to develop various ways to effectively engage stakeholders in the project, to manage their expectations, and to ultimately achieve acceptance of the project objectives. Stakeholder management is more than improving communications and

requires more than managing a team. Stakeholder management is about creation and maintenance of relationships with the aim to satisfy needs.
The process generates the stakeholder management plan, which contains detailed plans on how effective stakeholder management can be realized.

13.2.1 Plan Stakeholder Management: Inputs

13.2.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan is used to develop the stakeholder register as described in Section 13.1.3.1. The information used for the development of the stakeholder management plan includes, but is not limited to:

- The life cycle selected for the project and the processes that will be applied to each phase;
- How work will be executed to accomplish the project objectives;
- How human resources requirements will be met, and how roles and responsibilities, reporting relationships, and staffing management will be addressed and structured for the project;
- A change management plan that documents how changes will be monitored and controlled; and
- Need and techniques for communication among stakeholders.

13.2.1.2 Stakeholder Register

Described in Section 13.1.3.1. The stakeholder register provides the information needed to plan appropriate ways to engage project stakeholders.

13.2.1.3 Enterprise Environmental Factors

Described in Section 2.1.5. All enterprise environmental factors are used as inputs to this process, because the management of stakeholders should be adapted to the project environment. Of these, organizational culture, structure, processes, and political climate are of particular importance, because they help in determining the best options to support a better adaptive process for managing stakeholders.

13.2.1.4 Organizational Process Assets

Described in Section 2.1.4. All organizational process assets are used as inputs for the Plan Stakeholder Management process. Of these, lessons learned and historical information are of particular importance, because they provide insights on previous stakeholder management plans and their effectiveness. These can be used to plan the stakeholder management activities for the current project.

13.2.2 Plan Stakeholder Management: Tools and Techniques

13.2.2.1 Expert Judgment

Based on the project objectives, the project manager must apply expert judgment to decide upon the level of engagement required at each stage of the project from each stakeholder. As the project progresses, the required level of engagement may change, so the stakeholder management planning must be an iterative process, reviewed on a regular basis by the project manager.
For example, at the beginning of a project it may be necessary for senior stakeholders to be highly engaged, in order to clear away any obstacles to success. Once these have been successfully removed, it may be sufficient for senior stakeholders to change their level of engagement from leading to supportive.
In order to create the stakeholder management plan, judgment and expertise should be sought from groups or individuals with specialized training or subject matter expertise, such as:

- Senior management;
- Other units within the organization;
- Identified key stakeholders;
- Project managers who have worked on projects in the same area (directly or through lessons learned);
- Subject matter experts in business or project area;
- Industry groups and consultants; and
- Professional and technical associations, regulatory bodies, and nongovernmental organization (NGOs).

Expert judgment can be obtained through individual consultations (one-on-one meetings, interviews, etc.) or through a panel format (focus groups, surveys, etc).

13.2.2.2 Meetings

Meetings should be held with experts and the project team to define the required

engagement levels of all stakeholders. This information can be used to prepare the stakeholder management plan.

13.2.2.3 Analytical Techniques

The current engagement level of all stakeholders needs to be compared to the engagement levels from each individual stakeholder. Stakeholder engagement throughout the life cycle of the project is critical to project success.
The engagement level of the stakeholders can be classified as follows:

- **Unaware.** Unaware of project and potential impacts.
- **Resistant.** Aware of project and potential impacts and resistant to change
- **Neutral.** Aware of project yet neither supportive nor resistant
- **Supportive.** Aware of project and potential impacts and supportive to change
- **Leading.** Aware of project and potential impacts and actively engaged in ensuring the project is a success

The current engagement can be estimated using a table as shown in Figure 13-7, where C indicates the current engagement, and D indicates the desired engagement. The project team needs to identify the desired engagement level for the current phase of the project, based on available information.
The example in Figure 13-7 shows that stakeholder 3 is at the desired engagement level, while stakeholders 1 and 2 require further communications and additional actions to move them to the desired level of engagement.

Stakeholder	Unaware	Resistant	Neutral	Supportive	Leading
Stakeholder 1	C			D	
Stakeholder 2			C	D	
Stakeholder 3				D C	

Figure 13-7. Stakeholders Engagement Assessment Matrix

Through this analytical process, gaps between the current and desired engagement levels can be identified. Actions and communications required to close these gaps can be identified by the project team using expert judgment.

13.2.3 Plan Stakeholder Management: Outputs

13.2.3.1 Stakeholder Management Plan

The stakeholder management plan is a subsidiary plan of the project management plan (Section 4.2.3.1).The stakeholder management plan can be formal or informal, highly detailed or broadly framed, based on the needs of the project.
In addition to the data gathered in the stakeholder register, the stakeholder management plan often provides:

- Desired and current engagement levels of key stakeholders;
- Identified interrelationships between stakeholders;
- Stakeholder communication requirements for the current project phase;
- Information to be distributed to stakeholders, including language, format, content, and level of detail;
- Reason for the distribution of that information and the expected impact to stakeholder engagement;
- Time frame and frequency for the distribution of required information to stakeholders; and
- Method for updating and refining the stakeholder management plan as the project progresses and develops.

Project managers should be aware of the sensitive nature of the stakeholder management plan and take appropriate precautions. For example, information on stakeholders who are resistant to the project can be potentially damaging and due consideration should be given regarding the distribution of such information.

13.2.3.2 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- Project schedule, and
- Stakeholder register.

13.3 Manage Stakeholder Engagement

Manage Stakeholder Engagement is the process of communicating and working with stakeholders to meet their needs/expectations, address issues as they occur, and foster appropriate stakeholder engagement in project decisions and activities. The key benefit of this process is that it allows the project manager to increase support and minimize resistance from stakeholders, significantly increasing the chances to achieve project success. The inputs, tools and techniques, and outputs of this process are depicted in Figure 13-8. Figure 13-9 depicts the data flow diagram of the process.

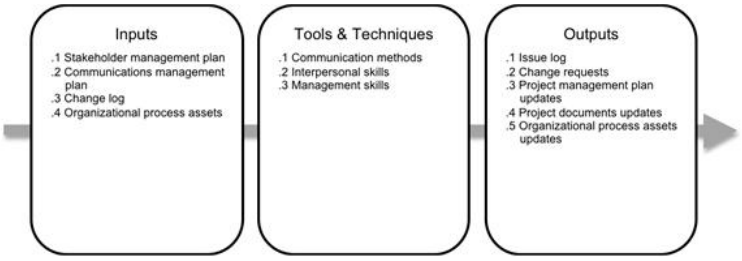


Figure 13-8. Manage Stakeholder Engagement: Inputs, Tools & Techniques, and Outputs

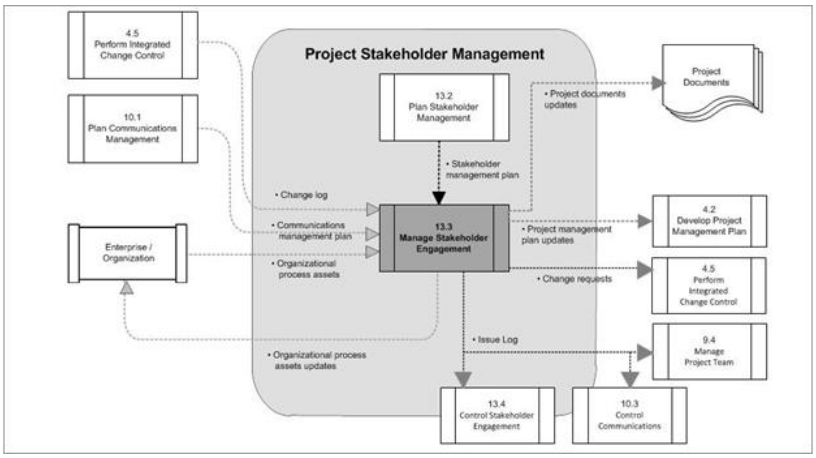


Figure 13-9. Manage Stakeholder Engagement Data Flow Diagram

Manage Stakeholder Engagement involves activities such as:

- Engaging stakeholders at appropriate project stages to obtain their commitment and ensure they are shared owners of the project;
- Managing stakeholder expectations through negotiation and communication, ensuring project goals are achieved;
- Addressing potential concerns that have not yet become issues and anticipating future problems, which may be raised by stakeholders. Such concerns need to be identified and discussed as soon as possible to assess associated project risks; and
- Clarifying and resolving issues that have been identified.

Managing stakeholder engagement helps to increase the probability of project success by ensuring that stakeholders clearly understand the project goals, objectives, benefits, and risks. This enables them to be active supporters of the project and to help guide activities and project decisions. By anticipating people's reactions to the project, preventive actions can be taken to win support or minimize negative impacts. The ability of stakeholders to influence the project is highest during the initial stages and gets progressively lower as the project progresses. The project manager is responsible for engaging and managing the various stakeholders in a project and may call upon the project sponsor to assist as needed. Active management of stakeholder involvement decreases the risk of the project failing to meet its goals and objectives.

13.3.1 Manage Stakeholder Engagement: Inputs

13.3.1.1 Stakeholder Management Plan

Described in Section 13.2.3.1. The stakeholder management plan provides guidance on how the various stakeholders can be best involved in the project. The stakeholder management plan describes the methods and technologies used for stakeholder communication. This plan is used to determine the level of interactions of various stakeholders and—together with other documents—helps define a strategy for managing stakeholders throughout the project life cycle.

13.3.1.2 Communications Management Plan

Described in Section 10.1.3.1. The communications management plan provides guidance and information on managing stakeholder expectations. The information used includes, but is not limited to:

- Stakeholder communications requirements;
- Information to be communicated, including language, format, content, and level of detail;
- Reason for distribution of information;
- Person or groups who will receive information; and
- Escalation process.

13.3.1.3 Change Log

Described in Section 4.5.3.2. A change log is used to document changes that occur during a project. These changes—and their impact on the project in terms of time, cost, and risk—must be communicated to the appropriate stakeholders.

13.3.1.4 Organizational Process Assets

Described in Section 2.1.4. The organizational process assets that can influence the Manage Stakeholder Engagement process include, but are not limited to:

- Organizational communication requirements,
- Issue management procedures,
- Change control procedures, and
- Historical information about previous projects.

13.3.2 Manage Stakeholder Engagement: Tools and Techniques

13.3.2.1 Communication Methods

The methods of communication identified for each stakeholder in the communications management plan are utilized during stakeholder management.
There are several communication methods used to share information among project stakeholders. These methods can be broadly classified into:

- **Interactive communication.** A communication between two or more parties performing a multidirectional exchange of information. It is the most efficient way to ensure a common understanding by all participants on specified topics, and includes meetings, phone calls, video conferencing, etc.
- **Push communication.** Sent to specific recipients who need to know the information. This ensures that the information is distributed but does not certify that it actually reached or was understood by the intended audience. Push communication includes letters, memos, reports, emails, faxes, voice mails, press releases etc.
- **Pull communication.** Used for very large volumes of information or for very large audiences, which require the recipients to access the communication content at their own discretion. These methods include intranet sites, e-learning, and knowledge repositories, etc.

The project manager decides, based on the stakeholders communication requirements, how, when, and which of these communication methods are to be used in the project.

13.3.2.2 Interpersonal Skills

The project manager applies interpersonal skills to manage stakeholders' expectations. For example:

- Building trust,
- Resolving conflict,
- Active listening, and
- Overcoming resistance to change.

13.3.2.3 Management Skills

Management is the act of directing and controlling a group of people for the purpose of coordinating and harmonizing the group toward accomplishing a goal beyond the scope of individual effort. Management skills used by the project manager include but are not limited to:

- Presentation skills,
- Negotiating,
- Writing skills, and
- Public speaking.

13.3.3 Manage Stakeholder Engagement: Outputs

13.3.3.1 Issue Log

Managing stakeholder engagement may result in the development of an issue log. This is updated as new issues are identified and current issues are resolved.

13.3.3.2 Change Requests

Managing stakeholder engagement may result in a change request to the product or the project. It may also include corrective or preventive actions, as appropriate.

13.3.3.3 Project Management Plan Updates

Elements of the project management plan that may be updated include, but are not limited to, the stakeholder management plan. This plan is updated when new or changed stakeholders requirements are identified. For example, some communications may no longer be necessary, an ineffective communication method may be replaced by another method, or a new communication requirement may be identified. It is also updated as a result of addressing concerns and resolving issues. For example, it may be determined that a stakeholder has additional informational needs

13.3.3.4 Project Documents Updates

Project documents that may be updated include, but are not limited to the stakeholder register. This is updated as information on stakeholders change, when new stakeholders are identified, or if registered stakeholders are no longer involved in or impacted by the project, or other updates for specific stakeholders are required.

13.3.3.5 Organizational Process Assets Updates

The organizational process assets, which may be updated, include, but are not limited to:

- **Stakeholder notifications**. Information may be provided to stakeholders about resolved issues, approved changes, and general project status.
- **Project reports.** Formal and informal project reports describe project status and include lessons learned, issues logs, project closure reports, and outputs from other Knowledge Areas (Sections 4-12).
- **Project presentations.** Information formally or informally provided by the project team to any or all of the project stakeholders.
- **Project records.** Project records include correspondence, memos, meeting minutes, and other documents describing the project.
- **Feedback from stakeholders.** Information received from stakeholders concerning project operations can be distributed and used to modify or improve future performance of the project.
- **Lessons learned documentation.** Documentation includes the root cause analysis of issues faced, reasoning behind the corrective action chosen, and other types of lessons learned about stakeholder management. Lessons learned are documented and distributed, and become part of the historical database for both the project and the performing organization.

13.4 Control Stakeholder Engagement

Control Stakeholder Engagement is the process of monitoring overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders. The key benefit of this process is that it will maintain or increase the efficiency of stakeholder engagement activities as the project evolves and its environment changes. The inputs, tools and techniques, and outputs of this process are depicted in Figure 13-10. Figure 13-11 depicts the data flow diagram of the process.

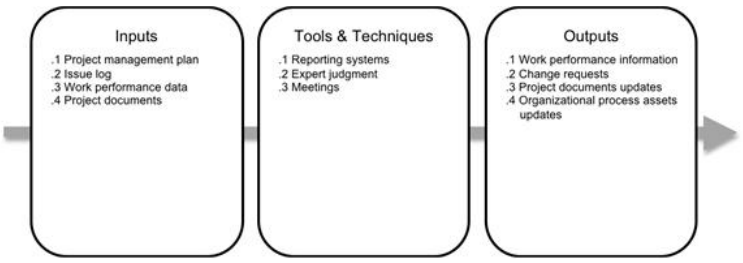


Figure 13-10. Control Stakeholder Engagement: Inputs, Tools & Techniques, and Outputs

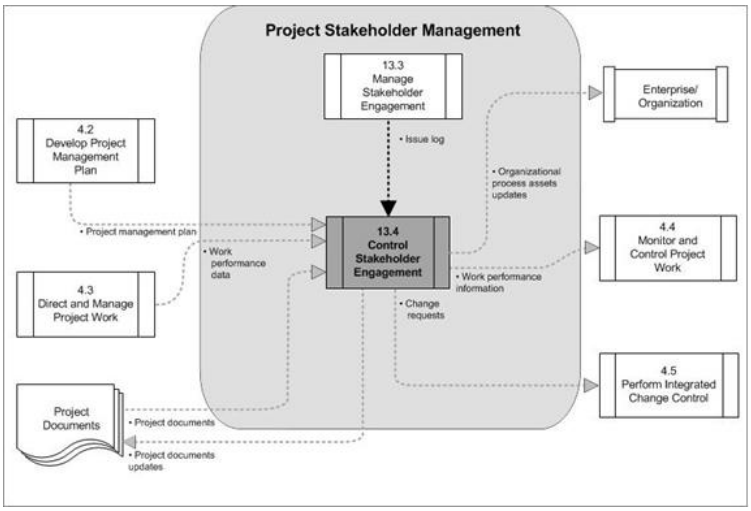


Figure 13-11. Control Stakeholder Engagement: Data Flow Diagram

Stakeholder engagement activities are included in the stakeholder management plan and are executed during the life cycle of the project. Stakeholder engagement should be continuously controlled.

13.4.1 Control Stakeholder Engagement: Inputs

13.4.1.1 Project Management Plan

Described in Section 4.2.3.1. The project management plan is used to develop the stakeholder management plan, as described in Section 13.1.3.1. The information used to Control Stakeholder Engagement includes, but is not limited to:

- The life cycle selected for the project and the processes that will be applied to each phase;
- How work will be executed to accomplish the project objectives;
- How human resources requirements will be met, how roles and responsibilities, reporting relationships, and staffing management will be addressed and structured for the project;
- A change management plan that documents how changes will be monitored and controlled; and
- Need and techniques for communication among stakeholders.

13.4.1.2 Issue Log

Described in Section 13.3.3.1. The issue log is updated as new issues are identified and current issues are resolved.

13.4.1.3 Work Performance Data

Described in Section 4.3.3.2. The work performance data are the raw observations and measurements identified during activities being performed to carry out the project work. Various measurements on project activities and deliverables are collected during various controlling processes. Data are often viewed as the lowest level of abstraction from which information is derived by other processes.
Examples of work performance data include reported percentage of work physically completed, technical performance measures, start and finish dates of schedule activities, number of change requests, number of defects, actual costs, actual durations etc.

13.4.1.4 Project Documents

Multiple project documents originating from initiation, planning, execution, or control processes may be used as supporting inputs for controlling stakeholder engagement. These include, but are not limited to:

- Project schedule,
- Stakeholder register,
- Issue log,
- Change log, and
- Project communications.

13.4.2 Control Stakeholder Engagement: Tools and Techniques

13.4.2.1 Reporting Systems

A reporting system provides a standard tool for the project manager to capture, store, and

distribute information to stakeholders about the project cost, schedule progress, and performance. It also allows the project manager to consolidate reports from several systems and facilitate report distribution to the project stakeholders. Examples of distribution formats may include table reporting, spreadsheet analysis, and presentations. Graphical capabilities can be used to create visual representations of project performance information.

13.4.2.2 Expert Judgment

To ensure comprehensive identification and listing of new stakeholders, reassessment of current stakeholders and removal of stakeholders no longer involved in the project, judgment, and expertise should be sought from groups or individuals with specialized training or subject matter expertise, such as:

- Senior management;
- Other units within the organization;
- Identified key stakeholders;
- Project managers who have worked on projects in the same area (directly or through lessons learned);
- Subject matter experts in the business or project area;
- Industry groups and consultants; and
- Professional and technical associations, regulatory bodies, and nongovernmental organizations.

Expert judgment can be obtained through individual consultations (such as one-on-one meetings or interviews) or through a panel format (such as focus groups or surveys).

13.4.2.3 Meetings

Status review meetings are used to exchange and analyze information about stakeholder engagement.

13.4.3 Control Stakeholder Engagement: Outputs

13.4.3.1 Work Performance Information

The work performance information is the performance data collected from various controlling processes, analyzed in context and integrated based on relationships across areas. Thus work performance data have been transformed into work performance information. Data per se are not used in the decision-making process, because the meaning may be misinterpreted. Information, however, is correlated and contextualized and provides a sound foundation for project decisions.
Work performance information is circulated through communication processes. Examples of performance information are status of deliverables, implementation status for change requests, and forecasted estimates to complete.

13.4.3.2 Change Requests

Analysis of project performance and interactions with stakeholders often generates change requests. These change requests are processed through the Perform Integrated Change Control process (Section 4.5) as follows:

- Recommended corrective actions include changes that bring the expected future performance of the project in line with the project management plan; and
- Recommended preventive actions can reduce the probability of incurring future negative project performance.

13.4.3.3 Project Documents Updates

Project documents that may be updated include, but are not limited to:

- **Stakeholder register.** This is updated as information on stakeholders change, when new stakeholders are identified, or if registered stakeholders are no longer involved in or impacted by the project, or other updates for specific stakeholders are required.
- **Issue log.** This is updated as new issues are identified and current issues are resolved.

13.4.3.4 Organizational Process Assets Updates

The organizational process assets, which may be updated include, but are not limited to:

- **Stakeholder notifications.** Information may be provided to stakeholders about resolved issues, approved changes, and general project status.
- **Project reports.** Formal and informal project reports describe project status and include lessons learned, issues logs, project closure reports, and outputs from other Knowledge Areas (Sections 4-12).
- **Project presentations.** Information formally or informally provided by the project team to any or all of the project stakeholders.
- **Project records.** Project records include correspondence, memos, meeting minutes, and other documents describing the project.

- **Feedback from stakeholders.** Information received from stakeholders concerning project operations can be distributed and used to modify or improve future performance of the project.
- **Lessons learned documentation.** Documentation includes the root cause analysis of issues faced, reasoning behind the corrective action chosen, and other types of lessons learned about stakeholder management. Lessons learned are documented and distributed so that they become part of the historical database for both the project and the performing organization.

References

{ED Note: All publications will be noted and numbered sequentially in the order in which they appear in the text. This will be done prior to publication.}

[1] *Project Management Lexicon*
[2] *Project Management Institute Code of Ethics and Professional Conduct*
[3] *Standard for Program Management* – Third Edition
[4] *Standard for Portfolio Management* – Third Edition
[5] *Organizational Project Management Maturity Model (OPM3®)* – Third Edition
[6] *ISO/IEC 15288 Systems Engineering – System Life Cycle Processes*
[7] *Practice Standard for Work Breakdown Structures* – Second Edition
[8] *Practice Standard for Earned Value Management* – Second Edition
[9] Practice Standard for Scheduling – Second Edition (p. 138)
[10] *International Organization for Standardization. 2005. ISO 9000. Quality Management Systems—Fundamentals and Vocabulary*. Geneva: ISO Press. p. 183
[11] *International Organization for Standardization. 1994. ISO 8402. Quality Management and Quality Assurance.* Geneva: ISO Press (Withdrawn 2000).

ANNEX A1

THE STANDARD FOR PROJECT MANAGEMENT

OF A PROJECT

A project is a temporary endeavor undertaken to create a unique product, service, or result. The temporary nature of projects indicates a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists.
Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Project management is accomplished through the appropriate application and integration of logically grouped project management processes.
Managing a project typically includes:

- Identifying requirements;
- Addressing the various needs, concerns, and expectations of the stakeholders as the project is planned and carried out;
- Setting and maintaining active communication with stakeholders; and
- Balancing the competing project constraints, which include, but are not limited to:
    - Scope,
    - Quality,
    - Schedule,
    - Budget,
    - Resources, and
    - Risk.

The specific project circumstances will influence the constraints on which the project manager needs to focus and require effective application and management of appropriate project management processes.

A1.1 What is a Standard?

The International Organization for Standardization (ISO) and others define a standard as a *"Document approved by a recognized body, that provides, for common and repeated use, rules, guidelines, or characteristics for products, processes or services with which compliance are not mandatory."*
In October 1998, PMI was accredited as a Standards Developer by the American National Standards Institute (ANSI). The processes outlined in this Annex, which are described in the PMBOK® Guide – Fifth Edition, provide the standard for project management of a

project.

A1.2 The Framework for This Standard

This standard describes the nature of project management processes in terms of the integration between the processes, their interactions, and the purposes they serve. Project management processes are grouped into five categories known as Project Management Process Groups (or Process Groups):

- **Initiating Process Group.** Those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase.
- **Planning Process Group.** Those processes required to establish the scope of the project, refine the objectives, and define the course of action required to attain the objectives that the project was undertaken to achieve.
- **Executing Process Group.** Those processes performed to complete the work defined in the project management plan to satisfy the project specifications.
- **Monitoring and Controlling Process Group.** Those processes required to track, review, and regulate the progress and performance of the project; identify any areas in which changes to the plan are required; and initiate the corresponding changes.
- **Closing Process Group.** Those processes performed to finalize all activities across all Process Groups to formally close the project or phase.

Project Management Process Groups are linked by the outputs they produce. The Process Groups are seldom either discrete or one-time events; they are overlapping activities that occur throughout the project. 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 with the project management plan and project documents, and, as the project progresses, it often entails updates to the project management plan and the project documents. Figure A1-1 illustrates how the Process Groups interact and shows the level of overlap at various times. If the project is divided into phases, the Process Groups interact within each phase.

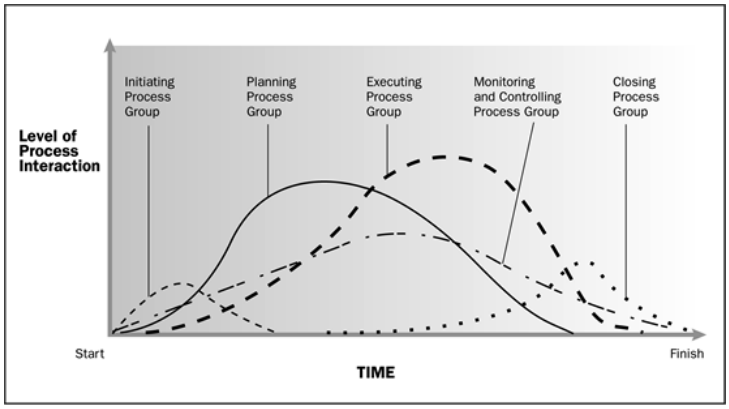


Figure A1-1. Process Group Interactions

An example of this would be the exit of a design phase, which requires customer acceptance of the design document. Once it is available, the design document provides the product description for the Planning and Executing Process Groups in one or more subsequent phases. When a project is divided into phases, the Process Groups are carried out, as appropriate, to effectively drive the project to completion in a controlled manner. In multiphase projects, processes are repeated within each phase until the criteria for phase completion have been satisfied.

A1.3 Project Management Process Groups

The following sections identify and describe the five Project Management Process Groups required for any project. These five Process Groups have clear dependencies and are typically performed in the same sequence on each project. They are independent of application areas or industry focus. Individual Process Groups and individual processes are often iterated prior to completing the project. The processes can have interactions within a Process Group and among Process Groups. The nature of these interactions varies from project to project and may or may not be performed in a particular order.

The process flow diagram, Figure A1-2, provides an overall summary of the basic flow and interactions among Process Groups and specific stakeholders. A Process Group includes the project management processes that are linked by the respective inputs and outputs where the result or outcome of one process becomes the input to another. **The Process Groups are not project phases.** As projects are separated into distinct phases or subprojects, such as feasibility study, concept development, design, prototype, build, test, etc., all of the Process Groups would normally be repeated for each phase or subproject.

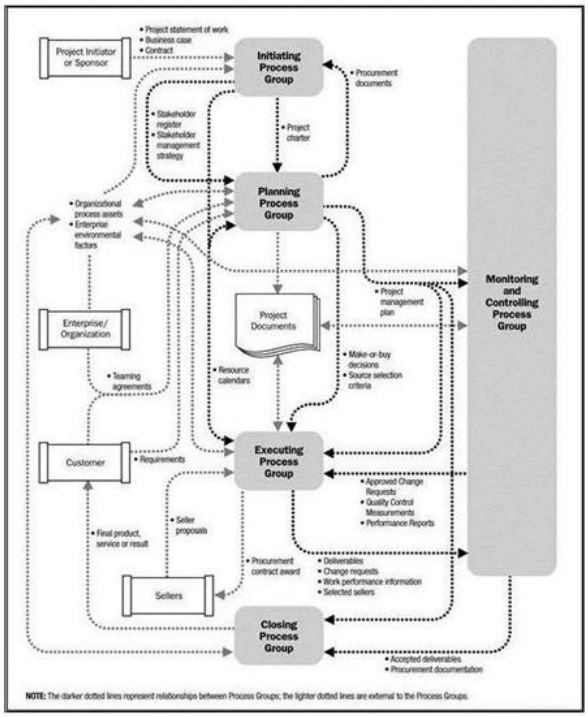


Figure A1-2. Project Management Process Interactions

Table A1-1 reflects the mapping of the 47 project management processes into the 5 Project Management Process Groups and the 10 Project Management Knowledge Areas. The project management processes are shown in the Process Group in which most of the activity takes place. For example, when a process that normally takes place in the Planning Process Group is updated in the Executing Process Group, it is not considered a new process. The iterative nature of project management means that processes from any group may be used throughout the project life cycle. For example, executing a risk response may trigger the Perform Quantitative Risk Analysis process to evaluate the impact.

Table A1-1. Project Management Process Group and Knowledge Area Mapping

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

A1.4 Initiating Process Group

The Initiating Process Group consists of those processes performed to define a new project or a new phase of an existing project by obtaining authorization to start the project or phase. Within the initiating processes, the initial scope is defined and initial financial resources are committed. Internal and external stakeholders who will interact and influence the overall outcome of the project are identified. If not already assigned, the project manager will be selected. This information is captured in the project charter and stakeholder register. When the project charter is approved, the project becomes officially authorized. Although the project management team may help to write the project charter, approval and funding are handled external to the project boundaries (Figure A1-3). The key purpose of this Process Group is to align the stakeholders' expectations and give them visibility about the scope, objective, and possible participation in the project or phase. These processes help to set the vision of the project—what is needed to be accomplished. As part of the Initiating Process Group, many large or complex projects may be divided into separate phases. In such projects, the Initiating processes are carried out during subsequent phases to validate the decisions made during the original Develop Project Charter and Identify Stakeholders processes. The Initiating processes at the start of each phase help to keep the project focused on the business need that the project was undertaken to address. The success criteria are verified, and the influence and objectives of the project stakeholders are reviewed. A decision is then made as to whether the project should be continued, delayed, or discontinued.

Involving the customers and other stakeholders during initiation generally improves the probability of shared ownership, deliverable acceptance, and customer and other stakeholder satisfaction.

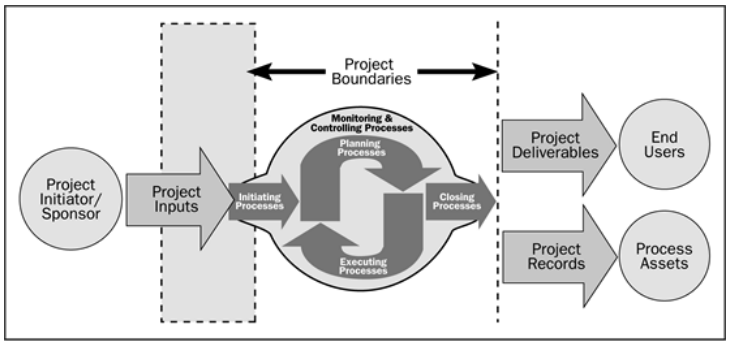


Figure A1-3. Project Boundaries

Initiating processes may be performed by organizational, program, or portfolio processes external to the project's scope of control. For example, prior to commencing a project, the need for high-level requirements may be documented as part of a larger organizational initiative. The feasibility of the new undertaking may be established through a process of evaluating alternatives. Clear descriptions of the project objectives are developed, including the reasons why a specific project is the best alternative to satisfy the requirements. The documentation for this decision may also contain the initial project scope statement, deliverables, project duration, and a forecast of the resources for the organization's investment analysis. As part of the Initiating processes, the project manager is given the authority to apply organizational resources to the subsequent project activities.

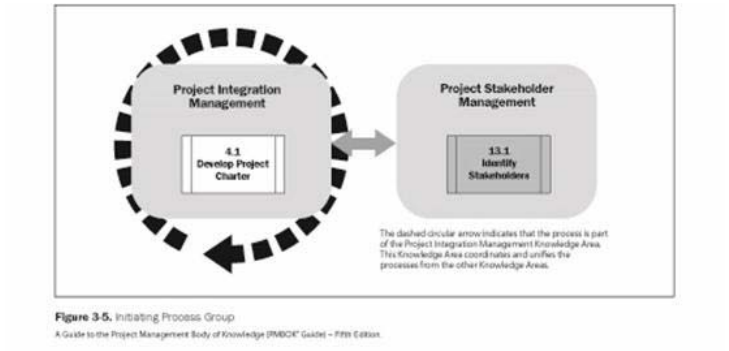


Figure A1-4. Initiating Process Group

A1.4.1 Develop Project Charter

Develop Project Charter is the process of developing a document that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities. The key benefit of this process is that the project then has a well-defined start and the process provides an upfront way for senior management to formally accept the project. The inputs and outputs for this process are depicted in Figure A1-5.

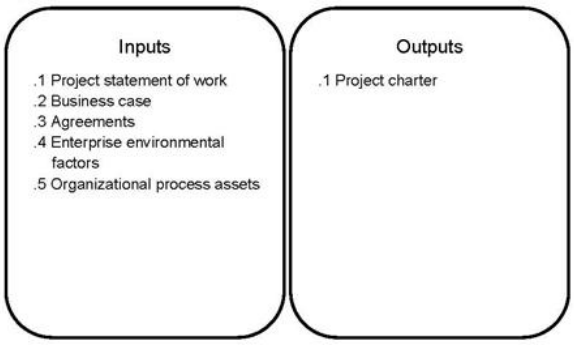


Figure A1-5. Develop Project Charter: Inputs and Outputs

A1.4.2 Identify Stakeholders

Identify Stakeholders is the process of identifying all relevant people or organizations impacted by the project, analyzing and documenting relevant information regarding their interests, involvement, interdependencies, and potential impact on project success. The key benefit of this process is that it allows the project manager to identify the appropriate level of focus necessary for each stakeholder or group of stakeholders. The inputs and outputs of this process are depicted in Figure A1-6.

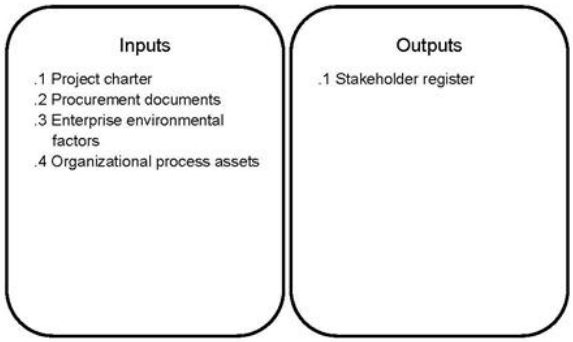


Figure A1-6. Identify Stakeholders: Inputs and Outputs

A1.5 Planning Process Group

The Planning Process Group consists of those processes performed to establish the total scope of the effort, define and refine the objectives, and develop the course of action required to attain those objectives. The planning processes develop the project management plan and the project documents that will be used to carry out the project. The multidimensional nature of project management creates repeated feedback loops for additional analysis. As more project information or characteristics are gathered and understood, additional planning 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. This progressive detailing of the project management plan is called progressive elaboration, indicating that planning and documentation are iterative and ongoing processes. The key benefit of this Process Group is to delineate the strategy and tactics as well as the course of action or a path to successfully complete the project or phase. When the Planning Process Group is well managed, it is much easier to get stakeholder buy-in and engagement. These processes describe how this will be done, resulting in the desired objectives.

The project management plan and project documents developed as outputs from the Planning Process Group will explore all aspects of the scope, time, costs, quality, communication, human resources, risk, procurements, and stakeholder management.

Updates arising from approved changes during the project may significantly impact parts of the project management plan and the project documents. Updates to these documents provide greater precision with respect to schedule, costs, and resource requirements to meet the defined project scope.

The project team should encourage involvement from all appropriate stakeholders when planning the project and developing the project management plan and project documents. Since the feedback and refinement process cannot continue indefinitely, procedures set by the organization dictate when the initial 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 upon the nature of the project. For example, for some projects there will be little or no identifiable risk until after significant 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 or project documents.

The Planning Process Group (Figure A1-7) includes the project management processes identified in Figures A1-9 through A1-32 (see Sections A1 5.1 through A1 5.24).

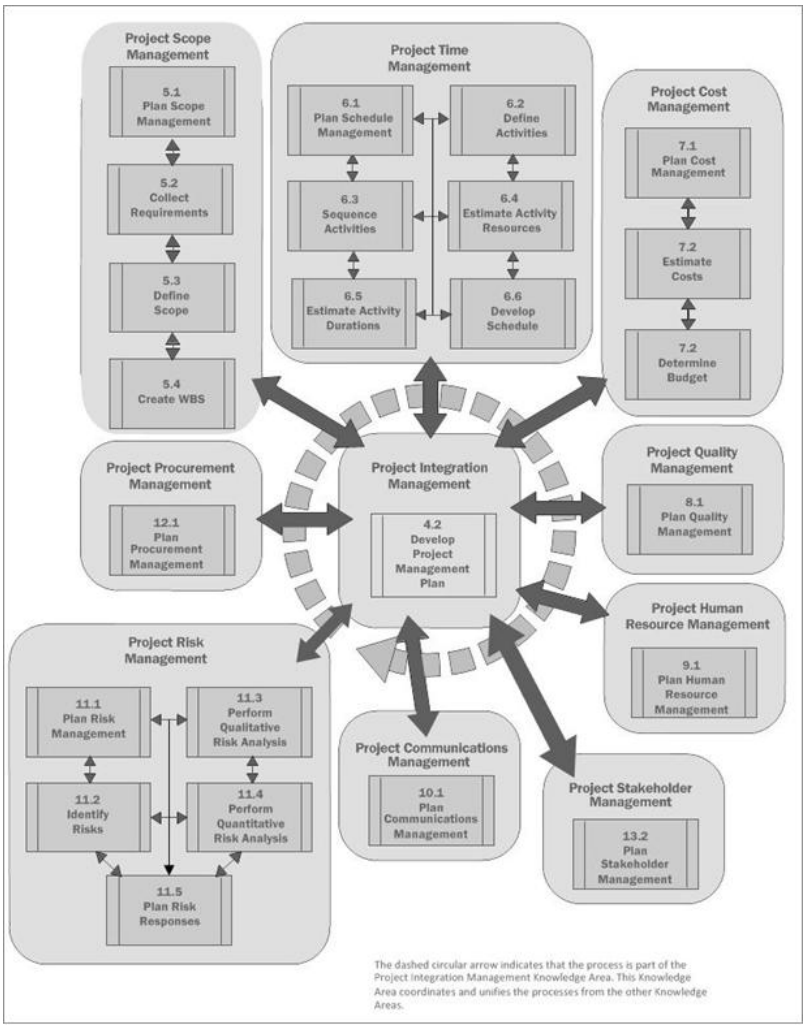


Figure A1-7. Planning Process Group

A1.5.1 Develop Project Management Plan

Develop Project Management Plan is the process of defining, preparing, and coordinating all subsidiary plans and integrating them into a comprehensive project management plan. The key benefit of this process is a central document that defines the basis of all project work. The inputs and outputs for this process are depicted in Figure A1-8.

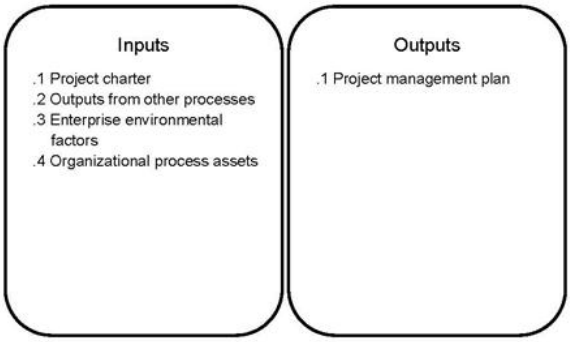


Figure A1-8. Develop Project Management Plan: Inputs and Outputs

A1.5.2 Plan Scope Management

Plan Scope Management is the process of creating a scope management plan that documents how the project scope will be defined, validated, and controlled. The key benefit of this process is that it provides guidance and direction on how scope will be managed throughout the project. The inputs and outputs of this process are depicted in Figure A1-9.

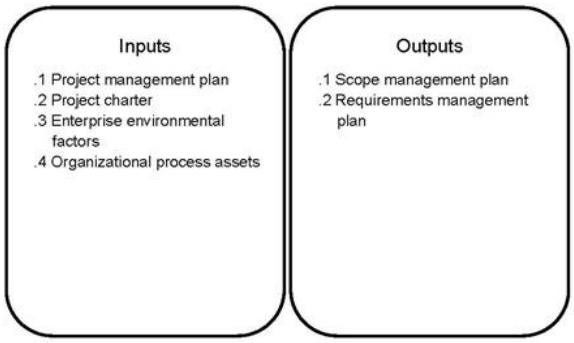


Figure A1-9. Plan Scope Management: Inputs and Outputs

A1.5.3 Collect Requirements

Collect Requirements is the process of planning for, defining, and documenting stakeholders' needs to meet the project objectives. The key benefit of this process is that it provides the basis for defining and managing the product scope. The inputs and outputs of this process are depicted in Figure A1-10.

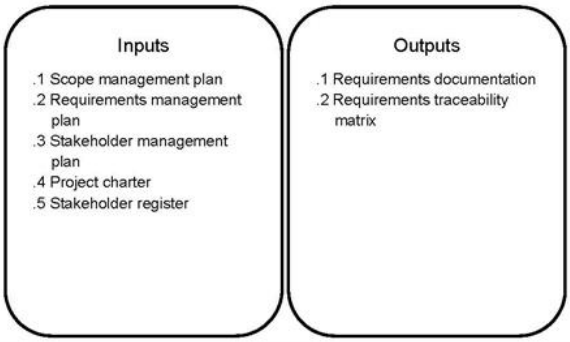


Figure A1-10. Collect Requirements: Inputs and Outputs

A1.5.4 Define Scope

Define Scope is the process of developing a detailed description of the project and product. The key benefit of this process is that it describes the project boundaries. The inputs and outputs of this process are depicted in Figure A1-11.

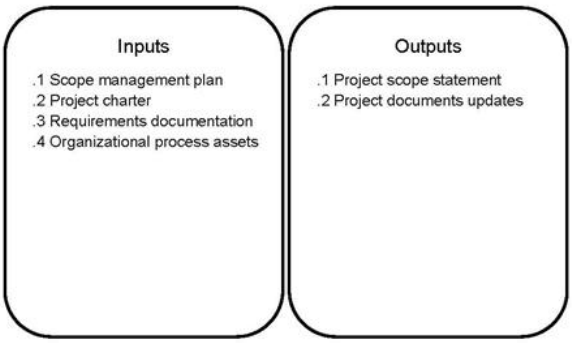


Figure A1-11. Define Scope: Inputs and Outputs

A1.5.5 Create WBS

Create WBS is the process of subdividing project deliverables and project work into smaller, more manageable components. The key benefit of this process is that it provides a structured vision of what has to be performed. The inputs and outputs of this process are depicted in Figure A1-12.

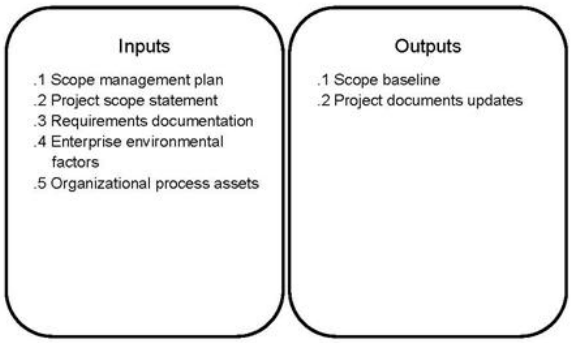


Figure A1-12. Create WBS: Inputs and Outputs

A1.5.6 Plan Schedule Management

Plan Schedule Management is the process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule. The key benefit of this process is that it ensures that the schedule management processes and their associated tools and techniques are documented. The inputs and outputs of this process are depicted in Figure A1-13.

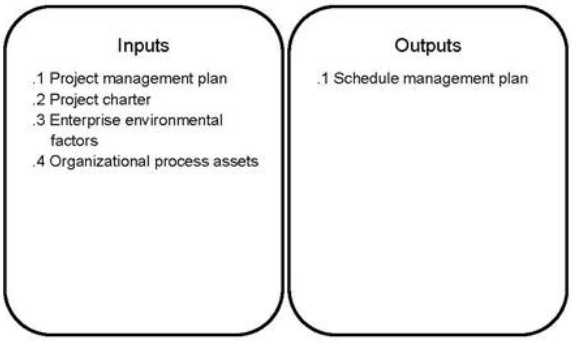


Figure A1-13. Plan Schedule Management: Inputs and Outputs

A1.5.7 Define Activities

Define Activities is the process of identifying the specific actions to be performed to produce the project deliverables. The key benefit of this process is that the defined activities provide a basis for estimating, scheduling, executing, monitoring, and controlling the project work. The inputs and outputs of this process are depicted in Figure A1-14.

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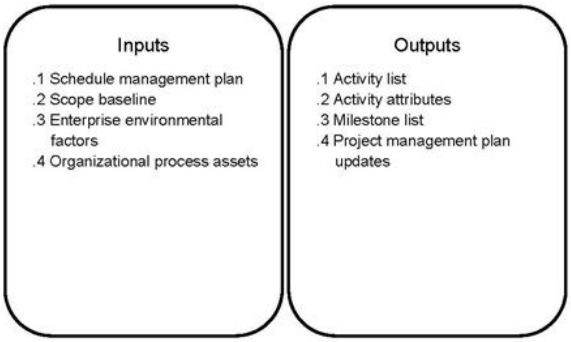

Figure A1-14. Define Activities: Inputs and Outputs

A1.5.8 Sequence Activities

Sequence Activities is the process of identifying and documenting relationships among the project activities. The key benefit of this process is that it documents the logical sequence of work to obtain the greatest efficiency given all project constraints. The inputs and outputs of this process are depicted in Figure A1-15.

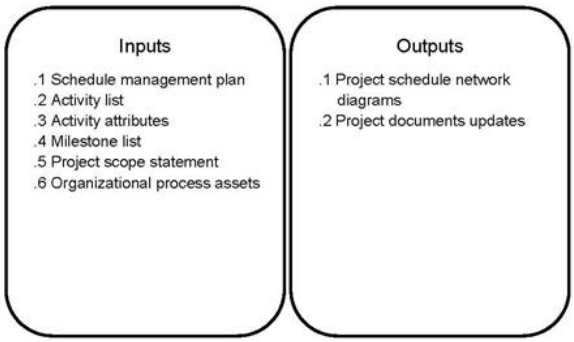

Figure A1-15. Sequence Activities: Inputs and Outputs

A1.5.9 Estimate Activity Resources

Estimate Activity Resources is the process of estimating the type and quantities of material, people, equipment, or supplies required to perform each activity. The key benefit of this process is that it identifies the type, quantity, and characteristics of resources required to complete the activity, which allows more accurate cost and duration estimates. The inputs and outputs of this process are depicted in Figure A1-16.

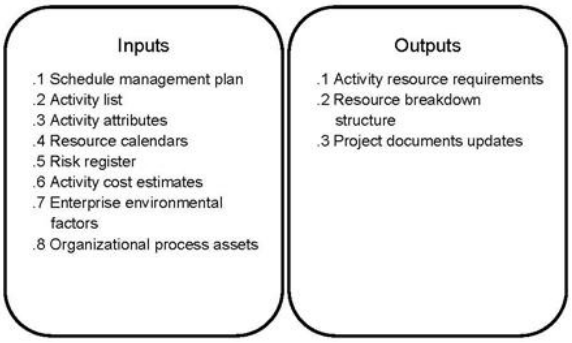

Figure A1-16. Estimate Activity Resources: Inputs and Outputs

A1.5.10 Estimate Activity Durations

Estimate Activity Durations is the process of approximating the number of work periods needed to complete the individual project activities utilizing the estimated resources. The key benefit of this process is that it provides the amount of time each activity will take to complete, which is a major input into the Develop Schedule process. The inputs and outputs of this process are depicted in Figure A1-17.

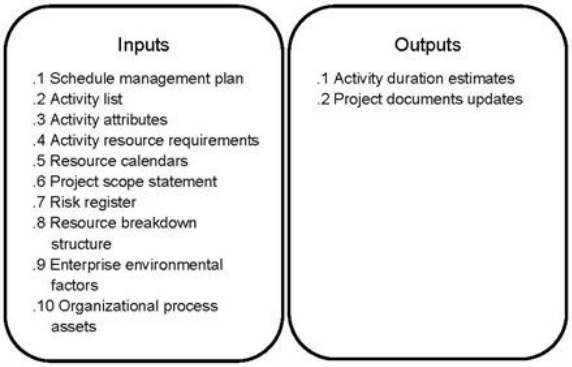

Figure A1-17. Estimate Activity Durations: Inputs and Outputs

A1.5.11 Develop Schedule

Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model. The key benefit of this process is that it generates a schedule with planned dates for completing project activities by entering schedule activities, durations, resources, and their availabilities into the scheduling tool. The inputs and outputs of this process are depicted in Figure A1-18.

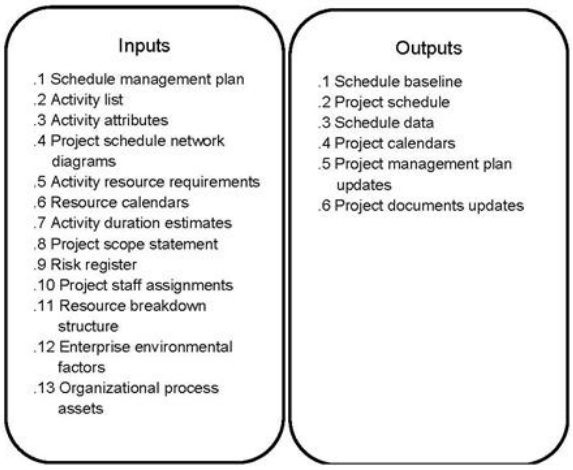

Figure A1-18. Develop Schedule: Inputs and Outputs

A1.5.12 Plan Cost Management

Plan Cost Management is a process that establishes the policies, procedures, and documentation for planning, managing, executing, and controlling project costs. The key benefit of this process is that it ensures that the cost management processes and their associated tools and techniques are documented. The inputs and outputs of this process are depicted in Figure A1-19.

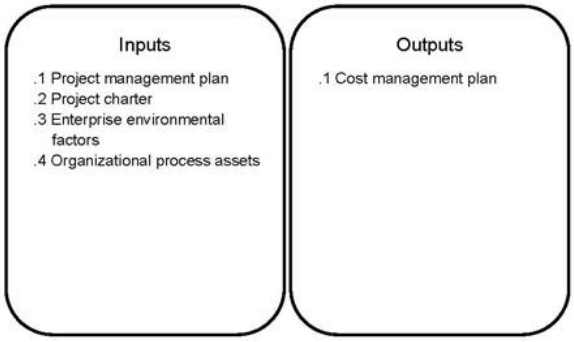

Figure A1-19. Plan Cost Management: Inputs and Outputs

A1.5.13 Estimate Costs

Estimate Costs is the process of developing an approximation of the monetary resources needed to complete project activities. The key benefit of this process is that it determines the amount of cost required to complete each activity. The inputs and outputs of this process are depicted in Figure A1-20.

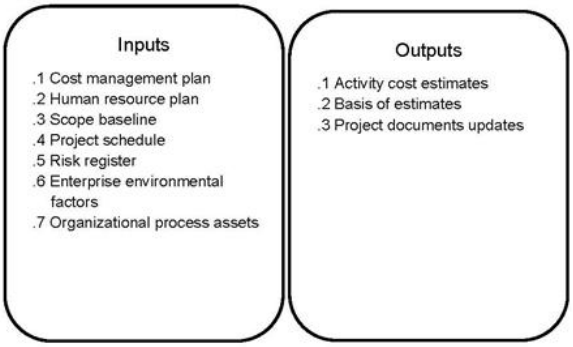

Figure A1-20. Estimate Costs: Inputs and Outputs

A1.5.14 Determine Budget

Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline. The key benefit of this process is that it determines the cost baseline which cost performance will be measured against and which future project performance can be monitored and controlled. The inputs and outputs of this process are depicted in Figure A1-21.

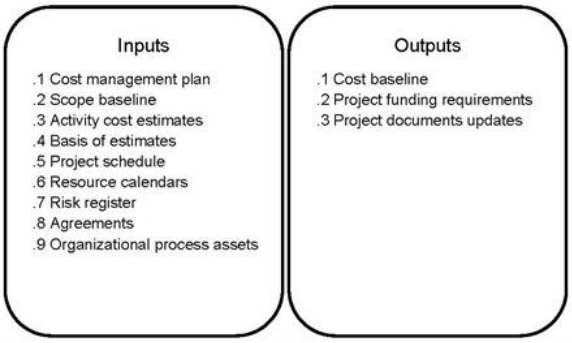

Figure A1-21. Determine Budget: Inputs and Outputs

A1.5.15 Plan Quality Management

Plan Quality Management is the process of identifying quality requirements and/or standards for the project and its deliverables, and documenting how the project will demonstrate compliance with relevant quality requirements. The key benefit of this process is that it provides guidance and direction on how quality will be managed throughout the project. The inputs and outputs of this process are depicted in Figure A1-22.

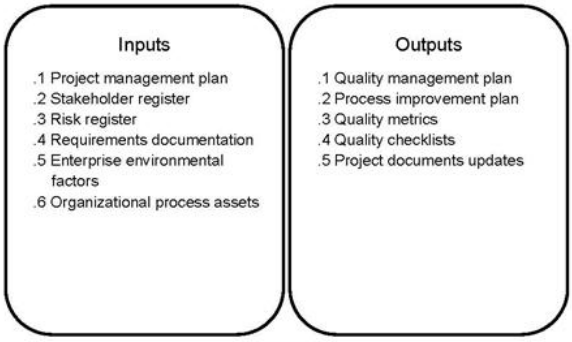

Figure A1-22. Plan Quality Management: Inputs and Outputs

A1.5.16 Plan Human Resource Management

Plan Human Resource Management is the process of identifying and documenting project roles, responsibilities, and required skills, reporting relationships, and creating a staffing management plan. The key benefit of this process is that it documents project roles and responsibilities, project organization charts, and the staffing management plan including the timetable for staff acquisition and release. The inputs and outputs of this process are depicted in Figure A1-23.

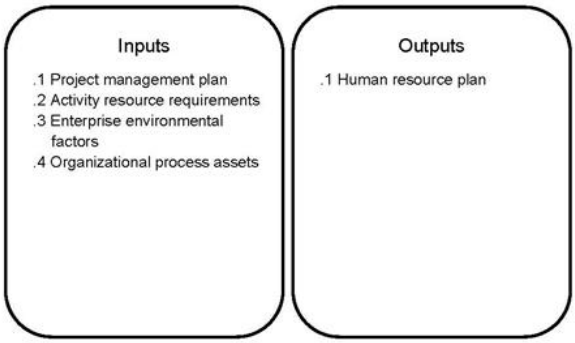

Figure A1-23. Plan Human Resource Management: Inputs and Outputs

A1.5.17 Plan Communications Management

Plan Communications Management is the process of gathering and analyzing the project stakeholder's information and requirements to develop an appropriate communications approach for the project. The key benefit of this process is that it documents the approach to communicate most effectively and efficiently with stakeholders. The inputs and outputs of this process are depicted in Figure A1-24.

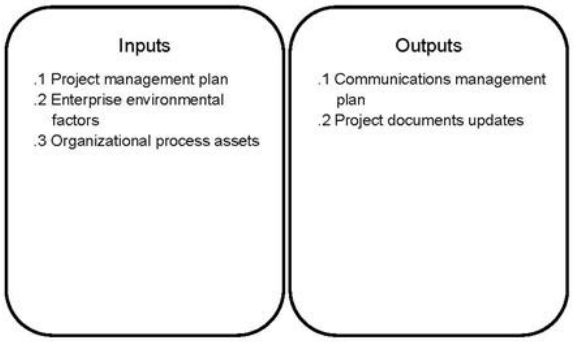

Figure A1-24. Plan Communications Management: Inputs and Outputs

A1.5.18 Plan Risk Management

Plan Risk Management is the process of defining how to conduct risk management activities for a project. The key benefit of this process is that it ensures that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization. The inputs and outputs of this process are depicted in Figure A1-25.

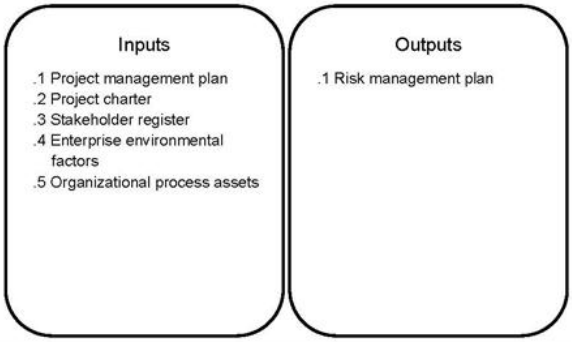

Figure A1-25. Plan Risk Management: Inputs and Outputs

A1.5.19 Identify Risks

Identify Risks is the process of determining which risks may affect the project and documenting their characteristics. The key benefit of this process is the documentation of existing risks and the knowledge and ability it provides to the project team to anticipate events. The inputs and outputs of this process are depicted in Figure A1-26.

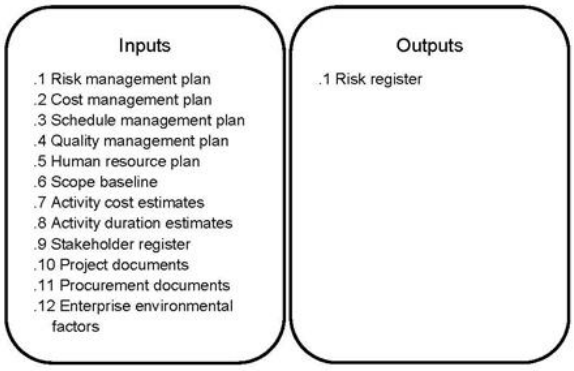

Figure A1-26. Identify Risks: Inputs and Outputs

A1.5.20 Perform Qualitative Risk Analysis

Perform Qualitative Risk Analysis is the process of prioritizing risks for further analysis or action by assessing and combining their probability of occurrence and impact. The key benefit of this process is that it enables organizations to reduce the level of uncertainty and to focus on high-priority risks. The inputs and outputs of this process are depicted in Figure A1-27.

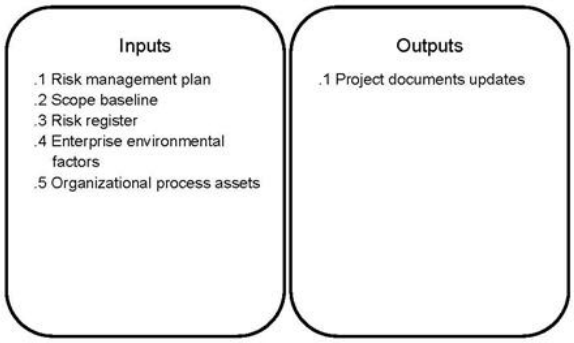

Figure A1-27. Perform Qualitative Risk Analysis: Inputs and Outputs

A1.5.21 Perform Quantitative Risk Analysis

Perform Quantitative Risk Analysis is the process of numerically analyzing the effect of identified risks on overall project objectives. The key benefit of this process is that it produces quantitative risk information to support decision making in order to reduce project uncertainty. The inputs and outputs of this process are depicted in Figure A1-28.

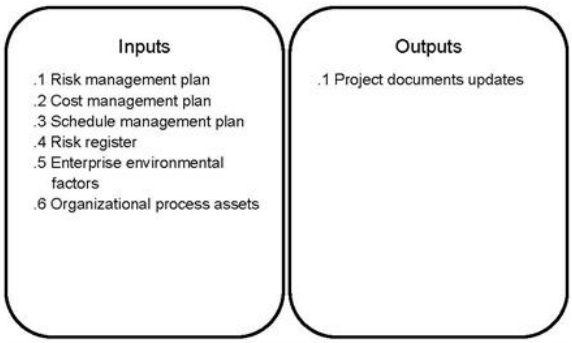

Figure A1-28. Perform Quantitative Risk Analysis: Inputs and Outputs

A1.5.22 Plan Risk Responses

Plan Risk Responses is the process of developing options and actions to enhance opportunities and to reduce threats to project objectives. The key benefit of this process is that it addresses the risks by their priority, inserting resources and activities into the budget, schedule and project management plan as needed. The inputs and outputs of this process are depicted in Figure A1-29.

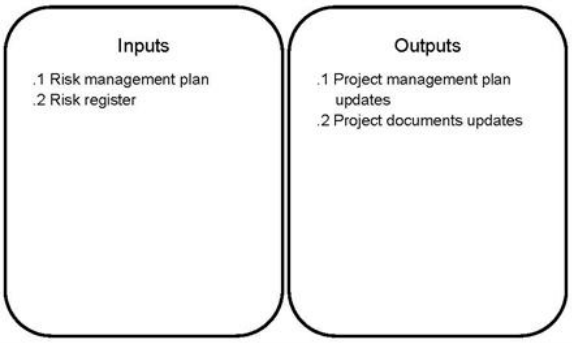

Figure A1-29. Plan Risk Responses: Inputs and Outputs

A1.5.23 Plan Procurement Management

Plan Procurement Managements is the process of documenting project purchasing decisions, specifying the approach, and identifying potential sellers. The key benefit of this process is that it determines whether to acquire outside support and, if so what to acquire, how to acquire it, how much is needed, and when to acquire it. The inputs and outputs of this process are depicted in Figure A1-30.

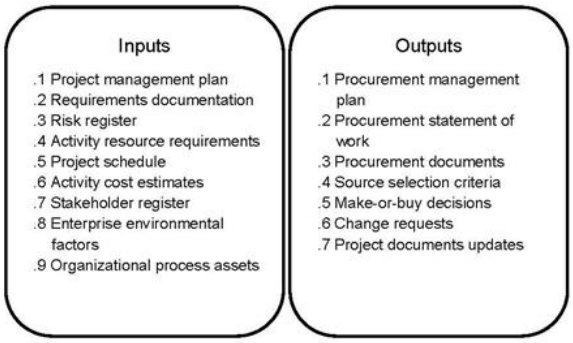

Figure A1-30. Plan Procurement Management: Inputs and Outputs

A1.5.24 Plan Stakeholder Management

Plan Stakeholder Management is the process of developing appropriate management strategies to effectively engage stakeholders in project decisions and execution based on the analysis of their needs, interests and potential impact. The key benefit of this process is that it provides a clear, actionable plan to interact with project stakeholders to support the project's interests. The inputs and outputs of this process are depicted in Figure A1-31.

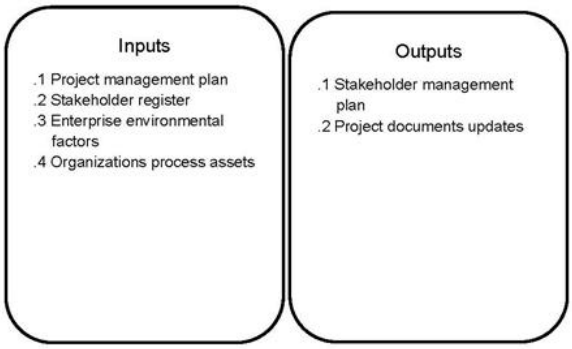

Figure A1-31. Plan Stakeholder Management: Inputs and Outputs

A1.6 Executing Process Group

The Executing Process Group consists of those processes performed to complete the work defined in the project management plan to satisfy the project specifications. 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 (Figure A1-32).

During project execution, results may require planning updates and rebaselining. This can include changes to expected activity durations, changes in resource productivity and availability, and unanticipated risks. Such variances may affect the project management plan or project documents and may require detailed analysis and development of appropriate project management responses. The results of the analysis can trigger change requests that, if approved, may modify the project management plan or other project documents and possibly require establishing new baselines. A large portion of the project's budget will be expended in performing the Executing Process Group processes. The Executing Process Group (Figure A1-32) includes the project management processes identified in Figures A1-33 through A1-40 (see Sections A1.6.1 through A1.6.8).

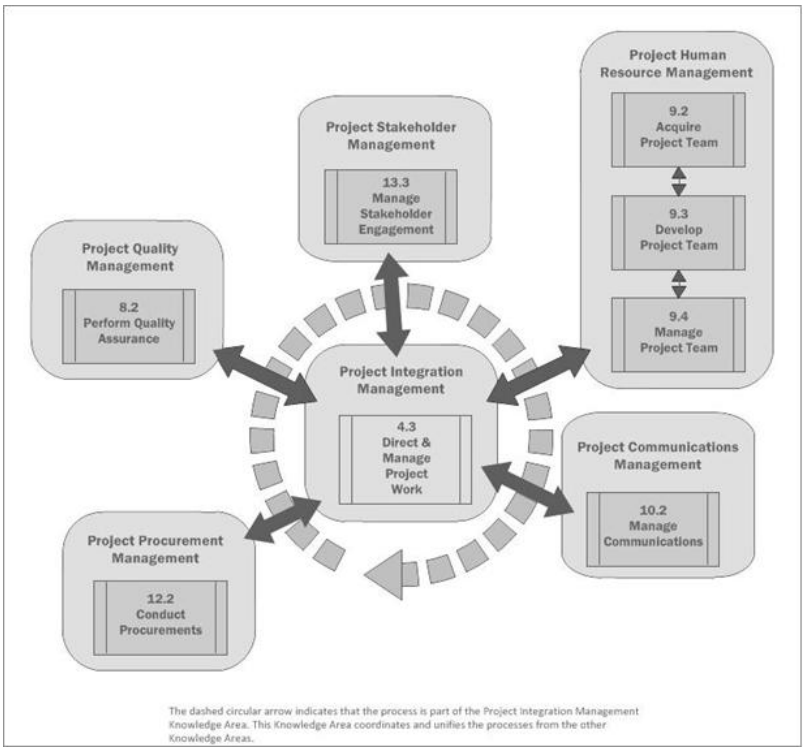

Figure A1-32. Executing Process Group

A1.6.1 Direct and Manage Project Work

Direct and Manage Project Work is the process of performing the work defined in the project management plan to achieve the project's objectives. The key benefit of this process is that it provides overall management of the project, including change control, cost and schedule management, and the successful delivery of the project. The inputs and outputs of this process are depicted in Figure A1-33.

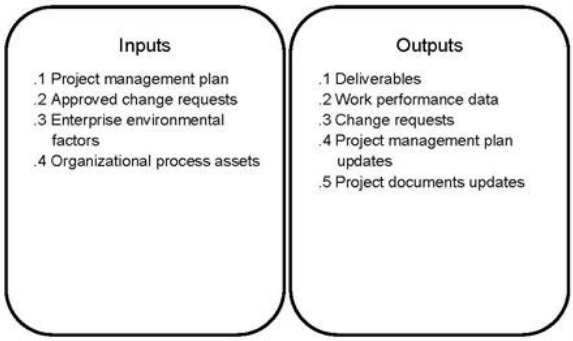

Figure A1-33. Direct and Manage Project Work: Inputs and Outputs

A1.6.2 Perform Quality Assurance

Perform Quality Assurance is the process of auditing the quality requirements and the results from control quality measurements to ensure that appropriate quality standards and operational definitions are used. The key benefit of this process is that it facilitates the improvement of quality processes. The inputs and outputs of this process are depicted in Figure A1-34.

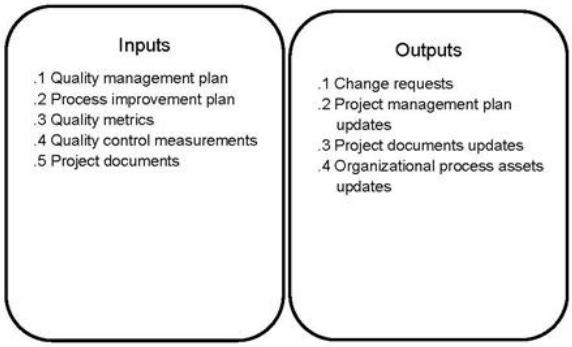

Figure A1-34. Perform Quality Assurance: Inputs and Outputs

A1.6.3 Acquire Project Team

Acquire Project Team is the process of confirming human resource availability and obtaining the team necessary to complete project assignments. The key benefit of this process is that it outlines and guides the process of team selection, responsibility, and assignment for implementation of a successful team. The inputs and outputs of this process are depicted in Figure A1-35.

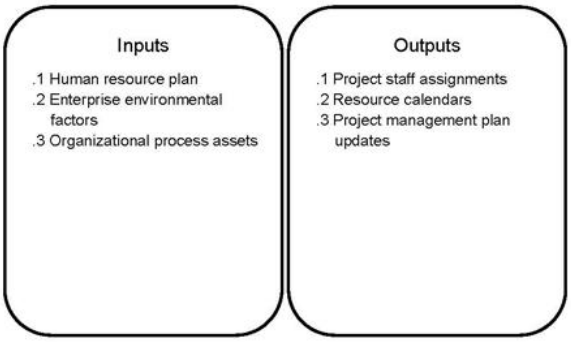

Figure A1-35. Acquire Project Team: Inputs and Outputs

A1.6.4 Develop Project Team

Develop Project Team is the process of improving the competencies, team interaction, and the overall team environment to enhance project performance. The key benefit of this process is that it results in improved teamwork, enhanced people skills and competencies, motivated employees, reduced staff turnover rates and improved overall project performance. The inputs and outputs of this process are depicted in Figure A1-36.

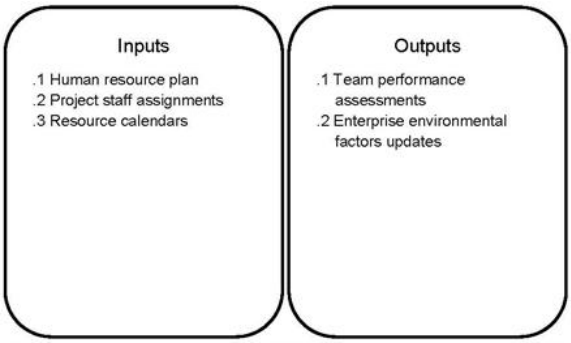

Figure A1-36. Develop Project Team: Inputs and Outputs

A1.6.5 Manage Project Team

Manage Project Team is the process of tracking team member performance, providing feedback, resolving issues, and managing changes to optimize project performance. The key benefit of this process is that it observes team behavior, manages conflict, resolves issues, and appraises team member performance. The inputs and outputs of this process are depicted in Figure A1-37.

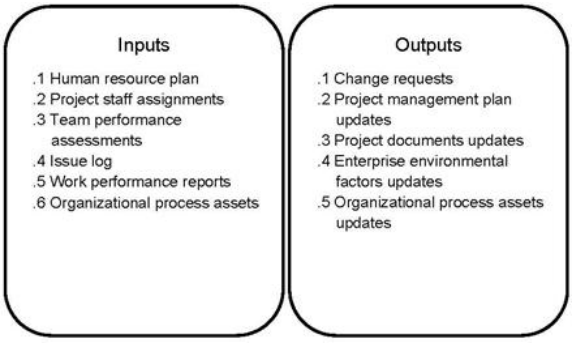

Figure A1-37. Manage Project Team: Inputs and Outputs

A1.6.6 Manage Communications

Manage Communications is the process of gathering project information for communications creation, distribution, storage, retrieval, and ultimate disposition in accordance with

the communications management plan. The key benefit of this process is that it enables an efficient communications flow between project stakeholders. The inputs and outputs of this process are depicted in Figure A1-38.

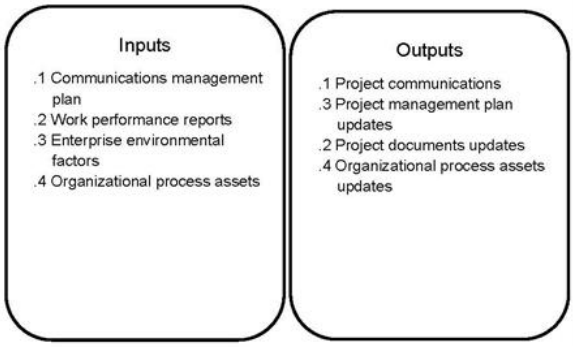

Figure A1-38. Manage Communications: Inputs and Outputs

A1.6.7 Conduct Procurements

Conduct Procurements is the process of obtaining seller responses, selecting a seller, and awarding a contract. The key benefit of this process is that it provides alignment of internal and external stakeholder expectations through established agreements. The inputs and outputs of this process are depicted in Figure A1-39.

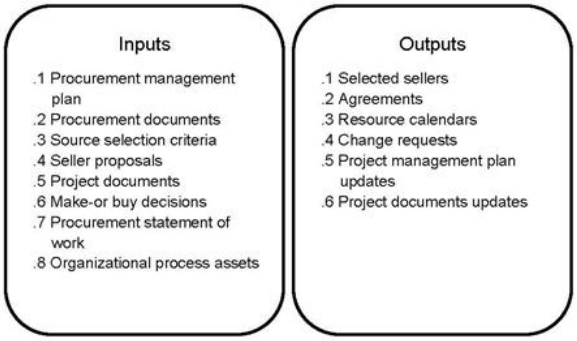

Figure A1-39. Conduct Procurements: Inputs and Outputs

A1.6.8 Manage Stakeholder Engagement

Manage Stakeholder Engagement is the process of communicating and working with stakeholders to meet their needs/expectations, address issues as they occur, and foster appropriate stakeholder engagement in project decisions and activities. The key benefit of this process is that it allows the project manager to increase support and minimize resistance from stakeholders, significantly increasing the chances to achieve project success. The inputs and outputs of this process are depicted in Figure A1-40.

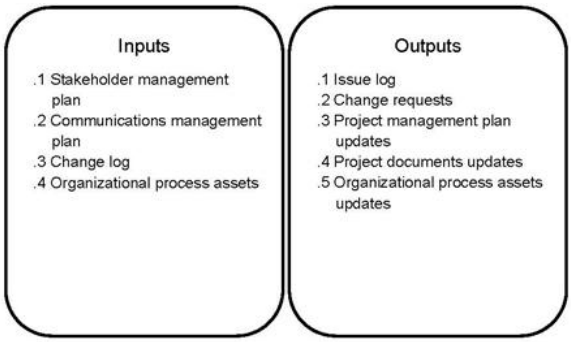

Figure A1-40. Manage Stakeholder Engagement: Inputs and Outputs

A1.7 Monitoring and Controlling Process Group

The Monitoring and Controlling Process Group consists of those processes required to track, review, and orchestrate the progress and performance of the project; as well as identify and initiate any areas in which changes to the plan are required. The key benefit of this Process Group is that project performance is measured and analyzed at regular intervals to identify variances from the project management plan. The Monitoring and Controlling Process Group also involves:

- Controlling changes and recommending preventive action in anticipation of possible problems,

• Monitoring the ongoing project activities against the project management plan and the project performance baseline, and
• Influencing the factors that could circumvent integrated change control or configuration management (as applicable in certain industrial sectors) so only approved changes are implemented.

This continuous monitoring provides the project team insight into the health of the project and identifies any areas requiring 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 multiphase projects, the Monitoring and Controlling Process Group coordinates project phases in order to implement corrective or preventive actions to bring the project into compliance with the project management plan. This review can result in recommended and approved updates to the project management plan. For example, a missed activity finish date may require adjustments to the current staffing plan, reliance on overtime, or trade-offs between budget and schedule objectives. The Monitoring and Controlling Process Group (Figure A1-41) includes the following project management processes (Figures A1-7.1 through A1-7.11):

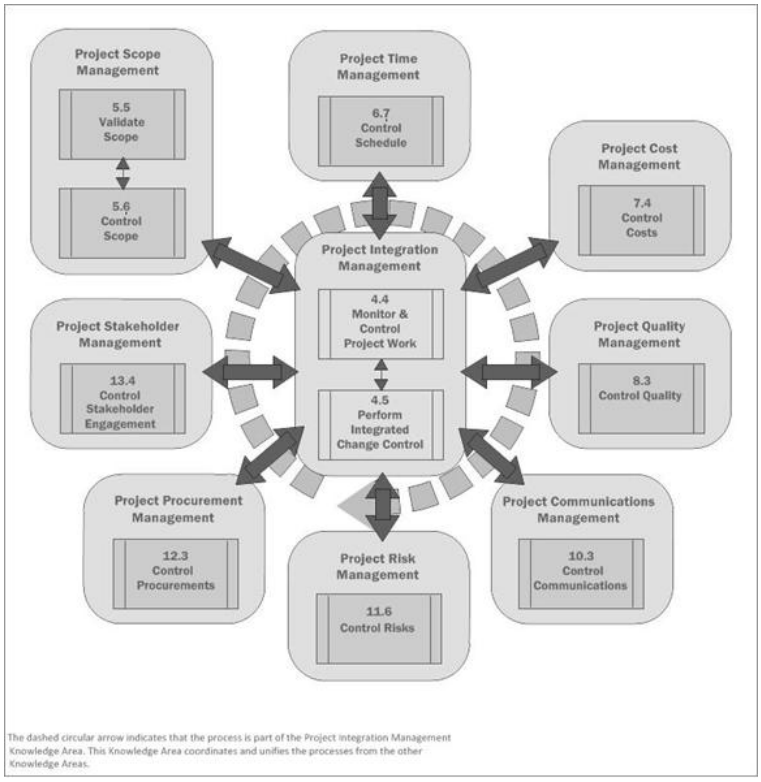

Figure A1-41. Monitoring and Controlling Process Group

A1.7.1 Monitor and Control Project Work

Monitor and Control Project Work is the process of tracking, reviewing, and regulating the progress to meet the performance objectives defined in the project management plan. The key benefit of this process is that it allows stakeholders to understand the current state of the project, the route taken, and budget, schedule and scope forecasts. The inputs and outputs of this process are depicted in Figure A1-42.

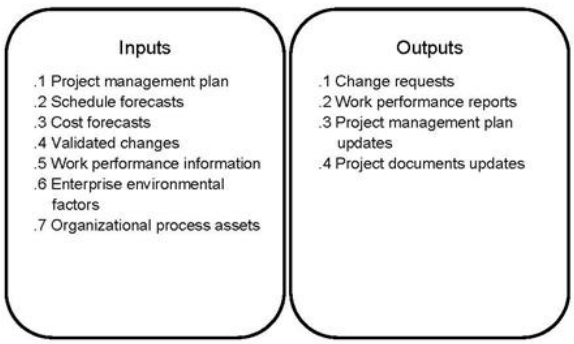

Figure A1-42. Monitor and Control Project Work: Inputs and Outputs

A1.7.2 Perform Integrated Change Control

Perform Integrated Change Control is the process whereby modifications to documents, deliverables, or baselines associated with the project are identified, documented, approved, or rejected. The key benefit of this process is that it allows for documented changes within the project. The inputs and outputs of this process are depicted in Figure A1-43.

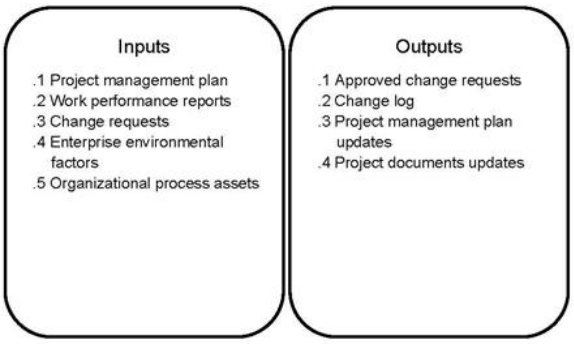

Figure A1-43. Perform Integrated Change Control: Inputs and Outputs

A1.7.3 Validate Scope

Validate Scope is the process of formalizing acceptance of the completed project deliverables. The key benefit of this process is that it brings objectivity to the acceptance process. The inputs and outputs of this process are depicted in Figure A1-44.

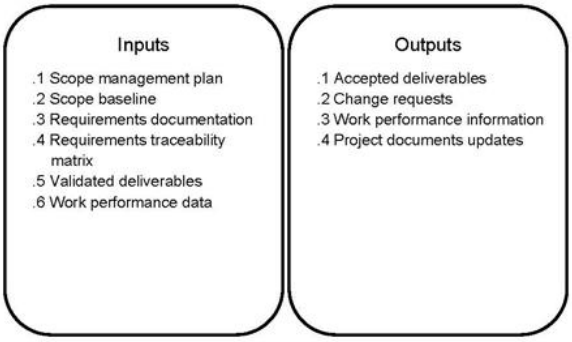

Figure A1-44. Validate Scope: Inputs and Outputs

A1.7.4 Control Scope

Control Scope is the process of monitoring the status of the project and product scope and managing changes to the scope baseline. The key benefit of this process is that it allows the scope baseline to be maintained throughout the project. The inputs and outputs of this process are depicted in Figure A1-45.

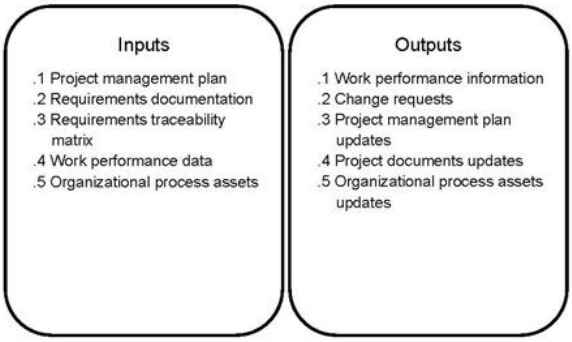

Figure A1-45. Control Scope: Inputs and Outputs

A1.7.5 Control Schedule

Control Schedule is the process of monitoring the status of the project activities to update project progress and managing changes to the schedule baseline. The key benefit of this process is that it provides the means to recognize variance from plan and take corrective action and thus minimize risk. The inputs and outputs of this process are depicted in Figure A1-46.

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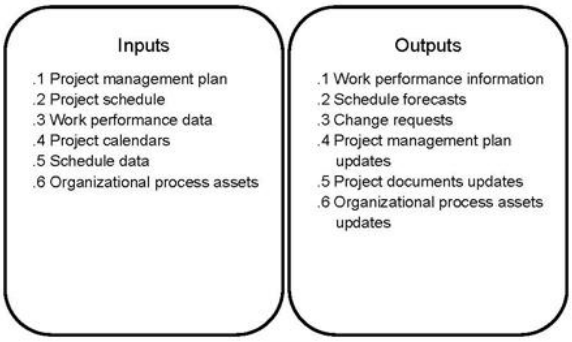

10033 Figure A1-46. Control Schedule: Inputs and Outputs

10034 **A1.7.6 Control Costs**

10035 Control Costs is the process of monitoring the status of the project to update the project
10036 budget and managing changes to the cost baseline. The key benefit of this process is that
10037 it provides the means to recognize variance from plan and take corrective action and thus
10038 minimize risk. The inputs and outputs of this process are depicted in Figure A1-47.
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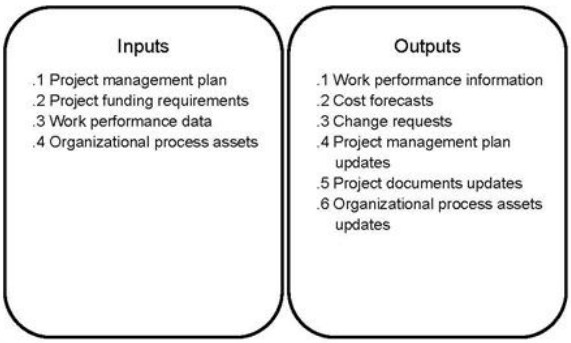

10041 Figure A1-47. Control Costs: Inputs and Outputs

10042 **A1.7.7 Control Quality**

10043 Control Quality is the process of monitoring and recording results of executing the
10044 quality activities to assess performance and recommend necessary changes. The key benefit
10045 of this process is that it identifies causes of poor process or product quality and
10046 recommends and/or takes action to eliminate them. The inputs and outputs of this process
10047 are depicted in Figure A1-48.
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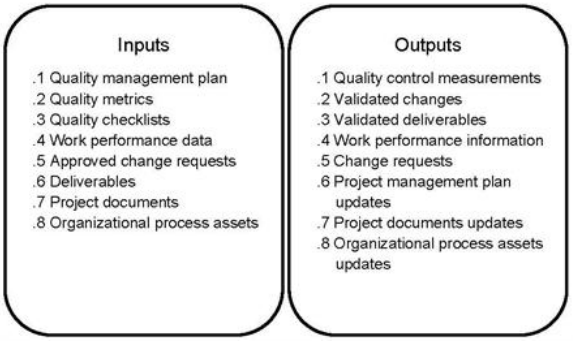

10050 Figure A1-48. Control Quality: Inputs and Outputs

10051 **A1.7.8 Control Communications**

10052 Control Communications is the process of monitoring and controlling of communications
10053 throughout the entire project life cycle to ensure the information needs of project
10054 stakeholders are met. The key benefit of this process is that it ensures an optimal
10055 information flow between all communication participants, at any moment in time. The inputs
10056 and outputs of this process are depicted in Figure A1-49.
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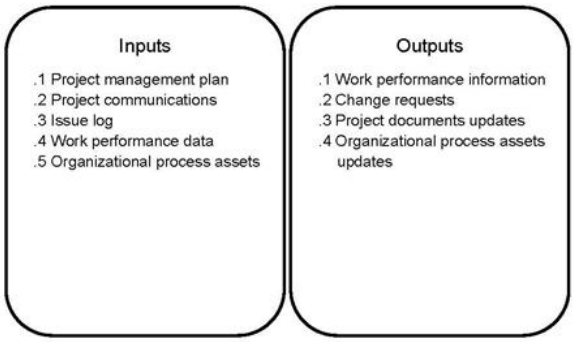

Figure A1-49. Control Communications: Inputs and Outputs

A1.7.9 Control Risks

Control Risks is the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project. The key benefit of this process is that it improves efficiency of the risk approach throughout the project life cycle to continuously optimize risk responses. The inputs and outputs of this process are depicted in Figure A1-50.

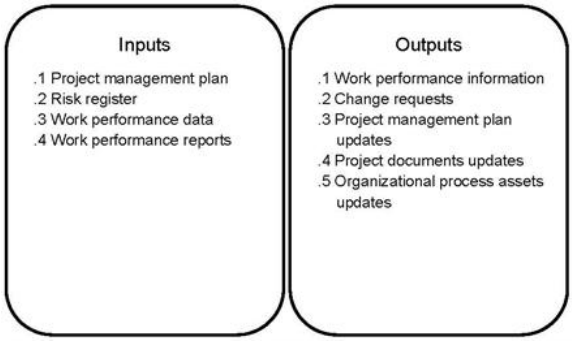

Figure A1-50. Control Risks: Inputs and Outputs

A1.7.10 Control Procurements

Control Procurements is the process of managing procurement relationships, monitoring contract performance, and making changes and corrections as needed. The key benefit of this process is that it ensures that the seller's performance meets procurement requirements and that the buyer performs according to the terms of the legal contract. The inputs and outputs of this process are depicted in Figure A1-51.

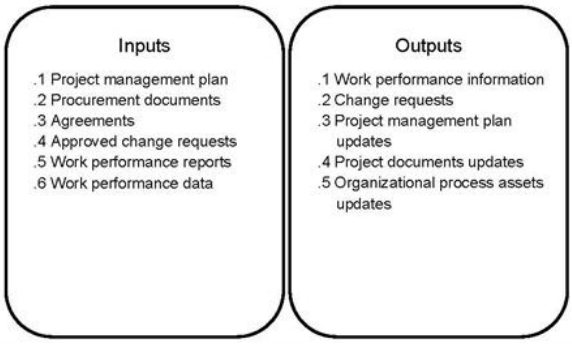

Figure A1-51. Control Procurements: Inputs and Outputs

A1.7.11 Control Stakeholder Engagement

Control Stakeholder Engagement is the process of monitoring overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders. The key benefit of this process is that it will maintain or increase the efficiency of stakeholder engagement activities as the project evolves and its environment changes. The inputs and outputs of this process are depicted in Figure A1-52.

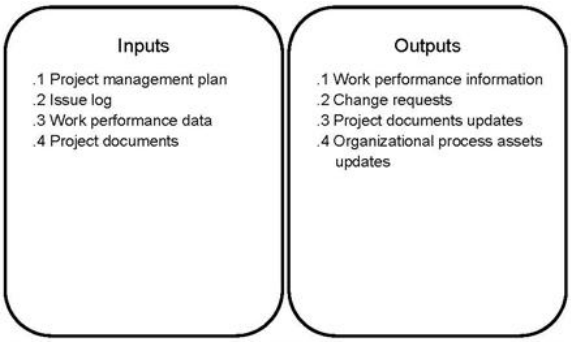

Figure A1-52. Control Stakeholder Engagement: Inputs and Outputs

A1.8 Closing Process Group

The Closing Process Group consists of those processes performed to conclude all activities across all Project Management Process Groups to formally complete the project, phase, or contractual obligations. 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 complete.

This Process Group also formally establishes that a prematurely closed project or a phase is complete in all facets. Prematurely closed projects include aborted projects, cancelled projects, projects in exception, etc.

At project or phase closure, the following may occur:

- Obtain acceptance by the customer or sponsor to formally close the project or phase,
- Conduct post-project or phase-end review,
- Record impacts of tailoring to any process,
- Document lessons learned,
- Apply appropriate updates to organizational process assets,
- Archive all relevant project documents in the project management information system (PMIS) to be used as historical data, and
- Close out all procurements.

The Closing Process Group (Figure A1-53) includes the following project management processes (See Sections A1.8.1 and A1.8.2):

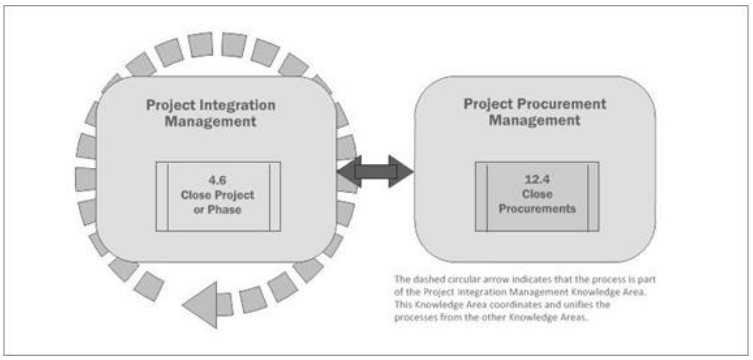

Figure A1-53. Closing Process Group

A1.8.1 Close Project or Phase

Close Project or Phase is the process of finalizing all activities across all of the Project Management Process Groups to formally complete the project or phase. The key benefit of this process is that it provides lessons learned and the formal ending of project related work. The inputs and outputs of this process are depicted in Figure A1-54.

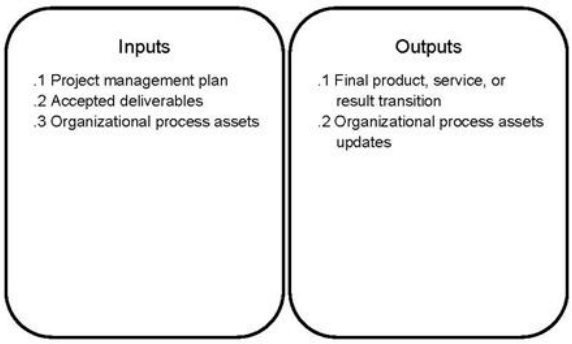

Figure A1-54. Close Project or Phase: Inputs and Outputs

A1.8.2 Close Procurements

Close Procurements is the process of completing each procurement. The key benefit of this process is that it documents agreements and related documentation for future reference. The inputs and outputs of this process are depicted in Figure A1-55.

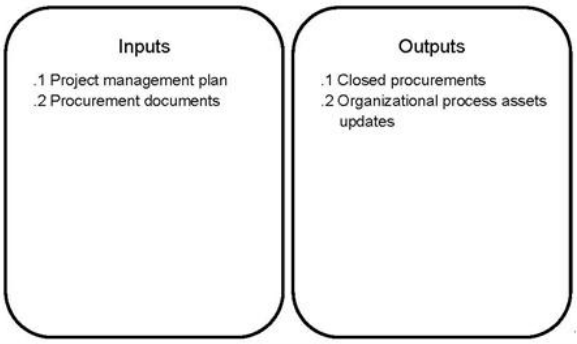

Figure A1-55. Close Procurements: Inputs and Outputs