

Chapter 1 Introduction

A Guide to the Project Management Body of Knowledge (PMBOK® Guide) is the recognized standard for the project management profession. As with other professions such as law, medicine, and accounting, the knowledge contained in this standard evolved from the good practices of project management practitioners who have contributed to the development of this standard. The complete Project Management Body of Knowledge is a collection of recognized good practices that are widely applied by project management professionals and practitioners for the successful management of projects.

The *PMBOK® Guide* provides guidelines for managing individual projects within an organization. It defines project management and related concepts, describes the project management life cycle, and outlines related processes.

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

1.1 Project Management Standard Purpose

1.2 What is a Project?

1.3 What is Project Management?

1.4 Relationship Between Project Management, Program Management, and Portfolio Management

1.5 Project Management in Operations Management

1.6 Role of the Project Manager

1.7 Project Management Body of Knowledge

1.8 Enterprise Environmental Factors

1.1 Project Management Standard Purpose

The increasing success of project management indicates that the application of appropriate knowledge, processes, skills, tools, and techniques can have an impact on the success of projects. To provide readers with a general overview of the project management discipline, the *PMBOK® Guide* identifies that subset of the Project Management Body of Knowledge 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.** This method that allows the standards to work for most projects most of the time is called “project tailoring.”

The project manager, with approval from the project sponsor, will typically use a certain level of rigor based on the type of project. It is important that agreed-upon tailoring requirements

are documented in the project management plan. This ensures that the project team will follow the standards defined for the 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 Institute (PMI) views this standard as a foundational project management reference for its professional development programs, including:

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

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

In addition to the standards that establish guidelines for project management processes, tools, and techniques, there is a code that guides practitioners of the profession of project management. The Project Management Institute *Code of Ethics and Professional Conduct* describes the expectations practitioners have of themselves and others. The Code is specific about the basic obligation of honesty and fairness. It requires that practitioners demonstrate a commitment to honesty, ethical conduct, and compliance with laws and regulations. It carries the obligation to comply with organizational and professional policies and laws. Since practitioners come from diverse backgrounds and cultures, the *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 PMI's website.

1.2 What is a Project?

Projects differ from other types of work. A project is a temporary endeavor undertaken to create a unique product, service, or result. These temporary and unique characteristics determine if a particular endeavor is a project.

If an organization determines the nature of the work to be temporary and unique, it may decide to apply project management principles. Managing work by applying the project management standard allows organizations to achieve a set of business objectives more efficiently and effectively.

The temporary nature of projects indicates a definite beginning and definite end. The end is reached when the project's objectives have been achieved, when the project is terminated because its objectives will not or cannot be met, or the need for the project no longer exists. Temporary does not necessarily mean short in duration; many projects last for several years. 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.

The duration of a project is finite. A project's duration can range from a few weeks to several years. It may involve a simple set of activities (such as organizing a picnic) or a very complex effort (such as the design of a new space shuttle). The project team, as a working unit, is created for the sole purpose of accomplishing a project's objectives. When a project attains its objective or it is terminated for some reason, the project reaches its end and the project team is disbanded. Typically, project team members move on to other projects or return to their original organizational assignments. Conversely, teams involved in the other types of work (i.e., non-project but "operational") are not necessarily disbanded when the work achieves its objectives; a new set of objectives is adopted and the work continues.

The unique nature of projects means every project creates a specific product, service, or result that differentiates it from other products, services, or results. Although repetitive elements may be present in some project deliverables, this does not change the fundamental uniqueness of the project work. For example, many office buildings are constructed with the same or similar materials or by the same team, but each facility is unique--with a different design, different location, different contractors, and so on.

An ongoing work effort is generally a stable 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 is quantifiable and 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, and
 - Implementing a new business process or procedure.

1.3 What is Project Management?

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. Project management is accomplished through the

appropriate application and integration of the project management process groups. These process groups consist of:

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

The project manager, along with the project team, is responsible for accomplishing the project objectives.

Managing a project typically includes:

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

Project managers deliver projects while balancing the requirements of the scope, schedule, quality, and budget. 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. 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 and balance the demands in order to deliver a successful project.

Project management processes are iterative because of the progressive elaboration that occurs throughout the project's life cycle. Progressive elaboration involves continuously improving and detailing a plan as more 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 Relationship Between Project Management, Program Management, and Portfolio Management

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

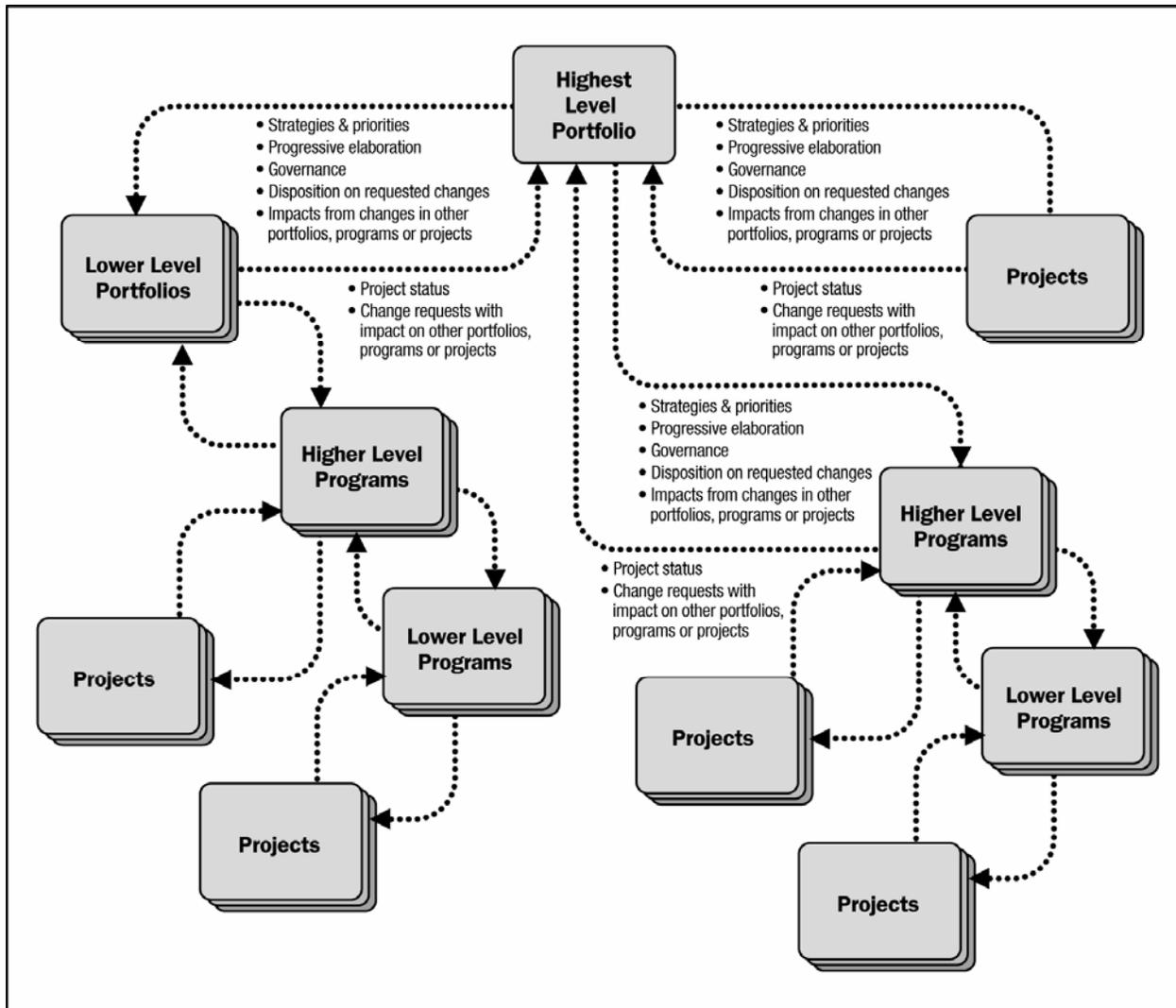


Figure 1-1. Portfolio, Program, and Project Management Interactions

1.4.1 Portfolio Management

A portfolio refers to a collection of projects or programs and other work that is grouped together to facilitate effective management. The projects or programs of a 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 and includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work. 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 refers to a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements of related work outside the scope of the discrete projects in the program. Some examples of programs include:

- A new car model program that involves projects for the design and upgrades of each major component (e.g., the transmission, engine, interior, and exterior) while ongoing manufacturing occurs on an assembly line, and
- An electronics firm that has program managers who are responsible for both individual product releases (projects) and the coordination of multiple releases over a period of time (an ongoing operation).

Program management can be viewed as the centralized, coordinated management of a group of projects to achieve the program's objectives and benefits. Programs can involve several repetitive or cyclical undertakings. For example, utility companies may combine a series of projects into an annual "construction program."

1.4.3 Projects and Strategic Planning

Projects are a means of organizing activities that cannot be addressed within the organization's normal operational limits. Projects are 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. Some examples of these include, but are not limited to:

- Market demands (e.g., an oil company authorizes a project to build a new refinery in response to chronic gasoline shortages),
- Organizational needs (e.g., a training company authorizes a project to create a new course to increase its revenues),
- Customer requests (e.g., an electric utility authorizes a project to build a new substation to serve a new industrial park),
- Technological advances (e.g., a software firm authorizes a new project to develop a new generation of video games after the introduction of new game-playing equipment by electronics firms), or
- 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 often also contribute to consolidated benefits as defined by the program.

Organizations manage their portfolios based on their strategic plan, which may dictate a hierarchy in the portfolio, program, or projects. One goal of portfolio management is to maximize the value of the portfolio by the careful examination of the candidate projects. Those projects not expected to meet the portfolio's strategic objectives may be excluded. The organization's strategic plan and available resources guide these investments in projects.

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 component projects by means of project prioritization. Organizational planning can direct the funding and support for the component projects on the basis of risk/reward categories, specific lines of business, or general types of projects, such as infrastructure and internal process improvement.

At the same time, projects provide feedback to programs and portfolios by means of status reports and change requests that may impact other projects, programs, and 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 that can be responsible for the centralized and coordinated management of the projects, programs, and portfolios under its domain. 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 is dependent upon the needs of the organization that it supports.

A PMO may be delegated authority to act as an integral stakeholder and a key decision-maker during the initiation phase of each project, to make recommendations, or to terminate projects to keep business objectives consistent. In addition, the PMO may be involved in the selection, management, and redeployment of shared or dedicated project resources.

Some of the key features of a PMO 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,
- Developing and managing project policies, procedures, templates, and other shared documentation, and
- Coordinating communication across projects.

Project managers and PMOs pursue different objectives and, as such, are driven by different requirements. All of these efforts, however, are aligned with the strategic needs of the organization. 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 and can view them as potential opportunities to better achieve business objectives.
- The project manager controls the assigned project resources to best meet project objectives, while the PMO optimizes the use of shared organizational resources across all projects.
- The project manager manages the scope, schedule, cost, and quality of the products of the work packages, while the PMO manages the overall risk, overall opportunity, and interdependencies among projects at the enterprise level.

1.5 Project Management in Operations Management

While business goals are achieved through operations, new objectives are typically initiated through projects. Though temporary in nature, projects can help achieve the organizational goals when they are aligned with operations. Organizations sometimes change their operations or products by creating strategic business initiatives that use projects, programs, and portfolios. Projects require project management while operations require business process management or operations management. Projects intersect with operations at various points during the product life cycle:

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

At each point, deliverables and knowledge are transferred from the project to operations for implementation of the delivered work. This occurs through a temporary 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 people assigned to do basically the same set of tasks according to the standards institutionalized in a product life cycle. Conversely, a project is a temporary endeavor where a team produces and executes a temporary project management plan.

1.6 Role of the Project Manager

The role of a project manager is distinct from that of a functional manager. Typically the functional manager is focused on providing management oversight for an operational department and the resources that support the functional area. The project manager is involved with the planning, controlling and monitoring, as well as managing and directing the resources associated with a project. The project manager is also responsible to the project stakeholders for delivering a project's objectives within scope, schedule, cost, and quality.

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 program manager that is ultimately responsible for enterprise-wide projects. In this type of structure, the project manager works closely with the program manager to achieve the project objectives and to ensure the project plan aligns with the overarching program plan.

Project managers assemble metrics (such as baseline and actual values for costs, schedule, work in progress, and work completed) for individual components and analyze these metrics to effectively manage their respective project. If the project is managed under a program or portfolio, the project manager regularly reports these metrics and the results of their analyses to the program/portfolio manager and other appropriate stakeholders.

1.6.1 Project Management Skills

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 or competencies required for the project, effective project management requires that the

project management team acquire the following three dimensions of project management competencies:

- .1 Project Management Knowledge Competency.** This refers to what the project management team knows about project management.
- .2 Project Management Performance Competency.** This refers to what the project management team is able to do or accomplish while applying their project management knowledge.
- .3 Personal Competency.** This refers to how the project management team behaves when performing the project or activity. Personal competency encompasses attitudes and core personality characteristics.

1.7 Project Management Body of Knowledge

The *PMBOK® Guide* is the standard for managing most projects most of the time across many types of industries. This standard describes project management processes, tools, and techniques for managing scope, schedule, quality, and cost, as well as any project environment aspects that influence the project's 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.

The following list contains some of the areas which have overlap or interdependencies:

- Definition of a project,
- Definition of a program,
- Definition of a portfolio,
- Relationship between project management and program management,
- Relationship between project management and portfolio management,
- Stakeholder management, and
- Governance.

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. Management of programs is addressed in *The Standard for Program Management*, and management of portfolios is addressed in *The Standard for Portfolio Management*. Examination of an enterprise's project management process capabilities is addressed in *Organizational Project Management Maturity Model (OPM3®)*. There are additional standards which address organizational project management maturity, project manager competency, and other topics that are generally recognized as good practices in those areas.

1.8 Enterprise Environmental Factors

Enterprise Environmental Factors (EEFs) refer to any or all external environmental factors and internal organizational environmental factors that surround or influence a project's success. These factors may come from any or all of the enterprises involved in the project and may include the

organizational culture and structure, infrastructure, existing resources, commercial databases, market conditions, project management software, etc..

Enterprise Environmental Factors may constrain project management options and may have a positive or negative influence on the outcome. They are considered as inputs to most planning processes.

Enterprise Environmental Factors include, but are not limited to the following:

- Organizational culture and structure,
- 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., hiring and firing guidelines, employee performance reviews, and training records),
- Company work authorization systems,
- Marketplace conditions,
- Stakeholder risk tolerances,
- Commercial databases (e.g., standardized cost estimating data, industry risk study information, and risk databases), or
- 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).

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. The project management team must understand this broader context to ensure work is carried out in alignment with the goals of the enterprise, and managed in accordance with the established practices of the organization. This chapter describes the basic structure of a project as well as other important high-level considerations including how projects impact ongoing operational work, the influence of stakeholders beyond the immediate project team, and how organizational structure affects the way the project is staffed, managed, and executed. The following major sections are discussed:

2.1 The Project Life Cycle -- Overview

2.2 Projects vs. Operational Work

2.3 Stakeholders

2.4 Organizational Influences on Project Management

2.1 The Project Life Cycle – Overview

A project life cycle is a collection of generally sequential project phases whose name and number are determined by the control needs of the organization or organizations involved in the project. A life cycle can be documented with a methodology. While every project has a definite start and a definite end, the specific deliverables and activities that take place in between will vary widely from project to project. The life cycle provides the basic framework for managing the project, regardless of the specific work involved.

2.1.1 Characteristics of the Project Life Cycle

Projects can vary in size and complexity from a simple project to a more elaborate and complex endeavor, such as designing and producing a new aircraft. No matter how large or small, simple or complex, all projects can be mapped to the following generic life cycle structure (see Figure 2-1):

- Starting the project,
- Organizing and preparing,
- Carrying out the project work, and
- Finishing 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. This high-level view can provide a common frame of reference for comparing projects--even if they are dissimilar in nature.

The generic life cycle structure generally consists of 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 2-1 illustrates this typical pattern.

- Figure 2-2 illustrates that the level of uncertainty and the risk of failing to achieve the project objectives are greatest at the start of the project. Uncertainty and overall project risk decrease over the life of the project.
- 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 2-2 illustrates the idea that the cost of changes and correcting errors typically increases substantially as the project approaches completion.

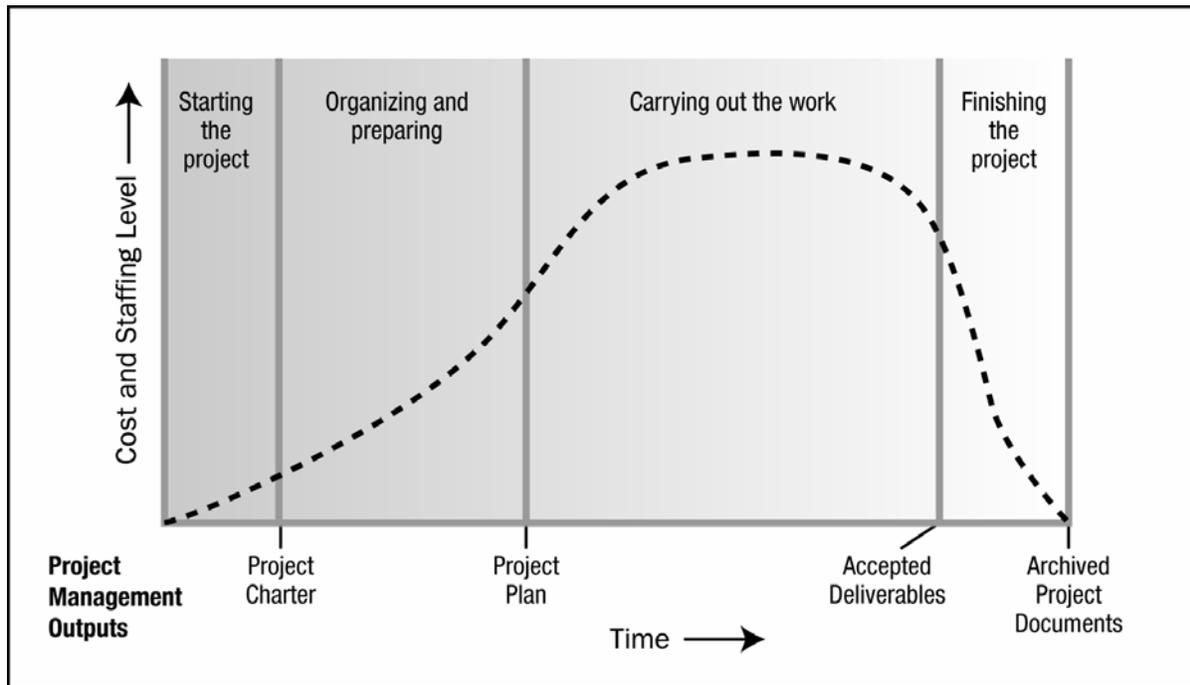


Figure 2-1. Typical Cost and Staffing Levels Across the Project Life Cycle

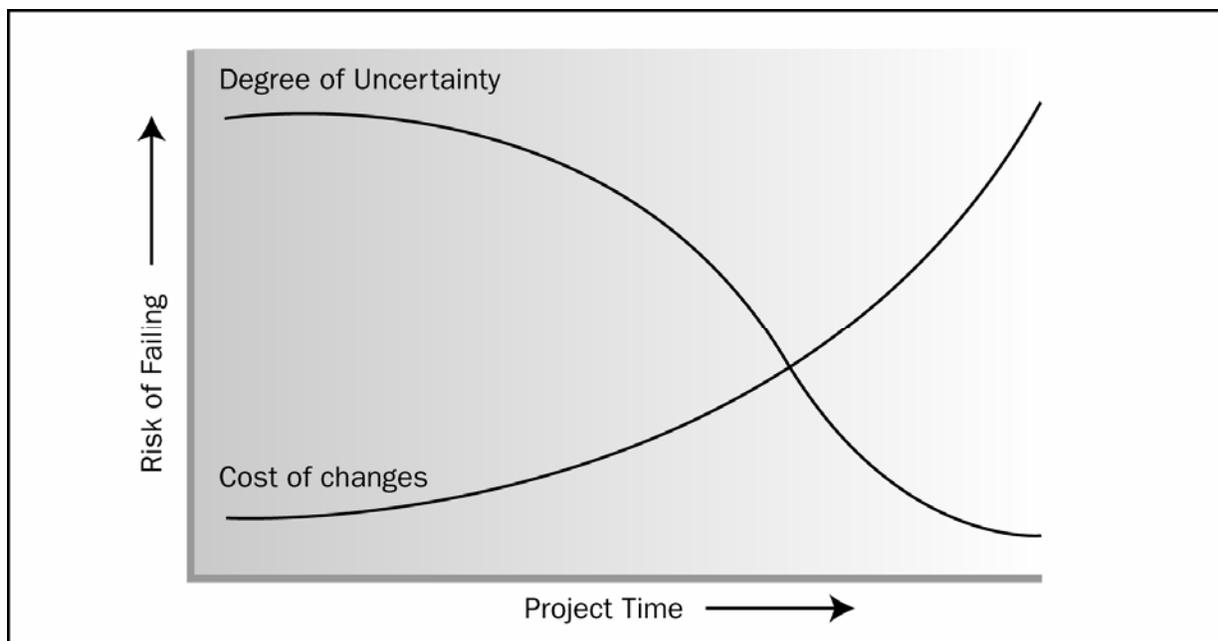


Figure 2-2. Stakeholder Influence Over Time

Within the context of the generic life cycle structure, a project manager may determine the need for more effective control over certain high-level work deliverables. 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 divided into phases.

2.1.2 Relationship to a Product's Life Cycle

Product life cycle is a collection of generally sequential, non-overlapping product phases whose name and number are determined by the manufacturing and control need of the organization. The last product life cycle phase for a product is generally the product's retirement. Generally, a project life cycle is contained within one or more product life cycles. Care should be taken to distinguish the project life cycle from the product life cycle. All projects have a purpose or objective, but in those cases where the objective is a service or result, there may be no product life cycle involved.

When the output of the project is related to a product, there are many possible relationships. For instance, the development of a new product could be a project on its own. Alternatively, an existing product might benefit from a project to add new functions or features, or a project might be created to develop a new model. Many facets of the product life cycle lend themselves to being run as small projects, for example: performing a feasibility study, conducting market research, running an advertising campaign, installing a product, holding focus groups, trialing a product in a test market, etc. In each of these examples the project life cycle would differ from the product life cycle.

Since one product may have many projects associated with it, additional efficiencies may be gained by managing all related projects collectively. For instance, a number of separate projects may be related to the development of a new automobile. Each project may be distinct, but still contributes a key deliverable necessary to bring the automobile to market. Oversight of all projects by a higher authority could significantly increase the likelihood of success. Managing a group of projects in a coordinated way, to obtain benefits not available from managing them separately, is within the scope of program management.

2.1.3 Project Phases

Project phases are a collection of logically related project activities, usually culminating in the completion of a major deliverable. Project phases are mainly completed sequentially, but can overlap in some project situations. Phases can be subdivided into subphases and then into components. A project phase is an element of a project life cycle. A project phase is not a project management process group.

Many projects can be effectively carried out as a single phase. Large or complex projects may be divided into separate phases. **Project phases are not the same as the divisions of the generic life cycle structure described in Section 2.1.1.** Regardless of the number of phases comprising a project, all phases have similar characteristics:

- Phases are generally sequential and involve some form of transfer or handoff of the work product produced as the phase deliverable.
- The work has a distinct focus that differs from any other phase. This often involves different organizations and different skill sets.
- Repeating project management process groups within each phase adds value by providing an extra degree of control necessary to effectively manage the project.

- The end of a phase represents a natural point to reassess the effort underway and to change or terminate the project if necessary. These are referred to as phase exits, phase gates, decision gates, or kill points.

Although many projects may have similar phase names with similar deliverables, few are identical. Some will have only one phase, as shown in Figure 2-3. Other projects may have six or more. Figure 2-4 shows an example of a project with three phases. Note that different phases typically have a different duration or length.

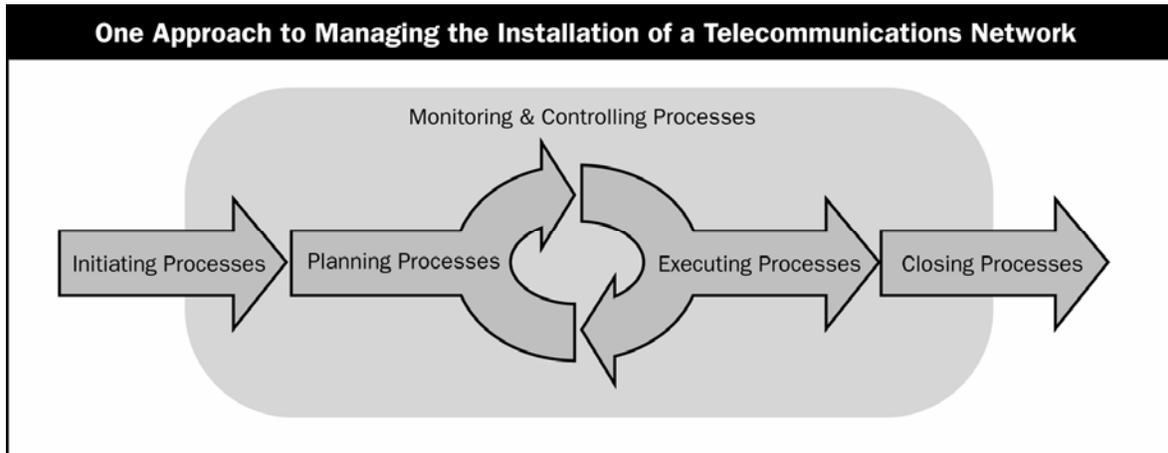


Figure 2-3. Example of a Single-Phase Project

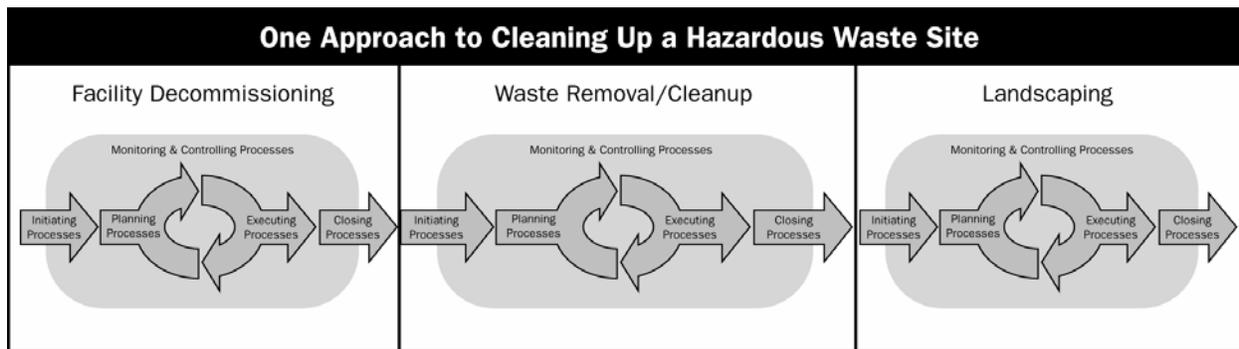


Figure 2-4. Example of a Three-Phase Project

There is no single 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 organizations have established policies that standardize all projects under a single model, while others allow the project management team to choose the most appropriate model for their individual project. For instance, one organization may treat a feasibility study as routine pre-project work, another may treat it as the first phase of a project, and a third might treat the feasibility study as a separate, stand-alone project. Likewise, one project team might divide a project into two phases where a different project team might have chosen 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.

.1 Project Governance Across the Life Cycle

Project governance is a management approach taken to support project delivery. Ultimately, governance provides a comprehensive, uniform method of controlling the project and ensuring its success. The project governance approach is described in the project management plan.

A project's governance must fit within the larger context of the program or organization sponsoring it. Within those constraints, as well as the additional limitations of budget and cost, it is up to the project manager and the project management team to determine the most appropriate method of carrying out the project. Decisions must be 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, what will the specific phased structure look like for the individual project?

The governance of larger and more complex projects split into multiple phases may require additional controls. Each phase is formally initiated to specify what is allowed and expected for that phase. A management review is often held to reach a decision to start the activities of a phase. This is especially true when a prior phase has not yet completed--for example, when an organization chooses a life cycle where more than one phase of the project progresses simultaneously. The beginning of a phase is also a time to revalidate earlier assumptions and define in more detail the activities and processes necessary to complete the phase deliverable or deliverables. For instance, if a particular phase does not require purchasing any new materials or equipment there would be no need to carry out the activities or processes associated with procurement.

A project phase is generally concluded and formally closed with a review of the deliverable to determine completeness and acceptance. A phase-end review can achieve the combined goal of obtaining authorization to close the current phase and initiate the subsequent one. Formal phase completion does not necessarily include authorizing the subsequent phase. If the project is completed, if the risk is deemed to be too great for the project to continue, or if the objectives are no longer required, a phase can be closed with the decision to not initiate any other phases.

.2 Phase-to-Phase Relationships

When large or complex projects are multi-phased, 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 three basic types of phase-to-phase relationships:

- *A sequential relationship*, where a phase can only start once the previous phase is complete. Figure 2-4 shows an example of a project with entirely sequential phases. The step-by-step nature of this approach reduces uncertainty, but may eliminate options for reducing the schedule.
- *An overlapping relationship*, where the phase starts prior to completion of the previous one (see Figure 2-5). 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.

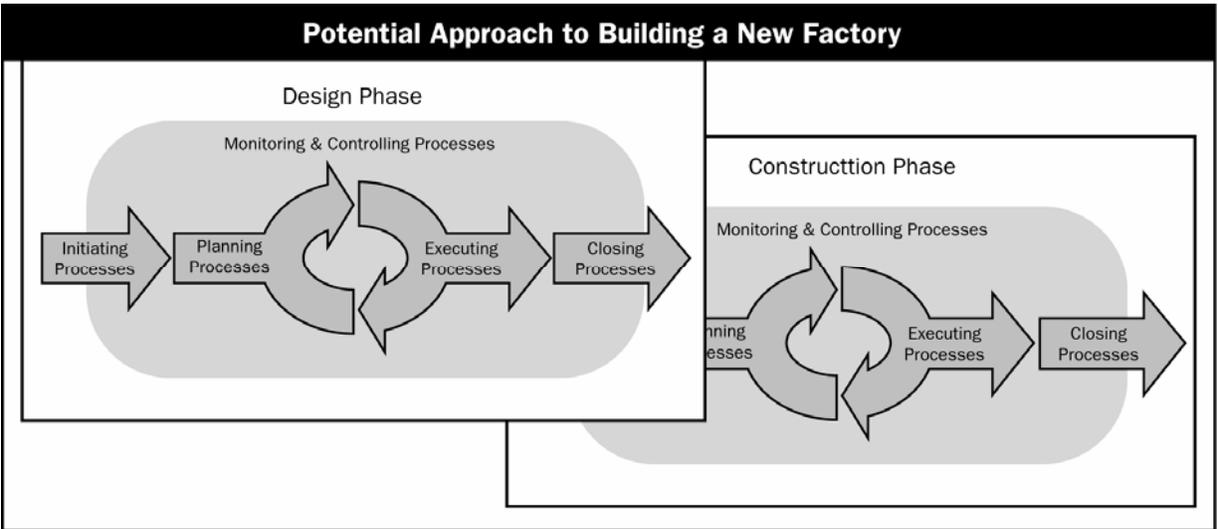


Figure 2-5. Example of a Project with Overlapping Phases

- *An iterative relationship*, where only one subset is planned at any given time and the planning for the next period is carried out as work progresses on the current deliverable. This approach is useful in largely undefined, uncertain, or rapidly changing environments such as research, but it can lead to rework and reduce the ability to provide long term planning or scope control for the project. It also entails having all of the project team members (e.g. designers, developers, etc.) available throughout the project.

For multi-phase projects, more than one phase-to-phase relationship could occur during different parts of a project. In theory, all three relationships could occur between different phases of an exceptionally large and complex project.

2.2 Projects vs. Operational Work

Organizations perform work to achieve a set of objectives. In many organizations the work performed can be categorized as either project or operations work.

These two types of work share a number of characteristics as follows:

- Performed by individuals,
- Constrained by limited resources,
- Planned, executed, and controlled, and
- Performed to achieve an organization's strategic plan.

Projects and operations differ primarily in that operations are ongoing and repetitive, while projects are temporary and unique. Although a project may span several years, it has a defined beginning, purpose, and end. The function of a project is to attain its objective and terminate. Conversely, operations work is ongoing and sustains the organization over time. Operations work does not terminate when its objectives are met. Instead it follows new directions to support the organization's strategic plans.

Operations work supports the business environment in which projects function. As a result, there is a significant amount of interaction between the operations departments and the project team as they work together to achieve project goals. An example of this is when a project is created to redesign a product. The project manager may work with multiple operational managers to research consumer preferences, draw up technical specifications, build a prototype, test it, and begin manufacturing.

The participation of resources from operations will vary from project to project. One example of this interaction is when individuals from operations are assigned as dedicated project resources. Their operational expertise is used to assist in the completion of project deliverables by working with the rest of the project team to complete the project on time and on budget.

Depending on the nature of the project, the deliverables may modify or contribute to the existing operations work. In this case, the operations department will integrate the deliverables into future business practices. Examples of these types of projects include, but are not limited to:

- Developing a new product or service,
- Installing products or services that require ongoing support,
- Internal projects that affect the structure, staffing levels, or culture of an organization, or
- Developing, acquiring, or enhancing an operational department's information system.

2.3 Stakeholders

Stakeholders are persons and organizations such as customers, sponsors, performing organization and the public, who are actively involved in the project or those whose interests may be positively or negatively affected by the execution, completion, or cancellation of the project. Stakeholders may also exert influence over the project and its deliverables. The project management team must identify both internal and external stakeholders in order to determine the requirements and expectations of all parties involved. Furthermore, the project manager must manage the influence of the various stakeholders in relation to the project requirements to ensure a successful outcome. Figure 2-6 illustrates the relationship between the project, the project team, and other common stakeholders.

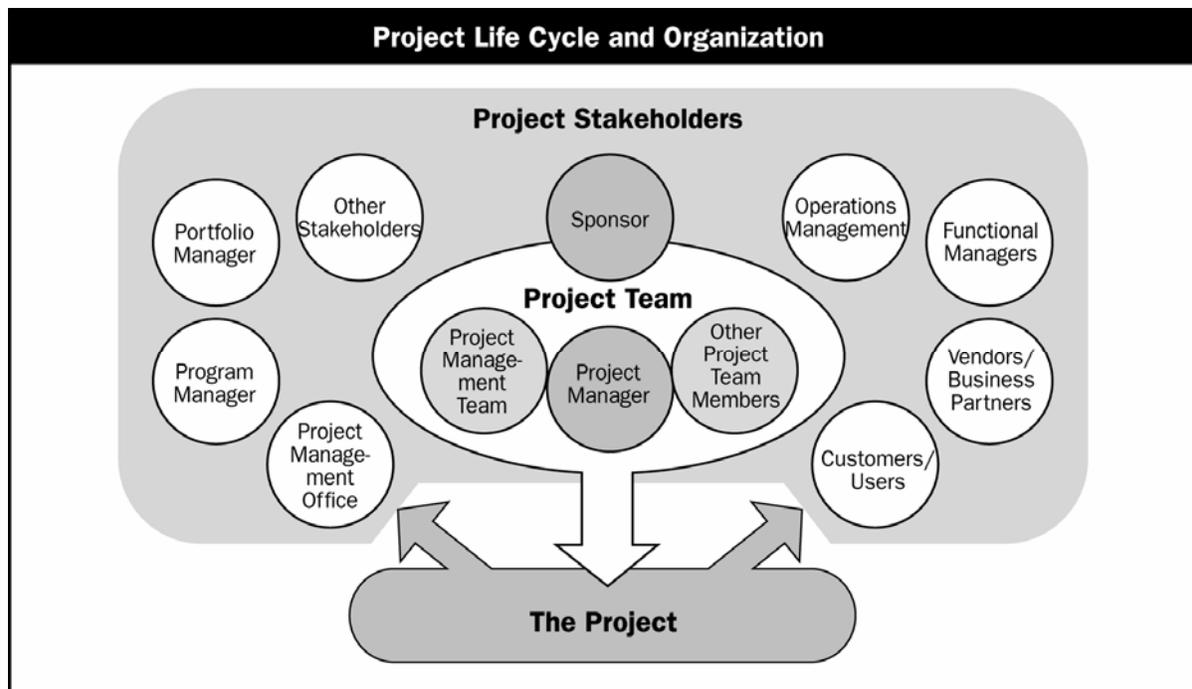


Figure 2-6. The Relationship Between Stakeholders and the Project

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

Stakeholder identification can be difficult at times. For instance, it could be argued that an assembly-line worker whose future employment depends on the outcome of a new product-design project is a stakeholder. Identifying stakeholders and understanding their relative degree of influence on a project is critical. Failure to do so can extend the timeline and raise costs substantially. An example is late recognition that the legal department is a significant stakeholder; this could cause delays and increase expenses because of the additional documentation requirements necessary to carry out project tasks.

A project can have both positive and negative stakeholders. Positive stakeholders are those who would normally benefit from a successful outcome from the project, while negative stakeholders are those who perceive negative outcomes from the project's success. For example, business leaders from a community that will benefit from an industrial expansion project may be positive stakeholders because they see economic benefit to the community. Conversely, environmental groups could be negative stakeholders if they view the project as harmful to the environment. In the case of positive stakeholders, their interests are best served by helping the project succeed. The interests of negative stakeholders are served by impeding the project's progress. Overlooking negative stakeholders can result in an increased likelihood of failure. 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.

2.3.1 Customers/Users

The customers/users are the persons or organizations that will use the project's product or service or result. Customers/users may be internal or external. There may also be multiple layers of customers. For example, the customers for a new pharmaceutical product can 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.

These customer/users are key sources of information for the project team because it is typically for customers or end users that the project has been created. The customers/users therefore play a significant role in determining the scope of the project, influencing how the project is carried out, and testing the product or service ultimately delivered by the project team. As a result of this close partnership, the customers/users carry significant responsibility for providing accurate and timely data to the project team as well as identifying risks and responding to other issues that arise. Customers and users deal primarily with the project team, but they may also have direct involvement with vendors, business partners, or other operational stakeholders involved with the work necessary to complete the project deliverable.

2.3.2 Sponsor

The sponsor is the person or group that provides the financial resources, in cash or in kind, for the project. When a project is first conceived, the person or group acting as the sponsor champions the cause of the project. This includes serving as spokesperson to higher levels of management to garner support throughout the organization and promote the benefits that the project will bring. The sponsor leads the project through the engagement or selection process until formally authorized, and therefore plays a significant role in the development of the initial scope and charter. Another key attribute of the sponsor is to provide financial resources, in cash or in kind, for the project.

Sponsors have a major stake in the project's success, and therefore, at times, may take an active role on the project team. 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 deals directly, and most often, with the project manager. For some projects, the sponsor may also interact with the project team and other key stakeholders, particularly when resolving issues that have been escalated. Some projects have multiple sponsors who fulfill this role.

2.3.3 Portfolio Managers/Portfolio Review Board

Portfolio managers are responsible for the high-level governance of a collection of projects or programs, which may or may not be interdependent. Portfolio managers could receive direction from the organization's business strategy or from the guidance of a director within the organization. Portfolio review boards are a committee usually made up of the organization's executives who act as a project selection panel. They review each project for its return on investment, the value of the project, risks associated with taking on the project, and other attributes

of the project. Portfolio review boards are not essential in every organization but, when used, provide additional support for project selection and prioritization. Portfolio review boards can also assist with responding to Request for Proposals (RFPs), tenders, or other opportunities that are developed externally.

2.3.4 Program Managers

Program managers are responsible for managing multiple projects when projects gain some measure of benefit by being managed collectively. The program manager ensures that all related projects are integrated, on schedule, on budget, and ultimately serve the common goal for which the program was created. The program manager interacts with each project manager to provide support and guidance on the individual projects.

2.3.5 Project Management Office

A project management office (PMO) organizes and manages control over projects within an organization, providing a uniform approach regardless of the discipline, technology, or purpose. The PMO can be a stakeholder if it has direct or indirect responsibility for the outcome of the project. The PMO can provide but is not limited to:

- Administrative support services such as policies, methodology and templates,
- Mentoring to project managers,
- Project support, guidance and training on how to manage projects and the use of tools,
- Resource alignment of project staff, or
- Centralized communication among project managers, project sponsors, managers, and other stakeholders.

2.3.6 Project Managers

The project manager is the person assigned by the performing organization to achieve the project objectives. This is a challenging, high-profile role with significant responsibility and constantly shifting priorities. It requires flexibility, good judgment, and strong negotiating skills. The project manager must be able to understand project detail, but manage from the big-picture perspective. As the person responsible for the success of the project, the project manager is in charge of all aspects of the project including, but not limited to:

- Developing the project plan and all related component plans,
- Keeping the project on track in terms of budget and schedule,
- Identifying, monitoring, and responding to risk, or
- Providing accurate and timely reporting of project metrics.

The project manager is the lead person responsible for interfacing with all stakeholders, particularly the project sponsor, project team, and other key stakeholders. As shown in Figure 2-6, the project manager occupies the center of the interactions between stakeholders and the project itself.

2.3.7 Project Team

A project team is comprised of the project manager, project management team, and other team members who carry out the work but who are not necessarily involved with management of the project. On some projects, the sponsor may also be part of the project team.

A properly functioning project team can mean the difference between a highly successful project and one that fails. While a team should be staffed with people who have the skills and talents necessary to carry out their respective roles, an effective team is one that demonstrates the ability to work well together and accept team members' strengths and weaknesses. This requires a willingness to communicate clearly, accurately, and fully and to commit to quality work and meeting deadlines. Individual team members must also be aware of how their work affects the work of other team members.

2.3.8 Functional Managers

Functional managers are individuals who play a management role within an administrative or functional area of the business, such as human resources, finance, accounting, or procurement. They are assigned their own permanent staff to carry out the ongoing work, and they have a clear directive to manage all tasks within their functional area of responsibility.

A project manager may need to work with a functional manager to make use of the services the functional group typically provides. For instance, a project manager may deal with a human resources manager to hire a new employee or a contractor with the right skill set for carrying out necessary project tasks. Likewise, a functional manager in finance may be a resource regarding funding of the project and other budgetary details.

Functional managers deal most often with the project manager or other members of the project management team. Functional managers typically have little interaction with other stakeholders with regard to project work.

2.3.9 Operations Management

Operational managers are individuals who have a management role in a core operational area of the business, such as research and development, design, manufacturing, provisioning, testing, or repair. Unlike functional management, these groups deal directly with producing and maintaining the saleable products or services of the enterprise. Management from these groups plays an important role, because resources with the appropriate technical expertise may need to be borrowed for purposes of the project. For example, a project to install a nationwide telecommunications network might make use of staff from the ordering department, technical specialists from the design group, installers from field operations, and testers from service implementation. Depending upon the project, these operational resources may provide full-time dedicated employees to the project, provide part-time assistance, or perform project activities on a routine basis along with non-project work.

After a project is completed, operations management sometimes provides long-term support. In these situations, a formal handoff occurs to pass technical project documentation and other permanent records into the hands of the appropriate operational management entity.

2.3.10 Vendors/Business Partners

Vendors, also called 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. When the project work is contracted almost entirely to a series of vendors and business partners the resulting group is referred to as a network organization.

As independent contractors, vendors/business partners often deal with the project management team and customers/users. They may also interface with project team members from operations who are involved with tasks related to the contracted product or service. It is the responsibility of vendors/business partners to carry out all contracted duties with the same standards of quality and professionalism as the enterprise itself.

2.4 Organizational Influences on Project Management

Projects are typically associated in some way with an enterprise. Examples of enterprises include corporations, government agencies, non-government organizations, healthcare institutions, international bodies, professional associations, and others. 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 maturity of the enterprise with respect to its project management system, culture, style, organizational structure and project management maturity can also influence the project. The following sections describe organizational characteristics and structures that are likely to influence the project.

2.4.1 Organizational Cultures and Styles

Cultures and styles may have a strong influence on a project's ability to meet its objectives. Cultures and styles are typically known as "cultural norms." The "norms" include a common knowledge regarding how to approach getting the work done, what means are considered acceptable for getting the work done, and who is influential in facilitating the work being performed.

Most organizations have developed unique cultures that manifest in numerous ways including, but not limited to:

- Shared visions, values, norms, beliefs, and expectations,
- Policies, methods, and procedures,
- View of authority relationships, or
- Work ethic and work hours.

The organizational culture is an enterprise environmental factor as described in Section 1.8. Therefore, a project management professional must understand the different organizational styles and cultures that may affect a project. For example, in some cases the person shown at the top of an organization chart may be a figurehead who is not truly in charge. The project manager must know which individuals in the organization are the decision makers and work with them to influence project success.

The project manager and project management team should identify and understand the aspects of the organization's culture and style that would most positively or negatively influence the success of the project. Being aware of the opportunities and influences from an organization's culture and style will allow the project manager and the project management team to manage them.

2.4.2 Organizational Structure

Organizational structure is an enterprise environmental factor that can have an effect on 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. Figure 2-7 shows key project-related characteristics of the major types of organizational structures.

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

Figure 2-7. Organizational Influences on Projects

The classic functional organization, shown in Figure 2-8, 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 independent of other departments.

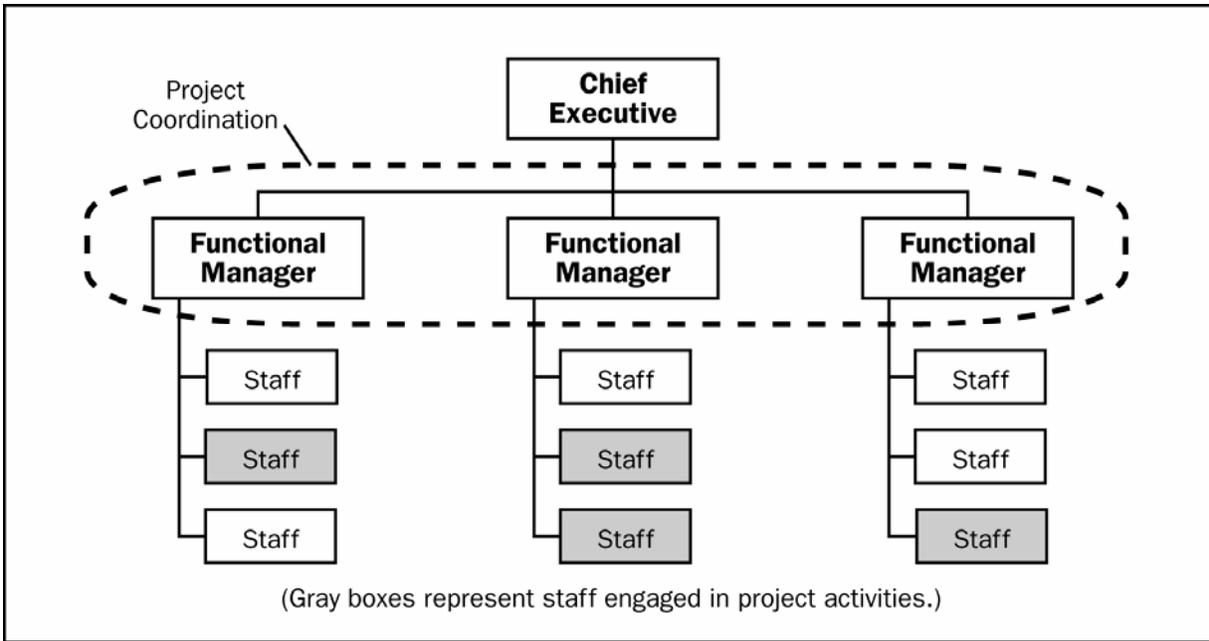


Figure 2-8. Functional Organization

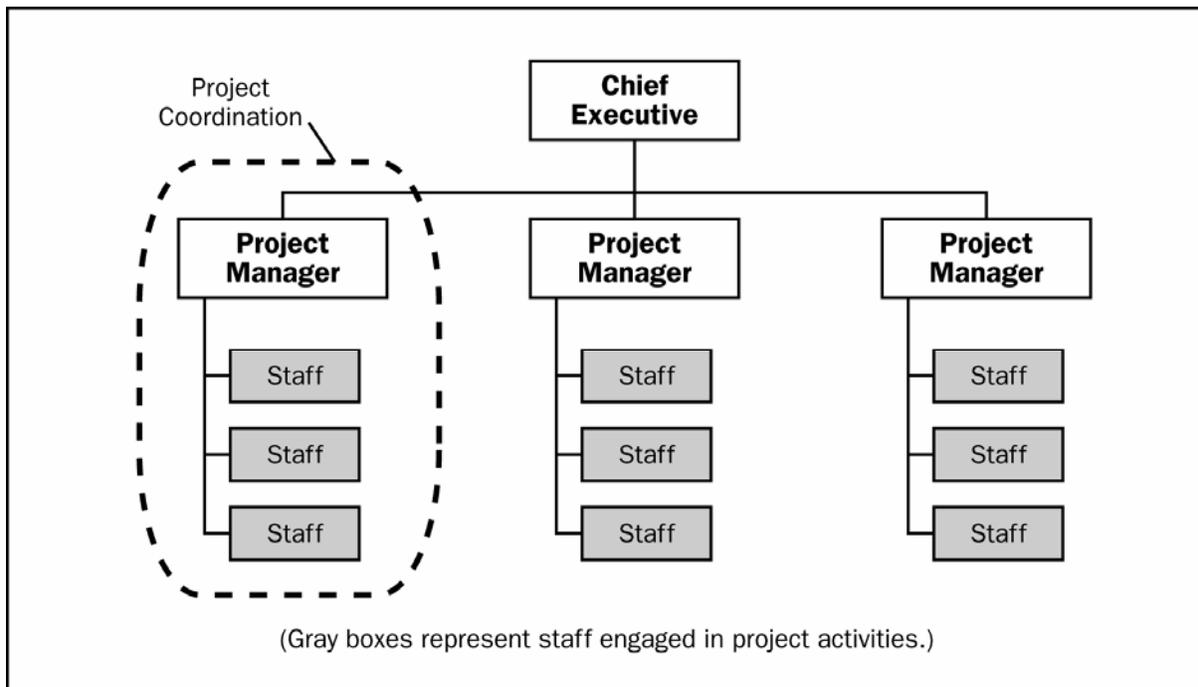


Figure 2-9. Projectized Organization

At the opposite end of the spectrum is the projectized organization, shown in Figure 2-9. In a projectized organization, team members are often co-located. Most of the organization's resources are involved in project work, and project managers have a great deal of independence and authority. Projectized organizations often have organizational units called departments, but

these groups either report directly to the project manager or provide support services to the various projects.

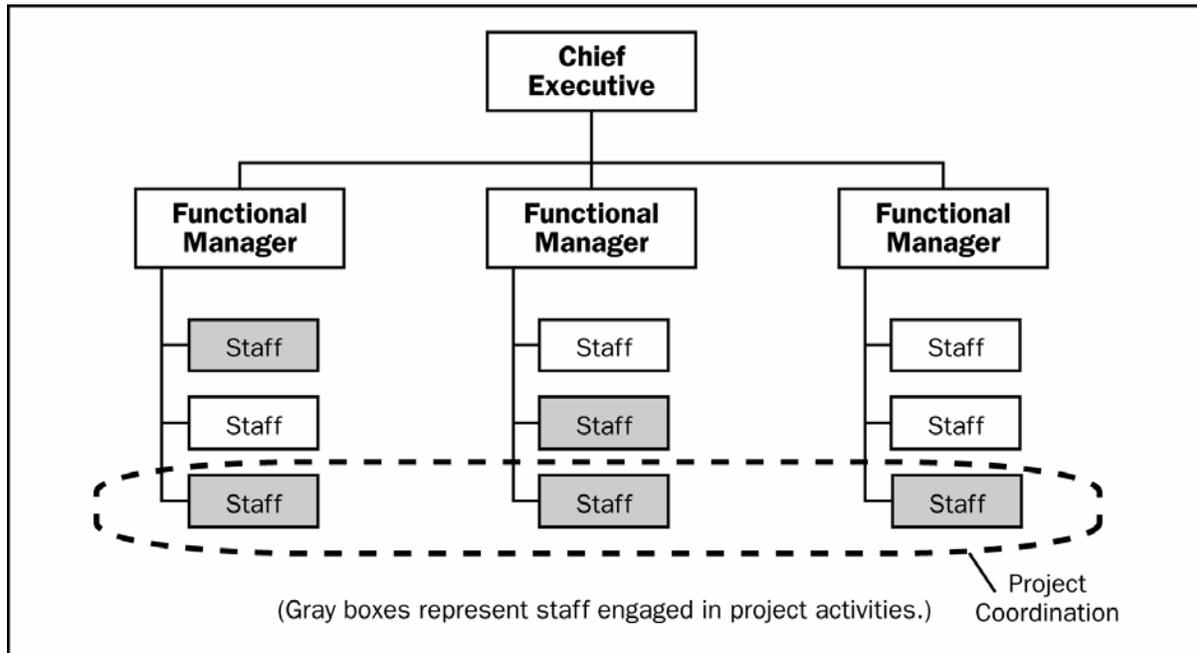


Figure 2-10. Weak Matrix Organization

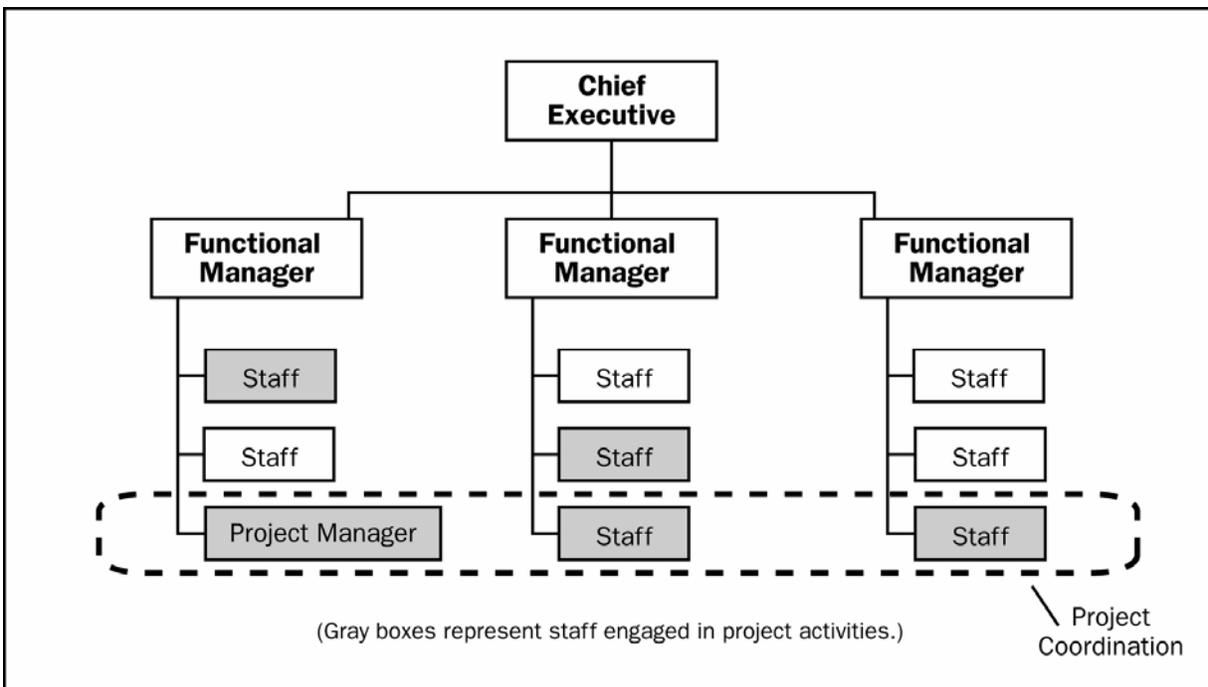


Figure 2-11. Balanced Matrix Organization

Matrix organizations, as shown in Figures 2-10 through 2-12, are a blend of functional and projectized characteristics. Weak matrices maintain many of the characteristics of a functional organization, and the project manager role is more of a coordinator or expeditor than that of a

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. Figure 2-6 provides additional details of the various matrix organizational structures.

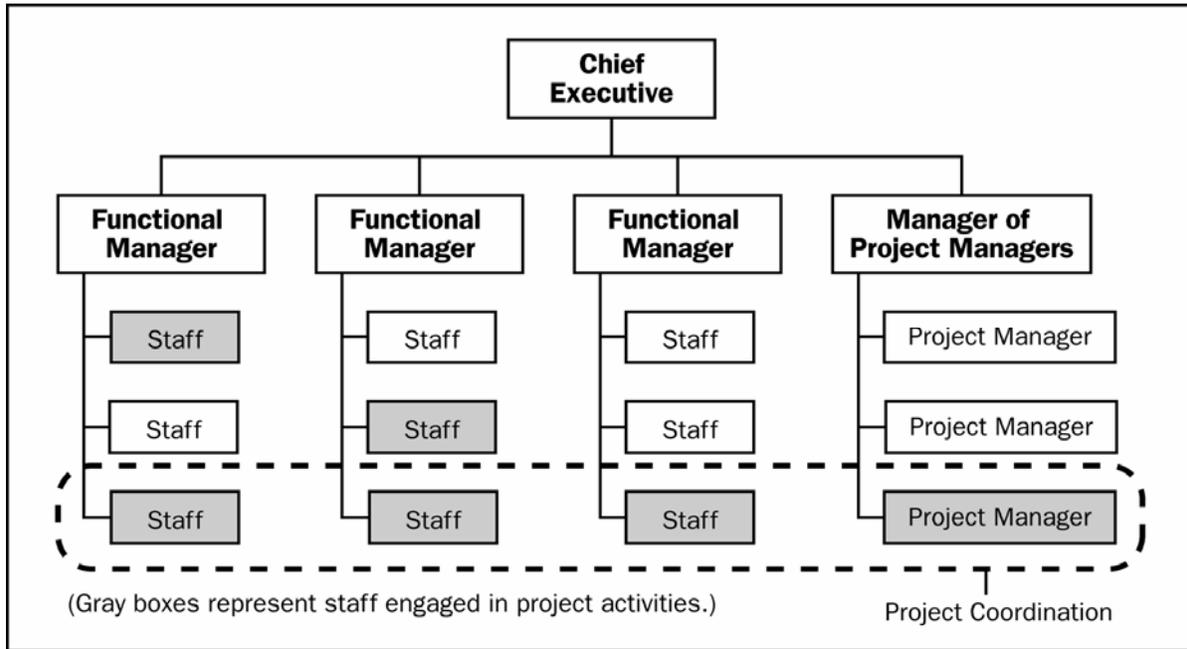


Figure 2-12. Strong Matrix Organization

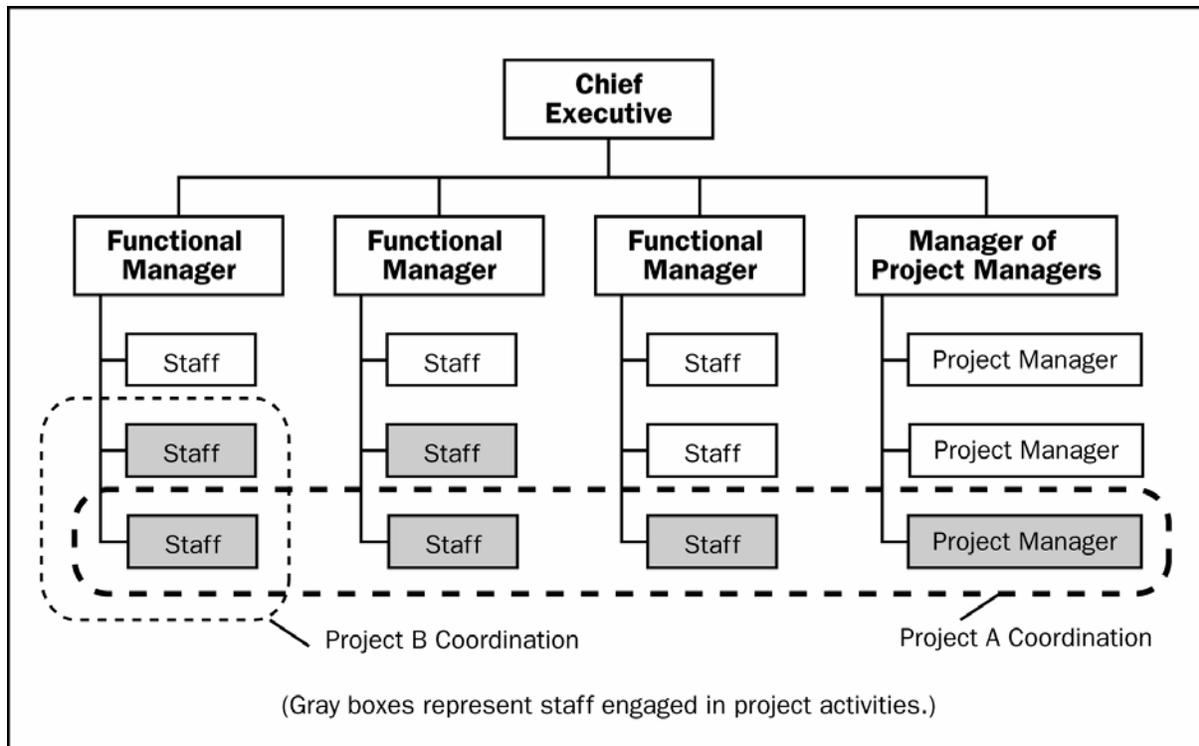


Figure 2-13. Composite Organization

Most modern organizations involve all these structures at various levels, as shown in Figure 2-13 (composite organization). For example, even a fundamentally functional organization may create a special project team to handle a critical project. Such a team may have many of the characteristics of a project team in a projectized organization. The team may include full-time staff from different functional departments, may develop its own set of operating procedures, and may operate outside the standard, formalized reporting structure.

2.4.3 Organizational Process Assets

Organizational process assets include any or all processes related to the assets from an organization(s) involved in a project that can be used to influence the project's success. These process assets include formal and informal plans, policies, procedures, and guidelines. The process assets also include the organizations' knowledge bases such as lessons learned and historical information. Organizational process assets also represent the organization's learning and knowledge from previous projects and may include completed schedules, risk data, and earned value data. Organizational process assets may take many different forms depending on the type of industry, organization, and application area. Updating and adding to the organizational process assets is generally the responsibility of the project team members as necessary throughout the project. Organizational process assets may be grouped into two categories:

.1 Processes and Procedures

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

- Organizational standard processes such as standards, policies (e.g., safety and health policy, ethics policy, and project management policy), standard product and project life

cycles, and quality policies and procedures (e.g., process audits, improvement targets, checklists, and standardized process definitions for use in the organization),

- Standardized guidelines, work instructions, proposal evaluation criteria, and performance measurement criteria,
- Templates (e.g., risk templates, work breakdown structure templates, and project schedule network diagram templates),
- Guidelines and criteria for tailoring the organization's set of standard processes to satisfy the specific needs of the project,
- Organization communication requirements (e.g., specific communication technology available, allowed communication media, record retention policies, and security requirements),
- Project closure guidelines or requirements (e.g., final project audits, project evaluations, product validations, and acceptance criteria),
- Financial controls procedures (e.g., time reporting, required expenditure and disbursement reviews, accounting codes, and standard contract provisions),
- Issue and defect management procedures defining issue and defect controls, issue and defect identification and resolution, and action item tracking
- Change control procedures, including the steps by which official company standards, policies, plans, and procedures--or any project documents--will be modified, and how any changes will be approved and validated,
- Risk control procedures, including risk categories, probability definition and impact, and probability and impact matrix, or
- Procedures for prioritizing, approving, and issuing work authorizations.

.2 Corporate Knowledge Base

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

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

Chapter 3 Project Management Processes for a Project

Project management is the application of knowledge, skills, tools, and techniques to project activities to meet project requirements. 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 must consider organizational project assets (OPAs) and enterprise environmental factors (EEFs). These must 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,
- 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.

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

- *Project management 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 12).
- *Product-oriented processes*, specify and create the project's product. Product-oriented processes are typically defined by the product life cycle (as discussed in Section 2.1.2) and vary by application area. 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 must be considered when determining the overall complexity of the house to be built.

This standard 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 those project management processes has been shown to enhance the chances of success over a wide range of projects.

This does not mean that the knowledge, skills and processes described should always be applied uniformly on all projects. 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 constituent inputs and outputs. This chapter should be used as a guide for those processes they must consider in managing their project. This effort is known as tailoring.

Project management is an integrative undertaking requiring 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 team morale 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.

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 Project Management 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 above processes, and includes the following major sections:

3.1 Common Project Management Process Interactions

3.2 Project Management Process Groups

3.3 Initiating Process Group

3.4 Planning Process Group

3.5 Executing Process Group

3.6 Monitoring and Controlling Process Group

3.7 Closing Process Group

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 constituent 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 effort, the Initiating Process Group begins the project, and the Closing Process Group ends it.

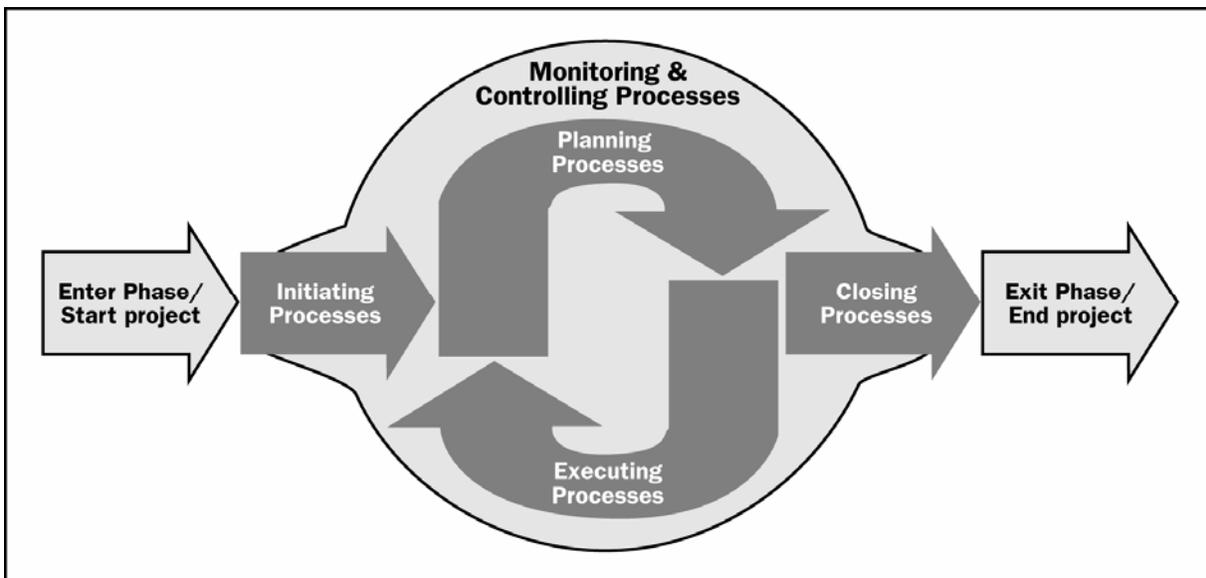


Figure 3-1. Project Management Process Groups

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.

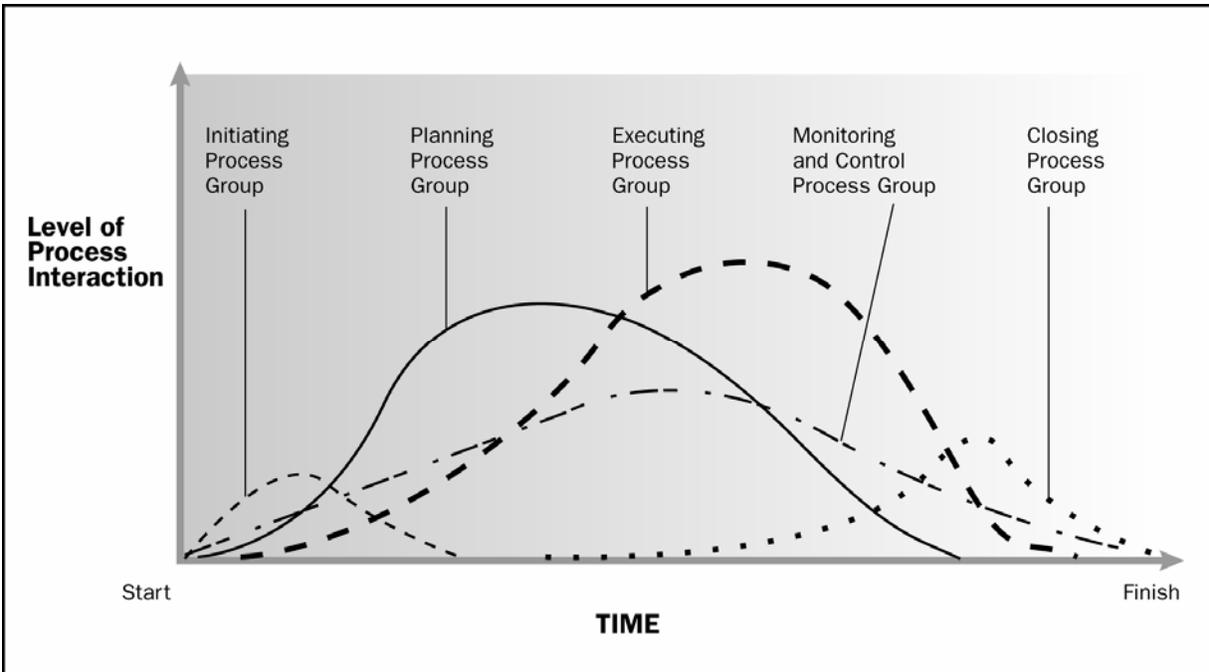


Figure 3-2. Process Groups Interact in a Phase or Project

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 invoked as appropriate to effectively drive the project to completion in a controlled manner. In multi-phase projects, processes are repeated within each phase until the criteria for phase completion have been satisfied. Additional information on project 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 constituent processes are often iterated prior to completing the project. The constituent 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 done 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 constituent 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.** When large or complex projects are separated into distinct phases or subprojects such as feasibility study, concept development, design, prototype, build, est, etc., all of the Process Group processes would normally be repeated for each phase or subproject.

Table 3-1 reflects the mapping of the 42 project management processes into the five Project Management Process Groups and the nine 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 execution process group, it is not considered a new process.

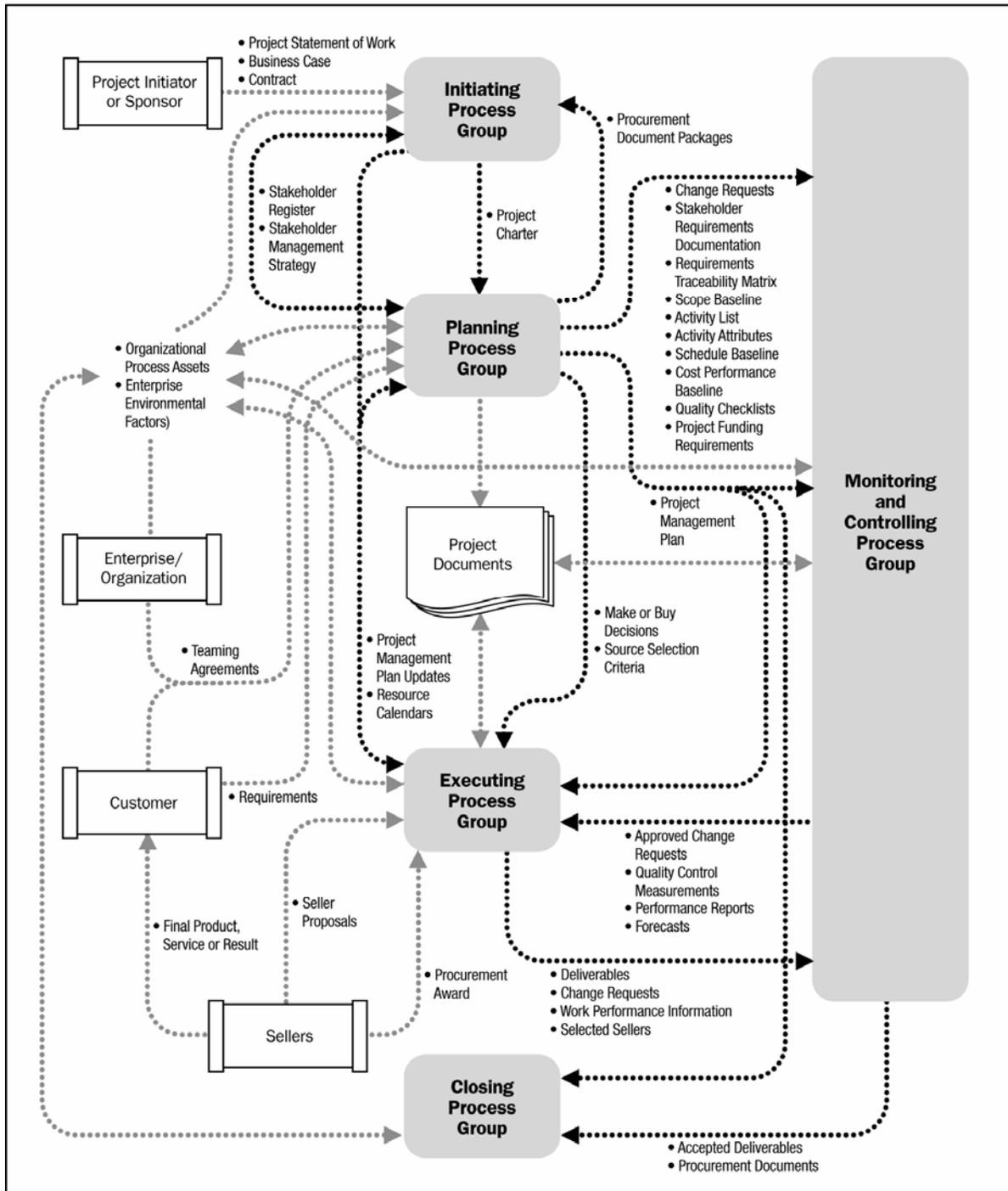


Figure 3-3. Project Management Process Interactions

Table 3-1. Project Management Process Groups and Knowledge Areas

Knowledge Area	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 Execution	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 Collect Requirements 5.2 Define Scope 5.3 Create Work Breakdown Structure		5.4 Verify Scope 5.5 Control Scope	
6. Project Time Management		6.1 Define Activities 6.2 Sequence Activities 6.3 Estimate Activity Resources 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	
7. Project Cost Management		7.1 Estimate Costs 7.2 Determine Budget		7.3 Control Costs	
8. Project Quality Management		8.1 Plan Quality	8.2 Perform Quality Assurance	8.3 Perform Quality Control	
9. Project Human Resource Management		9.1 Develop Human Resource Plan	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management	10.1 Identify Stakeholders	10.2 Plan Communications	10.3 Distribute Information 10.4 Manage Stakeholders Expectations	10.5 Report Performance	
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 Monitor and Control Risks	
12. Project Procurement Management		12.1 Plan Procurements	12.2 Conduct Procurements	12.3 Administer Procurements	12.4 Close Procurements

3.3 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. 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 external to the project boundaries (Figure 3-4).

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 Stakeholder processes. Invoking the Initiating processes at the start of each phase helps keep the project focused on the business need 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.

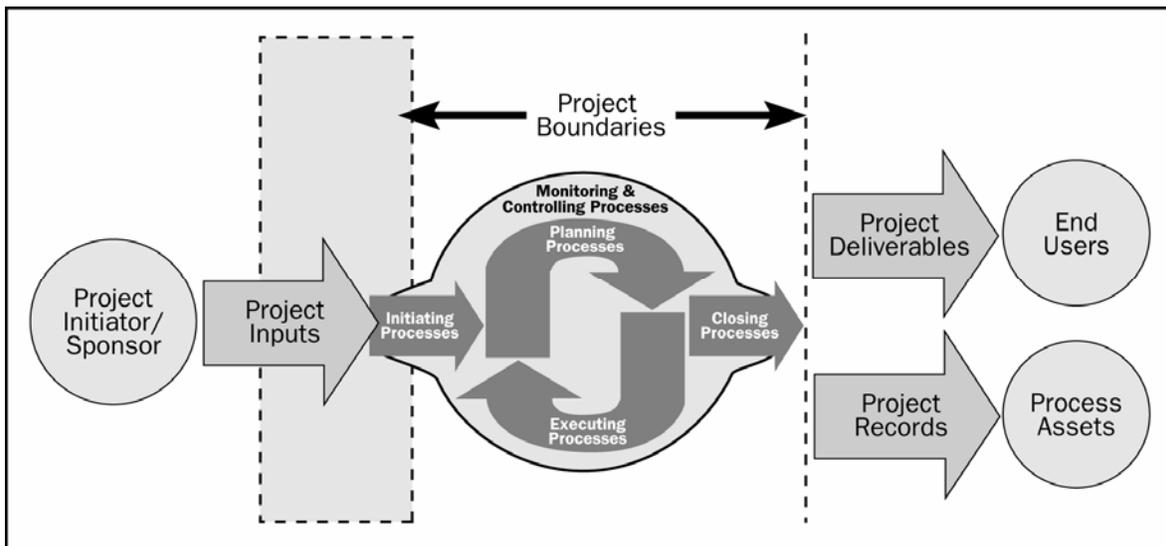


Figure 3-4. Project Boundaries

Initiating processes may be done 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.

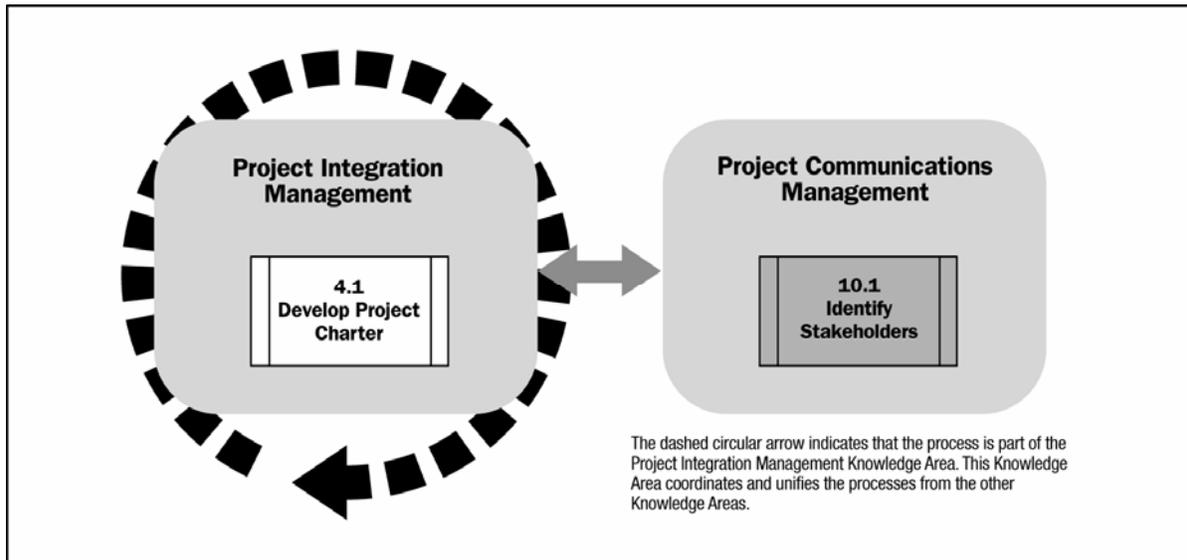


Figure 3-5. Initiating Process Group

The Initiating Process Group (Figure 3-5) includes the following project management processes (Tables 3-2 through 3-3):

3.3.1 Develop Project Charter

Develop Project Charter is the process of developing a document that formally authorizes a project or a phase and documenting initial requirements that satisfy the stakeholder’s needs and expectations. The charter links the project to the ongoing work of the organization and authorizes the project. Projects are chartered and authorized external to the project by the organization, a program or portfolio management body. In multi-phase projects, this process is used to validate or refine the decisions made during the previous iteration of Develop Project Charter.

Table 3-2. Develop Project Charter: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Project statement of work 2. Business case 3. Contract 4. Enterprise environmental factors 5. Organizational process assets 	<ol style="list-style-type: none"> 1. Project charter

3.3.2 Identify Stakeholders

Identify Stakeholder is the process of identifying all people or organizations impacted by the project, and documenting relevant information regarding interests, involvement, and impact on project success. This process links the project with the people or organizations that will be affected by the project to ensure a successful project. Stakeholder identification is necessary for managing stakeholders’ expectations and influence in relation to project requirements. Stakeholder

identification is an iterative process and as such the outputs of this process, Stakeholder Register, and Stakeholder Management Strategy should be revised during the subsequent phases of the project.

Table 3-3. Identify Stakeholders: Inputs and Outputs

Inputs	Outputs
.1 Project charter	.1 Stakeholder register
.2 Procurement document package	.2 Stakeholder management strategy
.3 Enterprise environmental factors	
.4 Organizational process assets	

3.4 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. The planning processes develop the project management plan and the project documents that will be used to carry out the project. The multi-dimensional 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 often called “rolling wave planning,” indicating that planning and documentation are iterative and ongoing processes.

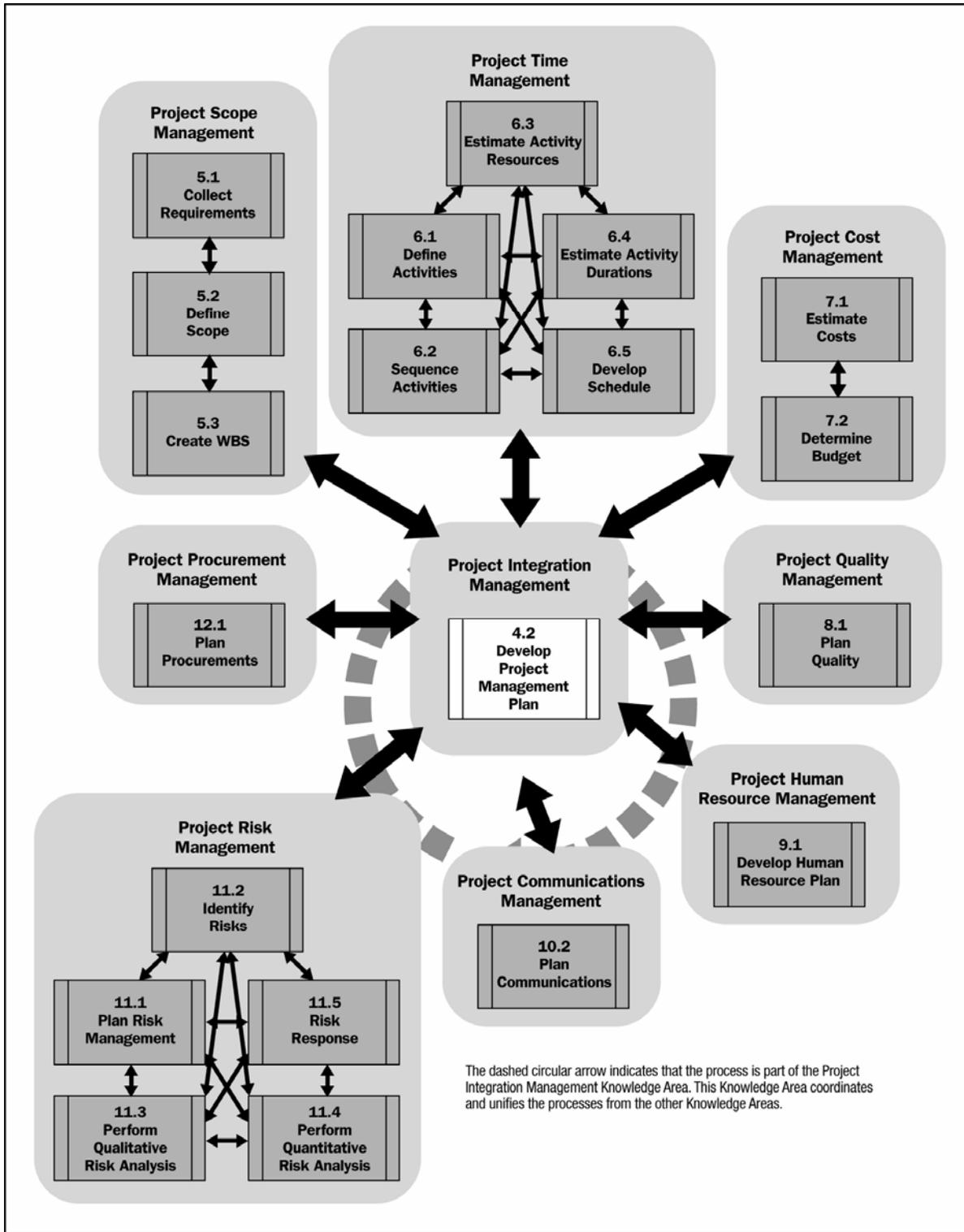


Figure 3-6. Planning Process Group

The project management plan and project documents developed as an output of the Planning Process Group will have an emphasis on exploring all aspects of the scope, time, costs, quality, communication, resources, risks, 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.

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 facilitates project planning across multiple processes. The following list identifies the processes the project team should address during the planning process.

The Planning Process Group (Figure 3-6) includes the following project management processes (Tables 3-4 through 3-23):

3.4.1 Develop Project Management Plan

Develop Project Management Plan is the process of documenting the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans. The project management plan becomes the primary source of information for how the project will be planned, executed, monitored and controlled, and closed.

Table 3-4. Develop Project Management Plan: Inputs and Outputs

Inputs	Outputs
.1 Project charter	.1 Project management plan
.2 Project scope statement	
.3 Outputs from planning processes	
.4 Enterprise environmental factors	
.5 Organizational process assets	

3.4.2 Collect Requirements

Collect Requirements is the process of defining the project and product requirements as well as a requirements management plan.

Table 3-5. Collect Requirements: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Project charter 2. Stakeholder register 	<ol style="list-style-type: none"> 1. Stakeholder requirements documentation 2. Requirements management plan 3. Requirements traceability matrix

3.4.3 Define Scope

Define Scope is the process of developing a detailed description of the project and product.

Table 3-6. Define Scope: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Project charter 2. Stakeholder requirements documentation 3. Organizational process assets 	<ol style="list-style-type: none"> 1. Project scope statement 2. Project document updates

3.4.4 Create Work Breakdown Structure

Create Work Breakdown Structure is the process of subdividing project deliverables and project work into smaller, more manageable components.

Table 3-7. Create Work Breakdown Structure: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Project scope statement 2. Stakeholder requirements documentation 3. Organizational process assets 	<ol style="list-style-type: none"> 1. Work breakdown structure (WBS) 2. WBS dictionary 3. Scope baseline 4. Project document updates

3.4.5 Define Activities

Define Activities is the process of identifying the specific actions to be performed to produce the project deliverables.

Table 3-8. Define Activities: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Scope baseline 2. Enterprise environmental factors 3. Organizational process assets 	<ol style="list-style-type: none"> 1. Activity list 2. Activity attributes 3. Milestone list

3.4.6 Sequence Activities

Sequence Activities is the process of identifying and documenting relationships among activities.

Table 3-9. Sequence Activities: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Activity list2. Activity attributes3. Milestone list4. Project scope statement5. Organizational process assets	<ol style="list-style-type: none">1. Project schedule network diagrams2. Project document updates

3.4.7 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.

Table 3-10. Estimate Activity Resources: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Activity list2. Activity attributes3. Resource calendars4. Enterprise environmental factors5. Organizational process assets	<ol style="list-style-type: none">1. Activity resource requirements2. Resource breakdown structure3. Project document updates

3.4.8 Estimate Activity Durations

Estimate Activity Duration is the process estimating the number of work periods needed to complete individual schedule activities with estimated resources.

Table 3-11. Estimate Activity Durations: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Activity list2. Activity attributes3. Activity resource requirements4. Resource calendars5. Project scope statement6. Enterprise environmental factors7. Organizational process assets	<ol style="list-style-type: none">1. Activity duration estimates2. Project document updates

3.4.9 Develop Schedule

Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.

Table 3-12. Develop Schedule: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Activity list2. Activity attributes3. Project schedule network diagrams4. Activity resource requirements5. Resource calendars6. Activity duration estimates7. Project scope statement8. Environmental enterprise factors9. Organizational process assets	<ol style="list-style-type: none">1. Project schedule2. Schedule baseline3. Schedule data4. Project document updates

3.4.10 Estimate Costs

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

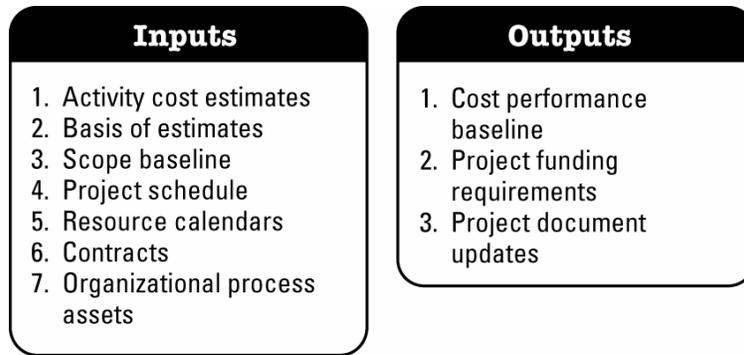
Table 3-13. Estimate Costs: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Scope baseline2. Project schedule3. Human resource plan4. Risk register5. Enterprise environmental factors6. Organizational process assets	<ol style="list-style-type: none">1. Activity cost estimates2. Basis of estimates3. Project document updates

3.4.11 Determine Budget

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

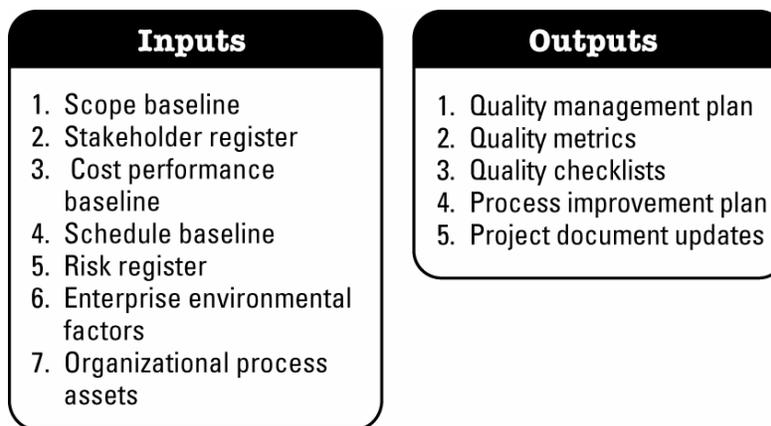
Table 3-14. Determine Budget: Inputs and Outputs



3.4.12 Plan Quality

Plan Quality is the process of identifying quality requirements and/or standards for the project and product and documenting how the project will demonstrate compliance.

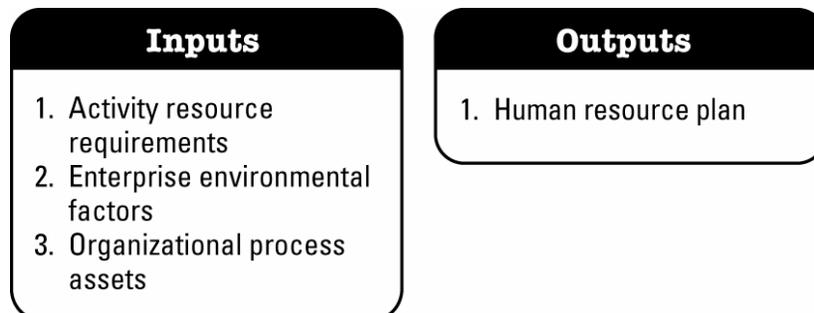
Table 3-15. Plan Quality: Inputs and Outputs



3.4.13 Develop Human Resource Plan

Develop Human Resource Plan is the process of identifying and documenting project roles, responsibilities, required skills, and reporting relationships, and creating a staffing management plan.

Table 3-16. Develop Human Resource Plan: Inputs and Outputs



3.4.14 Plan Communications

Plan Communications is the process of determining project stakeholder information needs and defining a communication approach.

Table 3-17. Plan Communications: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Stakeholder register2. Stakeholder management strategy3. Enterprise environmental factors4. Organizational process assets	<ol style="list-style-type: none">1. Communications management plan2. Project document updates

3.4.15 Plan Risk Management

Plan Risk Management is the process of defining how to conduct risk management activities for a project.

Table 3-18. Plan Risk Management: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Project scope statement2. Cost management plan3. Schedule management plan4. Communications management plan5. Enterprise environmental factors6. Organizational process assets	<ol style="list-style-type: none">1. Risk management plan

3.4.16 Identify Risks

Identify Risks is the process of determining which risks may affect the project and documenting their characteristics.

Table 3-19. Identify Risks: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Risk management plan2. Activity cost estimates3. Activity duration estimates4. Scope baseline5. Stakeholder register6. Cost management plan7. Schedule management plan8. Quality management plan9. Other project documents10. Enterprise environmental factors11. Organizational process assets	<ol style="list-style-type: none">1. Risk register

3.4.17 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.

Table 3-20. Perform Qualitative Risk Analysis: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Risk register2. Risk management plan3. Project scope statement4. Organizational process assets	<ol style="list-style-type: none">1. Risk register updates

3.4.18 Perform Quantitative Risk Analysis

Perform Quantitative Risk Analysis is the process of numerically analyzing the effect of identified risks on overall project objectives.

Table 3-21. Perform Quantitative Risk Analysis: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Risk register2. Risk management plan3. Cost management plan4. Schedule management plan5. Organizational process assets	<ol style="list-style-type: none">1. Risk register updates

3.4.19 Plan Risk Responses

Plan Risk Responses is the process of developing options and actions to enhance opportunities and to reduce threats to project objectives.

Table 3-22. Plan Risk Responses: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Risk register2. Risk management plan	<ol style="list-style-type: none">1. Risk register updates2. Risk related contract decisions3. Project management plan updates4. Project document updates

3.4.20 Plan Procurements

Plan Procurements is the process of documenting project purchasing decisions, the procurement approach, and identifying potential sellers.

Table 3-23. Plan Procurements: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Scope baseline2. Stakeholder requirements documentation3. Teaming agreements4. Risk register5. Risk-related contract decisions6. Activity resource requirements7. Project schedule8. Activity cost estimates9. Cost performance baseline10. Enterprise environmental factors11. Organizational process assets	<ol style="list-style-type: none">1. Procurement management plan2. Procurement statements of work3. Make-or-buy decisions4. Change requests5. Procurement document packages6. Source selection criteria

3.5 Executing Process Group

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 3-7).

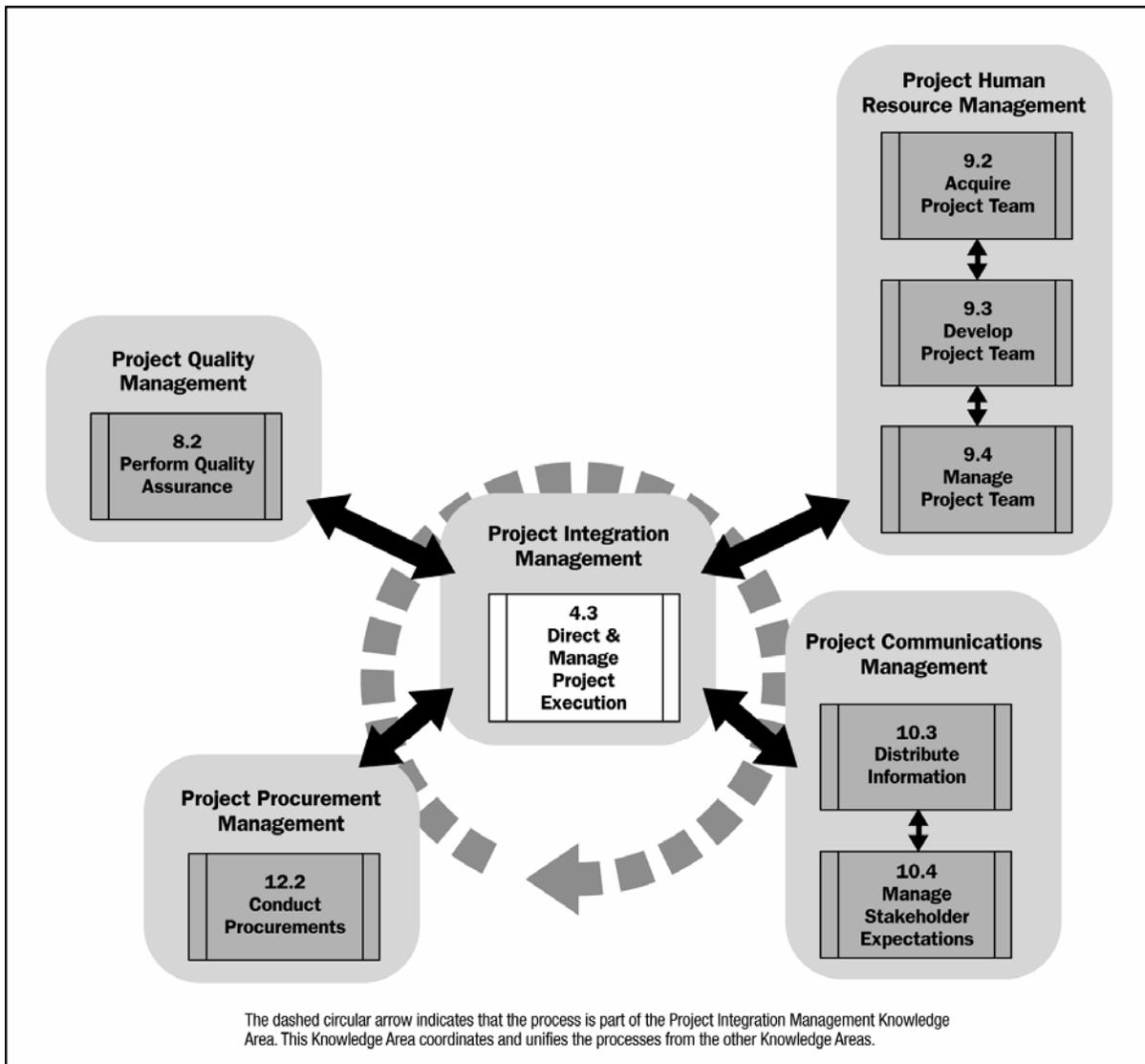


Figure 3-7. Executing Process Group

During project execution, variances will require planning updates and re-baselining. These variances 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 includes the following project management processes (Tables 3-24 through 3-31):

3.5.1 Direct and Manage Project Execution

Direct and Manage Project Execution is the process of performing the work defined in the Project Management Plan to achieve the project's objectives. The deliverables are the outputs from the

processes performed as defined in the project management plan. Information on the completion status of the deliverables is collected as part of project execution and an input to the performance reporting process. This work performance information will also be used as an input to the Monitoring and Controlling process group.

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

Inputs	Outputs
<ol style="list-style-type: none"> 1. Project management plan 2. Approved change requests 3. Enterprise environmental factors 4. Organizational process assets 	<ol style="list-style-type: none"> 1. Deliverables 2. Work performance data 3. Change requests 4. Project management plan updates 5. Project document updates

3.5.2 Perform Quality Assurance

Perform Quality Assurance is the process of auditing the quality requirements and the results from quality control measurements to ensure appropriate quality standards and operational definitions are used.

Table 3-25. Perform Quality Assurance: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Quality management plan 2. Quality metrics 3. Process improvement plan 4. Work performance data 5. Quality control measurements 	<ol style="list-style-type: none"> 1. Organizational process asset updates 2. Change requests 3. Project management plan updates 4. Project document updates

3.5.3 Acquire Project Team

Acquire Project Team is the process of confirming human resource availability and obtaining the team necessary to complete project assignments.

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

Inputs	Outputs
<ol style="list-style-type: none"> 1. Human Resource Plan 2. Enterprise environmental factors 3. Organizational process assets 	<ol style="list-style-type: none"> 1. Project staff assignments 2. Resource calendars 3. Project management plan updates

3.5.4 Develop Project Team

Develop Project Team is the process of improving the competencies, team interaction, and the overall team environment to enhance project performance.

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

Inputs	Outputs
<ol style="list-style-type: none">1. Project staff assignments2. Human resource plan3. Resource calendars	<ol style="list-style-type: none">1. Team performance assessment2. Enterprise environmental factor updates

3.5.5 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.

Table 3-28. Manage Project Team: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Project staff assignments2. Human resource plan3. Team performance assessments4. Performance reports5. Organizational process assets	<ol style="list-style-type: none">1. Change requests2. Project management plan updates3. Enterprise environmental factors updates4. Organizational process assets updates

3.5.6 Distribute Information

Distribute Information is the process of making relevant information available to project stakeholders as planned.

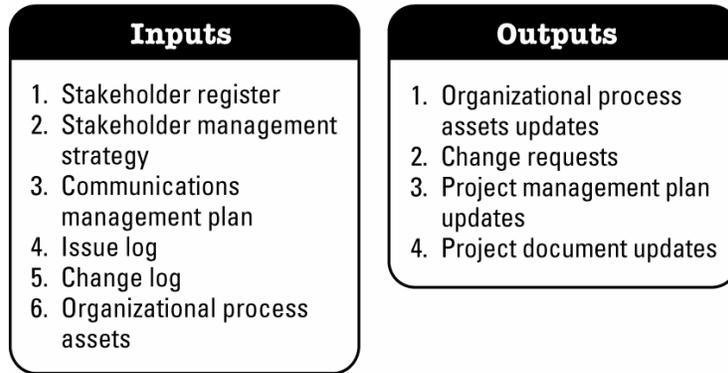
Table 3-29. Distribute Information: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Communications management plan2. Performance reports3. Organizational process assets	<ol style="list-style-type: none">1. Organizational process assets updates

3.5.7 Manage Stakeholder Expectations

Manage Stakeholder Expectations is the process of communicating and working with stakeholders to meet their needs and addressing issues as they occur.

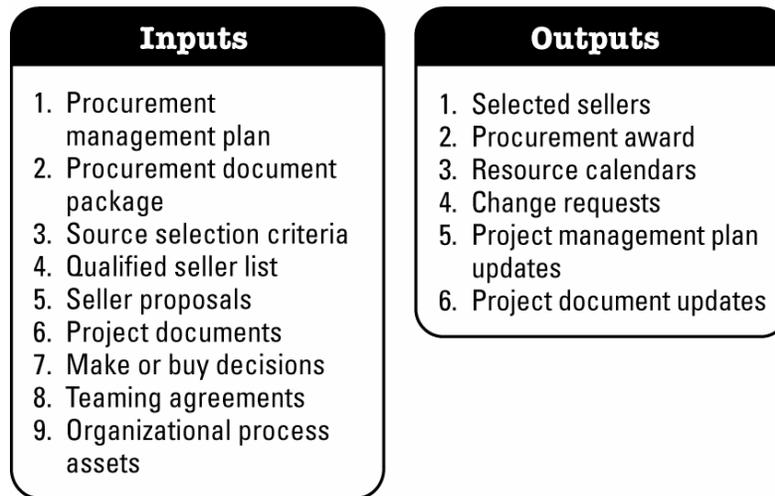
Table 3-30. Manage Stakeholder Expectations: Inputs and Outputs



3.5.8 Conduct Procurements

Conduct Procurements is the process of obtaining seller responses, selecting a seller and awarding a contract. This process also includes reviewing offers, choosing from among potential sellers, and negotiating a written contract with the seller.

Table 3-31. Conduct Procurements: Inputs and Outputs



3.6 Monitoring & 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. The key benefit of this Process Group is that project performance is observed and measured regularly and consistently to identify variances from the project management plan. The Monitoring and Controlling Process Group also includes:

- Controlling changes and recommending preventive action in anticipation of possible problems,
- 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 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 multi-phase 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 tradeoffs between budget and schedule objectives.

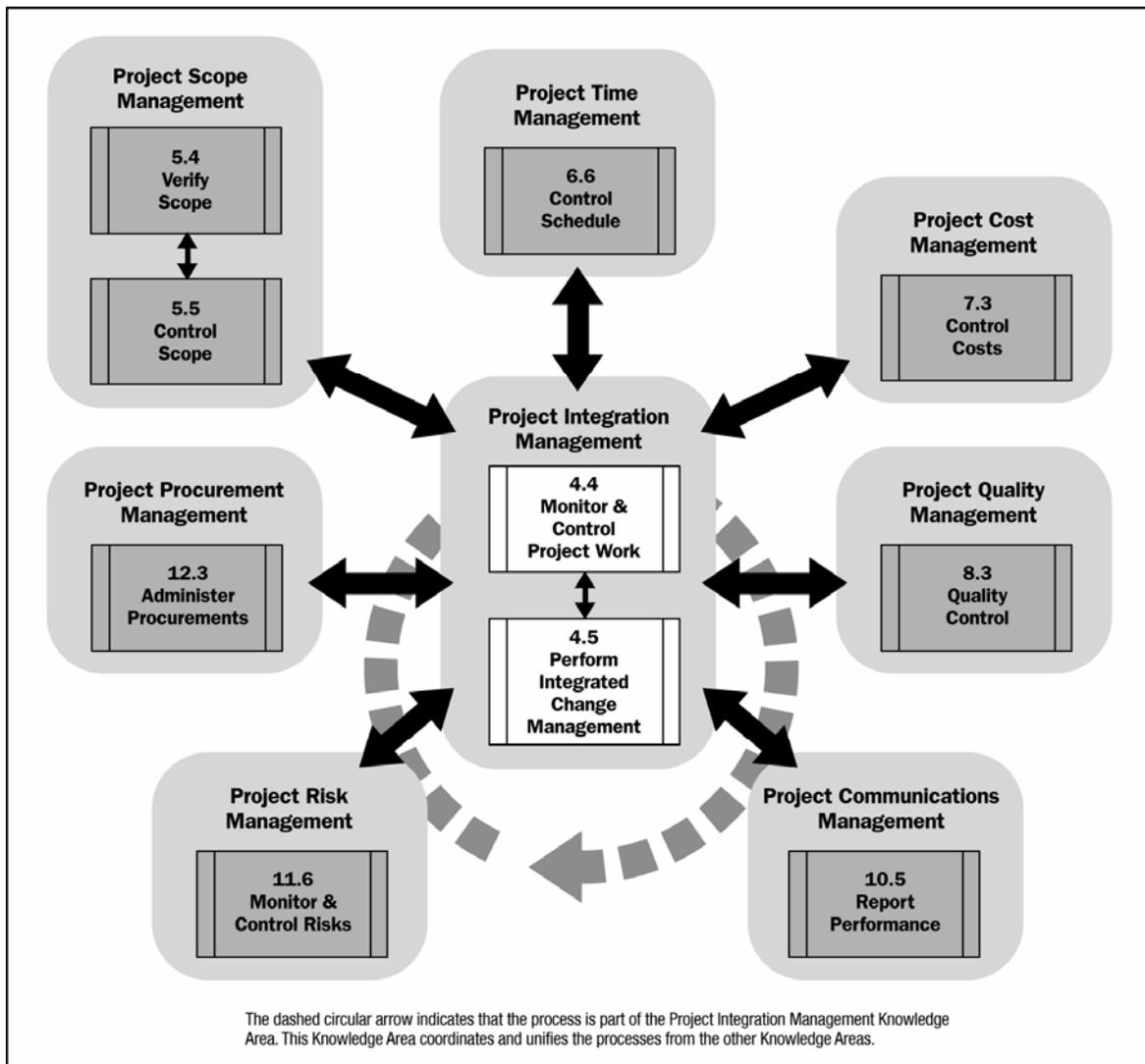


Figure 3-8. Monitoring & Controlling Process Group

The Monitoring and Controlling Process Group (Figure 3-8) includes the following project management processes (Tables 3-32 through 3-41):

3.6.1 Monitor and Control Project Work

Monitor and Control Project Work is the process of tracking, reviewing, and regulating the progress to meet the processes performance objectives defined in the Project Management Plan. Monitoring includes status reporting, progress measurement, and forecasting. Performance reports provide information on the project's performance with regard to scope, schedule, cost, resources, quality, and risk, which can be used as inputs to other processes.

Table 3-32. Monitor and Control Project Work: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Project management plan2. Work performance data3. Performance reports4. Forecasts5. Enterprise environmental factors6. Organizational process assets	<ol style="list-style-type: none">1. Change requests2. Project management plan updates3. Project document updates

3.6.2 Perform Integrated Change Control

Perform Integrated Change Control is the process of reviewing all change requests, approving changes, and managing changes to the deliverables, organizational process assets, project documents, and the project management plan.

Table 3-33. Perform Integrated Change Control: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Change requests2. Organizational process assets	<ol style="list-style-type: none">1. Change request status update2. Project management plan updates3. Project document updates

3.6.3 Verify Scope

Verify Scope is the process of formalizing acceptance of the completed project deliverables.

Table 3-34. Verify Scope: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Scope baseline2. Stakeholder requirements documentation3. Requirements traceability matrix4. Validated deliverables	<ol style="list-style-type: none">1. Accepted deliverables2. Change requests

3.6.4 Control Scope

Control Scope is the process of monitoring the status of the project and product scope and managing changes.

Table 3-35. Control Scope: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Project management plan2. Scope baseline3. Work performance data4. Stakeholder requirements documentation5. Requirements traceability matrix	<ol style="list-style-type: none">1. Work performance measurements2. Change requests3. Organizational process assets updates4. Project management plan updates5. Project document updates

3.6.5 Control Schedule

Control Schedule is the process of monitoring the status of the project to update project progress and managing changes to the schedule.

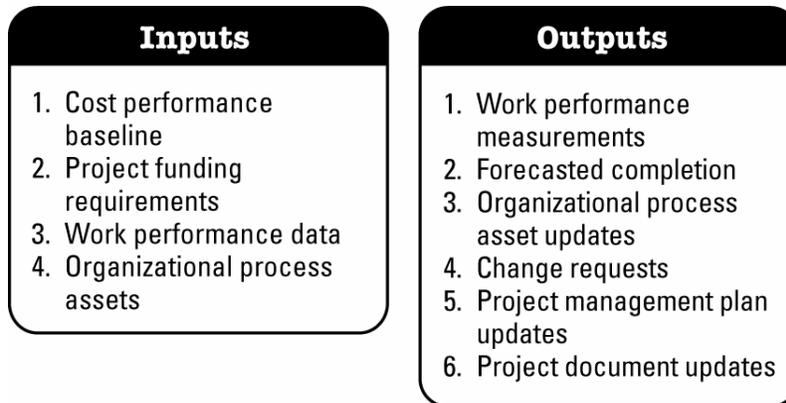
Table 3-36. Control Schedule: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Project management plan2. Project schedule3. Work performance data4. Organizational process assets	<ol style="list-style-type: none">1. Work performance measurements2. Organizational process assets updates3. Change requests4. Project management plan updates5. Project document updates

3.6.6 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.

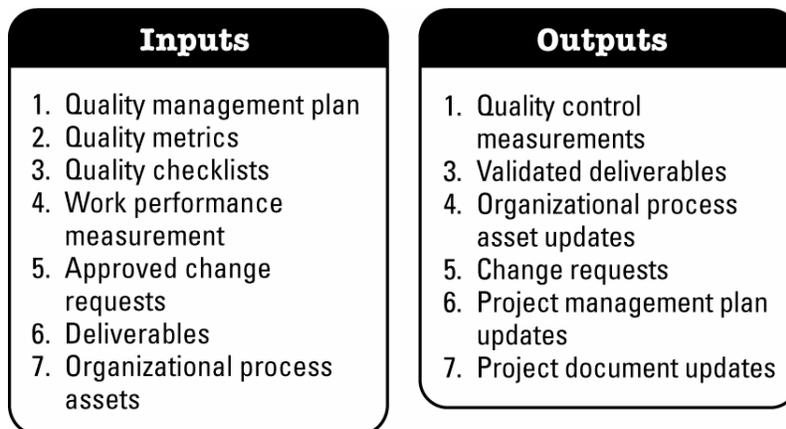
Table 3-37. Control Costs: Inputs and Outputs



3.6.7 Perform Quality Control

Perform Quality Control is the process of monitoring and recording results of executing the Quality Plan activities to assess performance and recommend necessary changes.

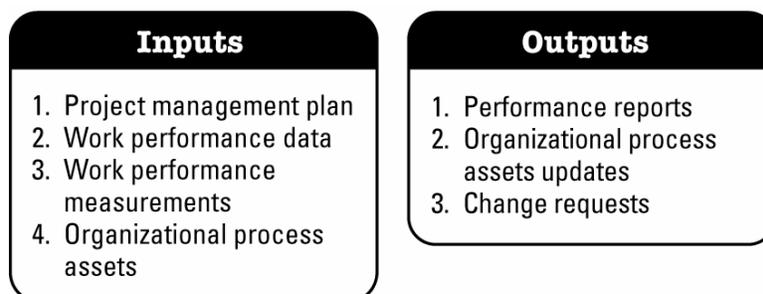
Table 3-38. Perform Quality Control: Inputs and Outputs



3.6.8 Report Performance

Report Performance is the process of collecting and distributing performance information including status reports, progress measurements, and forecasts.

Table 3-39. Report Performance: Inputs and Outputs



3.6.9 Monitor and Control Risks

Monitor and Control Risks is the process of executing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating the risk process throughout the project.

Table 3-40. Monitor and Control Risks: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Risk register2. Risk management plan3. Work performance data4. Performance reports	<ol style="list-style-type: none">1. Risk register updates2. Organizational process assets updates3. Change requests4. Project management plan updates5. Project document updates

3.6.10 Administer Procurements

Administer Procurements is the process of managing procurement relationships, monitoring contract performance, and making changes and corrections as needed. It includes the contract and relationship between the buyer and seller, reviewing and documenting how a seller is performing or has performed and, when appropriate, managing the contractual relationship with the external buyer of the project.

Table 3-41. Administer Procurements: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none">1. Procurement documents2. Procurement management plan3. Selected sellers4. Performance reports5. Approved change requests6. Work performance data	<ol style="list-style-type: none">1. Procurement documentation2. Organizational process assets updates3. Change requests4. Project management plan updates

3.7 Closing Process Group

Those processes performed to finalize all activities across all project process groups to formally close the project or phase. 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. At project or phase closure, the following may occur:

- Obtaining acceptance by the customer or sponsor,
- 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, or
- Closing out procurements.

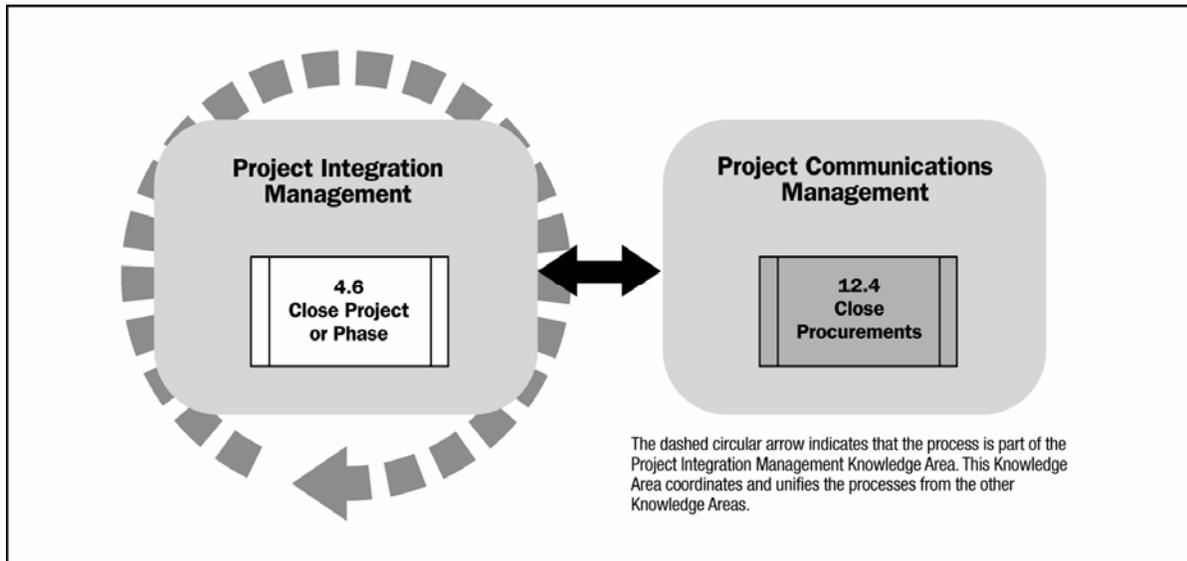


Figure 3-9. Closing Process Group

The Closing Process Group (Figure 3-9) includes the following project management processes (Tables 3-42 through 3-43):

3.7.1 Close Project or Phase

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

Table 3-42. Close Project or Phase: Inputs and Outputs

Inputs	Outputs
<ol style="list-style-type: none"> 1. Project management plan 2. Accepted deliverables 3. Organizational process assets 	<ol style="list-style-type: none"> 1. Final product, service, or result transition 2. Organizational process assets updates

3.7.2 Close Procurements

Close Procurements is the process of completing, settling, and closing each project procurement.

Table 3-43. Close Procurements: Inputs and Outputs

Inputs

1. Procurement management plan
2. Procurement documentation

Outputs

1. Closed procurements
2. Organizational process assets updates

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*.

Table 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 a project or a phase and documenting initial requirements that satisfy the stakeholder's needs and expectations.
- 4.2 Develop Project Management Plan**-The process of documenting the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans.
- 4.3 Direct and Manage Project Execution**-The process of executing the work defined in the project management plan to achieve the project's requirements.
- 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 of reviewing all change requests, approving changes, and managing changes to the deliverables, organizational process assets, project documents, and project management plan.
- 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.

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 Project Cost Management, Project Time Management, and Project Risk Management processes. 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.

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 different 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 must address every process, to determine the level of implementation for each process for each project.

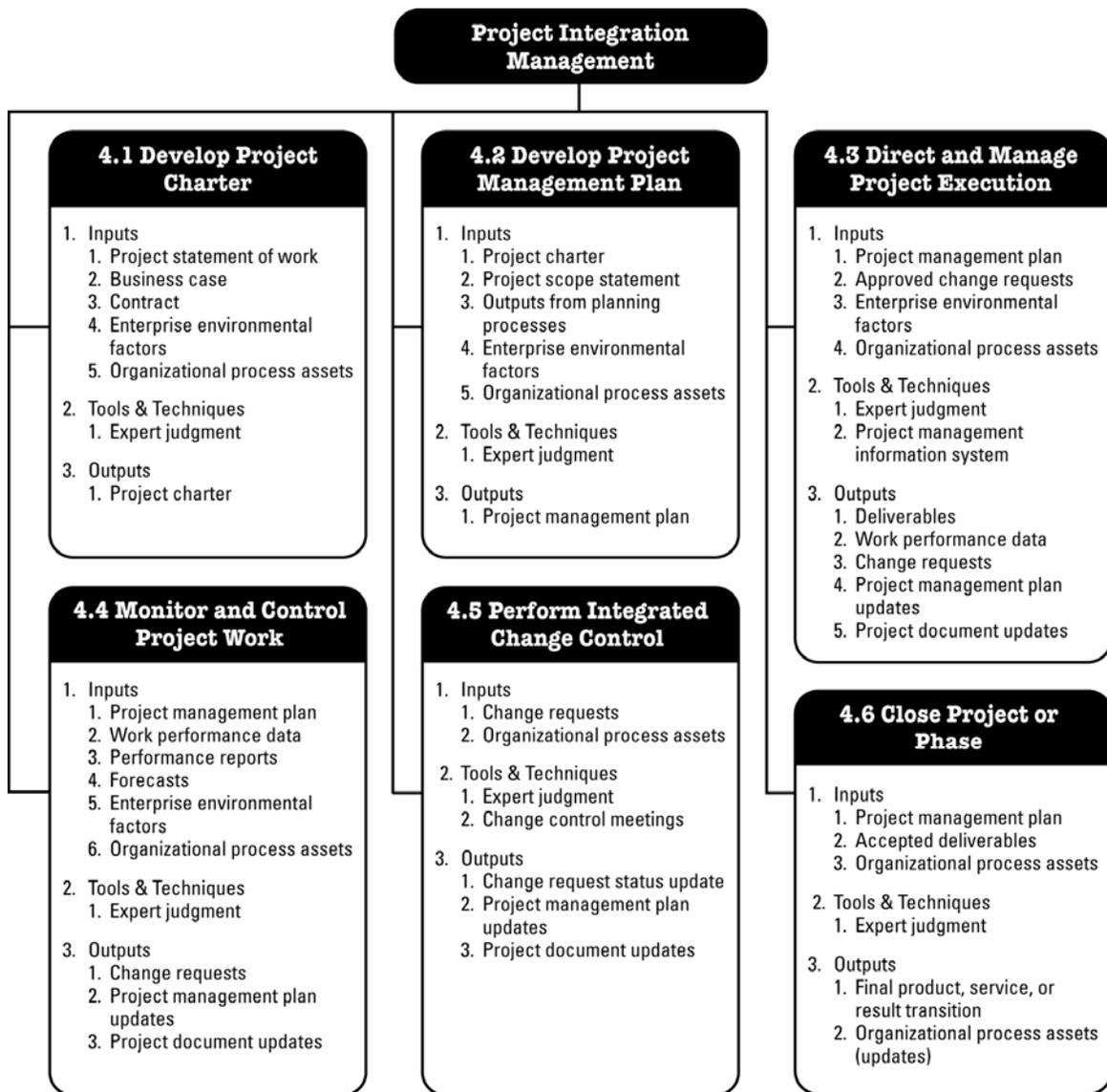
The integrative nature of projects and project management can be understood if we think of other types of activities performed while completing a project. Examples of some activities performed by the project management team are:

- 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.
- Measure and monitor project status, processes and products.

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

This Knowledge Area is concerned with effectively integrating the processes within the Project Process Groups to accomplish project objectives within an organization's defined procedures.

Table 4-1. Project Integration Management Overview



4.1 Develop Project Charter

Develop Project Charter is the process of developing a document that formally authorizes a project or a phase and documenting initial requirements that satisfy the stakeholder's needs and expectations. Creating the project charter and its approval formally initiates the project. This also establishes a partnership between the performing organization and the requesting organization (or customer, in the case of external projects). A project manager is identified and assigned as early in the project as is feasible. The project manager should always be assigned prior to the start of planning, and preferably while the project charter is being developed. 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.

A project initiator or sponsor, at a level that is appropriate to funding the project, authorizes the project by approving a project charter. Projects are usually chartered and authorized external

to 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 problem the project will address. Chartering a project links the project to the strategy and ongoing work of the organization.

Table 4-2 shows the inputs, tools and techniques, and outputs for this process and the data flow diagram is displayed in Figure 4-1.

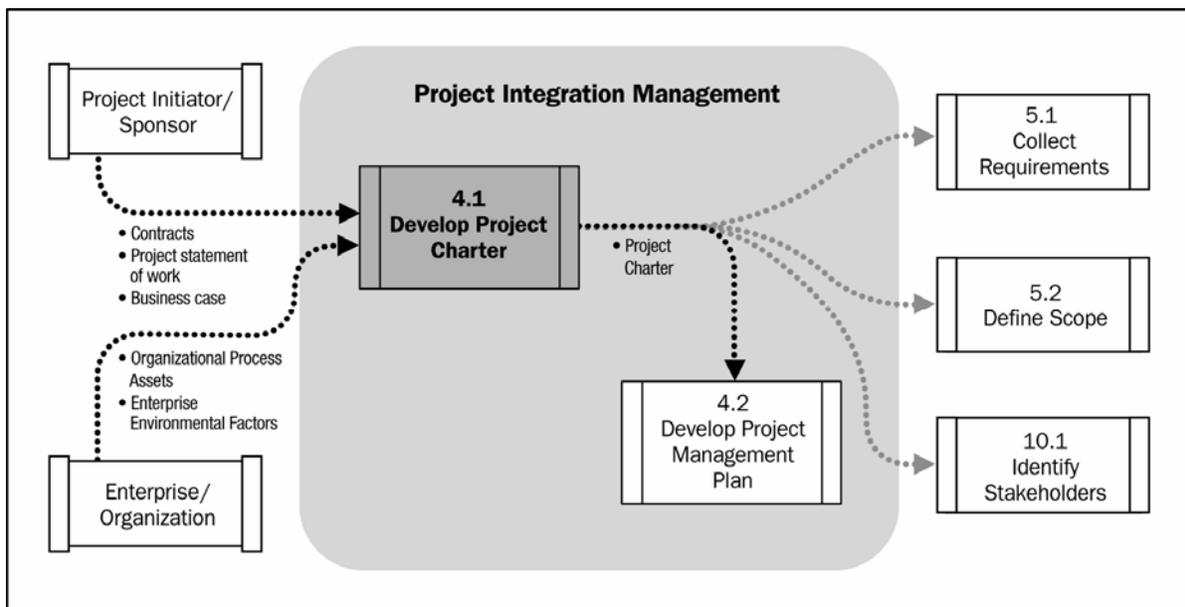
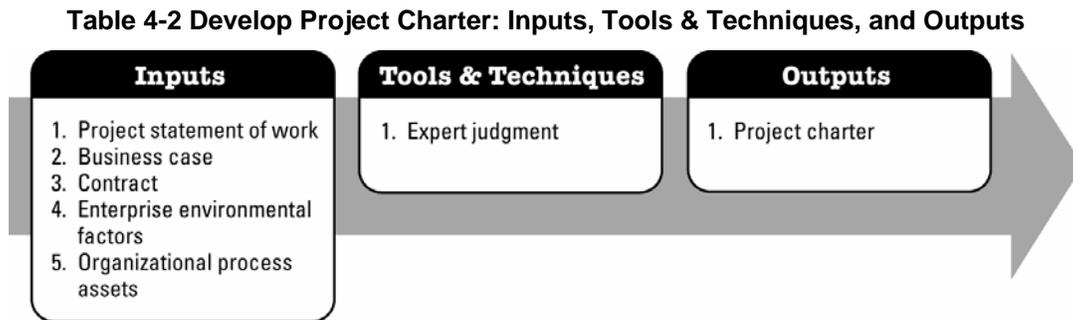


Figure 4-1. Develop Project Charter Data Flow Diagram

4.1.1 Develop Project Charter: Inputs

.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, request for proposal, request for information, request for bid, or as part of a contract. The SOW references:

- **Business need.** An organization's business need may be based on a market demand, technological advance, required training, legal requirement, or governmental standard.
- **Product scope description.** Documents the product 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.** All projects should support the organization's strategic goals. The strategic plan of the performing organization should be considered as a factor when making project selection decisions and prioritization.

.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 investing in. Typically, at a high level, the business need, which will be addressed by the project 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),
- Business 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), 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 multi-phase projects, the business case may be periodically reviewed to ensure that 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.

.3 Contract

A contract is an input if the project is being done for an external customer.

.4 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Develop Project Charter process include but are not limited to:

- Governmental or industry standards

- Organization infrastructure
- Marketplace conditions

This is not a complete list, but these factors should be considered on most projects.

.5 Organizational Process Assets

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

.1 Expert Judgment

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

- Other units within the organization,
- Consultants,
- Stakeholders, including customers or sponsors,
- Professional and technical associations,
- Industry groups,
- Subject matter experts, and
- Project Management Office (PMO).

4.1.3 Develop Project Charter: Outputs

.1 Project Charter

The project charter documents the business needs, project justification, 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 product characteristics,
- Summary milestone schedule,
- Summary budget,

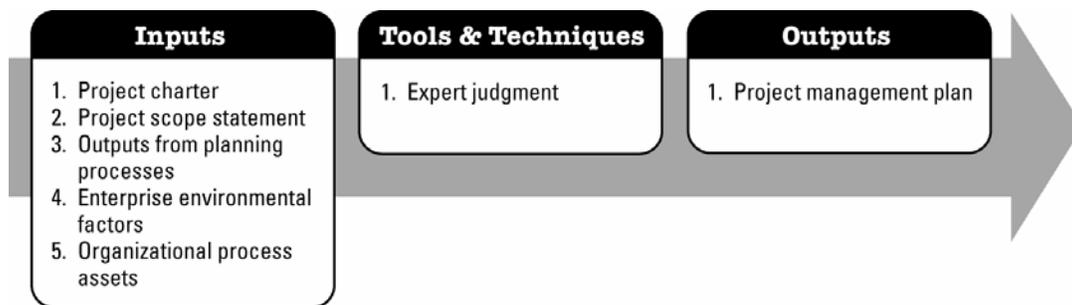
- Project approval requirements (what constitutes project success, who decides the project is successful, and who signs off on the project),
- Assigned project manager, responsibility, and authority level, and
- Name and responsibility of the person(s) authorizing the project charter.

4.2 Develop Project Management Plan

Develop Project Management Plan is the process of documenting the actions necessary to define, prepare, integrate, and coordinate all subsidiary plans. The project management plan defines how the project is executed, monitored and controlled, and closed. The project management plan content will vary depending upon the application area and complexity of the project. The project management plan is iterated through a series of integrated processes until 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.

Table 4-3 shows the inputs, tools and techniques, and outputs for this process and the data flow diagram is displayed in Figure 4-2.

Table 4-3. Develop Project Management Plan: Inputs, Tools & Techniques, and Outputs



4.2.1 Develop Project Management Plan: Inputs

.1 Project Charter

Described in Section 4.1.

.2 Project Scope Statement

Described in Section 5.2.

.3 Outputs from Planning Processes

Outputs from many of the planning processes described in Chapters 5 through 12 are integrated to create the project management plan. In addition, updates to these documents can necessitate updates to the project management plan.

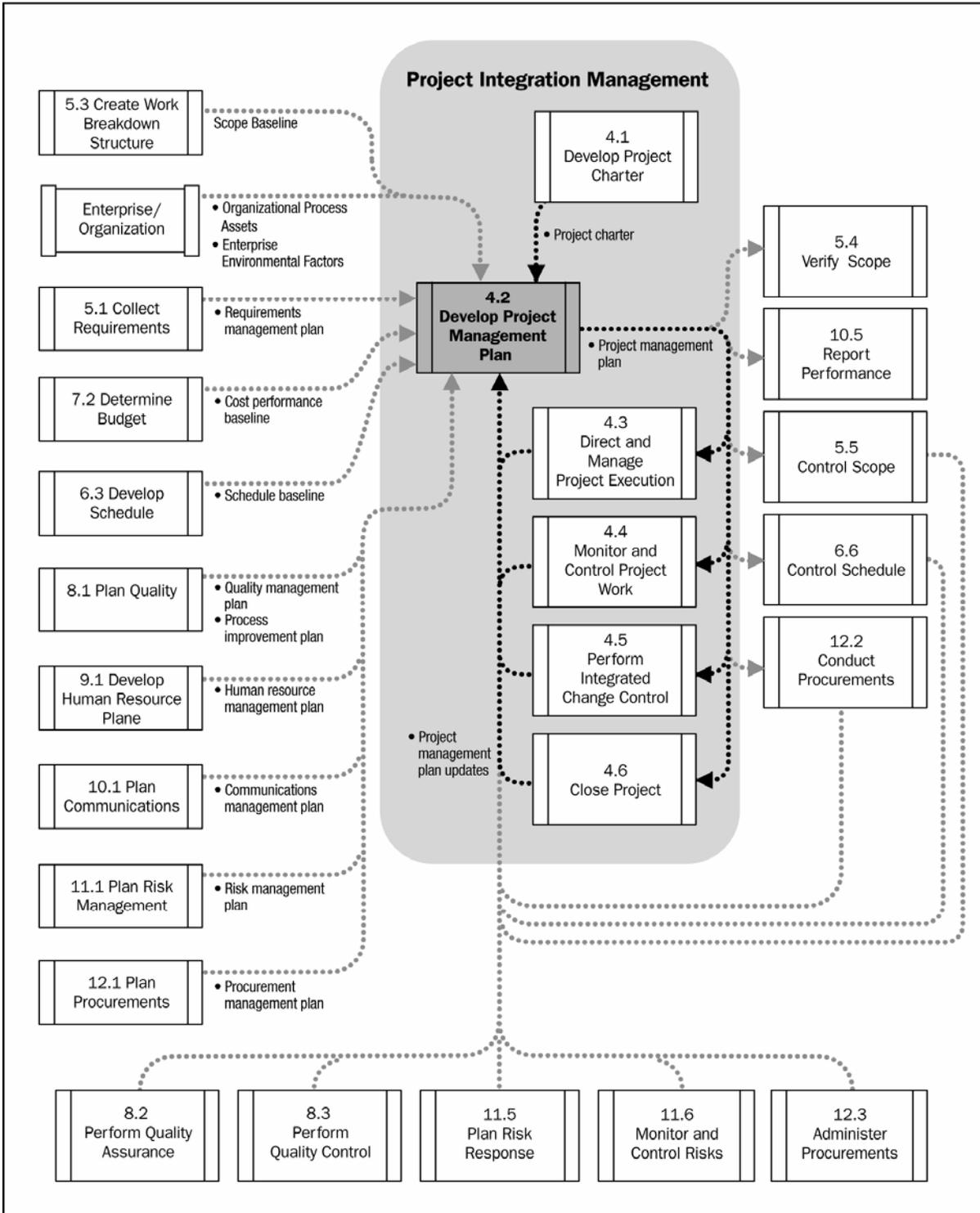


Figure 4-2. Develop Project Management Plan Data Flow Diagram

.4 Enterprise Environmental Factors

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 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),
- Infrastructure (e.g., existing facilities and capital equipment),
- Personnel administration (e.g., hiring and firing guidelines, employee performance reviews, and training records), 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).

.5 Organizational Process Assets

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--Elements of the project management plan that may be updated include, but are not limited to:
 - 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 quality baselines, performance measurement baselines, project calendars, project schedule network diagrams, risk registers, planned response actions, and defined risk impact);
- Historical information and lessons learned knowledge base; 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

.1 Expert Judgment

When developing the project management plan, expert judgment is applied to the following:

- 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.

4.2.3 Develop Project Management Plan: Outputs

.1 Project Management Plan

The project management plan integrates and consolidates all of the subsidiary management plans and baselines from the planning processes and includes:

- All of the selected project life cycle and, for multi-phase projects, the associated project phases,
- 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,
 - How the selected processes will be used to manage the specific project, including the dependencies and interactions among those processes, and the essential inputs and outputs.
- How work will be executed to accomplish the project objectives,
- How changes will be monitored and controlled,
- How configuration management will be performed,
- How integrity of the performance measurement baselines will be maintained,
- Need and techniques for communication among stakeholders, and
- Key management reviews for content, extent, and timing to facilitate addressing open issues and pending decisions.

The project management plan can be either summary level or detailed, and can be composed of one or more subsidiary plans. Each of the subsidiary plans is detailed to the extent required by the specific project. Once the project management plan is baselined, it may be changed when a change request is generated and approved through the Perform Integrated Change Control Process.

Subsidiary plans include, but are not limited to:

- Schedule management plan (introduction to Section 6),
- Cost management plan (introduction to Section 7),
- Quality management plan (Section 8.1.3.1),
- Process improvement plan (Section 8.1.3.4),
- Human resource plan (Section 9.1.3.1),
- Communications management plan (Section 10.2. 3.1),
- Risk management plan (Section 11.1.3.1), and
- Procurement management plan (Section 12.1.3.1).

- Project baselines include, but are not limited to:
- Schedule baseline,
- Cost performance baseline,
- Scope baseline, and
- Quality baseline.

Often the scope, schedule, and cost baseline will be combined into a performance measurement baseline that is used as an overall project baseline against which integrated performance can be measured. The performance measurement baseline is used for earned value measurements.

4.3 Direct and Manage Project Execution

Direct and Manage Project Execution is the process of executing the work defined in the project management plan to achieve the project's requirements. This process requires the project manager and the project team to perform multiple actions to execute the project management plan to achieve the project's objectives. Some of those actions are:

- 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 suppliers, and
- Collect and document lessons learned, and implement approved process improvement activities.

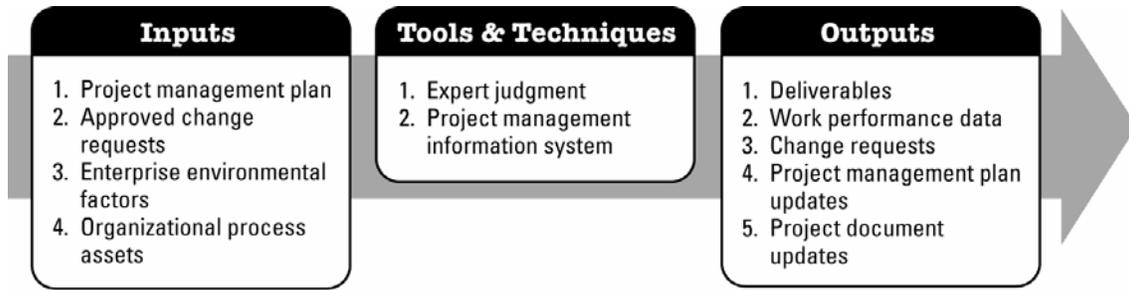
The project manager, along with the project management team, directs the performance of the planned project activities, and manages the various technical and organizational interfaces that exist within the project. The Direct and Manage Project Execution process is directly affected by the project application area. Deliverables are produced as outputs from processes performed to accomplish the project work planned and scheduled in the project management plan. Work performance information about the completion status of the deliverables, and what has been accomplished, is collected as part of project execution and is fed into the performance reporting process.

Direct and Manage Project Execution also requires implementation of approved changes covering:

- Corrective actions bringing anticipated project performance into compliance with the project management plan,
- Preventive actions reducing probability of potential negative consequences, and
- Defect repair requests correcting product defects found by the quality process.

Table 4-4 shows the inputs, tools and techniques, and outputs for this process and the data flow diagram is displayed in Figure 4-3.

Table 4-4 Direct and Manage Project Execution: Inputs, Tools & Techniques, and Outputs



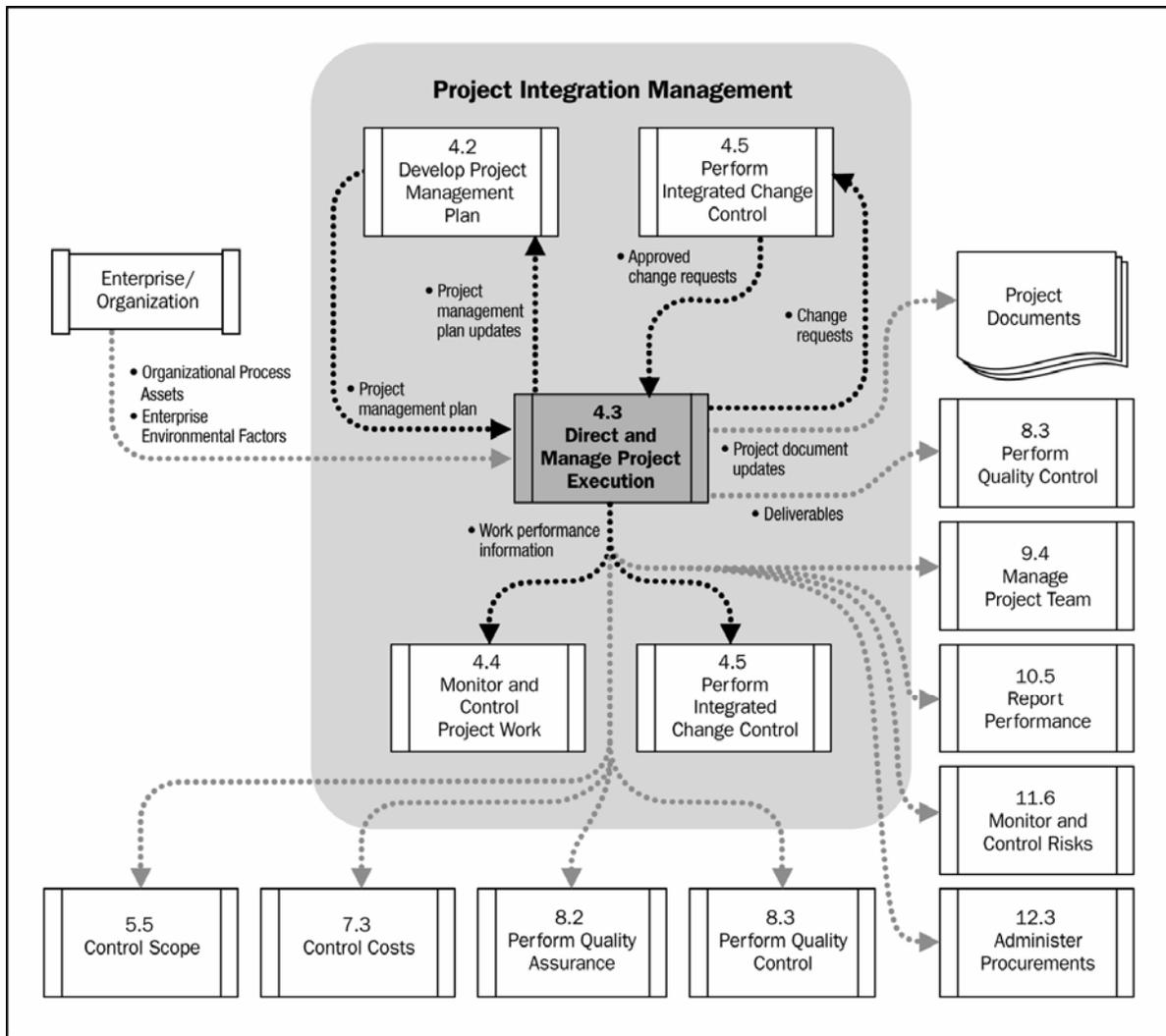


Figure 4-3. Direct and Manage Project Execution Data Flow Diagram

4.3.1 Direct and Manage Project Execution: Inputs

.1 Project Management Plan

Described in Section 4.2.

.2 Approved Change Requests

Approved change requests are scheduled for implementation by the project team. Approved change requests are the documented, authorized changes expand or reduce 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.

.3 Enterprise Environmental Factors

The enterprise environmental factors which can influence the Direct and Manage Project Execution process include but are not limited to:

- Organizational or company 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 Organizational Process Assets

The organizational process assets that can influence the Direct and Manage Project Execution 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, quality baselines, 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 Execution: Tools and Techniques

.1 Expert Judgment

Expert judgment is used to assess the inputs needed to direct and manage project execution to the project management plan. Such judgment and expertise is 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.

.2 Project Management Information Systems

The project management information system, part of the enterprise environmental factors, provides access to 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 used during the Direct and Manage Project Execution effort.

4.3.3 Direct and Manage Project Execution: Outputs

.1 Deliverables

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

.2 Work Performance Data

Raw data from project activities is routinely collected as the project progresses. This data can be related to various performance results including but not limited to:

- Deliverable status,
- Schedule progress, and
- Costs incurred.

.3 Change Requests

When issues are found while project work is being performed, change requests are issued which may expand, adjust, or reduce project scope to modify project policies or procedures, to modify project cost or budget, or to revise the project schedule. Other change requests cover 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 can include:

- **Corrective actions.** Recommendations required to bring future project performance into conformance with the project management plan.
- **Preventive actions.** Recommendations that reduce the probability of negative consequences associated with project risks.
- **Defects.** Found during the quality inspection and audit process, are recommended for correction by repair.
- **Updates.** Changes to formally controlled documentation, plans, etc., to reflect modified or additional ideas or content.

.4 Project Management Plan Updates

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

- Communications management plan,
- Human resources plan,
- Schedule management plan,
- Cost management plan,
- Requirements management plan, and
- Project baselines.

.5 Project Document Updates

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

- Requirements documents,

- Project logs (issue, assumptions, etc.),
- Stakeholder register.

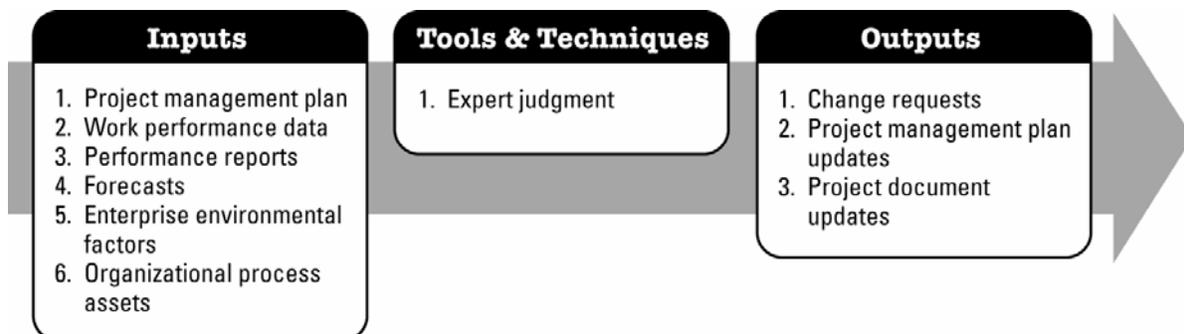
4.4 Monitor and Control Project Work

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. Monitoring is an aspect of project management performed throughout the project. Monitoring includes collecting, measuring, and disseminating performance information, and assessing measurements and trends to effect process improvements. Continuous monitoring gives the project management team insight into the health of the project, and identifies any areas that can require special attention. The Monitor and Control Project Work process is concerned with:

- Comparing actual project performance against the project management plan;
- Assessing performance to determine whether any corrective or preventive actions are indicated, and then recommending those actions as necessary;
- Analyzing, tracking, and monitoring project risks to make sure the risks are identified, their status is reported, and that appropriate risk response plans are being executed;
- Maintaining an accurate, timely information base concerning the project’s product(s) and their associated documentation through project completion;
- Providing information to support status reporting, progress measurement, and forecasting;
- Providing forecasts to update current cost and current schedule information; and
- Monitoring implementation of approved changes when and as they occur.

Table 4-5 shows the inputs, tools and techniques, and outputs for this process and the data flow diagram is displayed in Figure 4-4.

Table 4-5. Monitor and Control Project Work: Inputs, Tools & Techniques, and Outputs



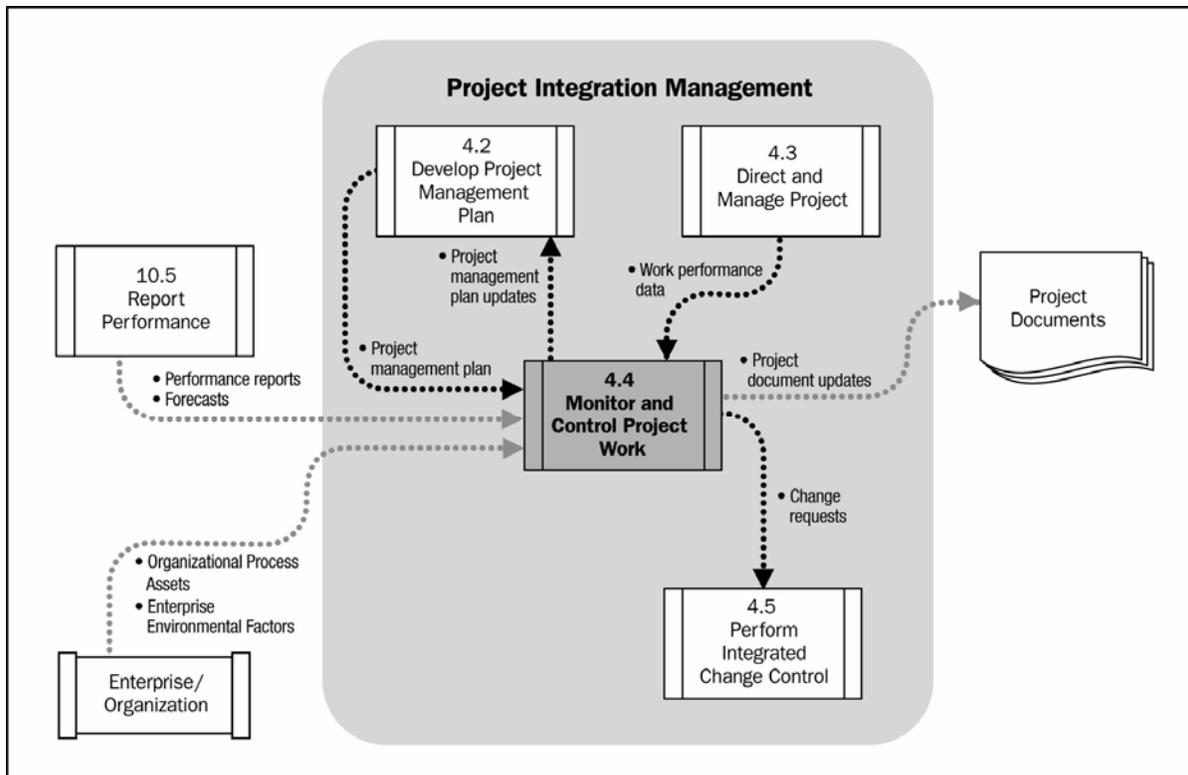


Figure 4-4. Monitor and Control Project Work Data Flow Diagram

4.4.1 Monitor and Control Project Work: Inputs

.1 Project Management Plan

Described in Section 4.2.

.2 Work Performance Data

Work performance data is used to compare planned performance to actual performance.

.3 Performance Reports

Reports should be prepared by the project team detailing activities, accomplishments, milestones, identified issues, and problems. Status reports can be used to report the key information, including but not limited to:

- Current status,
- Significant accomplishments for the period,
- Scheduled activities, and
- Issues.

.4 Forecasts

Forecasts include estimates or predictions of conditions and events in the project's future, based on information and knowledge available at the time of the forecast. Forecasts are updated and reissued

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

.5 Enterprise Environmental Factors

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).

.6 Organizational Process Assets

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 (time reporting, accounting codes, expenditure and disbursement reviews, and standard contract provisions),
- Issue and defect management procedures,
- 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

.1 Expert Judgment

Expert judgment is used by the project management team to interpret the information provided by the project management processes to monitor and control project performance. The project manager, in collaboration with the team, decides on its significance and determines the actions to be carried out based on the match between current reality and the existing plan.

4.4.3 Monitor and Control Project Work: Outputs

.1 Change Requests

As a result of comparing planned results to actual results, change requests are issued which may 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 actions.** Actions required to bring future performance into conformance with the project management plan.
- **Preventive actions.** Actions required to reduce the probability of negative consequences associated with project risks.
- **Defect repair.** Actions required to bring defective deliverables into conformance with requirements.

.2 Project Management Plan Updates

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

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

.3 Project Document 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 of reviewing all change requests, approving changes and managing changes to the deliverables, organizational process assets, project documents and the project management plan. 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 so those approved changes are incorporated into a revised baseline.

The Perform Integrated Change Control process includes the following change management activities in differing levels of detail, based upon the progress of project execution:

- Identifying that a change needs to occur or has occurred;
- Influencing the factors that circumvent integrated change control so that only approved changes are implemented;
- Reviewing and approving change requests promptly, which is essential, as a slow decision may negatively affect time, cost, or the feasibility of a change;

- Managing the approved changes when and as they occur;
- Maintaining the integrity of baselines by releasing only approved changes for incorporation into project plans and documents;
- Reviewing, assessing, and deciding on the action to be taken for all recommended corrective and preventive actions;
- Coordinating changes across the entire project (e.g., a proposed schedule change will often affect cost, risk, quality, and staffing); and
- Documenting the complete impact of change requests.

Changes may be requested by any stakeholder involved with the project. It is always provided in written form specified in the change control system/configuration management system. Change requests are subject to the process specified in change control system. The process may require information on estimated time impacts and estimated cost impacts.

Every documented change request may be either approved or rejected by some authority within the project management team or an external organization, for example, a change control board. Whenever required, the Perform Integrated Change Control process includes a change control board responsible for approving or rejecting all change requests. The roles and responsibilities of these boards are clearly defined within the configuration control and change control procedures, and are agreed upon by all stakeholders. Many large organizations provide for a multi-tiered board structure, separating responsibilities among the boards. If the project is being provided under a contract, then some proposed changes would need to be approved by the customer as per the contract.

Approved change requests can require new or revised cost estimates, schedule activity sequences, schedule dates, resource requirements, and analysis of risk response alternatives. These changes can require adjustments to the project management plan or other project plans/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.

A configuration management system with integrated change control provides a standardized, effective, and efficient way to centrally manage approved changes and baselines within a project. Configuration management with change control includes identifying, documenting, and controlling changes to the project and product baselines. Project-wide application of the configuration management system, including change control processes, accomplishes three main objectives:

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

Some of the configuration management activities included in the integrated change control process are as follows:

- **Configuration identification.** Selection and identification of a configuration item provides the basis for which 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 auditing.** Configuration verification and configuration audits ensure the composition of a project’s configuration items; corresponding changes are registered, assessed, approved, tracked, and correctly implemented. This ensures the functional requirements defined in the configuration documentation have been met.

Table 4-6 shows the inputs, tools and techniques, and outputs for this process and the data flow diagram is displayed in Figure 4,5.

Table 4-6 Perform Integrated Change Control: Inputs, Tools & Techniques, and Outputs



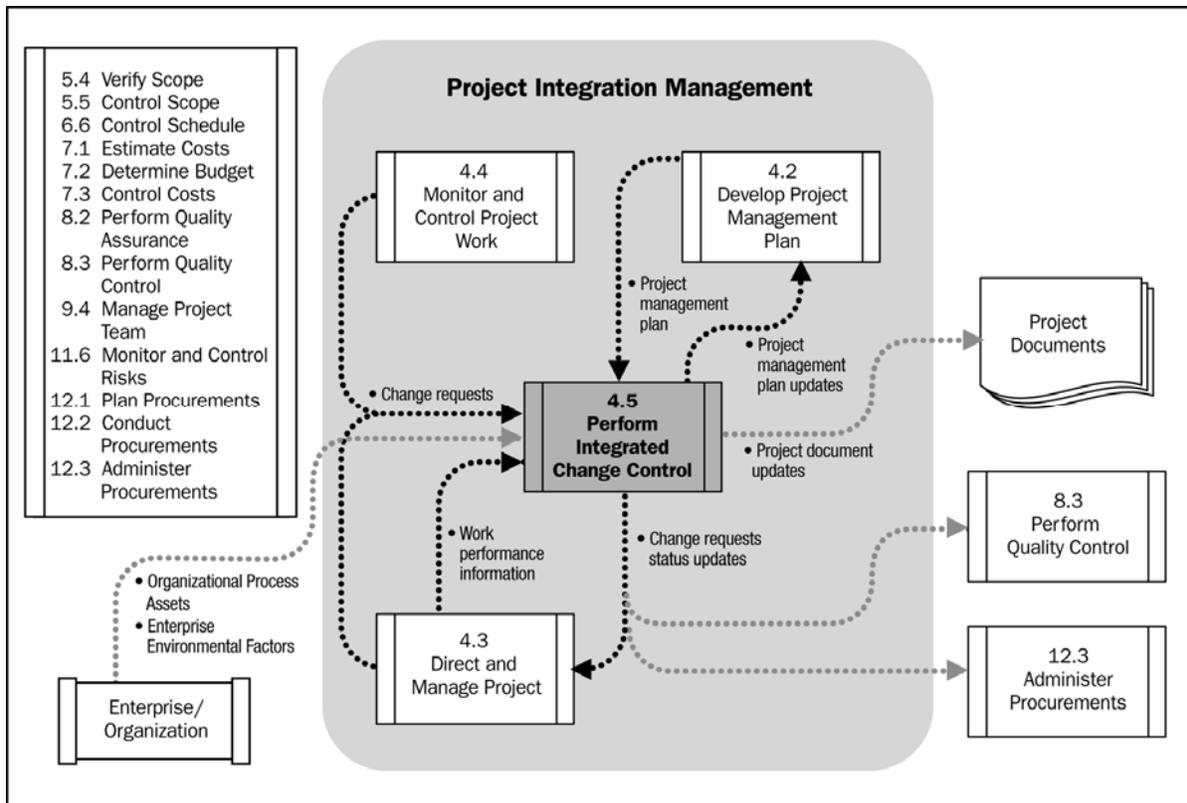


Figure 4.5 Perform Integrated Change Control Data Flow Diagram

4.5.1 Perform Integrated Change Control: Inputs

.1 Change Requests

Change requests can come from any of the control processes or the Project Integration Management processes. Change requests can include corrective action, preventive action, and defect repairs.

.2 Organizational Process Assets

The organizational process assets that can influence the 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 issued;
- 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 quality baselines, performance measurement baselines, project calendars, project schedule network diagrams, risk registers, planned response actions, and defined risk impact);
- 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

.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. Such judgment and expertise is applied to any technical and management details during this process and may be provided by other units within the organization, for example:

- Consultants
- Stakeholders, including customers or sponsors
- Professional and technical associations
- Industry groups
- Subject matter experts
- Project Management Office (PMO)

.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 all stakeholders. All change control board decisions are documented and communicated to the stakeholders for information and follow-up actions.

4.5.3 Perform Integrated Change Control: Outputs

If a change request is deemed feasible but outside the scope, then implementing that request will result in a baseline change. If the change request is not deemed feasible the change request will be rejected and possibly sent back to the requester for additional information.

.1 Change Request Status Updates

Change requests are processed according to the change control systems by the Project Manager or by an assigned team member.

.2 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.

.3 Project Document Updates

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

4.6 Close Project or Phase

Close Project Phase is the process of finalizing all activities across all of the Project Management Process Groups to formally close the project or phase. This includes finalizing all activities across all the Project Process Groups to formally close the project or phase and transfer the completed or cancelled project as appropriate. The Close Project or Phase process also establishes the procedures to coordinate activities needed to verify and document the project or phase deliverables,

to coordinate and interact to formalize acceptance of those deliverables by the customer or sponsor and to investigate and document the reasons for actions taken if a project is terminated before completion.

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 confirm that the project or phase has met all sponsors, customer, and other stakeholders’ requirements, verify that all deliverables have been provided and accepted.
- Actions and activities necessary to satisfy completion or exit criteria for the phase or project.
- Actions and activities necessary to transfer the project products or services to the next phase or to production and/or operations.
- 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.

Table 4-7 shows the inputs, tools and techniques, and outputs for this process and the data flow diagram is displayed in Figure 4-6.

Table 4-7 Close Project or Phase: Inputs, Tools & Techniques, and Outputs

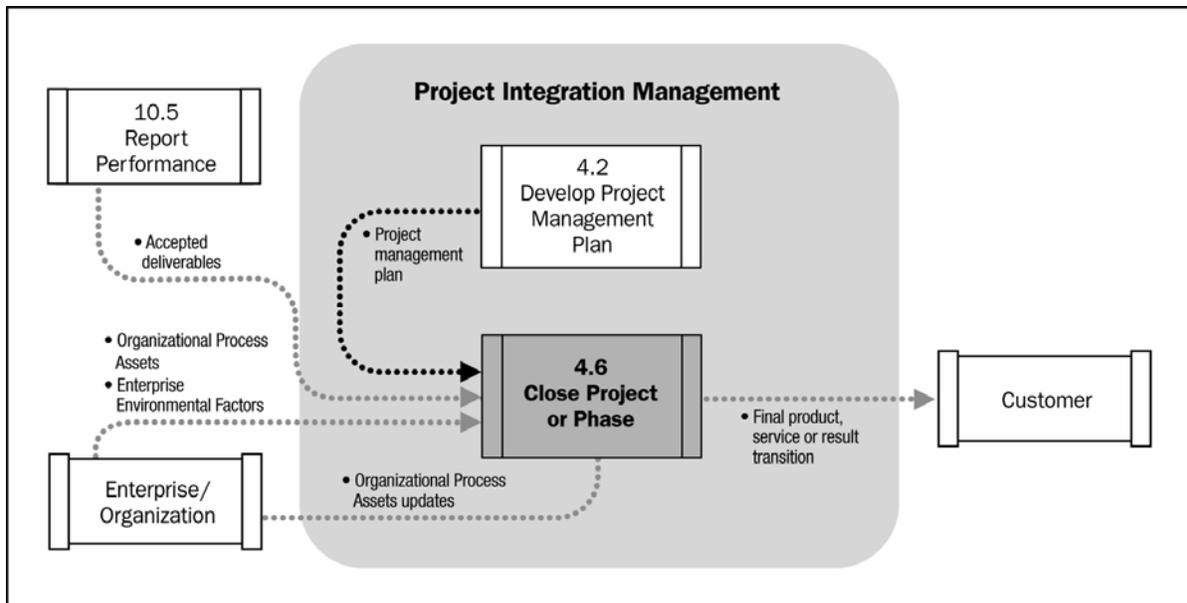
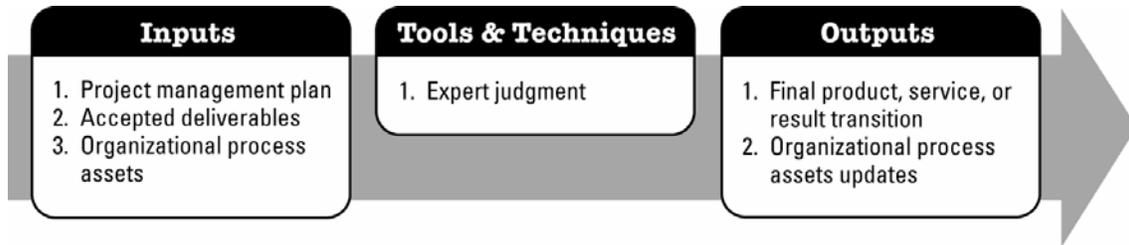


Figure 4-6. Close Project or Phase Data Flow Diagram

4.6.1 Close Project or Phase: Inputs

.1 Project Management Plan

Described in Section 4.2.

.2 Accepted Deliverables

Those deliverables that have been accepted through the Verify Scope process.

.3 Organizational Process Assets

The organizational process assets that can influence the Close Project or Phase process include but are not limited to:

- Project closure guidelines or requirements (e.g., final project audits, project evaluations, product validations, and acceptance 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 effort).

4.6.2 Close Project or Phase: Tools and Techniques

.1 Expert Judgment

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

4.6.3 Close Project or Phase: Outputs

.1 Final Product, Service, or Result Transition

Formal acceptance and handover 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). The acceptance includes receipt of a formal statement that the terms of the contract have been met.

.2 Organizational Process Assets Updates

The organizational process assets that can influence the Close Project or Phase process include but are not limited to:

- **Formal acceptance documentation.** Formal confirmation has been received from the customer or sponsor that customer requirements and specifications for the project's or phase's product, service, or result have been met. This document formally indicates the customer or sponsor has officially accepted the deliverables.
- **Project files.** Documentation resulting from the project's activities, for example, project management plan, scope, cost, schedule and quality baselines, project calendars, risk registers, planned risk response actions, and risk impact.
- **Project 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. 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.

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. Table 5-1 provides an overview of the Project Scope Management processes, which include the following:

- 5.1 Collect Requirements**--the process of defining and documenting the project and product features and functions needed to fulfill stakeholder's needs and expectations.
- 5.2 Define Scope**--the process of developing a detailed description of the project and product.
- 5.3 Create Work Breakdown Structure**--the process of subdividing project deliverables and project work into smaller, more manageable components.
- 5.4 Verify Scope**--the process of formalizing acceptance of the completed project deliverables.
- 5.5 Control Scope**--the process of monitoring the status of the project and product scope and managing changes.

These processes interact with each other and with the processes in the other Knowledge Areas. Each process can involve effort from one or more persons, based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete components with well-defined interfaces, in practice they will overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3, Project Management Processes. In the project context, the term scope can refer to:

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

This chapter primarily focuses on the processes used to manage the project 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 approved detailed project scope statement and its associated WBS and WBS dictionary are the scope baseline for the project. This baselined scope is then monitored, verified and controlled throughout the lifecycle of the project.

Table 5-1. Project Scope Management: Inputs, Tools & Techniques, and Outputs



Completion of the project scope is measured against the project management plan (Section 4.2). Completion of the product scope is measured against the product requirements (Section 5.1). 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.

5.1 Collect Requirements

Collect Requirements is the process of defining and documenting the project and product features and functions needed to fulfill stakeholder's needs and expectations. The project's success is directly influenced by the care taken in capturing and managing requirements. Requirements are a condition or capability that must be met or possessed by a system, product, service, result, or

component to satisfy a contract, standard, specification, or other formal document. Requirements include the quantified and documented needs, wants, and expectations of the sponsor, customer, and other stakeholders. These requirements need to be elicited, analyzed, and recorded in enough detail to be measured once the project execution phase begins. Collecting requirements is as much about defining and managing customer expectations as any other key project deliverable and becomes the very foundation of the work breakdown structure (WBS). Cost, schedule, and quality planning are all built upon these requirements. The development of requirements begins with an analysis of the information contained in the project charter (Section 4.1), and the stakeholder register (Section 10.1). Table 5-2 shows the inputs, tools and techniques, and outputs for the Collect Requirements process, and Figure 5-1 provides a summary of the basic flow and interactions within this process.

Table 5-2. Collect Requirements: Inputs, Tools & Techniques, and Outputs

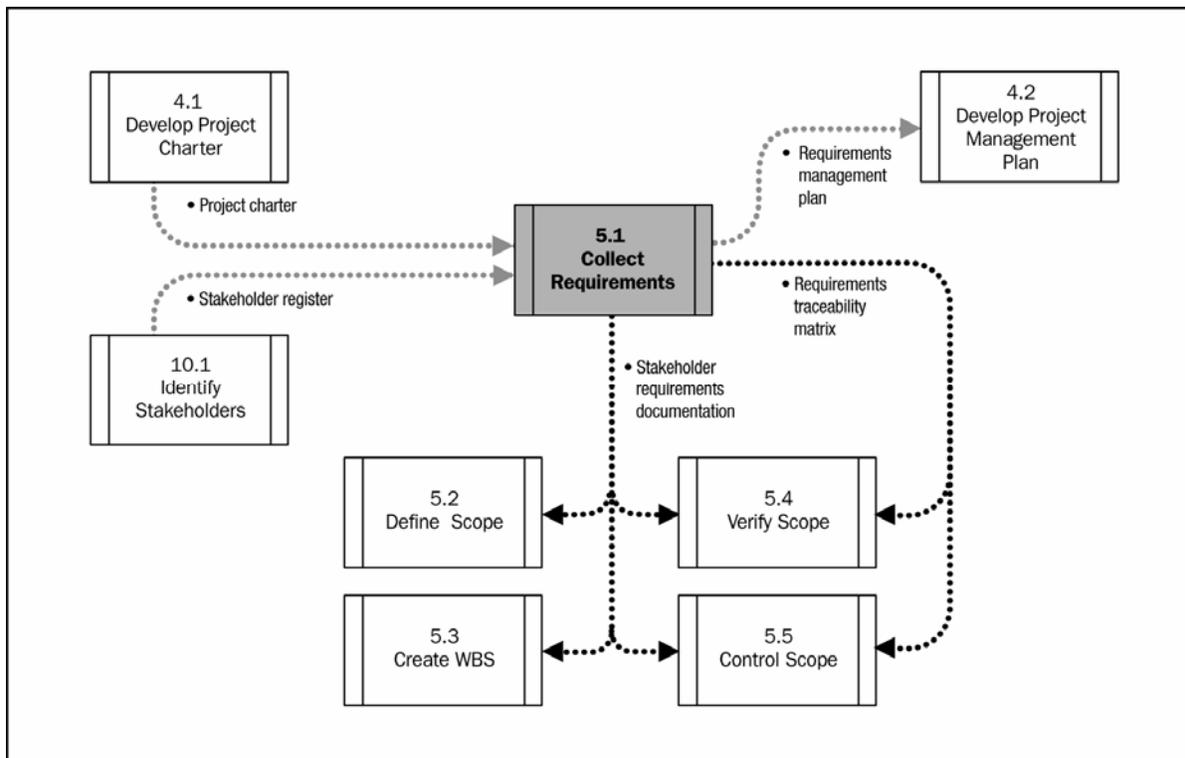
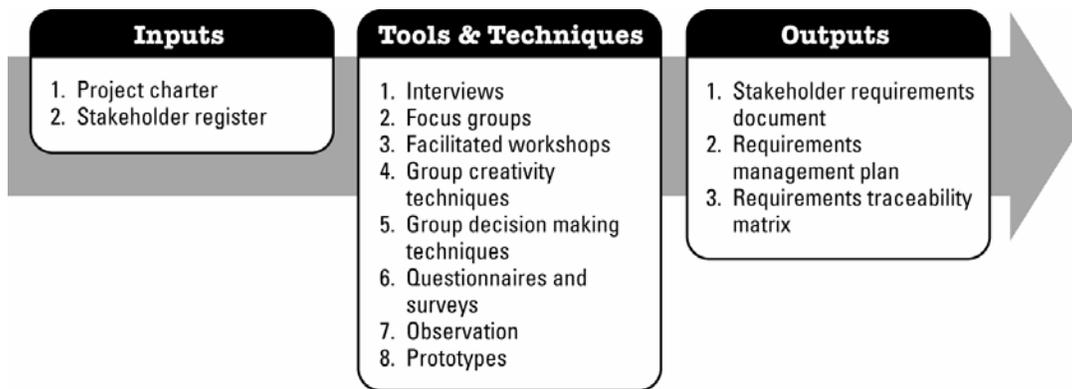


Figure 5-1. Collect Requirements Data Flow Diagram

5.1.1 Collect Requirements: Inputs

.1 Project Charter

The project charter is used to provide the high-level requirements and high-level product description of the project so that detailed requirements can be developed.

.2 Stakeholder Register

The stakeholder register is used to identify stakeholders that can provide information on detailed project and product requirements. The stakeholder register is described in Section 10.1.

5.1.2 Collect Requirements: Tools and Techniques

.1 Interviews

An interview is a formal or informal approach to discover 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 “one-on-one,” 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 project deliverables.

.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 natural than a one-on-one interview.

.3 Facilitated Workshops

Requirements workshops are focused sessions that bring key cross-functional stakeholders together to define 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 consensus, and improve communication among the participants. 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 Development (or Design) (JAD) sessions are used in the software development industry. These facilitated sessions focus on bringing users and the development team together to improve the software development process. In the manufacturing industry, Quality Function Deployment (QFD) is an example of another facilitated workshop technique that helps determine critical characteristics for new product development. QFD starts by collecting customer needs (called “voice of the customer”) and then objectively sorts, prioritizes, and sets goals for those needs.

.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.** Generate and collect multiple ideas related to project and product requirements.
- **Nominal Group Technique.** Enhances brainstorming with a voting process used to rank the most useful ideas for further brainstorming or for prioritization.
- **The Delphi Technique.** A selected group of experts answers questionnaires and provides feedback regarding the responses from each round or requirements gathering.
- **Idea/Mind Mapping.** Ideas created through individual brainstorming are consolidated into a single map to reflect commonality and differences in understanding, and generate new ideas.

.5 Group Decision Making Techniques

Group decision making is an assessment process of multiple alternatives with an expected outcome in the form of future actions resolution. These can be used to generate, classify and prioritize requirements for the project.

There are multiple methods of reaching a group decision, for example:

- **Unanimity.** Everyone agrees on a single course of action.
- **Majority.** Support from more than 50% of the members of the group.
- **Consensus.** The majority defines a course of action, but the minority agrees to accept it.
- **Plurality.** The largest block in a group decides even if a majority is not achieved.
- **Dictatorship.** One individual makes the decision for the group.

Almost any of the decision methods described previously can be applied to the group techniques potentially used in the requirements gathering process.

.6 Questionnaires and Surveys

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

.7 Observation

Observation provides 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, also called "job shadowing" is usually done externally by the observer viewing the user perform his or her 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.

.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 more quickly and less expensively than only discussing abstract representations of their requirements. Prototypes support the concept of progressive elaboration because they are used 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.

5.1.3 Collect Requirements: Outputs

.1 Stakeholder Requirements Documentation

Stakeholder 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 must be unambiguous (measurable and testable), traceable, complete, and consistent. The format of a stakeholder 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 stakeholder requirements documentation can include but are not limited to:

- Business problem to be solved or opportunity to be seized, describing the limitations of the current situation and why the project has been undertaken;
- Business and project objectives for traceability;
- Functional requirements, describing business process, information, and interaction with the product, as appropriate which can be documented textually in a requirements list, in models, or both;
- Non-functional requirements, such as level of service, performance, security, compliance, supportability, retention/purge, etc.;
- Quality requirements;
- Business rules stating the guiding principles of the organization;
- Impacts to other organizational areas, such as 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.

.2 Requirements Management Plan

The requirements management plan documents how requirements will be analyzed, documented, and managed throughout the project. The phase-to-phase relationship, described in 2.1.3.2, 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, service or result requirements 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, that is, which requirements attributes will be captured on the traceability matrix and to which other project documents requirements will be traced.

.3 Requirements Traceability Matrix

The requirements traceability matrix is a table that links requirements to their origin and traces them throughout the project life cycle. 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 stakeholder 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 problems, 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, requirement, 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.

5.2 Define Scope

Define Scope is the process of developing a detailed description of the project and product. 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 additional risks, assumptions, and constraints are added as necessary.

Table 5-3. Define Scope: Inputs, Tools & Techniques, and Outputs



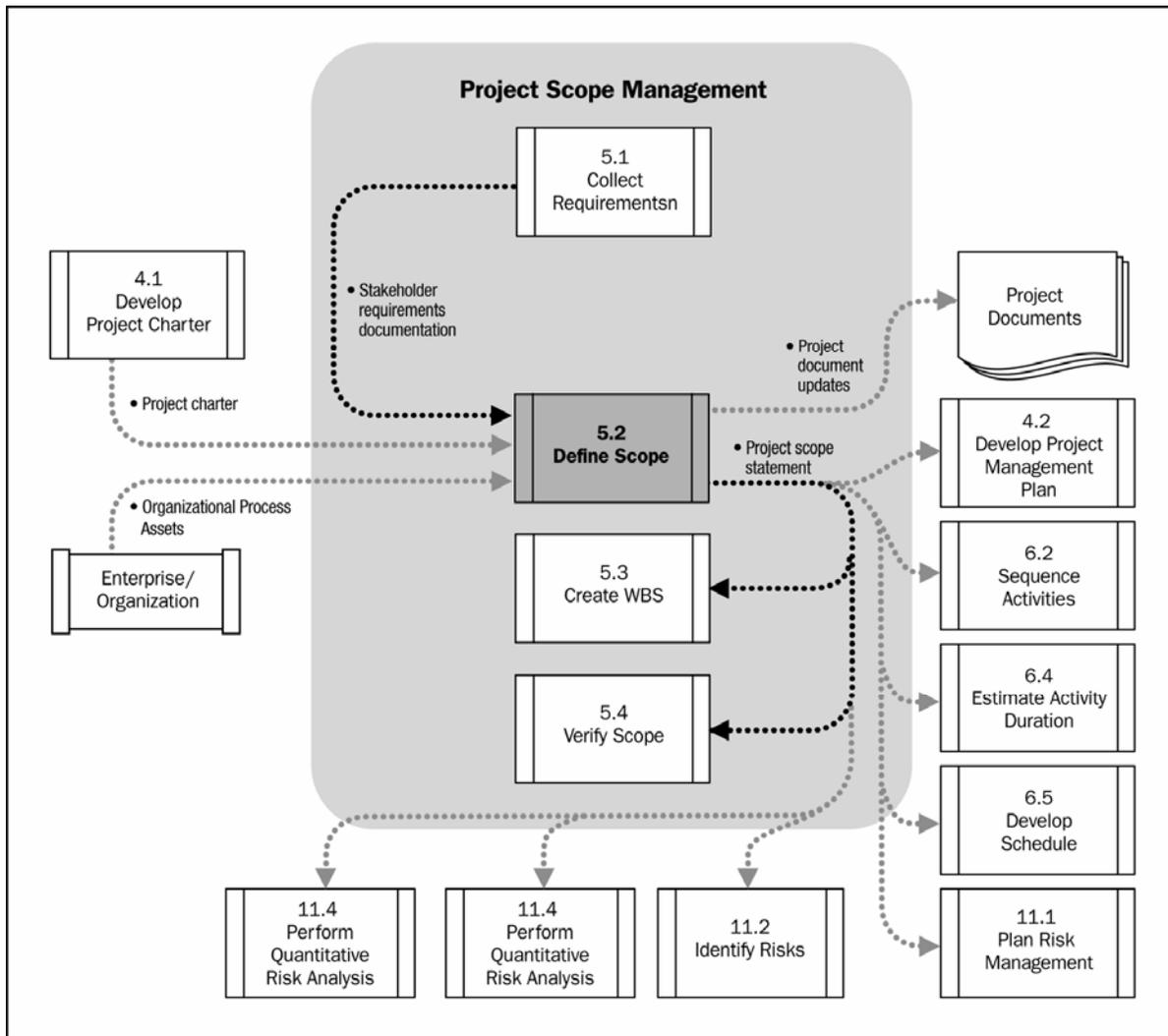


Figure 5-2. Define Scope Data Flow Diagram

5.2.1 Define Scope: Inputs

.1 Project Charter

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

.2 Stakeholder Requirements Documentation

Described in Section 5.1.3.1.

.3 Organizational Process Assets

Examples of organizational process assets that can influence the Define Scope process 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 projects.

5.2.2 Define Scope: Tools and Techniques

.1 Expert Judgment

Expert judgment is often used to analyze the information needed to develop the project scope statement. Such judgment and expertise is applied to any technical details. 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, and
- Subject matter experts.

.2 Product Analysis

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, systems engineering, value engineering, value analysis, and functional analysis.

.3 Alternatives Identification

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

.4 Facilitated Workshops

Described in Section 5.1.2.3.

5.2.3 Define Scope: Outputs

.1 Project Scope Statement

The project scope statement describes, in detail, the project's deliverables and the work required to create those deliverables. The project scope statement also provides a common understanding of the project scope among 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 includes, either directly, or by reference to other documents, the following:

- **Product scope description.** Progressively elaborates the characteristics of the product, service, or result that as described in the project charter.
- **Project deliverables.** Deliverables include both the outputs that comprise the product or service of the project, as well as ancillary results, such as project management reports and documentation. The deliverables may be described at a summary level or in great detail.
- **Project boundaries.** Generally identifies what is included within the project. It states explicitly what is out of scope for the project; and whether a stakeholder should assume that a particular stated product, service, or result requirement could be included in the project when, in actuality, it is not.
- **Product acceptance criteria.** Defines the process and criteria for accepting completed products.
- **Project constraints.** Lists and describes the specific project constraints associated with the project scope that limits the team's options. For example, a predefined budget or any imposed dates (schedule milestones) that are issued by the customer or performing organization. When a project is performed under contract, 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 specific project assumptions associated with the project scope and the potential impact of those assumptions if they prove to be false. Project teams frequently identify, document, and validate assumptions as part of their planning process. Information on assumptions may be listed in the project scope statement or in a separate log.

.2 Project Document Updates

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

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

5.3 Create WBS

Create WBS is the process of subdividing project deliverables and project work into smaller, more manageable components. The WBS is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team, to accomplish the project objectives and create the required deliverables, with each descending level of the WBS representing an increasingly detailed definition of the project work. 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 contained within the lowest-level WBS components, which are called work packages, 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 effort and not to the effort itself.

Table 5-4. Create WBS: Inputs, Tools & Techniques, and Outputs

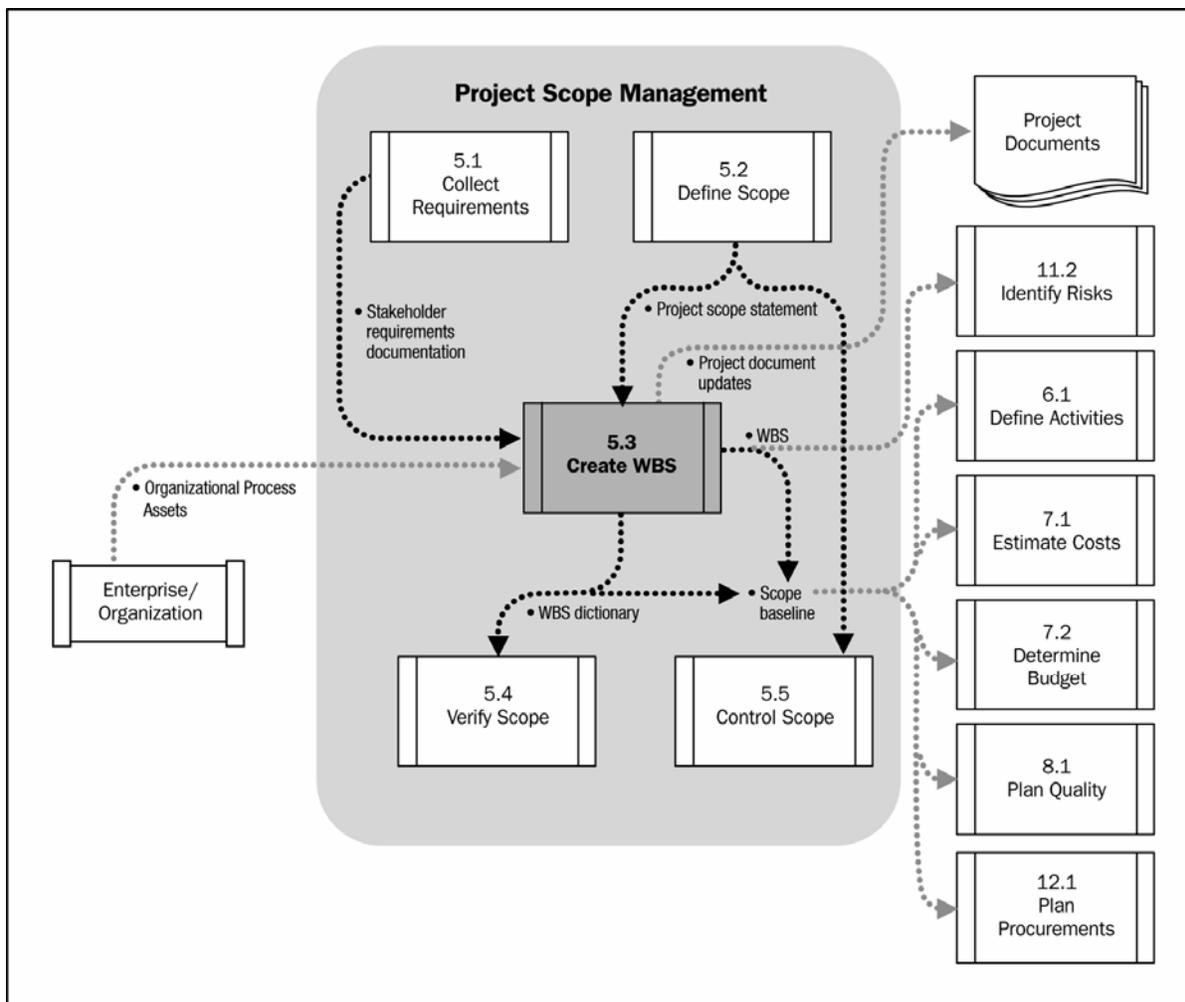
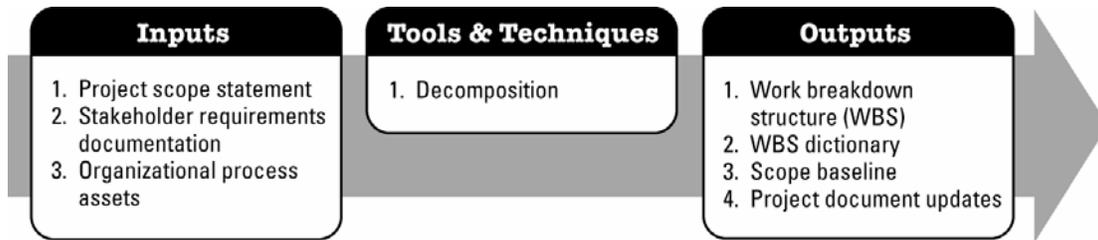


Figure 5-3. Create WBS Data Flow Diagram

5.3.1 Create WBS: Inputs

.1 Project Scope Statement

Described in Section 5.2.3.1.

.2 Stakeholder Requirement Documentation

Described in Section 5.1.3.1.

.3 Organizational Process Assets

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.

5.3.2 Create WBS: Tools and Techniques

.1 Decomposition

Decomposition is the subdivision of project deliverables into smaller, more manageable components until the work and deliverables are defined to the work package level. The work package level is the lowest level in the WBS, and is the point at which the cost and schedule for the work can be reliably estimated. The level of detail for work packages will vary with the size and complexity of the project.

Decomposition 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.

Structuring and organizing the deliverables and associated project work into a WBS that can meet the control and management requirements of the project management team are analytical techniques that may be done with the use of a WBS template if one exists. A portion of a WBS with some branches of the WBS decomposed down through the work package level is shown in Figure 5-7.

The WBS structure can take a number of forms, for example:

- Using phases of the project life cycle as the first level of decomposition, with the project deliverables inserted at the second level, as shown in Figure 5-8.
- Using major deliverables as the first level of decomposition, as shown in Figure 5-9.
- Using subprojects which may be developed by organizations outside the project team, such as contracted work. The seller then develops the supporting contract work breakdown structure as part of the contracted work.

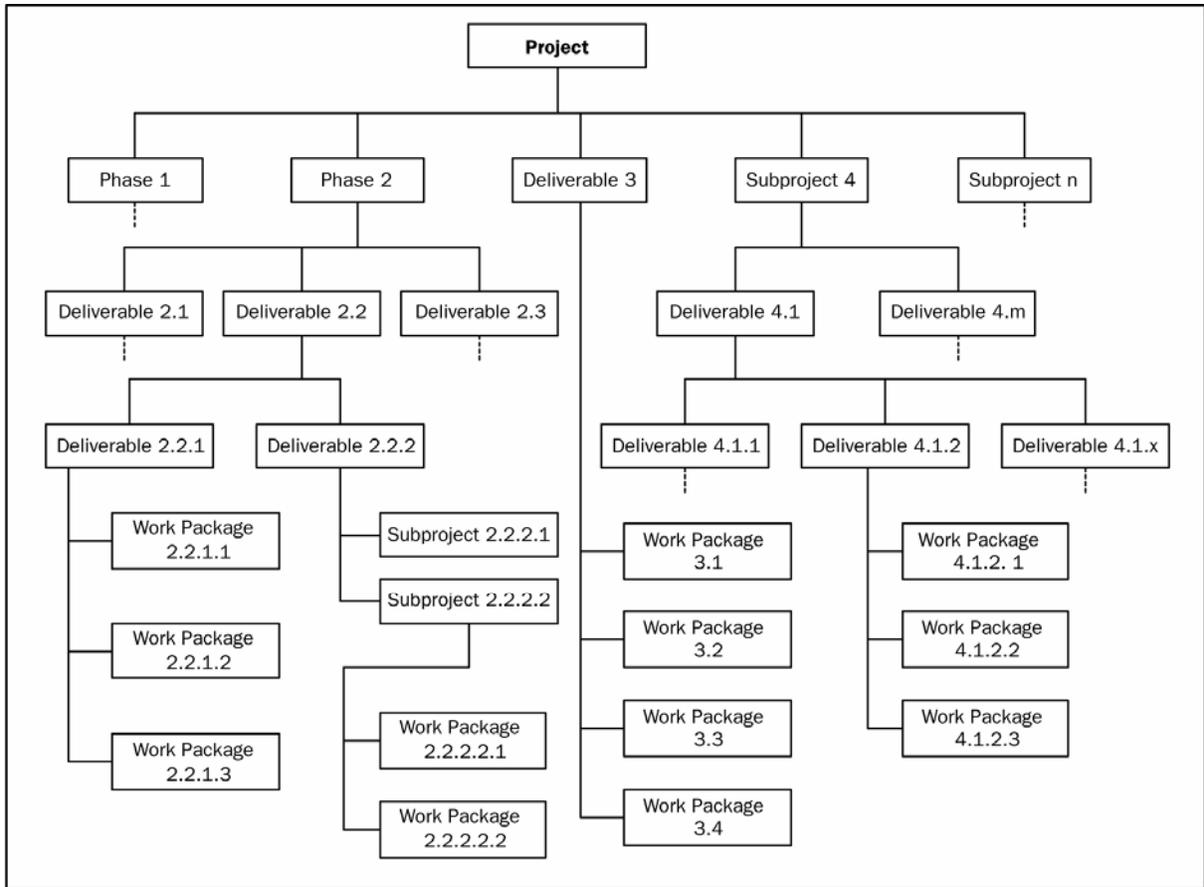


Figure 5-4. Sample Work Breakdown Structure with Some Branches Decomposed Down Through Work Packages

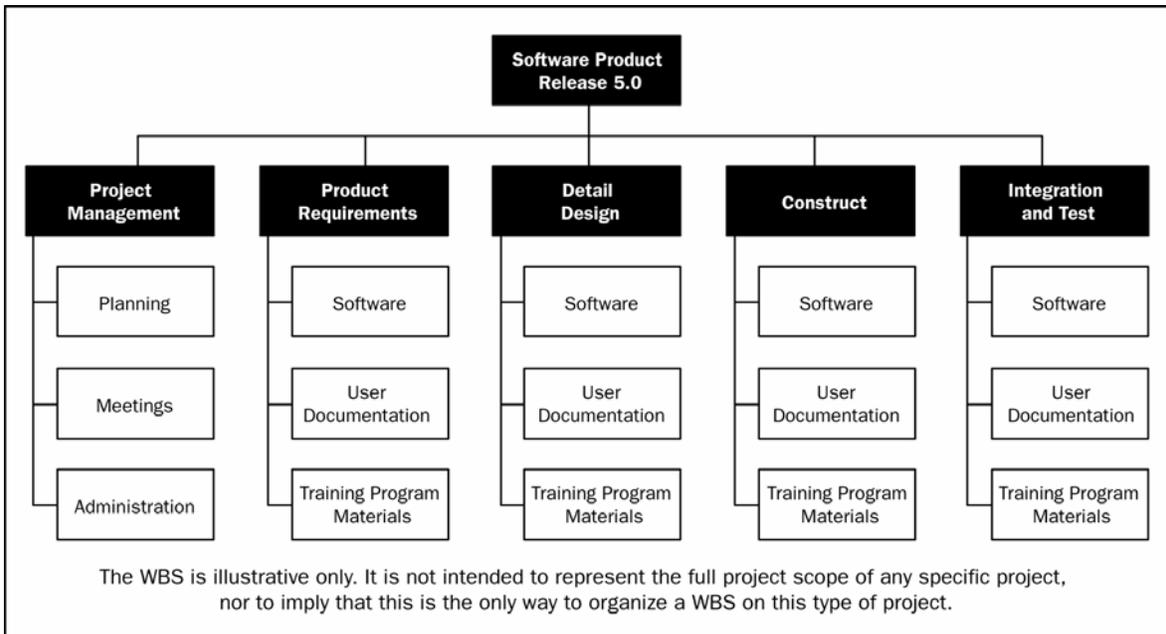


Figure 5-5. Sample Work Breakdown Structure Organized by Phase

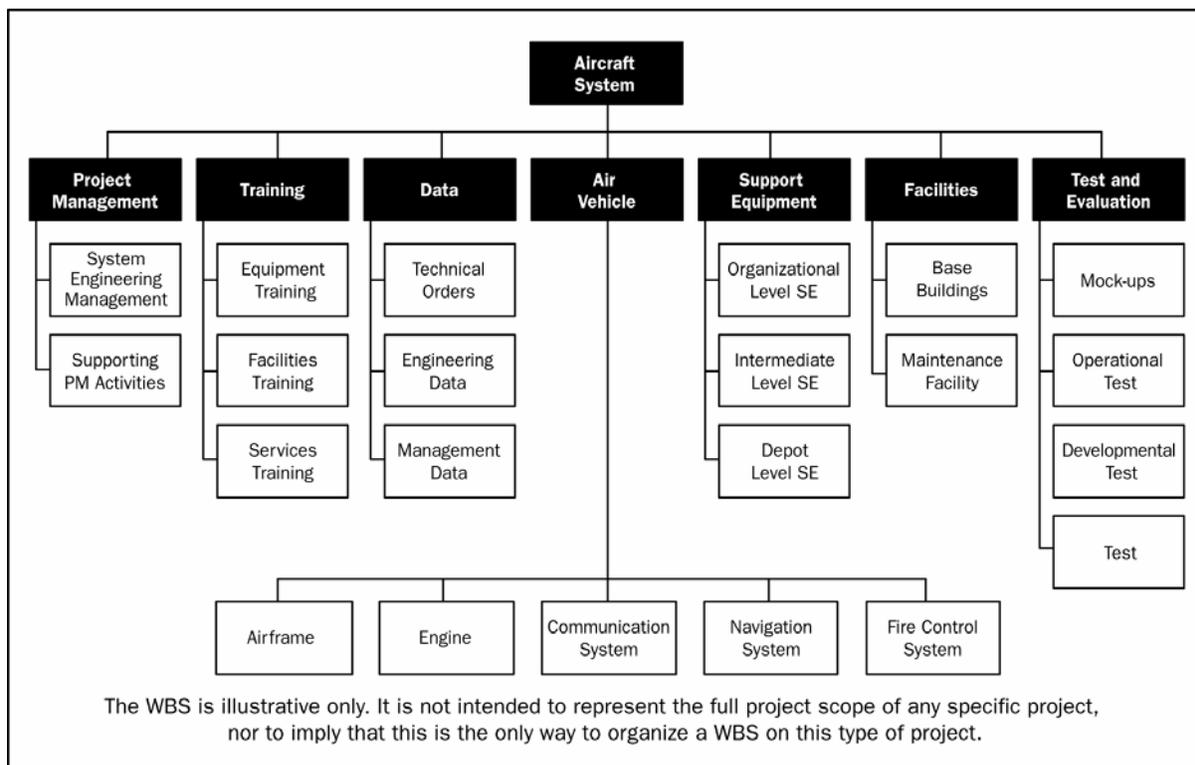


Figure 5-6. Sample Work Breakdown with Major Deliverables

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. 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 more levels of decomposition. As the work is decomposed to lower levels of detail, the ability to plan, manage, and control the work is enhanced. However, excessive decomposition can lead to non-productive management effort, inefficient use of resources, and decreased efficiency in performing the work.

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

The PMI Standard for Work Breakdown Structures provides guidance for the generation, development, and application of work breakdown structures. This standard contains industry-specific examples of WBS templates that can be tailored to specific projects in a particular application area.

5.3.3 Create WBS: Outputs

.1 Work Breakdown Structure (WBS)

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 earned value for performance measurement. Control accounts are placed as selected management points of the WBS. Each control account may include one or more work packages, but each of the work packages may be associated with only one control account.

.2 WBS Dictionary

The WBS dictionary is a document generated by the Create WBS process that supports the WBS. The detailed content of the components contained in a WBS, including work packages and control accounts, are described in a WBS dictionary. Information in the WBS dictionary includes, but is not limited to:

- Code of account identifier,
- Statement of work,
- Responsible organization,
- List of schedule milestones
- Associated schedule activities,
- Resources required,
- Cost estimates
- Quality requirements,
- Technical references, and
- Contract information.

.3 Scope Baseline

The approved detailed project scope statement (Section 5.2.3.1) and its associated WBS and WBS dictionary are the scope baseline for the project. The scope baseline is a component of the project management plan.

.4 Project Document Updates

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

- **Stakeholder requirements documentation.** If approved change requests result from the Create WBS process, then the stakeholder requirements documentation may need to be updated to include approved changes.

5.4 Verify Scope

Verify Scope is the process of formalizing acceptance of the completed project deliverables. Verifying the project scope includes reviewing deliverables to ensure that each is completed satisfactorily. If the project is terminated early, the project scope verification process should establish and document the level and extent of completion. Scope verification differs from quality

control in that scope verification is primarily concerned with acceptance of the deliverables, while quality control is primarily concerned with correctness of the deliverables and meeting the quality requirements specified for the deliverables. Quality control is generally performed before scope verification, but these two processes can be performed in parallel. Table 5-5 provides the associated inputs, tools, techniques, and outputs and the process flow diagram, Figure 5-11, provides an overall summary of the basic flow and interactions within this process.

Table 5-5. Verify Scope: Inputs, Tools & Techniques, and Outputs

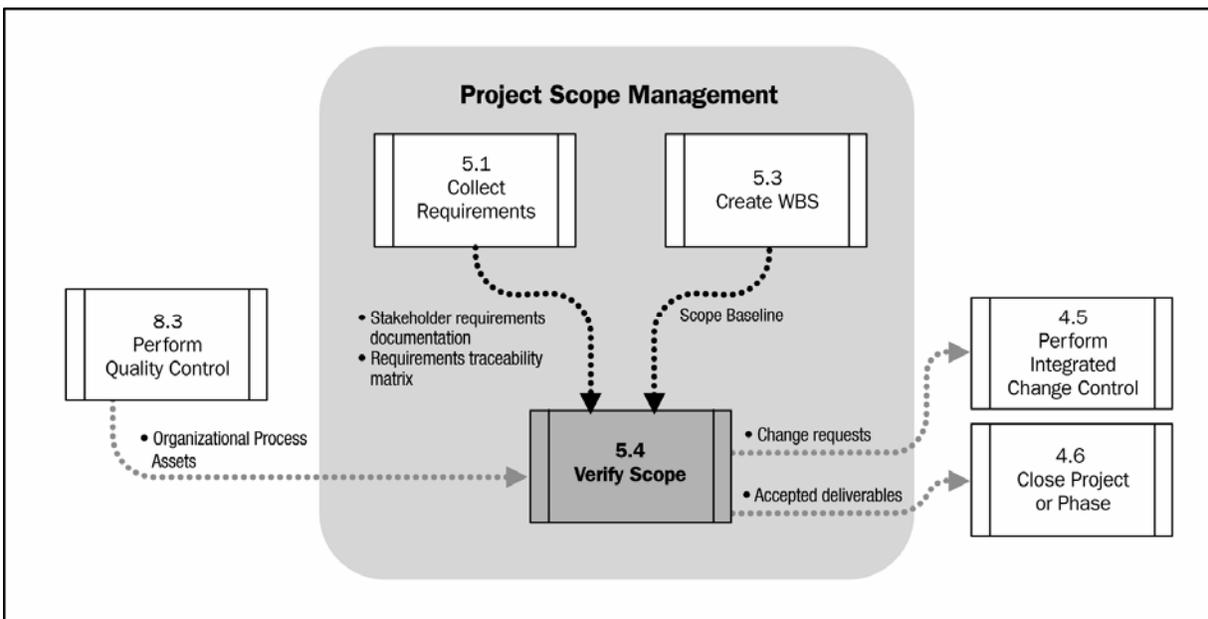
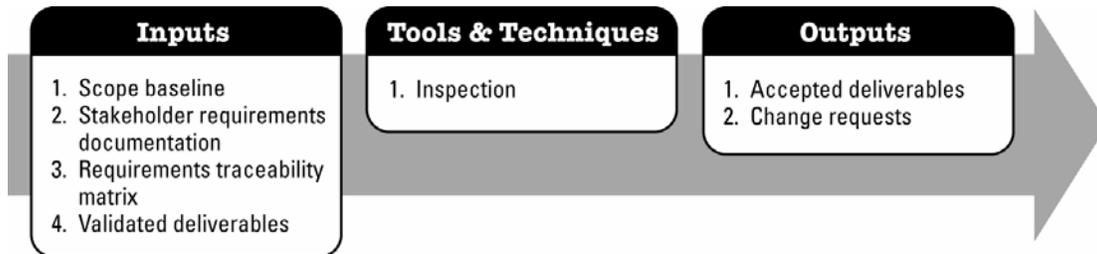


Figure 5-7 Verify Scope Data Flow Diagram

5.4.1 Verify Scope: Inputs

.1 Project Management Plan

Components of the project management plan used in Verify Scope include the scope baseline:

- **Project scope statement.** The project scope statement includes the product scope description, the project deliverables and defines the product user acceptance criteria. The project scope statement is described in Section 5.2.3.1.
- **WBS.** The WBS defines each deliverable and the decomposition of the deliverables into work packages.

- **WBS dictionary.** The WBS dictionary has a detailed statement of work and technical documentation for each WBS element.

.2 Stakeholder Requirements Documentation

The stakeholder requirements documentation lists all the project, product, technical and other types of requirements that must be present for the project and product. Stakeholder requirements documentation is described in Section 5.1.3.1.

.3 Requirements Traceability Matrix

The requirements traceability matrix links requirements to their origin and tracks them throughout the project life cycle, which is described in Section 5.1.3.3.

4. Validated Deliverables

Validated deliverables have been completed and checked for correctness by the Perform Quality Control process.

5.4.2 Verify Scope: Tools and Techniques

.1 Inspection

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

5.4.3 Verify Scope: Outputs

.1 Accepted Deliverables

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

.2 Change Requests

Change requests that are generated from the Verify Scope process normally include requests for defect repair. The change requests are processed for review and disposition through the Perform Integrated Change Control process (see Section 4.5).

5.5 Control Scope

Control Scope is the process of monitoring the status of the project and product scope and controlling changes. Controlling the project scope ensures all requested changes and recommended corrective actions are processed through the project Perform Integrated Change Control process (see Section 4.5). Project scope control is also used to manage the actual changes when they occur and is integrated with the other control processes. Uncontrolled changes are often referred to as project scope creep. Change is inevitable, thereby mandating some type of change control process. Table 5-6 provides the associated inputs, tools, techniques, and outputs and the process flow

diagram, Figure 5-12, provides an overall summary of the basic flow and interactions within this process.

Table 5-6. Control Scope: Inputs, Tools & Techniques, and Outputs

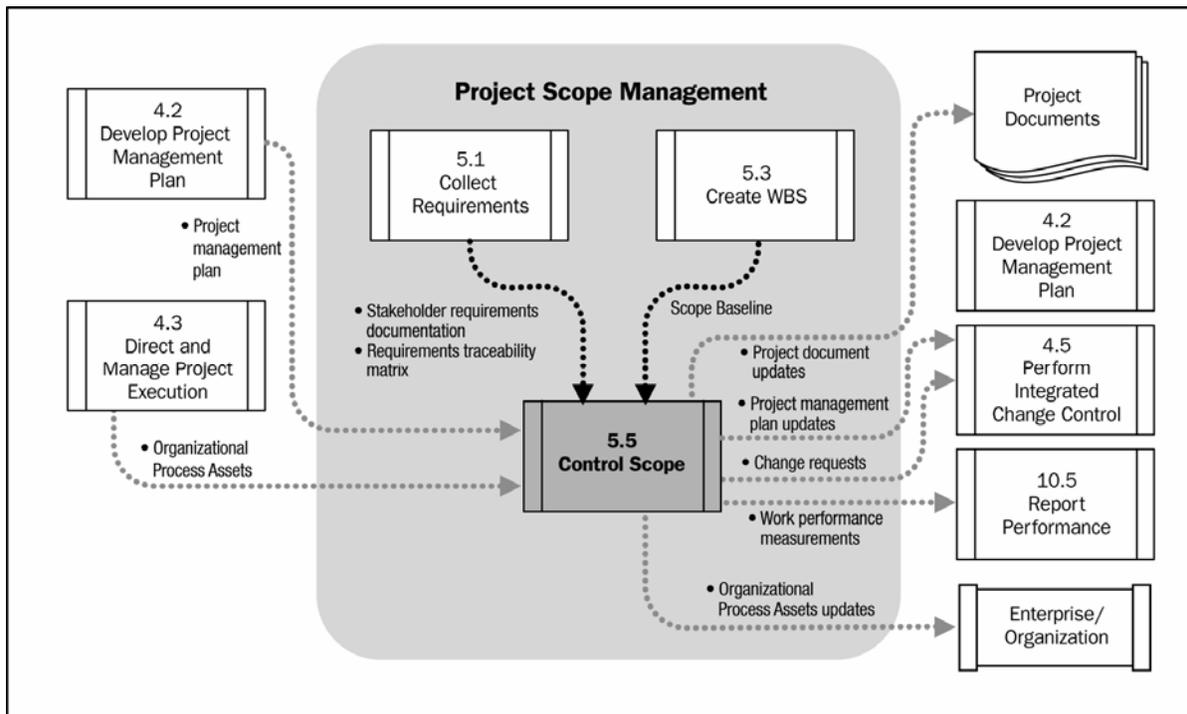
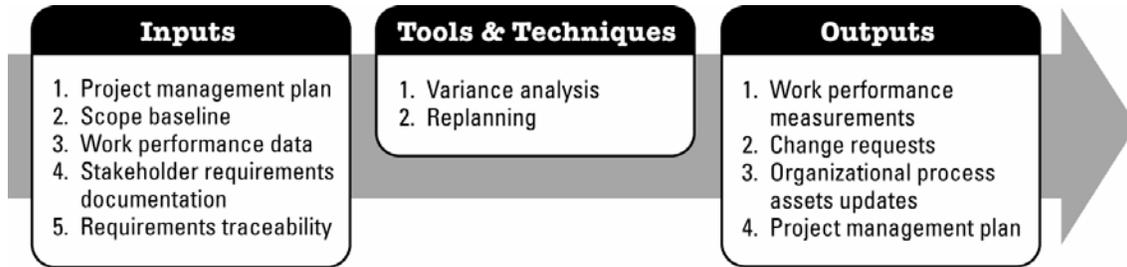


Figure 5-8. Control Scope Data Flow Diagram

5.5.1 Control Scope: Inputs

.1 Project Management Plan

The project management plan described in Section 4.2.3.1 contains the following information that is used to control scope:

- **Scope baseline.** The scope baseline is used to compare with actual results to determine if a change, corrective action or preventive action is necessary.
- **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, require formal change control and the process for controlling changes to such items.

.2 Work Performance Data

Data from project progress is collected such as which deliverables have started, their progress and which deliverables have finished.

.3 Stakeholder Requirements Documentation

Described in Section 5.1.3.1.

.4 Requirements Traceability Matrix

Described in Section 5.1.3.3.

5.5.2 Control Scope: Tools and Techniques

.1 Variance Analysis

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

.2 Replanning

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

5.5.3 Control Scope: Outputs

.1 Work Performance Measurements

The work performance data is analyzed and compared to plan to generate metrics used to evaluate progress. These metrics may include planned vs. actual technical performance. This information is used as an input to Report Performance (see Section 10.5).

.2 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 change control

.3 Change Requests

The results of project scope control can generate change requests, which are processed for review and disposition according to the Perform Integrated Change Control process (see Section 4.5). Change requests can include preventive or corrective actions or defect repairs.

.4 Project Management Plan Updates

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

Chapter 6 Project Time Management

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

- 6.1 Define Activities**—The process of identifying the specific actions to be performed to produce the project deliverables.
- 6.2 Sequence Activities**—The process of identifying and documenting relationships among activities.
- 6.3 Estimate Activity Resources**—The process of estimating the type and quantities of material, people, equipment, and supplies required to perform each schedule activity.
- 6.4 Estimate Activity Durations**—The process of approximating the number of work periods needed to complete individual activities with estimated resources.
- 6.5 Develop Schedule**—The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule.
- 6.6 Control Schedule**—The process of monitoring the status of the projects to update project progress and managing changes to the schedule.

These processes interact with each other and with processes in the other Knowledge Areas. Each process can involve effort from one or more persons or groups of persons, based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete components with well-defined interfaces, in practice they can overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3.

Some advanced 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*. However, in general practice the schedule and the schedule model are referred to as the schedule. Therefore, the *PMBOK® Guide* uses the term *schedule*. PMI's Practice Standard for Project Scheduling has additional information on schedule models. On some projects, especially those of smaller scope, defining activities, sequencing activities, estimating activity resources, estimating activity durations, and developing the schedule are so tightly linked that they are viewed as a single process that can be performed by a person over a relatively short period of time. These processes are presented here as distinct processes because the tools and techniques for each are different.

Although not shown here as a discrete process, the work involved in performing the six processes of Project Time Management is preceded by a planning effort by the project management team. This planning effort is part of the Develop Project Management Plan process (Section 4.2), which produces a schedule management plan that selects a scheduling methodology, a scheduling tool, and sets the format and establishes criteria for developing and controlling the project schedule.

The project time management processes, and their associated tools and techniques are documented in the schedule management plan. The schedule management plan is contained in,

or is a subsidiary plan 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.

Unless overridden by the Develop Project Management Plan process, the scheduling methodology is developed from the organizational process assets and the selection of a scheduling tool is determined by enterprise environmental factors.

Developing the project schedule uses the outputs from the processes to define activities, sequence activities, estimate activity resources, and to estimate activity durations in combination with the scheduling tool to produce the schedule. When finalized and approved the project team has completed the baseline project schedule for use in the Control Schedule process. As the project activities are being executed, the majority of effort in the time management Knowledge Area will most likely be devoted to the Control Schedule process (Section 6.6) to provide a means to complete the project in a timely manner. Figure 6-1 provides a scheduling overview that shows how the scheduling method, tools and outputs from the Project Time Management processes interact to create a project schedule.

Table 6-1. Project Time Management Overview

Project Time Management Overview

6.1 Define Activities

1. Inputs
 1. Scope baseline
 2. Enterprise environmental factors
 3. Organizational process assets
2. Tools & Techniques
 1. Decomposition
 2. Rolling wave planning
 3. Templates
 4. Expert judgment
3. Outputs
 1. Activity list
 2. Activity attributes
 3. Milestone list

6.4 Estimate Activity Durations

1. Inputs
 1. Activity list
 2. Activity attributes
 3. Activity resource requirements
 4. Resource calendars
 5. Project scope statement
 6. Enterprise environmental factors
 7. Organizational process assets
2. Tools & Techniques
 1. Expert judgment
 2. Analogous estimating
 3. Parametric estimating
 4. Three-point estimates
 5. Reserve analysis
3. Outputs
 1. Activity duration estimates
 2. Project document updates

6.2 Sequence Activities

1. Inputs
 1. Activity list
 2. Activity attributes
 3. Milestone list
 4. Project scope statement
 5. Organizational process assets
2. Tools & Techniques
 1. Precedence diagramming method
 2. Dependency determination
 3. Applying leads and lags
 4. Schedule network templates
3. Outputs
 1. Project schedule network diagrams
 2. Project document updates

6.5 Develop Schedule

1. Inputs
 1. Activity list
 2. Activity attributes
 3. Project schedule network diagrams
 4. Activity resource requirements
 5. Resource calendars
 6. Activity duration estimates
 7. Project scope statement
 8. Environmental enterprise factors
 9. Organizational process assets
2. Tools & Techniques
 1. Schedule network analysis
 2. Critical path method
 3. Critical chain method
 4. Resource leveling
 5. What-if scenario analysis
 6. Applying leads and lags
 7. Schedule compression
 8. Scheduling tool
3. Outputs
 1. Project schedule
 2. Schedule baseline
 3. Project document updates
 4. Schedule data

6.3 Estimate Activity Resources

1. Inputs
 1. Activity list
 2. Activity attributes
 3. Resource calendars
 4. Enterprise environmental factors
 5. Organizational process assets
2. Tools & Techniques
 1. Expert judgment
 2. Alternatives analysis
 3. Published estimating data
 4. Bottom-up estimating
 5. Project management software
3. Outputs
 1. Activity resource requirements
 2. Resource breakdown structure
 3. Project document updates

6.6 Control Schedule

1. Inputs
 1. Project management plan
 2. Project schedule
 3. Work performance data
 4. Organizational process assets
2. Tools & Techniques
 1. Progress reporting
 2. Performance measurement
 3. Schedule comparison bar charts
 4. Variance analysis
 5. Change control system
 6. Project management software
 7. Resource leveling
 8. What-if scenario analysis
 9. Adjusting leads and lags
 10. Schedule compression
 11. Scheduling tool
3. Outputs
 1. Work performance measurements
 2. Organizational process assets updates
 3. Change requests
 4. Project management plan updates
 5. Project document updates

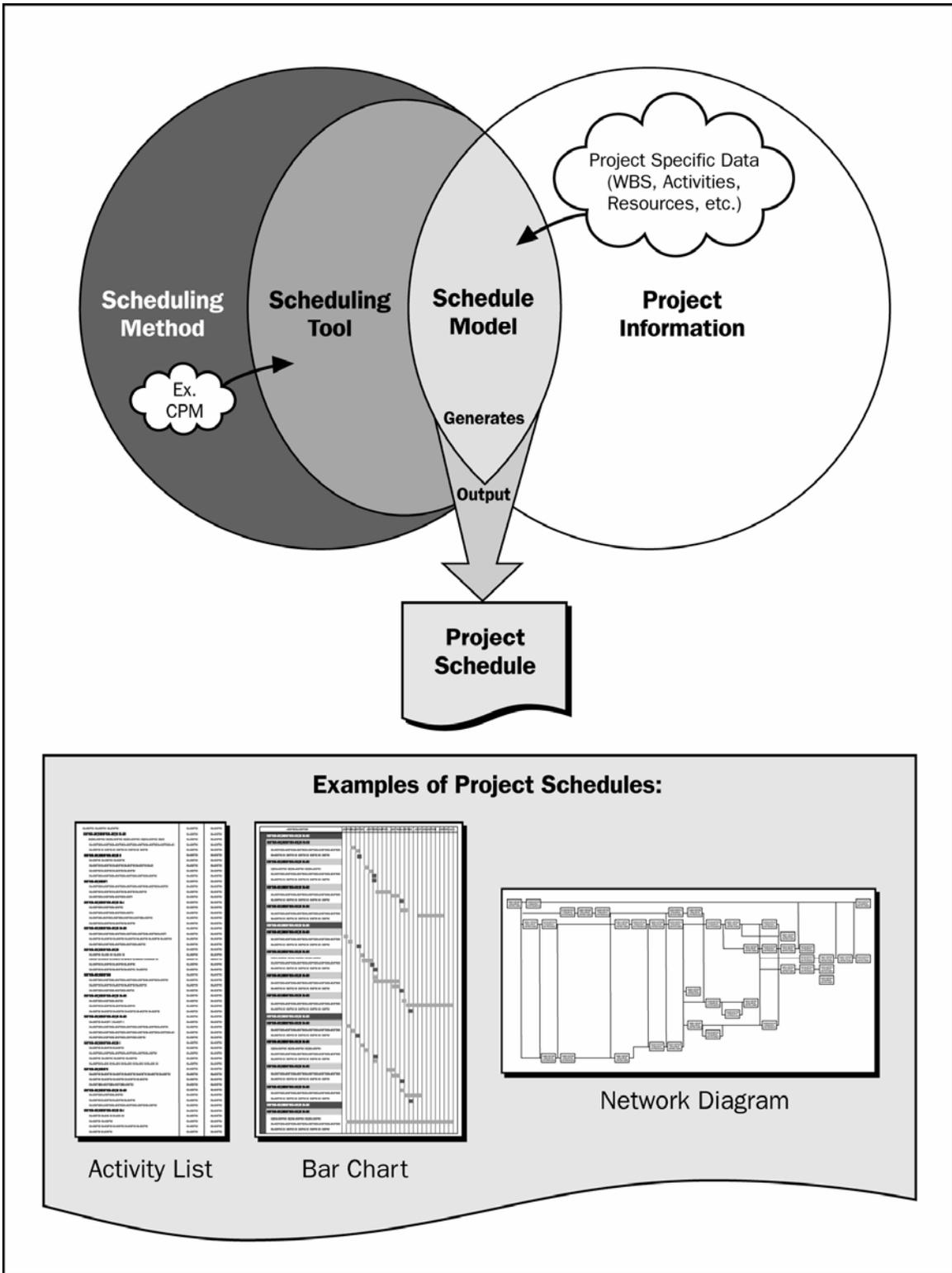


Figure 6-1. Scheduling Overview

6.1 Define Activities

Define Activities is the process of identifying the specific actions to be performed to produce the project deliverables. The Create WBS process identifies the deliverables at the lowest level in the Work Breakdown Structure (WBS), the work package. Project work packages are typically decomposed into smaller components called activities to provide a basis for estimating, scheduling, executing, and monitoring and controlling the project work. Implicit in this process is defining and planning the schedule activities such that the project objectives will be met. See Table 6-2 and Figure 6-2.

Table 6-2. Define Activities: Inputs, Tools & Techniques, and Outputs

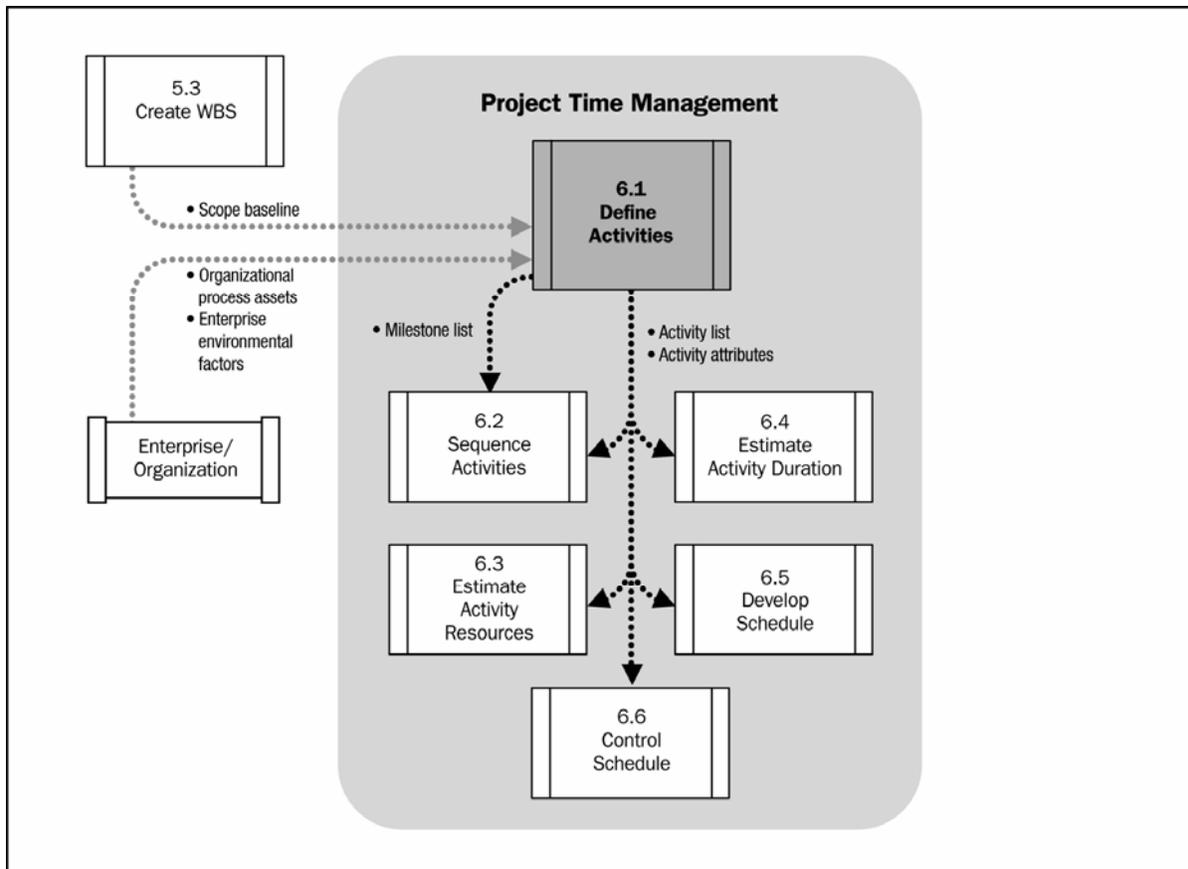
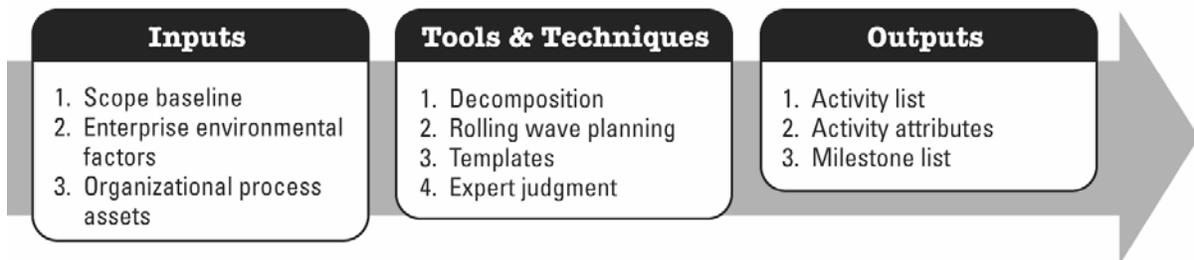


Figure 6-2 Define Activities Data Flow Diagram

6.1.1 Define Activities: Inputs

.1 Scope Baseline

The project deliverables, constraints, and assumptions documented in the project scope baseline (Section 5.2.3.1) are considered explicitly while defining activities.

.2 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Define Activities process include but are not limited to:

- Project management information systems (PMIS).

.3 Organizational Process Assets

The organizational process assets that can influence the Define Activities process include but are not limited to:

- Existing formal and informal activity planning-related policies, procedures, and guidelines, such as the scheduling methodology, that are considered in developing the activity definitions; and
- Lessons-learned knowledge base, which contains historical information regarding activities lists used by previous similar projects.

6.1.2 Define Activities: Tools and Techniques

.1 Decomposition

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

The activity list, WBS, and WBS dictionary can be developed either sequentially or concurrently, with the WBS and WBS dictionary in the Scope Baseline being 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. This is often performed by the project team members responsible for the work package.

.2 Rolling Wave Planning

The WBS and WBS dictionary reflect the project scope evolution as it becomes more detailed until the work package level is reached. Rolling wave planning is a form of progressive elaboration planning where the work to be accomplished in the near term is planned in detail at a low level of the WBS. Future work is planned for WBS components that are at a relatively high level of the WBS. The work to be performed within another one or two reporting periods in the near future is planned in detail as work is being completed during the current period. Therefore, activities can exist at various levels of detail in the project's life cycle. During early strategic planning, when information is less defined, activities may be kept at the milestone level.

.3 Templates

A standard activity list or a portion of an activity list from a previous project is often usable as a template (Section 4.1.1.4) for a new project. The related activity attributes information in the templates can also contain a list of resource skills and their required hours of effort, identification of risks, expected deliverables, and other descriptive information. Templates can also be used to identify typical schedule milestones.

.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.

6.1.3 Define Activities: Outputs

.1 Activity List

The activity list is a comprehensive list including all schedule activities that are planned to be performed on the project. The activity list includes the activity identifier and a scope of work description for each schedule activity in sufficient detail to ensure that project team members understand what work is required to be completed. The activity's scope of work can be in physical terms, such as linear feet of pipe to be installed, designated placement of concrete, number of drawings, lines of computer program code, or in conceptual terms such as a design or chapters in a book.

.2 Activity Attributes

Activity attributes extend the activity by identifying the multiple components associated with each activity. The components for each activity include the Activity ID, WBS ID, and Activity Name, and may include activity codes, activity description, predecessor activities, successor activities, logical relationships, leads and lags, 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 schedule activity type such as level of effort, discrete effort, and apportioned effort. 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. The activity attributes are used in the schedule.

.3 Milestone List

A milestone list identifies all milestones and indicates whether the milestone is mandatory or optional based upon project requirements.

6.2 Sequence Activities

Sequence Activities is the process of identifying and documenting relationships among activities. Schedule activities are sequenced with logic relationships. Every activity and milestone except the first and last are connected to at least one predecessor and one successor. It may be necessary to use lead or lag time on the logical relationships between activities to support later development of a realistic and achievable project schedule. Sequencing can be performed by using project management software or by using manual or automated techniques.

Table 6-3 Sequence Activities: Inputs, Tools & Techniques, and Outputs

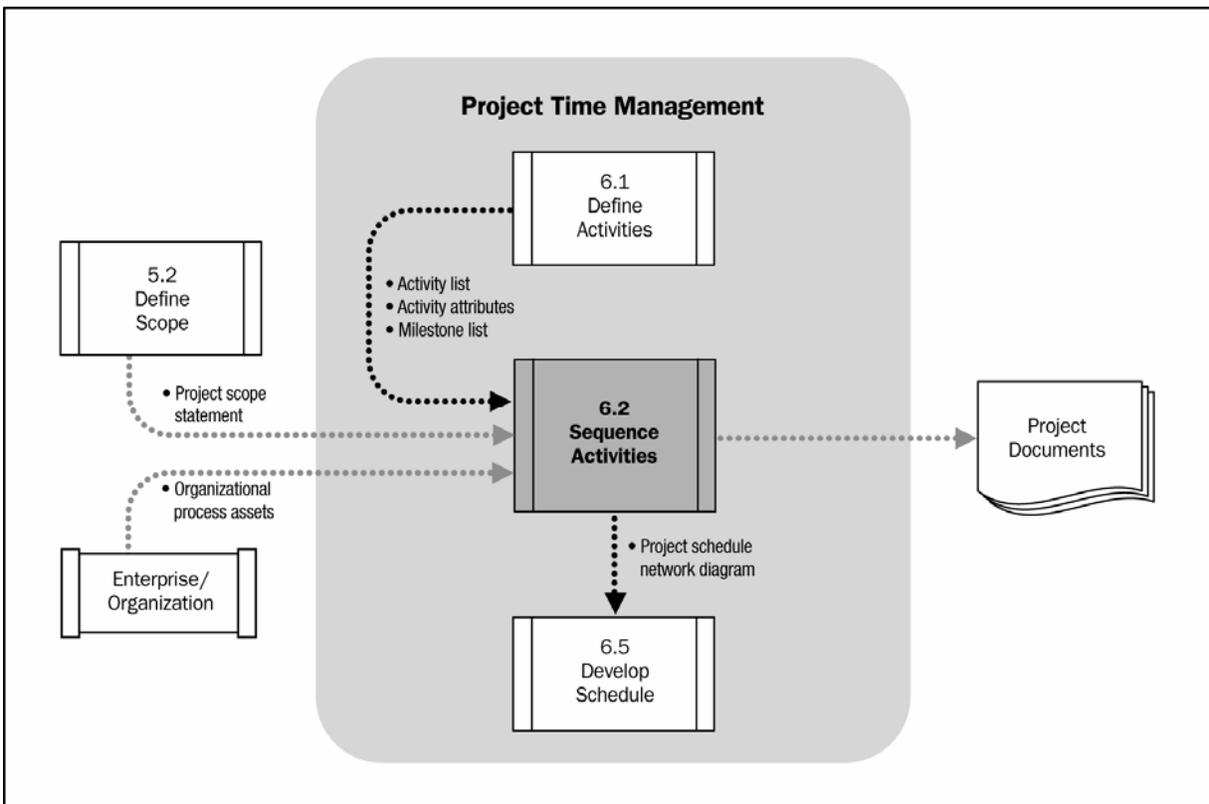
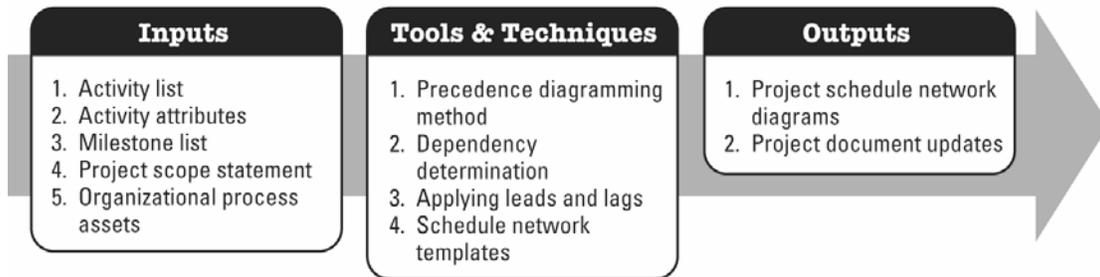


Figure 6-3. Sequence Activities Data Flow Diagram

6.2.1 Sequence Activities: Inputs

.1 Activity List

Described in Section 6.1.3.1.

.2 Activity Attributes

Described in Section 6.1.3.2. Activity attributes may describe a necessary sequence of events or defined predecessor or successor relationships.

.3 Milestone List

Described in Section 6.1.3.3. The milestone list may have defined due dates for specific milestones.

.4 Project Scope Statement

The project scope statement (Section 5.2.3.1) contains the product scope description, which includes product characteristics that often can affect activity sequencing, such as the physical layout of a plant to be constructed or subsystem interfaces on a software project. While these effects are often apparent in the activity list, the product scope description is generally reviewed to ensure accuracy.

.5 Organizational Process Assets

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.

6.2.2 Sequence Activities: Tools and Techniques

.1 Precedence Diagramming Method (PDM)

PDM is a method used in Critical Path Methodology (CPM) for constructing a project schedule network diagram that uses boxes or rectangles, referred to as nodes, to represent activities and connects them with arrows that show the logical relationships that exist between them. Figure 6-4 shows a simple project schedule network diagram drawn using PDM. This technique is also called Activity-On-Arrow (AOA), and is the method used by most project management software packages.

PDM includes four types of dependencies or precedence relationships:

- **Finish-to-start.** The initiation of the successor activity depends upon the completion of the predecessor activity.
- **Finish-to-finish.** The completion of the successor activity depends upon the completion of the predecessor activity.
- **Start-to-start.** The initiation of the successor activity depends upon the initiation of the predecessor activity.
- **Start-to-finish.** The completion of the successor activity depends upon the initiation of the predecessor activity.

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

.2 Dependency Determination

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

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

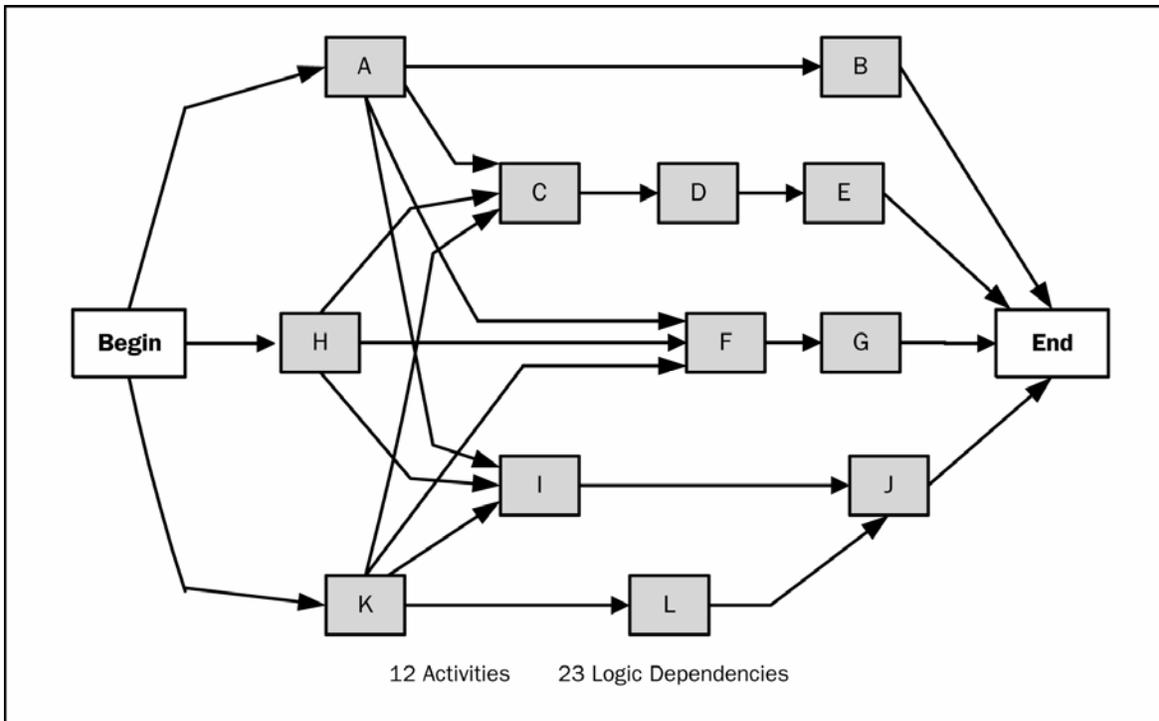


Figure 6-4. Precedence Diagram Method

- **Discretionary dependencies.** The project management team determines which dependencies are discretionary during the process of establishing the sequence of activities. Discretionary dependencies are fully documented since they can create arbitrary total float values and can limit later scheduling options. Discretionary dependencies are sometimes referred to as preferred logic, preferential logic, or soft logic. Discretionary dependencies are 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. Some discretionary dependencies include preferred schedule activity sequences based upon previous experience on a successful project performing the same type of work.
- **External dependencies.** The project management team identifies external dependencies during the process of establishing the sequence of activities. External dependencies are those that involve a relationship between project activities and non-project activities. For example, the testing activity in a software project can 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. This input can be based on historical information (Section 4.1.1.4) from previous projects of a similar nature or from seller contracts or proposals (Section 12.4.3.2).

.3 Applying Leads and Lags

The project management team determines the dependencies (Section 6.2.2.3) 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.

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

A lag directs a delay in the successor activity. For example, to account for a ten-day curing period for concrete, a ten-day lag on a finish-to-start relationship could be used, which means the successor activity cannot start until ten days after the predecessor is completed.

.4 Schedule Network Templates

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

6.2.3 Sequence Activities: Outputs

.1 Project Schedule Network Diagrams

Project schedule network diagrams are schematic displays of the project's schedule activities and the logical relationships among them, also referred to as dependencies. Figure 6-4 illustrates a project schedule network diagram. A project schedule network diagram can be produced manually or by using project management software. It can include full project details, or have one or more summary activities. A summary narrative accompanies the diagram and describes the basic approach used to sequence the activities. Any unusual activity sequences within the network are fully described within the narrative.

.2 Project Document Updates

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

- Activity lists and
- Activity attributes.

6.3 Estimate Activity Resources

Estimate Activity Resources is the process of estimating the type and quantities of material, people, equipment, and supplies required to perform each schedule activity. The Estimate Activity Resource process is closely coordinated with the Estimate Costs process (Section 7.1). For example:

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

a designer to a seminar on robotics, or by including someone from manufacturing as a member of the project team.

Table 6-4. Estimate Activity Resources: Inputs, Tools & Techniques, and Outputs

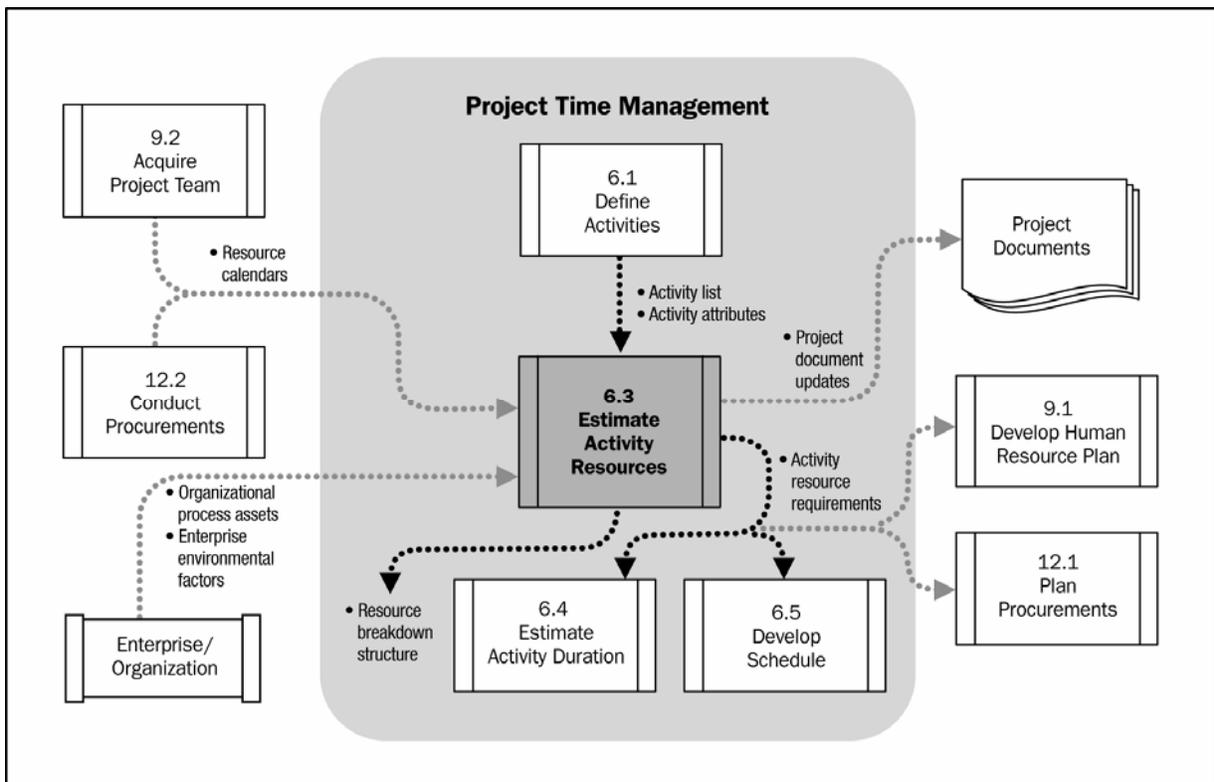
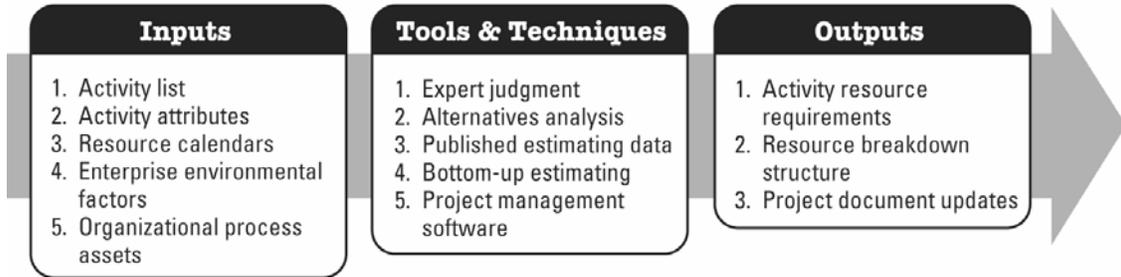


Figure 6-5. Estimate Activity Resource Data Flow Diagram

6.3.1 Estimate Activity Resources: Inputs

.1 Activity List

The activity list (Section 6.1.3.1) identifies the activities for resources that are estimated.

.2 Activity Attributes

The activity attributes (Section 6.1.3.2) developed during the define activities and sequence activities processes provide the primary data input for use in estimating those resources required for each activity in the activity list.

.3 Resource Calendars

Information on which resources (such as people, equipment, and material) are potentially available during planned activity duration)(Sections 9.2.3.2 and 12.2.3.3) is used for estimating resource types. Resource calendars specify when and how long identified project resources will be available during the duration of 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). For example, during the early phases of an engineering design project, the pool of resources might include junior and senior engineers in large numbers. During later phases of the same project, however, the pool can be limited to those individuals who are knowledgeable about the project as a result of having worked on the earlier phases of the project.

.4 Enterprise Environmental Factors

The enterprise environmental factors that can influence include but are not limited to resource availability.

.5 Organizational Process Assets

The organizational process assets that can influence the Estimate Activity Resources process includes but is 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.

6.3.2 Estimate Activity Resources: Tools and Techniques

.1 Expert Judgment

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

.2 Alternatives Analysis

Many schedule activities have alternative methods of accomplishment. They include using various levels of resource capability or skills, different size or type of machines, different tools (hand versus automated), and make-or-buy decisions regarding the resource (Section 12.1.3.3).

.3 Published Estimating Data

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

.4 Bottom-Up Estimating

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 schedule activity.

.5 Project Management Software

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

6.3.3 Estimate Activity Resources: Outputs

.1 Activity Resource Requirements

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

.2 Resource Breakdown Structure

The resource breakdown structure is a hierarchical structure of the identified resources by resource category and resource type. The Resource Breakdown Structure is useful for organizing and reporting project schedule data with resource utilization information.

.3 Project Document Updates

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

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

6.4 Estimate Activity Durations

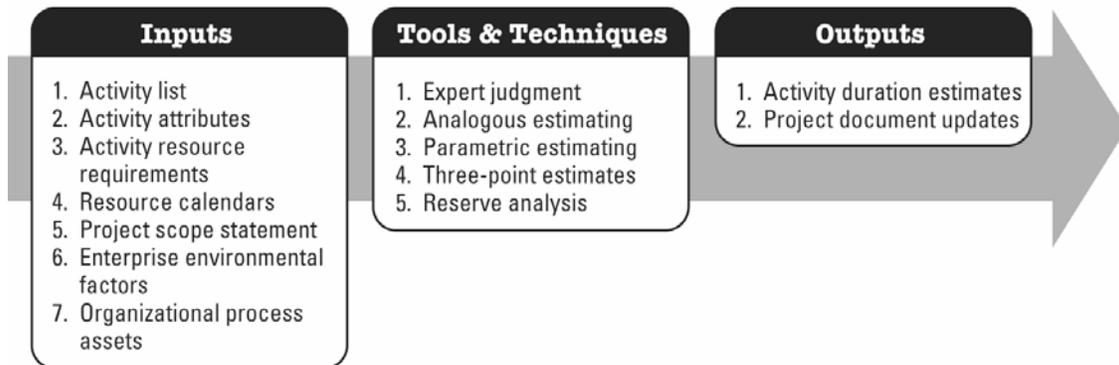
Estimate Activity Durations is the process of approximating the number of work periods needed to complete individual activities with estimated resources. Estimating activity durations uses information on activity scope of work, required resource types, estimated resource quantities, and resource calendars. The inputs for 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 schedule activity. The duration estimate is progressively elaborated, and the process considers the quality and availability of the input data. For example, as the project engineering and design work evolves,

more detailed and precise data is available, and the accuracy of the duration estimates improves. Thus, the duration estimate can be assumed to be progressively more accurate and of better quality.

The Estimate Activity Durations process requires that the amount of work effort required to complete the schedule activity is estimated and the amount of resources to be applied to complete the schedule activity is estimated; these 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.

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

Table 6-5. Estimate Activity Duration: Inputs, Tools & Techniques, and Outputs



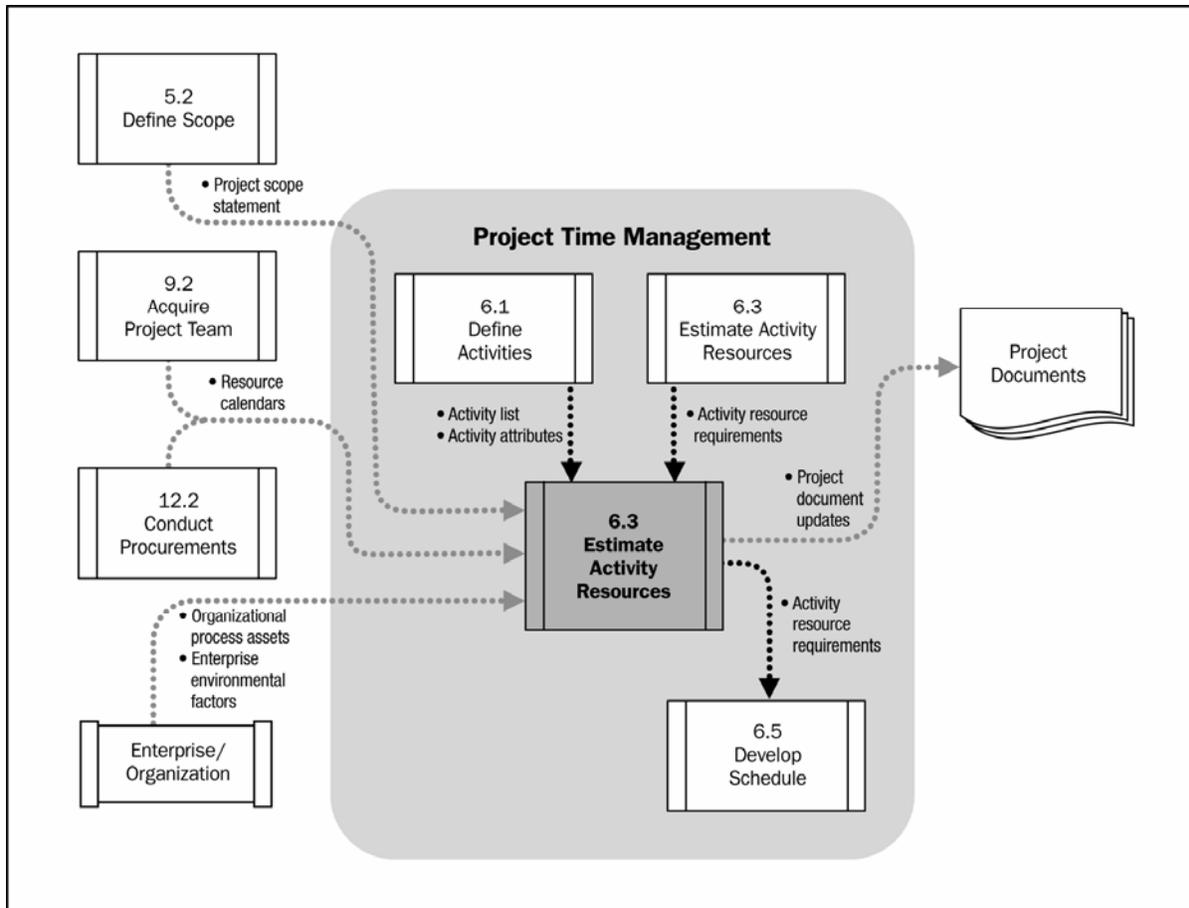


Figure 6-6. Estimate Activity Durations Data Flow Diagram

6.4.1 Estimating Activity Durations: Inputs

.1 Activity List

Described in Section 6.1.3.1.

.2 Activity Attributes

Described in Section 6.1.3.2.

.3 Activity Resource Requirements

The estimated activity resource requirements (Section 6.3.3.1) 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 a schedule activity requires two engineers working together to efficiently complete a design activity, but only one person is applied to the work, the schedule activity will generally take at least twice as much time to complete. However, as additional resources are added or lower skilled resources are applied to some schedule activities, projects can experience a reduction in efficiency. This inefficiency could result in a percentage increase of work production which is less than the equivalent percentage increase in resources applied. New resources added to the project may also require that existing project resources divert some of their effort from the project work to training the new resources.

The time spent by existing project resources incorporating the new resources may further decrease the overall efficiency of the expanded project team.

.4 Resource Calendars

The composite resource calendar (Section 6.3.1.1), developed as part of the Activity Resource Estimating process, includes the availability, capabilities, and skills of human resources (Section 9.2). The type, quantity, availability, and capability, when applicable, of both equipment and material resources, which could significantly influence the duration of schedule activities, are also considered. For example, when a senior and junior staff member are assigned full time, a senior staff member can generally be expected to complete a given activity in less time than a junior staff member.

.5 Project Scope Statement

The constraints and assumptions from the project scope statement (Section 5.2.3.1) are considered when estimating the schedule activity durations. 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 contract terms and requirements.

.6 Enterprise Environmental Factors

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, and
- Commercially available reference databases.

.7 Organizational Process Assets

The organizational process assets that can influence the Estimate Activity Durations process include but are not limited to:

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

6.4.2 Estimating Activity Durations: Tools and Techniques

.1 Expert Judgment

Activity durations are often difficult to estimate because of the number of factors that can influence them, such as resource levels or resource productivity. Expert judgment, guided by historical information, can be used whenever possible. The individual project team members may also provide duration estimate information or recommended maximum activity durations from prior similar projects. If such expertise is not available, the duration estimates are more uncertain and risky.

.2 Analogous Estimating

Analogous duration estimating uses the actual duration of a previous, similar activity as the basis for estimating the duration of a future activity. It is frequently used to estimate project duration when there is a limited amount of detailed information about the project for example, in the early phases of a project. Analogous estimating uses historical information (Section 4.1.1.4) and expert judgment.

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

.3 Parametric Estimating

Activity durations can be quantitatively determined by multiplying the quantity of work to be performed by the productivity rate. For example, productivity rates can be estimated on a design project by the number of drawings times labor hours per drawing, or a cable installation in meters of cable times labor hours per meter. The total resource quantities are multiplied by the production capability per work period, and divided by the number of those resources being applied to determine activity duration in work periods.

.4 Three-Point Estimates

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

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

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

.5 Reserve Analysis

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

6.4.3 Estimating Activity Durations: Outputs

.1 Activity Duration Estimates

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

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

.2 Project Document Updates

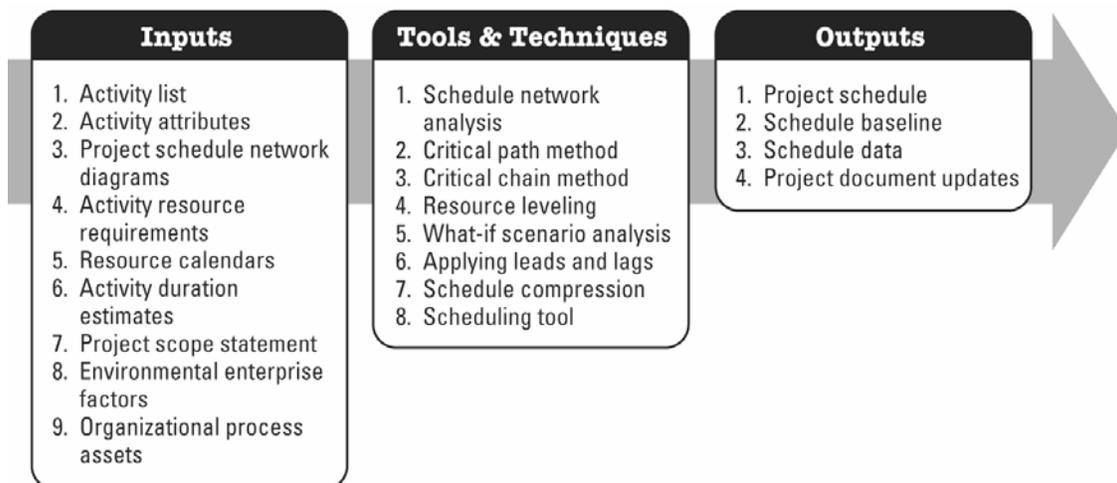
Project documents that may be updated include but are not limited to:

- Activity attributes,
- Assumptions made in developing the activity duration estimate.

6.5 Develop Schedule

Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule. Entering the activities, durations and resources, into the scheduling tool generates a schedule with planned dates for completing project activities. Developing the project schedule is often an iterative process. It determines the planned start and finish dates for project activities and milestones. Schedule development can require the review and revision of duration estimates and resource estimates to create an approved project schedule that can serve as a baseline to track progress. Developing the schedule continues throughout the project as work progresses, the project management plan changes, and anticipated risk events occur or disappear as new risks are identified.

Table 6-6. Develop Schedule Overview: Inputs, Tools & Techniques, and Outputs



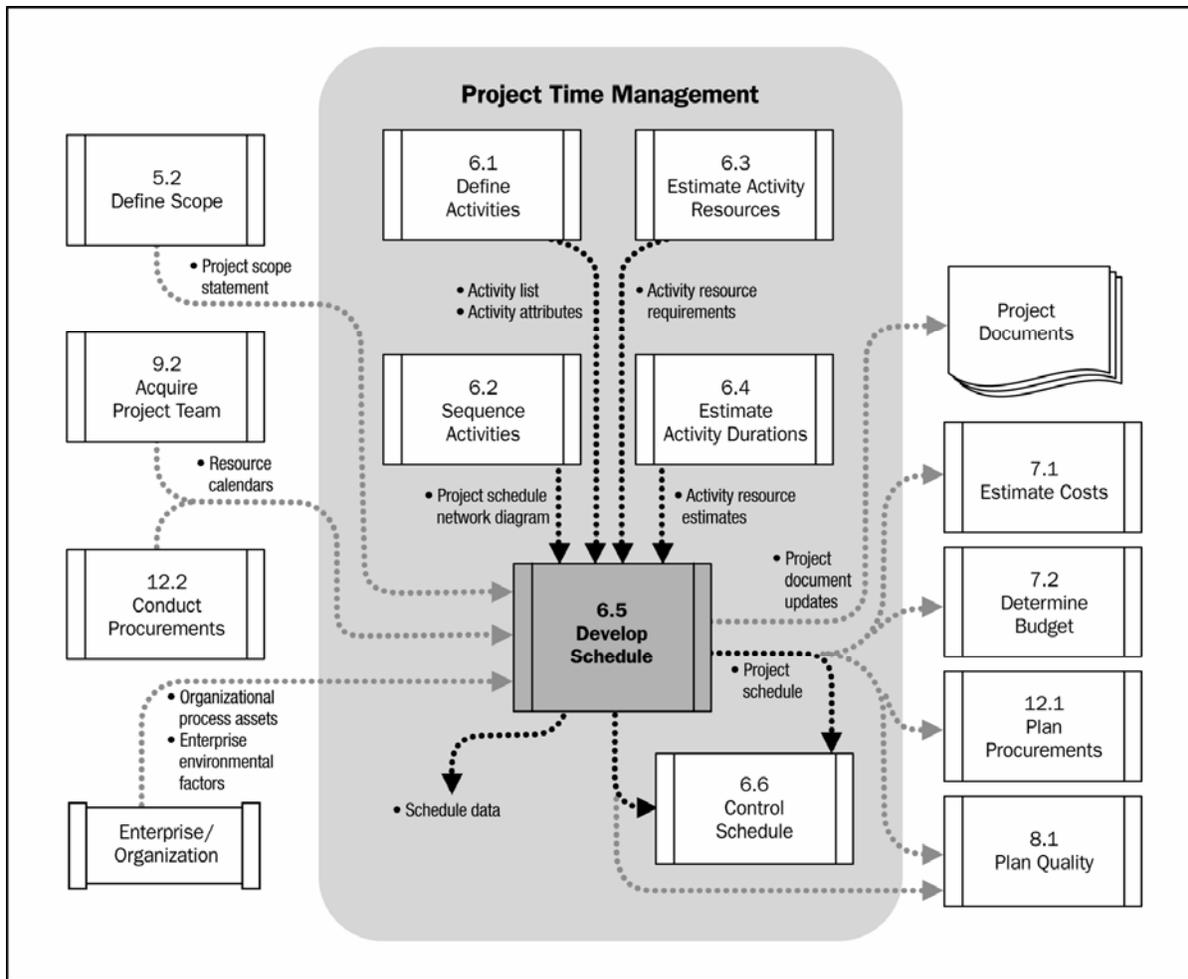


Figure 6-7. Develop Schedule Data Flow Diagram

6.5.1 Develop Schedule: Inputs

.1 Activity List

Described in Section 6.1.3.1.

.2 Activity Attributes

Described in Section 6.1.3.2.

.3 Project Schedule Network Diagrams

Described in Section 6.2.3.1.

.4 Activity Resource Requirements

Described in Section 6.3.3.1.

.5 Resource Calendars

Described in Sections 6.3.1.3 and 6.4.1.4.

.6 Activity Duration Estimates

Described in Section 6.4.3.1.

.7 Project Scope Statement

The project scope statement (Section 5.2.3.1) contains assumptions and constraints that can impact the development of the project schedule.

.8 Environmental Enterprise Factors

The Environmental Enterprise Factors that can influence the Develop Schedule process include but are not limited to a scheduling tool that can be used in developing the schedule.

.9 Organizational Process Assets

The organizational process assets that can influence the Develop Schedule process include but are not limited to:

- Scheduling methodology, and
- Project calendar.

6.5.2 Develop Schedule: Tools and Techniques

.1 Schedule Network Analysis

Schedule network analysis is a technique that generates the project schedule. 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, and scheduled start and finish dates for the uncompleted portions of project schedule 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.

.2 Critical Path Method

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

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

delaying the early start date of any immediate successor activity within the network path--can also be determined.

.3 Critical Chain Method

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

The critical chain method adds duration buffers that are non-work schedule activities to maintain focus on the planned activity durations. Once the buffer schedule activities are determined, the planned activities are scheduled to their latest possible planned start and finish dates. Consequently, in lieu of managing the total float of network paths, the critical chain method focuses on managing the buffer activity durations and the resources applied to planned schedule activities.

.4 Resource Leveling

Resource leveling is a schedule network analysis technique applied to a schedule that has already been analyzed by the critical path method. Resource leveling is used to address schedule activities that need to be performed to meet specified delivery dates, to address a situation where shared or critical required resources are only available at certain times or are only available in limited quantities, or to keep selected resource usage at a constant level during specific time periods of the project work. This resource usage leveling approach can cause the original critical path to change.

The critical path method calculation (Section 6.5.2.2) produces a preliminary early start schedule and late start schedule that can require more resources during certain time periods than are available, or can require changes in resource levels that are not manageable. Allocating scarce resources to critical path activities first can be used to develop a project schedule that reflects such constraints. Resource leveling often results in a projected duration for the project that is longer than the preliminary project schedule. This technique is sometimes called the resource-based method, especially when implemented using schedule optimization project management software. Resource reallocation from non-critical to critical activities is a common way to bring the project back on track, or as close as possible, to its originally intended overall duration. Utilization of extended hours, weekends, or multiple shifts for selected resources can also be considered using different resource calendars to reduce the durations of critical activities. Resource productivity increases are another way to shorten durations that have extended the preliminary project schedule. Different technologies or machinery, such as reuse of computer code, automatic welding, electric pipe cutters, and automated processes, can all have an impact on resource productivity. Some projects can have a finite and critical project resource. In this case, the resource is scheduled in reverse from the project ending date, which is known as reverse resource allocation scheduling, and may not result in an optimal project schedule. The resource leveling technique produces a resource-limited schedule, sometimes called a resource-constrained schedule, with scheduled start dates and scheduled finish dates.

.5 What-If Scenario Analysis

This is an analysis of the question “What if the situation represented by scenario ‘X’ happens?” A schedule network analysis is performed using the schedule to compute the different scenarios, such as delaying a major component delivery, extending specific engineering durations, or introducing external factors, such as a strike or a change in the permitting process. The outcome of the what-if scenario analysis can be used to assess the feasibility of the project schedule under adverse conditions, and in preparing contingency and response plans to overcome or mitigate the impact of unexpected situations. Simulation involves calculating multiple project durations with different sets of activity assumptions. The most common technique is Monte Carlo Analysis (Section 11.4.2.2), in which a distribution of possible activity durations is defined for each activity and used to calculate a distribution of possible outcomes for the total project.

.6 Applying Leads and Lags

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

.7 Schedule Compression

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

- **Crashing.** A schedule compression technique in which cost and schedule tradeoffs are analyzed to determine how to obtain the greatest amount of compression for the least incremental cost. Examples of crashing could include approving overtime, bringing in additional resources, or paying to expedite delivery. 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 phases or activities that normally would be performed in sequence are performed in parallel. An example would be to construct the foundation for a building before all the architectural drawings are complete. Fast tracking may result in rework and increased risk. This approach may require work to be performed without completed detailed information, such as engineering drawings. It results in trading cost for time, and increases the risk of achieving the shortened project schedule.

.8 Scheduling Tool

The scheduling tool helps to manage schedule components and the rules for relating and using the components to represent the process for completing a project. This is easily visualized by running a scheduling program and, before the addition of any activities or other project specific data, observing the various components in that tool which are available to build the schedule. The scheduling tool and the supporting data are used in conjunction with manual methods or other project management software to perform schedule network analysis to generate the project schedule.

6.5.3 Develop Schedule: Outputs

.1 Project Schedule

As 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 would remain preliminary until resource assignments have been confirmed and scheduled start and finish dates are established. This process usually happens no later than completion of the project management plan (Section 4.2). A project target schedule may also be developed with a defined target start and target finish for each schedule activity. The project schedule may be presented in summary form, sometimes referred to as the master schedule or milestone schedule, or presented in detail. Although a project schedule can be presented in tabular form, it is more often presented graphically, using one or more of the following formats:

- **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 6-8.
- **Bar charts.** These charts, with bars representing activities, show activity start and end dates, as well as expected durations. Bar charts are relatively easy to read, and are frequently used in management presentations. For control and management communication, the broader, more comprehensive summary activity, sometimes referred to as a hammock activity, is used between milestones or across multiple interdependent work packages, and is displayed in bar chart reports. An example is the summary schedule portion of Figure 6-8 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 6-4, 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 6-8. This example also shows how each work package is planned as a series of related activities.

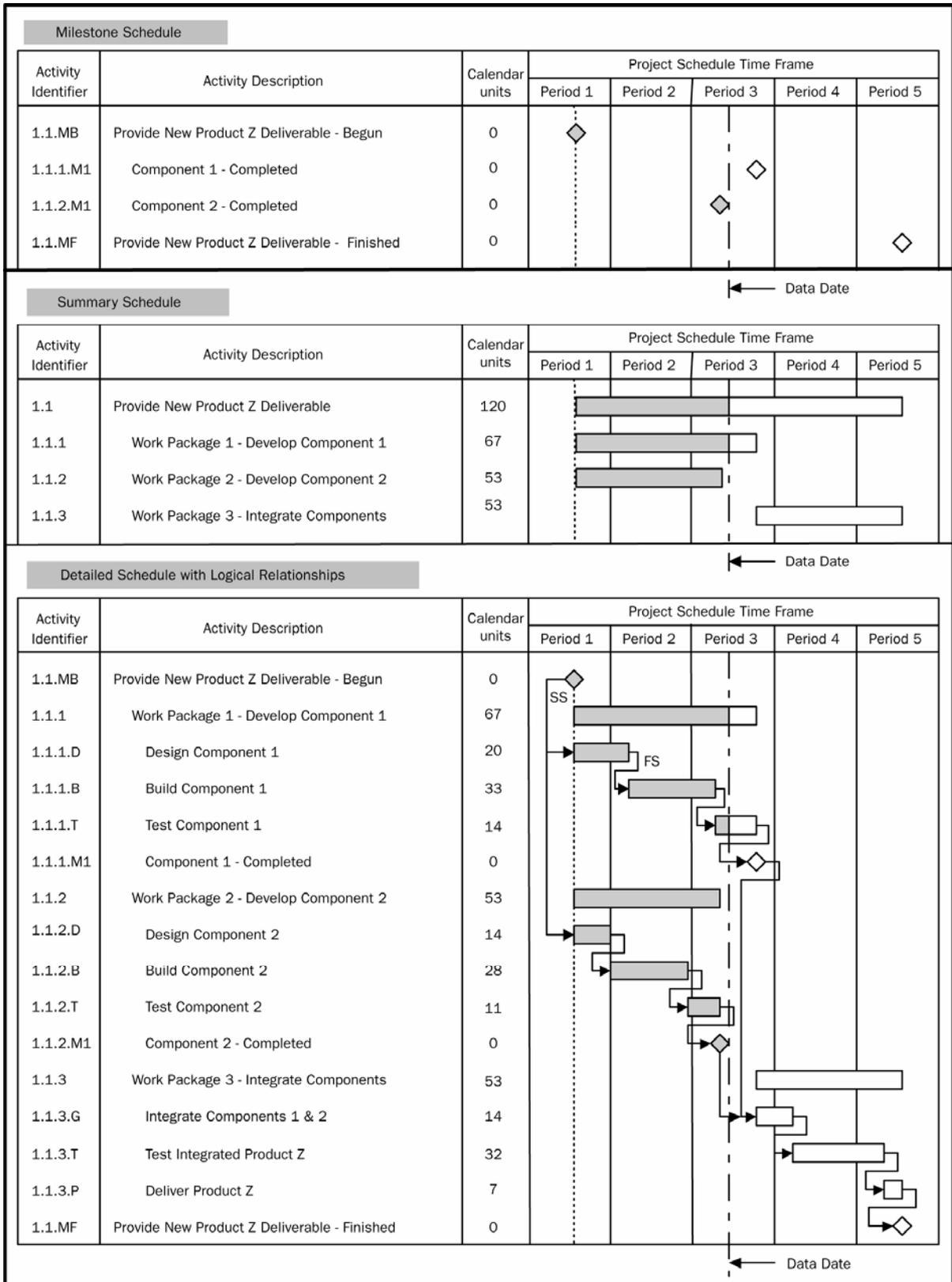


Figure 6-8. Project Schedule--Graphic Examples

Figure 6-8 shows the schedule for a sample project being executed, with the work in progress reported through the data date, which is sometimes also called the as-of date or time now date. For a simple project schedule, Figure 6-8 gives a graphic display of a Milestone Schedule, a Summary Schedule, and a Detailed Schedule. Figure 6-8 also visually shows the relationships among the three different levels of schedule presentation.

.2 Schedule Baseline

A schedule baseline is a specific version of the project schedule developed from the schedule network analysis. It is accepted and approved by the project management team as the schedule baseline with baseline start dates and baseline finish dates. The schedule baseline is a component of the project management plan.

.3 Schedule Data

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

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

For example, the schedule data could include such items as human resource histograms, cash-flow projections, and order and delivery schedules.

.4 Project Documents Updates

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

- **Resource requirements.** Resource leveling can have a significant effect on preliminary estimates of the types and quantities of resources required. If the resource-leveling analysis changes the project resource requirements, then the project resource requirements are updated.
- **Activity attributes.** Activity attributes (Section 6.1.3.2), are updated to include any revised resource requirements and any other revisions generated by the Develop Schedule process.
- **Calendar.** The calendar for each project may use different calendar units as the basis for scheduling the project.
- **Risk Log.** The risk log may need to be updated to reflect opportunities or threats perceived through scheduling assumptions.

6.6 Control Schedule

Control Schedule is the process of monitoring the status of the projects to update project progress and managing changes to the schedule. Schedule control is concerned with:

- Determining the current status of the project schedule,
- Influencing the factors that create schedule changes,

- Determining that the project schedule has changed, and
- Managing the actual changes as they occur.

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

Table 6-7. Control Schedule Overview: Inputs, Tools & Techniques, and Outputs

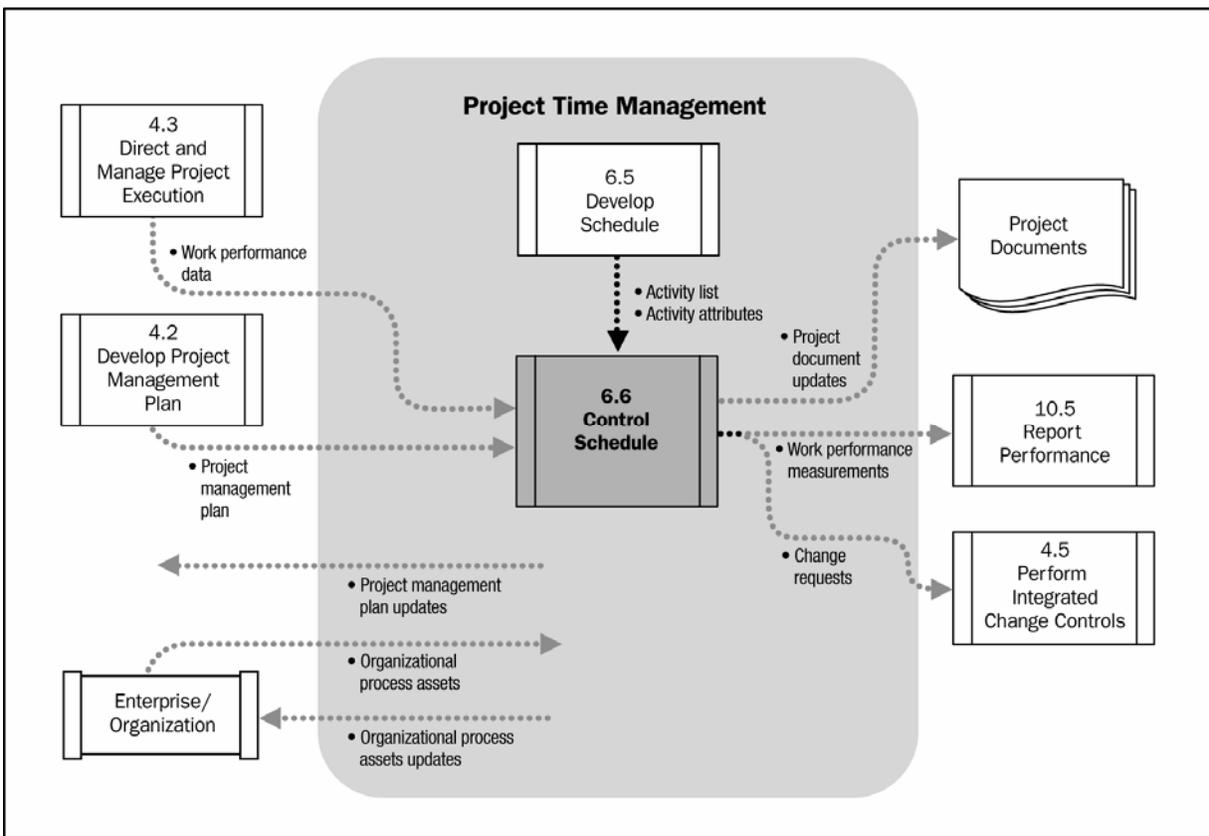
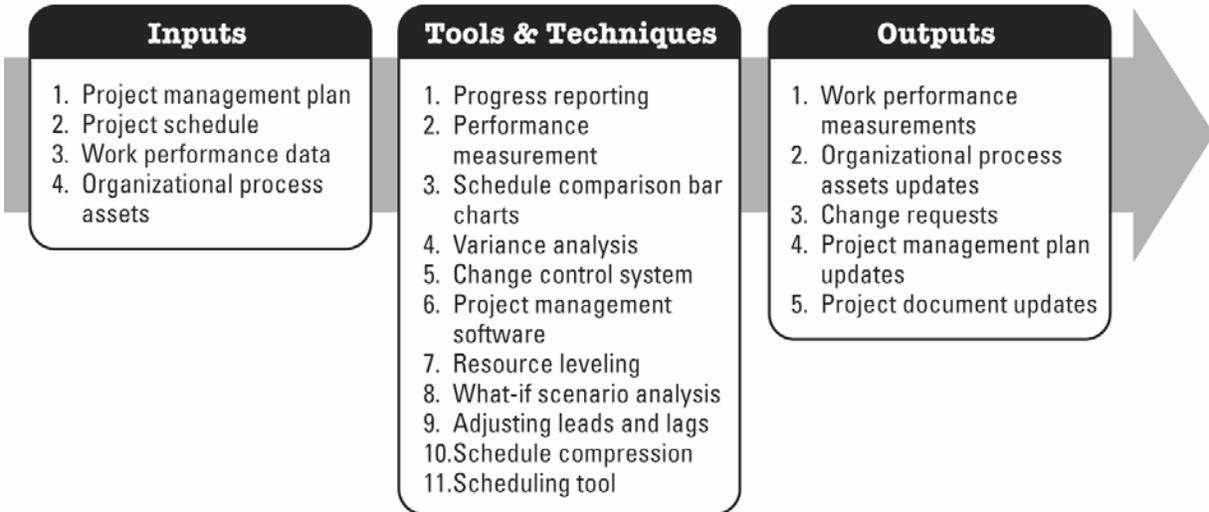


Figure 6-9. Control Schedule Data Flow Diagram

6.6.1 Control Schedule: Inputs

.1 Project Management Plan

The project management plan described in Section 4.2.3.1 contains the following information that is used to control the schedule:

- **Schedule Baseline.** The schedule baseline provides the basis for measuring and reporting schedule performance as part of the performance measurement baseline.
- Schedule management plan.

.2 Project Schedule

The most recent version of the project schedule with notations to indicate updates, completed activities, and started activities.

.3 Work Performance Data

Data from project activities such as which activities have started, how far they have progressed and which activities have finished is collect to compare against the schedule and the schedule baseline.

.4 Organizational Process Assets

The organization process assets that influence the Control Schedule process include but are not limited to:

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

6.6.2 Control Schedule: Tools and Techniques

.1 Progress Reporting

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

.2 Performance Measurement

Performance measurement techniques produce the Schedule Variance (SV) (Section 7.3.2.5) and Schedule Performance Index (SPI) (Section 7.3.2.3), are used to assess the magnitude of any project schedule variations that do occur. An important part of schedule control is to decide if the schedule variation requires corrective action. For example, a major delay on any 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.

.3 Schedule Comparison Bar Charts

To facilitate analysis of schedule progress, it is convenient to use a comparison bar chart, which displays two bars for each activity. One bar shows the current actual status, and the other shows the

status of the approved project schedule baseline. This shows graphically where the schedule has progressed as planned or where slippage has occurred.

.4 Variance Analysis

Performing the schedule variance analysis during the schedule monitoring process is a key function of schedule control. Comparing target schedule dates with the actual/forecast start and finish dates provides useful information for the detection of deviations, and for the implementation of corrective actions in case of delays. The total float variance is also an essential planning component to evaluate project time performance.

.5 Change Control System

The change control system defines the procedures by which the project schedule can be changed. It includes the paperwork, tracking systems, and approval levels necessary for authorizing changes. The change control system is operated as part of the Perform Integrated Change Control process (Section 4.5).

.6 Project Management Software

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

.7 Resource Leveling

Resource leveling is used to distribute work evenly among resources. Described in Section 6.5.2.4.

.8 What-If Scenario Analysis

What-if scenario analysis is used to review various scenarios to bring the schedule into alignment with the plan. Described in Section 6.5.2.5.

.9 Adjusting Leads and Lags

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

.10 Schedule Compression

Schedule compression techniques are used to find ways to bring project activities that are behind into alignment with the plan. Described in Section 6.5.2.5.

.11 Scheduling Tool

Schedule data is updated and compiled into the schedule to reflect actual progress of the project and remaining work to be completed. The scheduling tool 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.

6.6.3 Control Schedule: Outputs

.1 Work Performance Measurements

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

.2 Organizational Process Assets Updates

Lessons learned documentation of the causes of variance, the reasoning behind the corrective actions chosen, and other types of lessons learned from schedule control are documented in the organizational process assets so they become part of the historical database for both the project and other projects of the performing organization.

.3 Change Requests

Schedule variance analysis, along with review of progress reports, results of performance measures, and modifications to the project schedule can 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 (4.6). Preventative actions may include recommended changes to reduce the probability of negative schedule variances.

.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. The original schedule baseline is saved before creating the new schedule baseline to prevent the loss of historical data for the project schedule.
- **Schedule management plan.** The schedule management plan (Chapter 6 introductory material) component of the project management plan (Section 4.2.3.1) may be updated to reflect any approved changes resulting from the Schedule Control process, and how the project schedule will be managed.
- **Scope baseline.** The scope baseline may be updated to reflect changes to resources.
- **Cost baseline.** The cost baseline may be updated to reflect changes caused by compression or crashing techniques.

.5 Project Document Updates

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

- **Schedule Data.** A project schedule update is any modification to the project schedule data information that is used to manage the project. Appropriate stakeholders are notified of significant modifications as they occur. New project schedule network diagrams are developed to display approved remaining durations and modifications to the work plan. In some cases, project schedule delays can be so severe that development of a new target schedule with revised target start and finish dates is needed to provide realistic data for directing the work, and for measuring performance and progress.
- **Project Schedule** An updated project schedule will be generated from the updated, schedule data to reflect the schedule changes and manage the project.

Chapter 7 Project Cost Management

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

- 7.1 Estimate Costs**--the process of developing an approximation of the monetary resources needed to complete project activities.
- 7.2 Determine Budget**- -the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline.
- 7.3 Control Costs**- -the process of monitoring the status of the project to update the project budget and managing changes to the cost baseline.

These processes interact with each other and with processes in the other knowledge areas as well. Each process can involve effort from one or more persons or groups of persons based upon the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3.

On some projects, especially ones of smaller scope, cost estimating and cost budgeting are so tightly linked that they are viewed as a single process that can be performed by a single person over a relatively short period of time. These processes are presented here as distinct processes because the tools and techniques for each are different. The ability to influence cost is greatest at the early stages of the project, making early scope definition critical (Section 5.2).

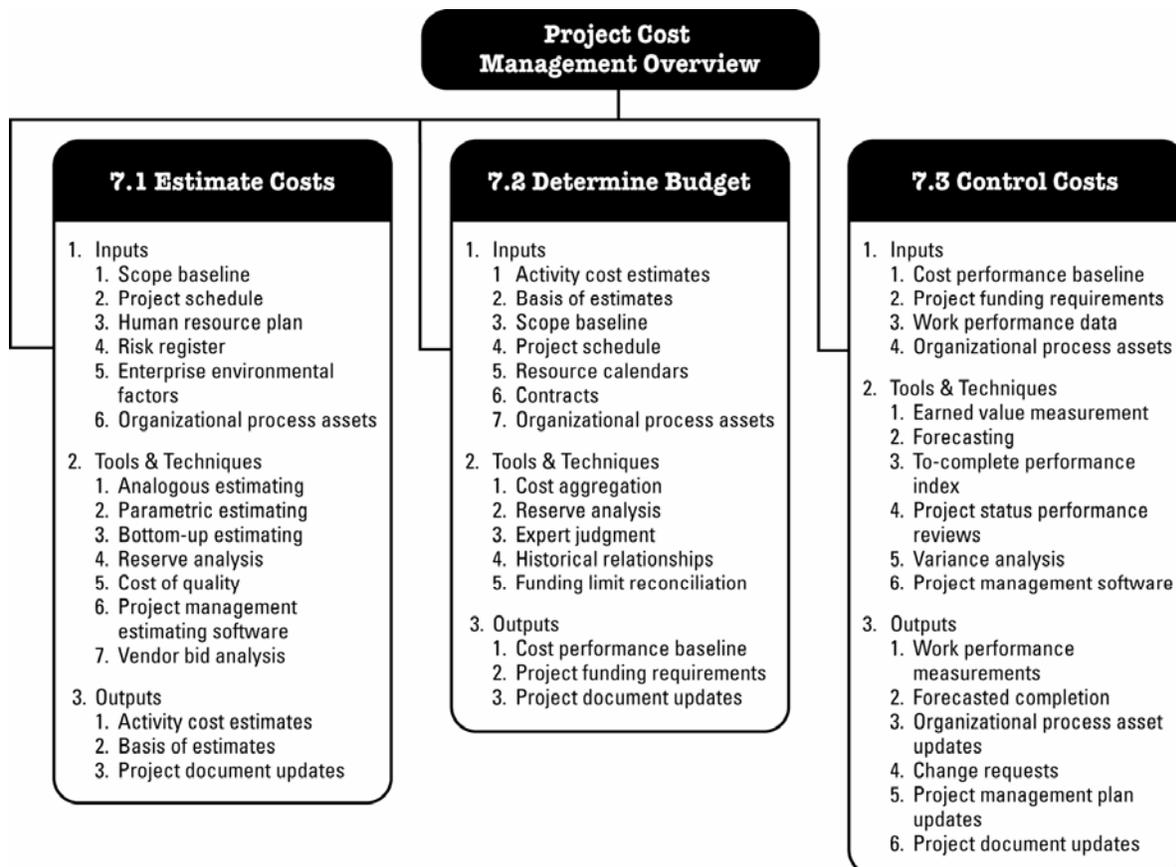
The work involved in performing the three processes of Project Cost Management is preceded by a planning effort of the project management team. This planning effort is part of the Develop Project Management Plan process (Section 4.2), which produces a cost management plan that sets out the format and establishes the criteria for planning, structuring, estimating, budgeting, and controlling project costs. The cost management processes and their associated tools and techniques are usually selected during the project life cycle definition (Section 2.1), and are documented in the cost management plan. For example, the cost management plan can establish the following:

- **Level of accuracy.** Schedule activity cost estimates will adhere to a rounding of the data to a prescribed precision (e.g., \$100, \$1,000), based on the scope of the activities and magnitude of the project, and may include an amount for contingencies.
- **Units of measure.** Each unit used in measurements (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 5.3.3.1) 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 need 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 could:
 - Define the WBS and points at which measurement of control accounts will be performed,
 - Establish the earned value measurement metrics (e.g., weighted milestones, fixed-formula, percent complete, etc.) to be employed, and
 - Specify the earned value management computation formulas for determining the projected estimate at completion (EAC) forecasts and other tracking methodologies.
- **Reporting formats.** The formats and frequency for the various cost reports are defined.
- **Process descriptions.** Descriptions of each of the three cost management processes are documented.

All of this information is included in the cost management plan, a component of the project management plan, either as text within the body of the plan or as appendices. The cost management plan may be formal or informal, highly detailed or broadly framed, based upon the needs of the project.

Table 7-1. Project Cost Management Overview



Project Cost Management should consider the requirements for capturing costs of the project stakeholders. Different stakeholders will measure project costs in different ways and at different times. For example, the cost of an acquired item can be measured when the acquisition decision is made or committed, the order is placed, the item is delivered, 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 scope and schedule 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 is done outside the project. In others, such as a capital facilities project, Project Cost Management can include this work. When such predictions and analyses are included, Project Cost Management may address additional processes and numerous general 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 Estimate Costs

Estimate Costs is the process of developing an approximation of the monetary resources needed to complete project activities. 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, euro, yen, etc.), although in some instances other units of measure, such as staff hours or staff days, are used to facilitate comparisons both within and across projects.

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. For example, a project in the initiation phase could have a rough order of magnitude (ROM) estimate in the range of $\pm 50\%$. Later in the project, as more information is known, estimates could narrow to a range of $\pm 10\%$. 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 project processes in other knowledge areas. Once received, all of this information will remain available as inputs to all three 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 schedule activity.

Table 7-2. Estimate Costs: Inputs, Tools & Techniques, and Outputs

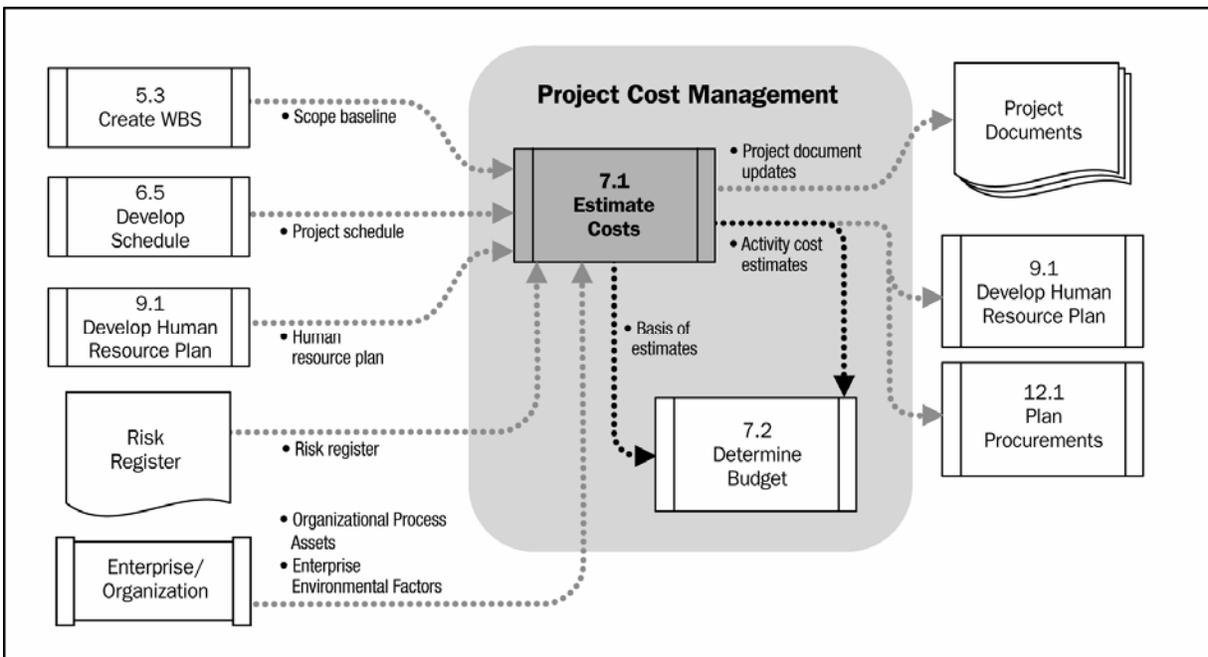
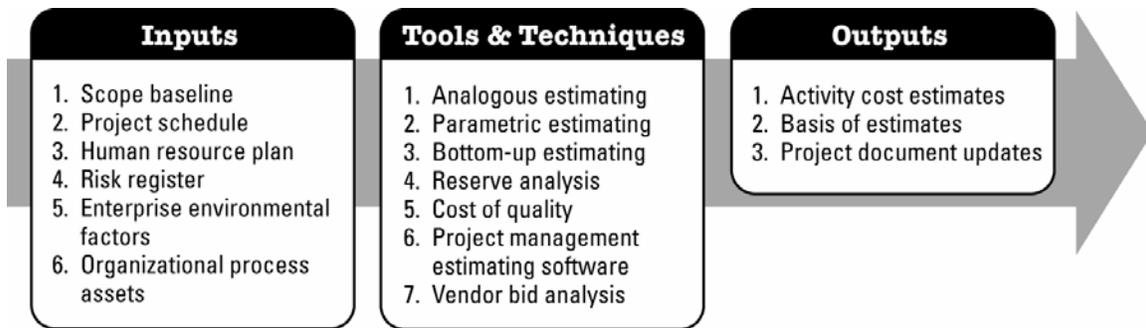


Figure 7-1. Estimate Costs Data Flow Diagram

7.1.1 Estimate Costs: Inputs

.1 Scope Baseline

- Scope statement.** The scope statement (Section 5.2.3.1) provides the product description, acceptance criteria, key deliverables, project boundaries, assumptions, and constraints about the project. 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 project WBS (Section 5.3.3.1) provides the relationships among all the components of the project and the project deliverables (Section 4.3.3.1).
- WBS dictionary.** The WBS dictionary (Section 5.3.3.2) 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 that includes requirements with contractual and legal implications are health, safety, security, performance, environmental, insurance, intellectual property rights, equal employment opportunity, licenses, and permits. All of this information is considered when developing the cost estimates.

.2 Project Schedule

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 6.3) involves determining the availability and quantities required of staff and materiel needed to perform schedule activities. It is closely coordinated with cost estimating. Estimate Activity Durations (Section 6.4.3.1) 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 schedule activity. Schedule activity duration estimates can also affect cost estimates that have time-sensitive costs included in them, such as union labor with regularly expiring collective bargaining agreements or materials with seasonal cost variations.

.3 Human Resource Plan

Project staffing attributes, personnel rates, and related rewards/recognition (Section 9.1.3.1) are necessary components for developing the schedule cost estimates.

.4 Risk Register

The risk register (Section 11.2.3.1) should be reviewed to consider risk mitigation costs. Risks, which can be either threats or opportunities, typically have an impact on both schedule 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.

.5 Enterprise Environmental Factors

The enterprise environmental factors that influence the Estimate Cost process include but are not limited to:

- **Market conditions.** Market conditions describe what products, services, and results are available in the market, from whom, and under what terms and conditions.
- **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.

.6 Organizational Process Assets

The organizational process assets that influence the Estimate Cost process include but are not limited to:

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

- **Cost estimating templates.** An organization may have developed templates (or a pro forma standard) for use by the project team. The organization can continuously improve the template based on its application and usefulness in prior projects.
- **Historical information.** Documents and data on prior projects including project files, records, correspondence, closed contracts, and closed projects, obtained from various sources within the organization, can influence the cost of the project.
- **Project files.** Organizations involved in the project may maintain records of previous project performance that are detailed enough to aid in developing cost estimates. In some organizations, individual team members may maintain such records.
- **Project team knowledge.** Members of the project team may recall previous actual costs or cost estimates. While such recollections can be useful, they are generally far less reliable than documented performance.
- **Lessons learned.** Lessons learned could include cost estimates obtained from previous projects that are similar in scope and size.
- **Resource cost rates.** The person determining the rates or the group preparing the estimates should use the unit cost rates (such as staff cost per hour or bulk material cost per cubic yard) for each resource to estimate activity costs. Gathering quotes (Section 12.2) is one method of obtaining rates. For products, services, or results to be obtained under contract, standard rates with escalation factors can be included in the contract. Obtaining data from commercial databases and seller published price lists is another source of cost rates. If the actual rates are not known, then the rates will need to be estimated.
- **Basic assumptions.** 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. Great care should be exercised to exclude the inappropriate application of indirect costs to projects within an organization. When a decision is made to include or exclude indirect costs in the project estimate, the same approach needs to be applied consistently to the cost estimate, the project budget, and the monitoring and control of actual costs.

7.1.2 Estimate Costs: Tools and Techniques

.1 Analogous Estimating

Analogous cost estimating is an estimating technique that 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 activity, as the basis for estimating the same parameter or measure for a future activity. 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 (e.g., in the early phases of a project). Analogous cost estimating relies on expert judgment.

Analogous cost estimating is generally less costly than other techniques, but it is also generally less accurate. It is most reliable when previous activities are similar in fact, and not just in appearance, and the persons or groups preparing the estimates have the needed expertise. Analogous cost estimates can be applied to a total project or to segments of a project, used in conjunction with other estimating methods.

.2 Parametric Estimating

Parametric estimating is an estimating technique that uses a statistical relationship between historical data and other variables (e.g., square footage in construction or lines of code in software development) to calculate an estimate for activity parameters, such as scope, 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.

.3 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 is typically influenced by the size and complexity of the individual schedule activity or work package.

.4 Reserve Analysis

Cost estimates may include reserves (sometimes called contingency allowances). This has the inherent problem of potentially overstating the cost estimate for the activity. Contingency reserves are provisions in the project management plan to mitigate cost risks. They are estimated costs used at the discretion of the project manager to deal with anticipated, but not certain, events. These events are “known unknowns” and are part of the project scope and cost baselines.

.5 Cost of Quality

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

.6 Project Management Estimating Software

Project management cost estimating software applications, computerized spreadsheets, simulation, and statistical tools are becoming more widely accepted 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 Vendor Bid Analysis

Cost estimating methods may include analysis of what the project should cost, based on the responsive bids from qualified vendors. Where projects are awarded to a vendor under competitive processes, additional cost estimating work can 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.

7.1.3 Estimate Costs: Outputs

.1 Activity Cost Estimates

A quantitative assessment of the probable costs is required to complete an activity. This type of estimate can be presented in summary form or in detail. Costs are estimated for all resources that are applied to the activity cost estimate. This includes, but is not limited to, 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.

.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., \$10,000 ($\pm 10\%$) to indicate that the item is expected to cost between a range of values), and
- Indication of the confidence level of the final estimate.

.3 Project Document Updates

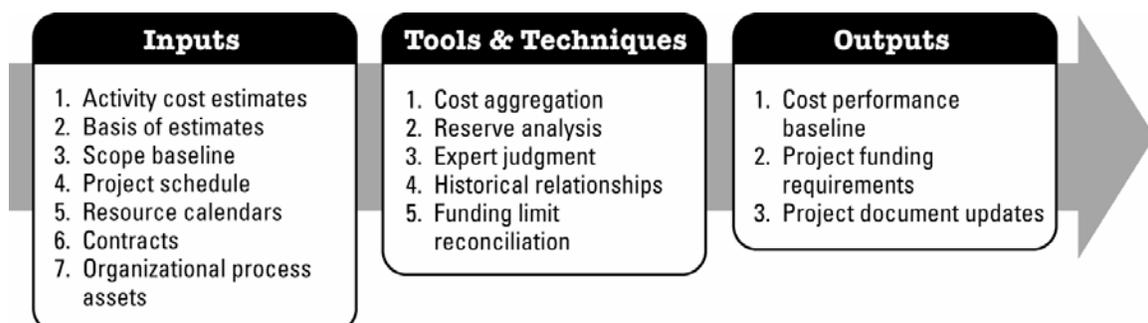
Project documents that may be updated include but are not limited to risk register

7.2 Determine Budget

Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline. This baseline includes all authorized budgets, but excludes management or contingency reserves.

Project budgets constitute the funds authorized to execute the project. Budgets may differ from the estimates. Project cost performance will be measured against the authorized budget.

Table 7-3. Determine Budget: Inputs, Tools & Techniques, and Outputs



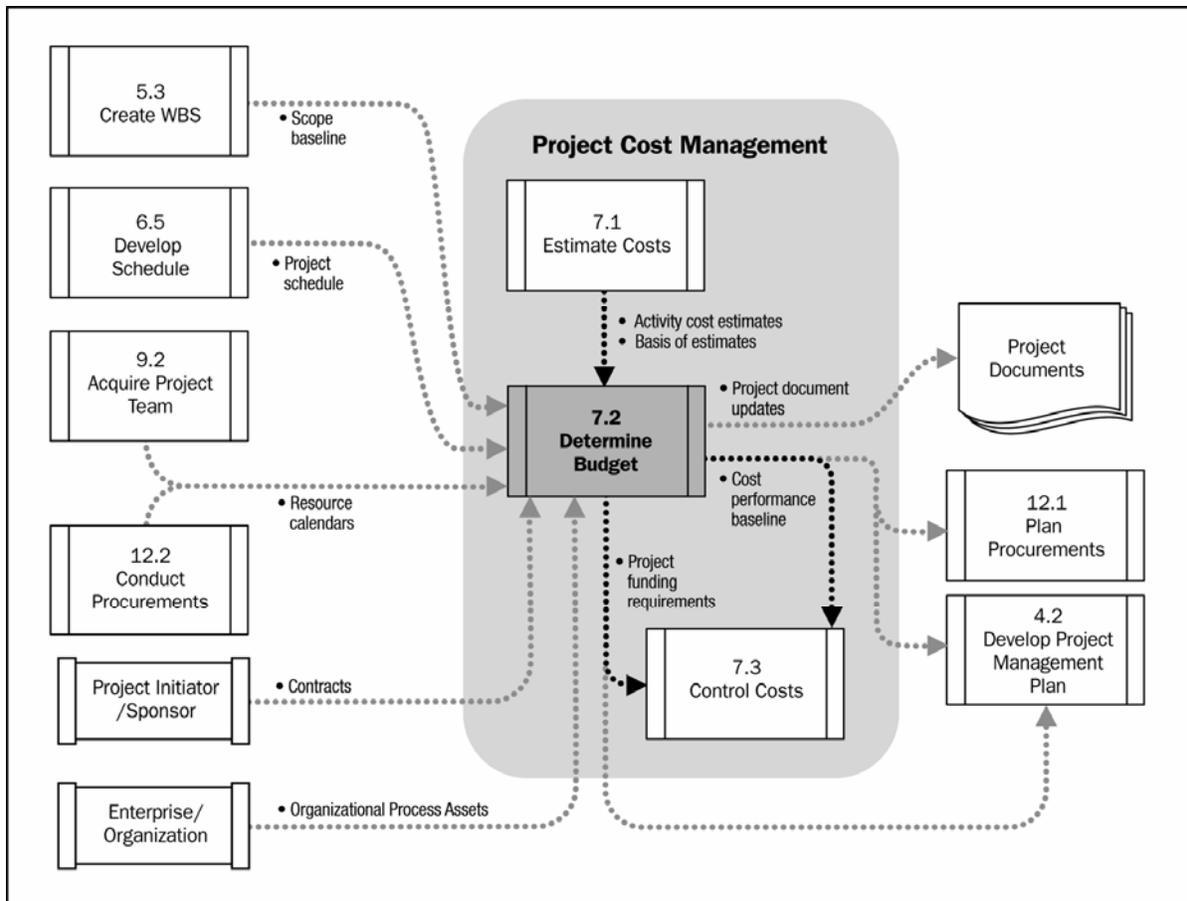


Figure 7-2. Determine Budget Data Flow Diagram

7.2.1 Determine Budget: Inputs

.1 Activity Cost Estimates

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

.2 Basis of Estimates

Supporting detail for cost estimates should be specified as described in Section 7.1.3.2. Any basic assumptions dealing with the inclusion or exclusion of indirect costs in the project budget are specified in the basis of estimates.

.3 Scope Baseline

- **Scope Statement.** Formal limitations by period for the expenditure of project funds can be mandated by the organization, by contract (Section 12.4.3.2) or by other entities such as government agencies. These funding constraints are reflected in the project scope statement.
- **Work breakdown structure.** The project WBS (Section 5.3.3.1) provides the relationships among all the project deliverables and their various components.

- **WBS dictionary.** The WBS dictionary (Section 5.3.3.2) and related detailed statements of work provide an identification of the deliverables and a description of the work in each WBS component required to produce each deliverable.

.4 Project Schedule

The project schedule (Section 6.5.3.1), as part of the project management plan, includes planned start and finish dates for the project's activities, milestones, work packages, planning packages, and control accounts. This information is used to aggregate costs to the calendar periods in which the costs are planned to be incurred.

.5 Resource Calendars

Resource calendars provide information on which resources are assigned to the project and when they are assigned. This information is used to indicate resource costs over the duration of the project.

.6 Contracts

Applicable contract information and costs relating to products, services, or results that have been purchased are included when determining the budget.

.7 Organizational Process Assets

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.

7.2.2 Determine Budget: Tools and Techniques

.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.

.2 Reserve Analysis

Reserve analysis (Section 11.6.2.5) establishes the contingency reserves that are allowances for unplanned but potentially required changes that can result from realized risks identified in the risk register.

Management contingency reserves are budgets reserved for unplanned changes to project scope and cost. These are “unknown unknowns” and the project manager may be required to obtain approval before obligating or spending this reserve. Management contingency reserves are not a part of the project cost baseline, but are included in the total budget for the project. They are not included as a part of the earned value measurement calculations.

.3 Expert Judgment

Judgment provided based upon expertise in an application area, knowledge area, discipline, industry, etc., as appropriate for the activity being performed should be used 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: other units within the performing organization; consultants; stakeholders, including customers; professional and technical associations; and industry groups.

.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 can be simple (e.g., residential home construction is based on a certain cost per amount 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.

.5 Funding Limit Reconciliation

The expenditure of funds should be reconciled with the funding limits that are set by the customer or performing organization on the commitment of funds for the project. A variance between the funding limits and the expenditures will sometimes necessitate the rescheduling of work to level out the load of required expenditures, which is accomplished by placing imposed date constraints for some work packages, schedule milestones, or WBS components into the project schedule. Rescheduling can impact the allocation of resources. The final product of these planning iterations will be a cost performance baseline.

7.2.3 Determine Budget: Outputs

.1 Cost Performance Baseline

The cost performance baseline is an authorized time-phased budget used to measure, monitor, and control overall cost performance on the project. It is developed as a summation of the approved budgets by time period and is typically displayed in the form of an S-curve, as is illustrated in Figure 7-3.

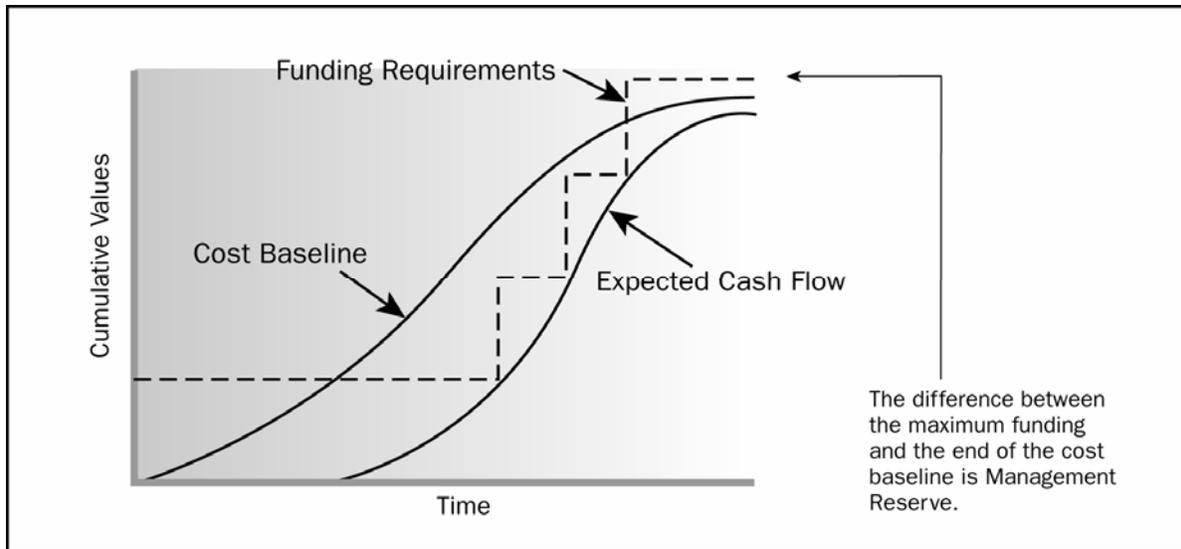


Figure 7-3. Cash Flow, Cost Baseline, and Funding Display

.2 Project Funding Requirements

Total funding requirements and periodic funding requirements (e.g., annual or quarterly) are derived from the cost baseline. Funding usually occurs in incremental amounts that are not continuous, and, therefore, appears as a step function as shown in Figure 7-3. The total funds required are those included in the cost baseline plus the management contingency reserve amount. Some portion of the management contingency reserve may be included incrementally in each funding step or funded when needed, depending upon the organizational policies.

.3 Project Document Updates

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

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

7.3 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. 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. Thus much of the effort of cost control centers on the relationship of 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 performance 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
- Acting to bring expected cost overruns within acceptable limits.

Project cost control seeks out the causes of positive and negative variances and is part of the Perform Integrated Change Control process (Section 4.5).

Table 7-4. Control Costs: Inputs, Tools & Techniques, and Outputs

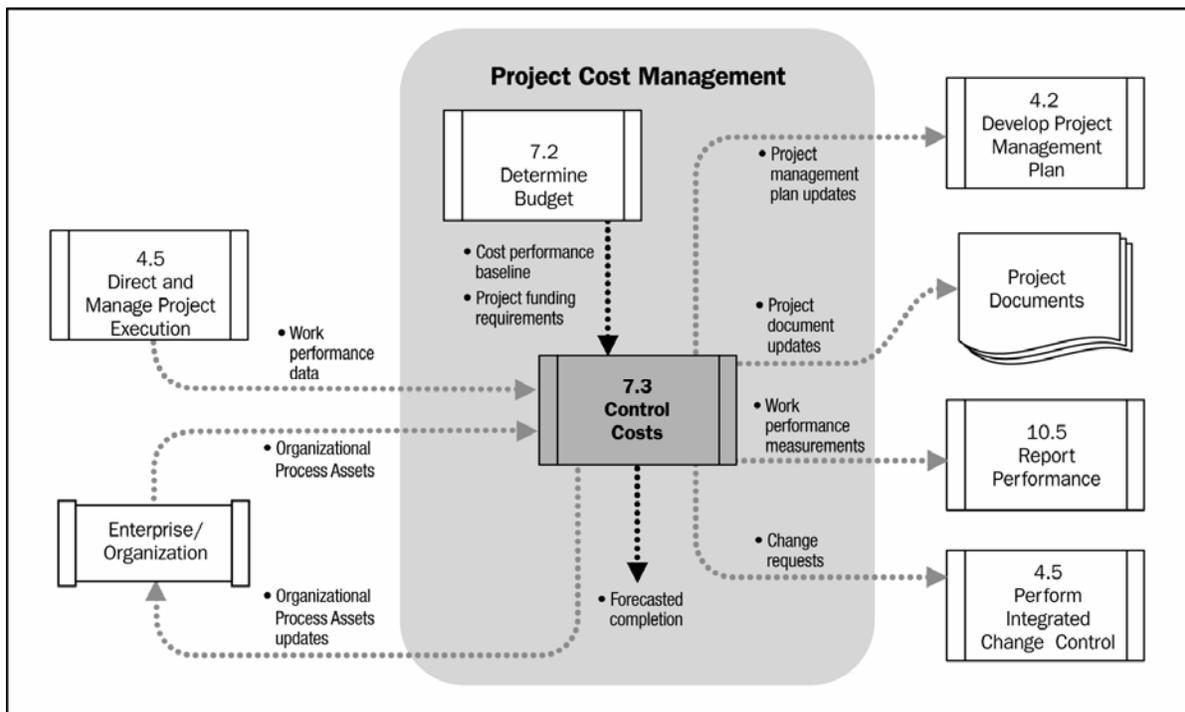
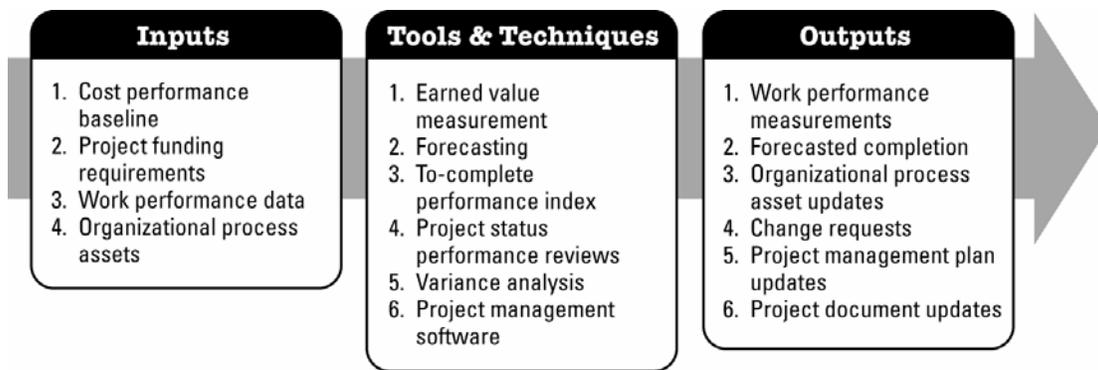


Figure 7-4. Control Costs Data Flow Diagram

7.3.1 Control Costs: Inputs

.1 Cost Performance Baseline

The baseline against which cost performance will be measured is described in Section 7.2.3.1.

.2 Project Funding Requirements

Project funding requirements are described in Section 7.2.3.2.

.3 Work Performance Data

Work performance data pertaining to the status and cost of project activities being performed is collected. This information includes but is not limited to:

- Deliverables that have been completed and those not yet completed,
- Costs authorized and incurred, and
- Estimates for completing the schedule activities.

.4 Organizational Process Assets

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.

7.3.2 Control Costs: Tools and Techniques

.1 Earned Value Measurement

The earned value technique in its various forms is a commonly used method of performance measurement. It integrates project scope, cost, and schedule measures to help the project management team assess project performance. The EVM methodology integrates scope, schedule, and resources, to objectively 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 the schedule work to be accomplished for a schedule activity or work breakdown structure component. It includes the detailed authorized work, plus the budget for such authorized work, allocated by phase over the life of the project. 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 the value of work performed expressed in terms of the approved budget assigned to that work for a schedule activity or work breakdown structure component. 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 PV baseline and the EV measured cannot be greater than the authorized PV budget. The term EV is often used to describe the percentage completion of a project. 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 total cost actually incurred and recorded in accomplishing work performed for a schedule activity or work breakdown structure component. It is the total cost incurred in accomplishing the work that the EV measured. The AC has 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 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. EVM SVs are best used in conjunction with critical path methodology (CPM) scheduling and risk management. Formula: $SV = EV - PV$.
- **Cost variance.** Cost variance (CV) 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 EVM CV is particularly critical because it indicates the relationship of physical performance to the costs spent. Any negative EVM CV is often non-recoverable to the project. Formula: $CV = EV - AC$.

The SV and CV values can be converted to efficiency indicators to reflect the cost and schedule performance of any project, to compare it 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 schedule efficiency on a project. 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 the project is ahead of its planned schedule. The SPI is equal to the ratio of the EV to the PV. Formula: $SPI = EV/PV$.
- **Cost performance index.** The cost performance index (CPI) is a measure of cost efficiency on a project. It is the most critical EVM metric and measures the cost efficiency for the work completed. A CPI value 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. Formula: $CPI = EV/AC$.

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 7-5 uses S-curves to display EV data for a project that is performing over budget and behind the work plan.

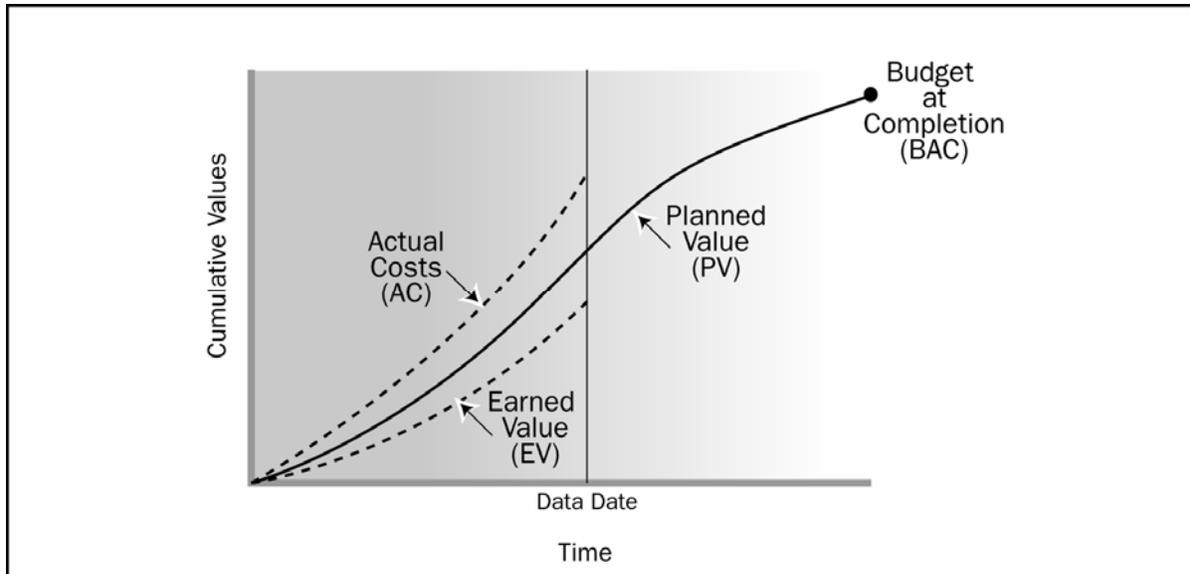


Figure 7-5. Earned Value, Planned Value, and Actual Costs

.2 Forecasting

As the project progresses, the project team develops a forecast for the estimate at completion (EAC) that differs from the budget at completion (BAC) based on the project performance. 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 information (Section 4.3.3.2) provided as the project is executed and progressed. 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 effort. 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.** This 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. This method may be problematic in that it interferes with the conduct of project work. The personnel who are performing the project work have to stop working to provide a detailed bottom-up ETC of the remaining work. Typically there is no separate budget to perform the ETC, so additional costs are incurred for the project to conduct the ETC. Formula: $EAC = AC + \text{bottom-up ETC}$.

The project manager's manual EAC can be quickly compared with a range of calculated EVM EACs representing various risk scenarios. While EVM data can 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. Formula: $EAC = AC + BAC - EV$.

- **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. Formula: $EAC = BAC / \text{cumulative CPI}$.
- **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 weight the CPI and SPI at different values (e.g., 80/20, 50/50, or some other ratio) according to the project manager's judgment. Formula: $AC + [(BAC - EV) / (\text{cumulative CPI} \times \text{cumulative SPI})]$.

Each of these approaches can be correct 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.

.3 To-Complete Performance Index (TCPI)

The to-complete performance index (TCPI) is the calculated projection of cost performance 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 cost performance goal. Formula for the TCPI based on the BAC: $(BAC - EV) / (BAC - AC)$.

The TCPI is conceptually displayed in Figure 7-6. The formula 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 plan (as shown in Figure 7-6), all future work of the project will need to immediately be performed in the range of the TCPI (BAC) (as reflected in the top line of Figure 7-6) 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 formula for the TCPI based on the EAC: $(BAC - EV) / (EAC - AC)$.

.4 Project Status Performance Reviews

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

Performance reviews are meetings held to assess the status and progress of schedule activities, work packages, or control accounts, and are typically used in conjunction with one or more of the following performance-reporting techniques:

- **Variance analysis.** Variance analysis as used in EVM compares actual project performance to planned or expected performance. Cost and schedule variances are the most frequently analyzed, but variances from plan in other areas of the project can be of equal or greater importance.
- **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.** The earned value technique compares the baseline plan to actual schedule and cost performance.

.5 Variance Analysis

The cost management plan describes how cost variances will be managed (for example, having different responses to major or minor variances). 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.

.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.

7.3.3 Control Costs: Outputs

.1 Work Performance Measurements

The calculated CV, SV, CPI, and SPI values for WBS components, in particular the work packages and control accounts, are documented and communicated (Section 10.2.3.1) to stakeholders.

.2 Forecasted Completion

Either a calculated EAC value or a bottom-up EAC value is documented and the value communicated (Section 10.2.3.1) to stakeholders.

.3 Change Requests

Analysis of project performance can generate a request for a change to increase or decrease the budget. Change requests (Section 4.3.3.3) are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5):

- **Recommended corrective actions** A corrective action is a documented direction for executing the project work to bring expected future performance of the project work in line with the project management plan.

.4 Organizational Process Assets Updates

Elements of the organizational process assets that may be updated include but are not limited to:

- **Lessons learned.** Lessons learned are documented so they can become part of the historical databases for both the project and the performing organization. Lessons learned documentation includes the root causes of variances, the reasoning behind the corrective action(s) chosen, and other types of lessons learned from cost, resource, or resource production control.

.5 Project Management Plan Updates

Elements of the Project Management Plan that may be updated include but are not limited to:

- Cost performance baseline, and
- Cost management plan.

Cost performance baseline updates are generally revised only in response to approved changes in project scope. However, in some cases, cost variances can be so severe that a revised cost baseline is needed to provide a realistic basis for performance measurement.

.6 Project Document Updates

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

- Cost estimates, and
- Basis of estimates.

Chapter 8 Project Quality Management

Project Quality Management processes 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. It implements the quality management system through policy and procedures with continuous process improvement activities conducted throughout, as appropriate.

Table 8-1 provides an overview of the Project Quality Management processes which include the following:

- 8.1 Plan Quality-** -The process of identifying quality requirements and/or standards for the project and product, and documenting how the project will demonstrate compliance.
- 8.2 Perform Quality Assurance**—The process of auditing the quality requirements and the results from quality control measurements to ensure appropriate quality standards and operational definitions are used.
- 8.3 Perform Quality Control**—The process of monitoring and recording results of executing the Quality Plan activities to assess performance and recommend necessary changes.

These processes interact with each other and with the processes in the other Knowledge Areas. Each process can involve effort from one or more persons or groups of persons based on the project requirements. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3.

Project Quality Management addresses the management of the project and the product of the project. Project Quality Management applies to all projects, regardless of the nature of their product. Product quality measures and techniques are specific to the type of product produced by the project. For example, quality management of software products uses different approaches and measures than building a nuclear power plant. Project Quality Management approaches apply to both. In either case, failure to meet product or project quality requirements can have serious negative consequences for any or all of the project stakeholders. For example:

- Meeting customer requirements by overworking the project team may result in increased employee attrition, overlooked errors, or rework.
- Meeting project schedule objectives by rushing planned quality inspections may result in errors going undetected.

Quality is “the degree to which a set of inherent characteristics fulfill requirements [1].” Quality and grade are not the same. Grade is a category assigned to products or services having the same functional use but different technical characteristics [2]. While a quality level that fails to meet quality requirements is always a problem; low grade may not be. For example, a software product can be of high quality (no obvious defects, readable manual) and low grade (a limited number of features), or of low quality (many defects, poorly organized user documentation) and high grade (numerous features). The project manager and the project

management team are responsible for managing the tradeoffs involved to deliver the required levels of both quality and grade.

Precision and accuracy are not equivalent. Precision means the values of repeated measurements are clustered and have little scatter. Accuracy means that the measured value is very close to the true value. Precise measurements are not necessarily accurate. A very accurate measurement is not necessarily precise. The project management team must determine appropriate levels of accuracy and precision.

The basic approach to quality management described in this section is intended to be compatible with that of the International Organization for Standardization (ISO). This is compatible with proprietary approaches to quality management such as those recommended by Deming, Juran, Crosby, and others; and non-proprietary approaches such as Total Quality Management (TQM), Six Sigma, failure mode and effect analysis design reviews, voice of the customer, cost of quality, and continuous improvement.

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

- **Customer satisfaction.** Understanding, evaluating, defining, and managing expectations so that customer requirements are met. This requires a combination of conformance to requirements (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.** One of the fundamental tenets of modern quality management states that quality is planned, designed, and built in—not inspected in. The cost of preventing mistakes is generally much less than the cost of correcting them when they are found by inspection.
- **Continuous improvement.** The plan-do-check-act cycle is the basis for quality improvement as defined by Shewhart and modified by Deming. In addition, quality improvement initiatives undertaken by the performing organization, such as TQM and Six Sigma, should improve the quality of the project's management as well as the quality of the project's product. Process improvement models include Malcolm Baldrige, Organizational Project Management Maturity Model (OPM3[®]), Capability Maturity Model (CMM[®]), and Capability Maturity Model Integrated (CMMISM).

Cost of quality (COQ) refers to the total cost of all efforts related to quality throughout the product life cycle. Project decisions can impact operational costs of quality as a result of product returns, warranty claims, and recall campaigns. Therefore, due to the temporary nature of a project, the sponsoring organization may choose to invest in product quality improvement, especially defect prevention and appraisal, to reduce the external cost of quality.

8.1 Plan Quality

Plan Quality is the process of identifying quality requirements and/or standards for the project and product, and documenting how the project will demonstrate compliance.

Quality planning should be performed in parallel with the other project planning processes. For example, proposed changes in the product 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 most frequently used on projects. There are many others that may be useful on certain projects or in some application areas.

Table 8-1. Project Quality Management Overview

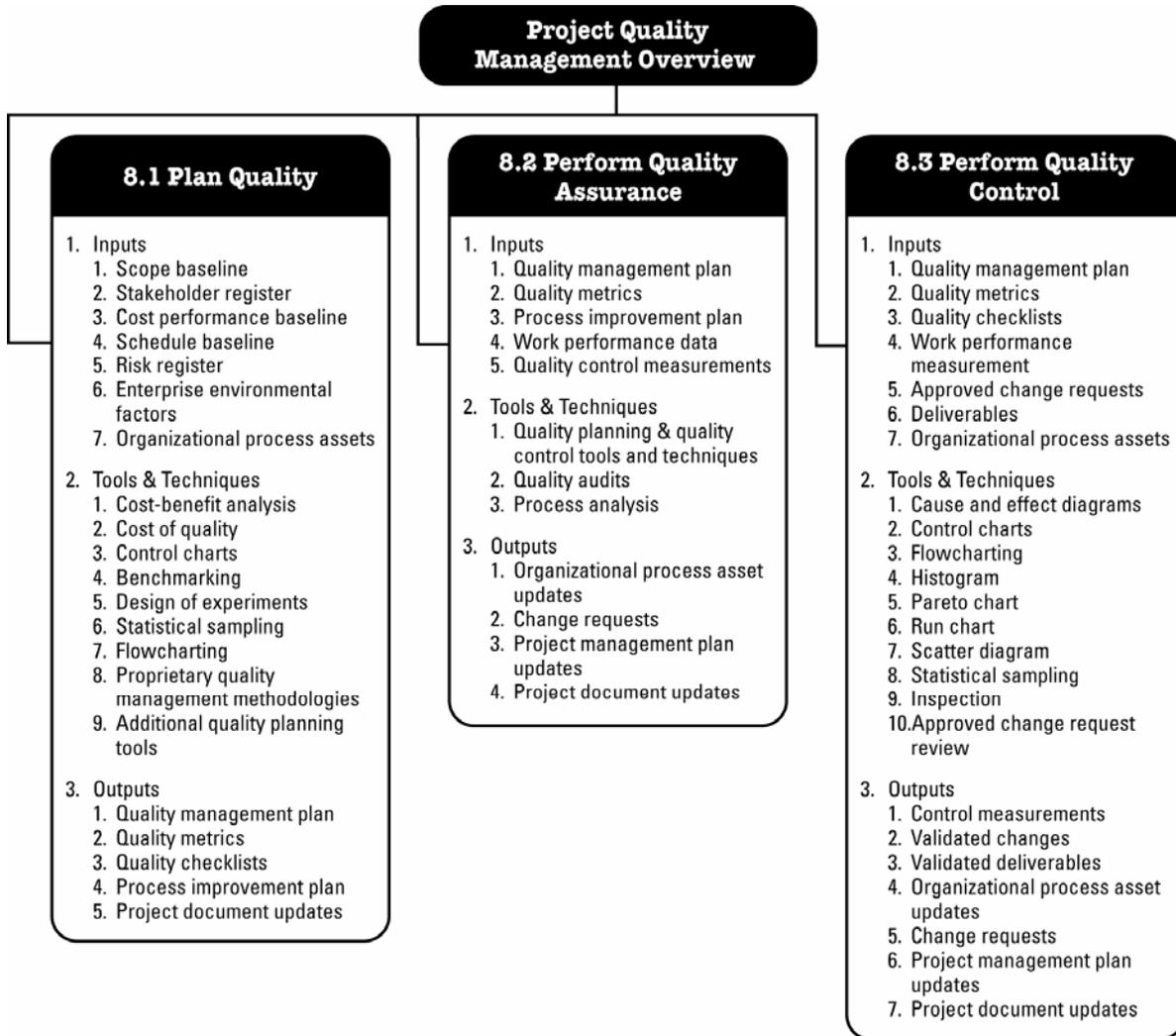
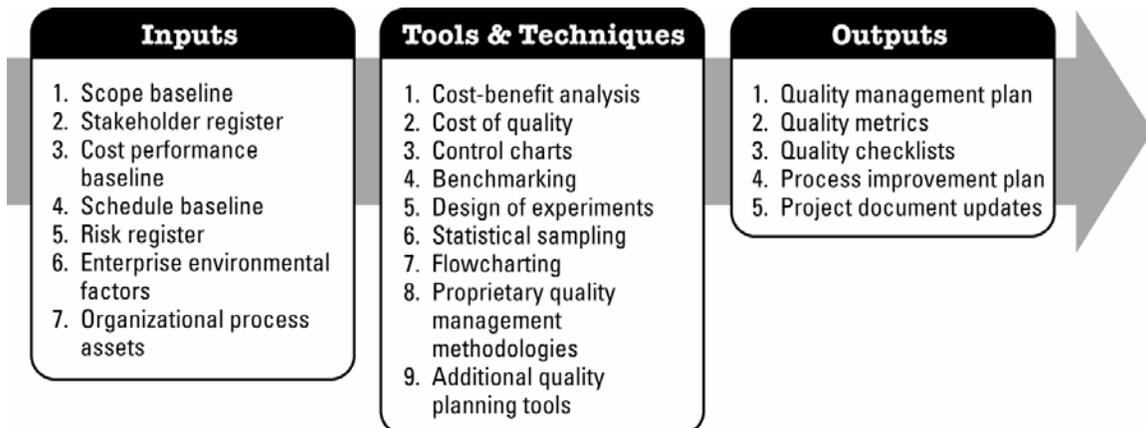


Table 8-2. Plan Quality Inputs, Tools & Techniques and Outputs



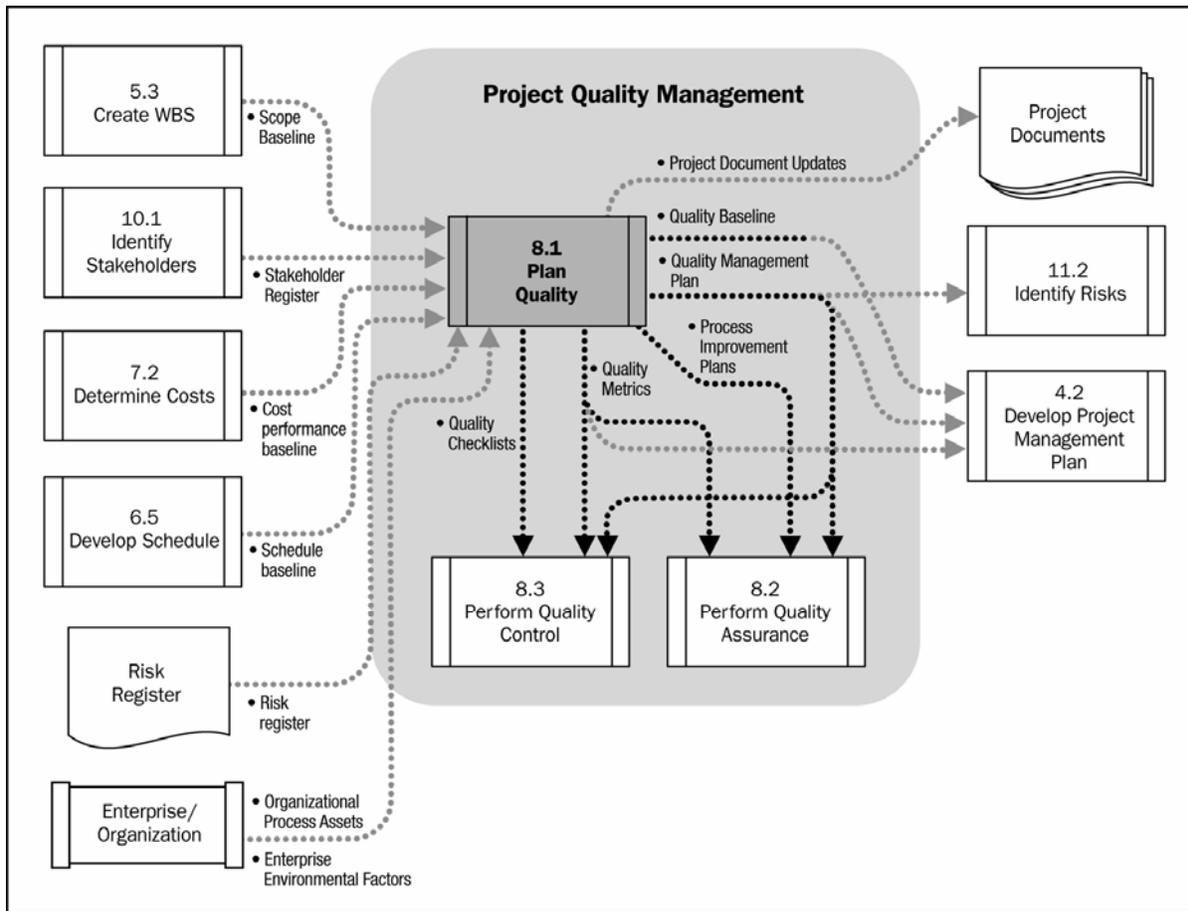


Figure 8-1. Plan Quality Data Flow Diagram

8.1.1 Plan Quality: Inputs

.1 Scope Baseline

- **Scope statement.** The **scope statement** contains the project description, major project deliverables, and acceptance criteria. The product scope description will often contain details of technical issues and other concerns that can affect quality planning. The definition of acceptance criteria can significantly increase or decrease project costs quality costs. Satisfying all acceptance criteria implies the needs of the customer have been met.
- **WBS.** The WBS identifies the deliverables, the work packages and the control accounts used to measure project performance.
- **WBS Dictionary.** The WBS dictionary defines technical information for WBS elements.

.2 Stakeholder Register

The stakeholder register may identify stakeholders with a particular interest in quality.

.3 Cost Performance Baseline

The cost performance baseline documents the accepted time phase used to measure cost performance (Section 7.2.3.1).

.4 Schedule Baseline

The schedule performance baseline documents the accepted schedule performance measures including start and finish dates (Section 6.5.3.2).

.5 Risk Register

The risk register contains information on threats and opportunities that may impact quality requirements (Section 11.2.3.1).

.6 Enterprise Environmental Factors

The enterprise environmental factors that influence the Plan Quality process include but are not limited to:

- Governmental agency regulations,
- Rules, standards, and guidelines specific to the application area, and
- Working/operating conditions of the project/product which may affect project quality.

.7 Organizational Process Assets

The organizational process assets that influence the Plan Quality process include but are not limited to:

- Organizational quality policies, procedures and guidelines,
- Historical databases,
- Lessons learned from previous projects, and
- Quality policy, as endorsed by senior management, sets the intended direction of a performing organization with regard to quality. The quality policy of the performing organization for their products often can be adopted “as is” for use by the project. If the performing organization lacks a formal quality policy, or if the project involves multiple performing organizations (as with a joint venture), then the project management team will need to develop a quality policy for the project. Regardless of the origin of the quality policy, the project management team must ensure that the project stakeholders are fully aware of the policy used for the project through the appropriate distribution of information.

8.1.2 Plan Quality: Tools and Techniques

.1 Cost-Benefit Analysis

The primary benefits of meeting quality requirements can include less rework, higher productivity, lower costs, and increased stakeholder satisfaction. A business case for each quality activity compares the cost of the quality step to the expected benefit.

.2 Cost of Quality

The term, 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 8.2 provides some examples to consider in each area.

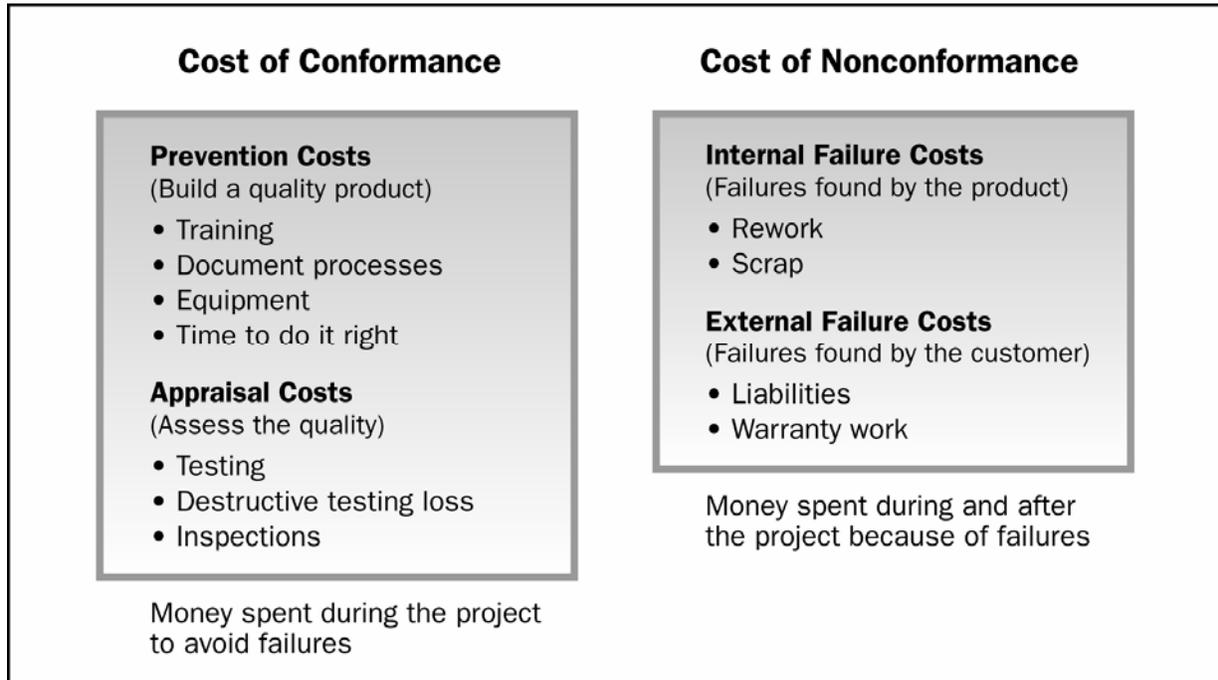


Figure 8-2. Costs of Quality

.3 Control Charts

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 ever allowed. There may be penalties associated with exceeding the specification limits. Upper and lower control limits are set between the project manager and appropriate stakeholders to reflect the points at which corrective action will be taken to prevent exceeding specification limits.

Control charts can be used to monitor any type of output variable. 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 process is in control. Figure 8-3 shows a control chart that tracks recorded project hours. Figure 8-4 shows measured product defects compared to fixed limits.

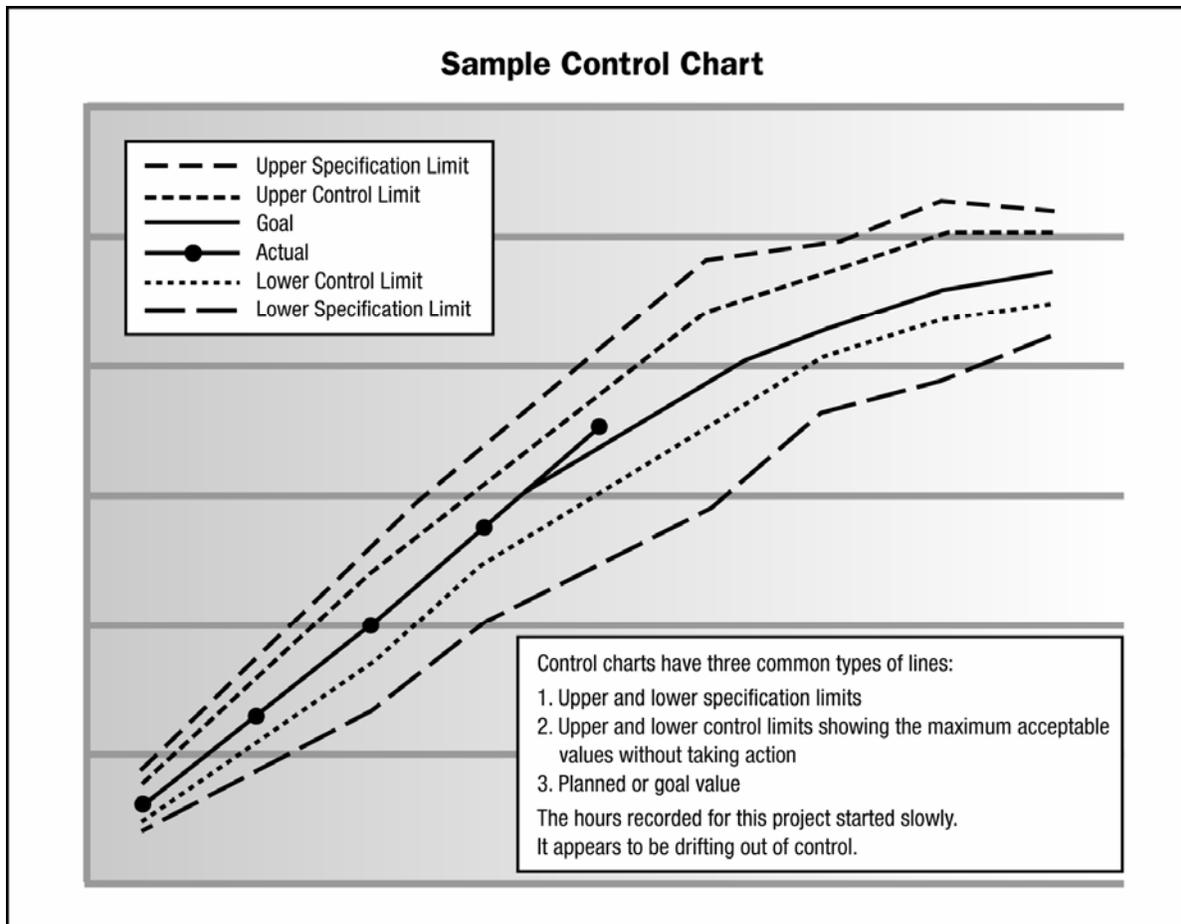


Figure 8-3. Sample Control Chart

Figure 8-4. Control Chart of Consecutive Measurements with Fixed Limits

.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. These other projects can be within the performing organization or outside of it and can be within the same, or in another, application area.

.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 should be used during the Plan Quality process to determine the number and type of tests and their impact on cost of quality.

DOE also plays a role in the optimization of products or processes. DOE can be 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 of 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 synergism 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.

.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 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 actually represents the population of interest.

.7 Flowcharting

A flowchart is a graphical representation of a process showing the relationships among process steps. There are many styles, but all process flowcharts show activities, decision points, and the order of processing. During quality planning, flowcharting can help the project team anticipate quality problems that might occur. An awareness of potential problems can result in the development of test procedures or approaches for dealing with them. Figure 8-5 is an example of a process flowchart for design reviews.

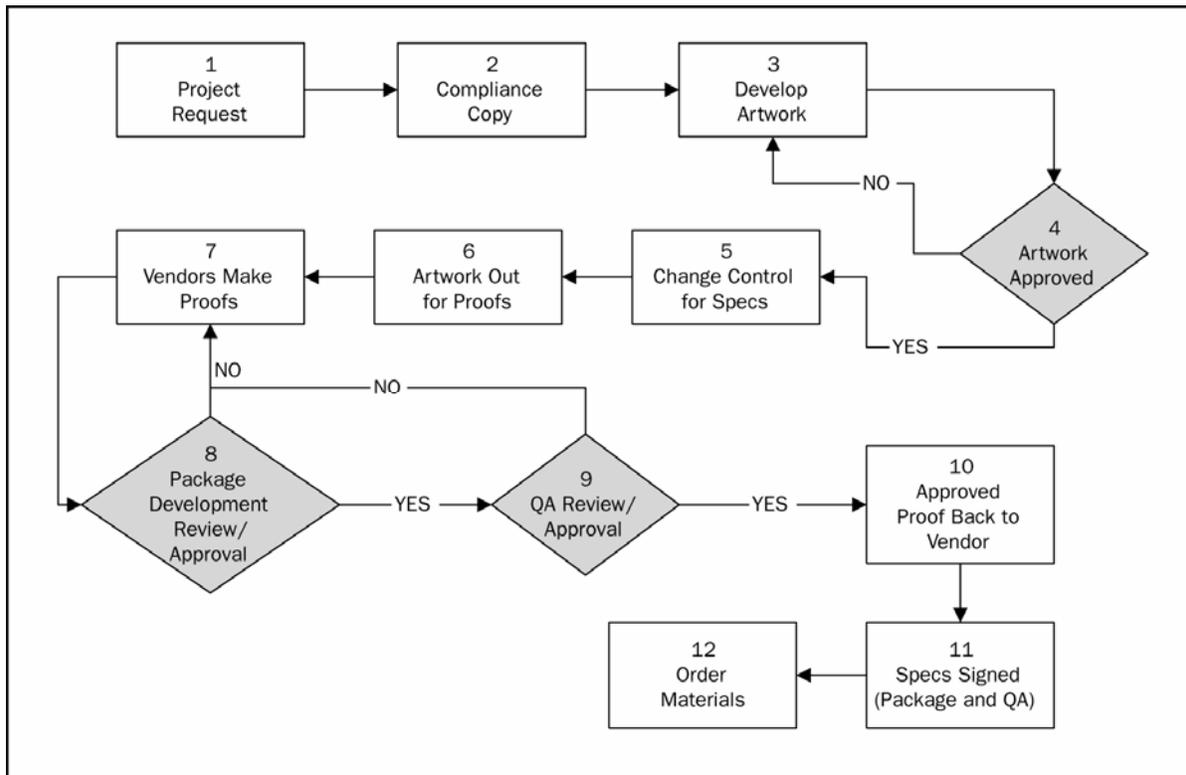


Figure 8-5. Process Flowchart

.8 Proprietary Quality Management Methodologies

These include Lean Six Sigma, Quality Function Deployment, CMM[®], etc. Many other methodologies exist—this is not intended to be a recommended or complete list.

.9 Additional Quality Planning Tools

Other quality planning tools are often used to help better define the situation and help plan effective quality management activities. These include, but are not limited to:

- Brainstorming (defined in Section 10.1.2.4).
- Affinity diagrams, used to visually identify logical groupings based on natural relationships.
- Force field analysis, which are diagrams of the forces for and against change.
- Nominal group techniques, to allow ideas to be brainstormed in small groups; and then reviewed by a larger group.
- Matrix diagrams, which allow organization of two, three, or four groups of information relationships between factors, causes, and objectives. Data in a matrix is organized in rows and columns with intersecting cells that can be filled with information that describes the demonstrated relationship between the items located in the row and column.
- Prioritization matrices, which provide a way of ranking diverse set of problems and/or issues (usually generated through brainstorming) by their importance.

8.1.3 Plan Quality: Outputs

.1 Quality Management Plan

The quality management plan describes how the project management team will implement the performing organization's quality policy. It is a component or a subsidiary plan of the project management plan (Section 4.2).

The quality management plan provides input to the overall project management plan and includes quality control, quality assurance, and continuous process improvement approaches for the project.

The quality management plan may be formal or informal, highly detailed, or broadly framed. The style and detail is 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 reduction of cost and schedule overruns caused by rework.

.2 Quality Metrics

A metric is an operational definition that describes, in very specific terms, a project or product attribute and how the quality control process measures it. A measurement is an actual value. For example, a metric related to the quality objective of staying within the approved budget by $\pm 10\%$ could be to measure every deliverable and determine the % variance from the approved budget for that deliverable. Quality metrics are used in the quality assurance and quality control processes. Some examples of quality metrics include on-time performance, budget control, defect frequency, failure rate, availability, reliability, and test coverage.

.3 Quality Checklists

A checklist is a structured tool, usually component-specific, used to verify that a set of required steps has been performed. Checklists range from 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 are used in the quality control process.

.4 Process Improvement Plan

The process improvement plan is a subsidiary of the project management plan (Section 4.2). The process improvement plan details the steps for analyzing processes to identify activities which enhance their value. Areas to consider include:

- **Process boundaries.** Describes the purpose, start and end of processes, their inputs/outputs, data required, the owner, and stakeholders of processes.
- **Process configuration.** A flowchart of processes to facilitate analysis with interfaces identified.
- **Process metrics.** Along with thresholds, allows control over status of processes.
- **Targets for improved performance.** Guides the process improvement activities.

.5 Project Document Updates

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

- Stakeholder register, and
- Roles and responsibilities matrix.

8.2 Perform Quality Assurance

Quality assurance is the process of auditing the quality requirements and the results from quality control measurements to ensure appropriate quality standards and operational definitions are used. Quality assurance is an execution process that uses data created during Perform Quality Control (Section 8.3).

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.

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.

Table 8-3. Perform Quality Assurance: Inputs, Tools & Techniques, and Outputs

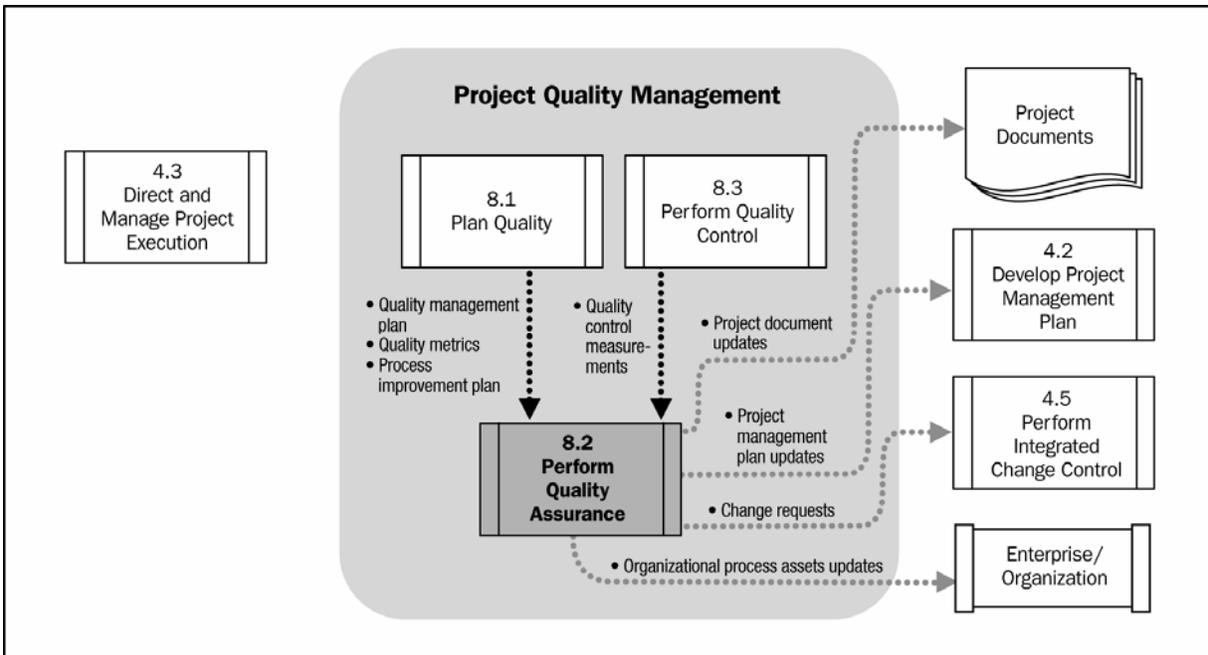


Figure 8-6. Perform Quality Assurance Data Flow Diagram

8.2.1 Perform Quality Assurance: Inputs

.1 Quality Management Plan

The quality management plan describes how quality assurance will be performed within the project.

.2 Quality Metrics

Described in Section 8.1.3.2.

.3 Process Improvement Plan

Described in Section 8.1.3.4.

.4 Work Performance Data

Raw data from project activities is routinely collected as the project progresses. This data can be related to various performance results, including but not limited to:

- Technical performance measures,
- Project deliverables status,

- Schedule progress, and
- Costs incurred.

.5 Quality Control Measurements

Quality control measurements are the results of quality control activities. They are used to analyze and evaluate the quality standards and processes of the performing organization (Section 8.3.3.1).

8.2.2 Perform Quality Assurance: Tools and Techniques

.1 Quality Planning and Quality Control Tools and Techniques

The quality planning (Section 8.1.2) and quality control (Section 8.3.2) tools and techniques can also be used for quality assurance activities.

.2 Quality Audits

A quality audit is a structured, independent review to determine whether project activities comply with organizational and project policies, processes, and procedures. The objective of a quality audit is to identify missing, inefficient or ineffective policies, processes, and procedures in use on the project. The subsequent effort to correct these 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 confirm the implementation of approved change requests including corrective actions, defect repairs, and preventive actions.

.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 non-value-added activities identified during process operation. Process analysis includes root cause analysis, a specific technique to identify a problem, discover the underlying causes that lead to it, and develop preventive actions.

8.2.3 Perform Quality Assurance: Outputs

.1 Organizational Process Assets Updates

Elements of the organizational process assets that may be updated include but are not limited to the quality standards.

.2 Change Requests

Quality improvement includes taking action to increase the effectiveness and/or efficiency of the policies, processes, and procedures of the performing organization. Change requests are created and used as input into Perform Integrated Change Control (Section 4.5) process to allow full consideration of the recommended improvements. Change requests can be used to take corrective action or preventative action or to perform defect repair.

.3 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.

.4 Project Document Updates

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

- Quality audits reports,
- Training plans, and
- Process documentation.

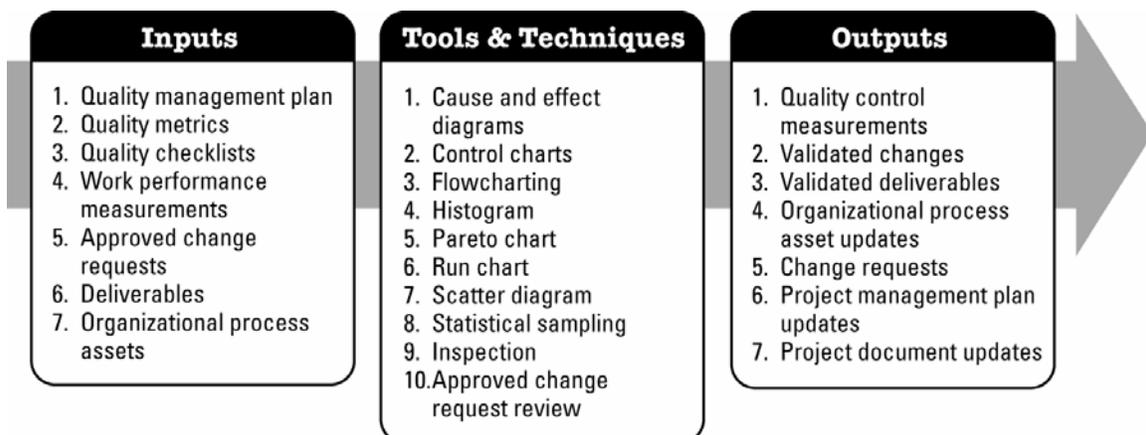
8.3 Perform Quality Control

Perform Quality Control is the process of monitoring and recording results of executing the Quality Plan activities to assess performance and recommend necessary changes. Quality control is performed throughout the project. Quality standards include project processes and product goals. Project results include deliverables and project management results, such as cost and schedule performance. Quality control is often performed by a quality control department or similarly titled organizational unit. Quality control activities identify causes of poor process or product quality and recommend and/or take action to eliminate them.

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

- Prevention (keeping errors out of the process) and inspection (keeping errors out of the hands of the customer).
- Attribute sampling (the result either conforms or does not conform) and variables sampling (the result is rated on a continuous scale that measures the degree of conformity).
- Special causes (unusual events) and common causes (normal process variation). Common causes are also called random causes.
- Tolerances (specified range of acceptable results) and control limits (thresholds, which if exceeded, indicate that the process is out of control).

Table 8-4. Perform Quality Control: Inputs, Tools & Techniques, and Outputs



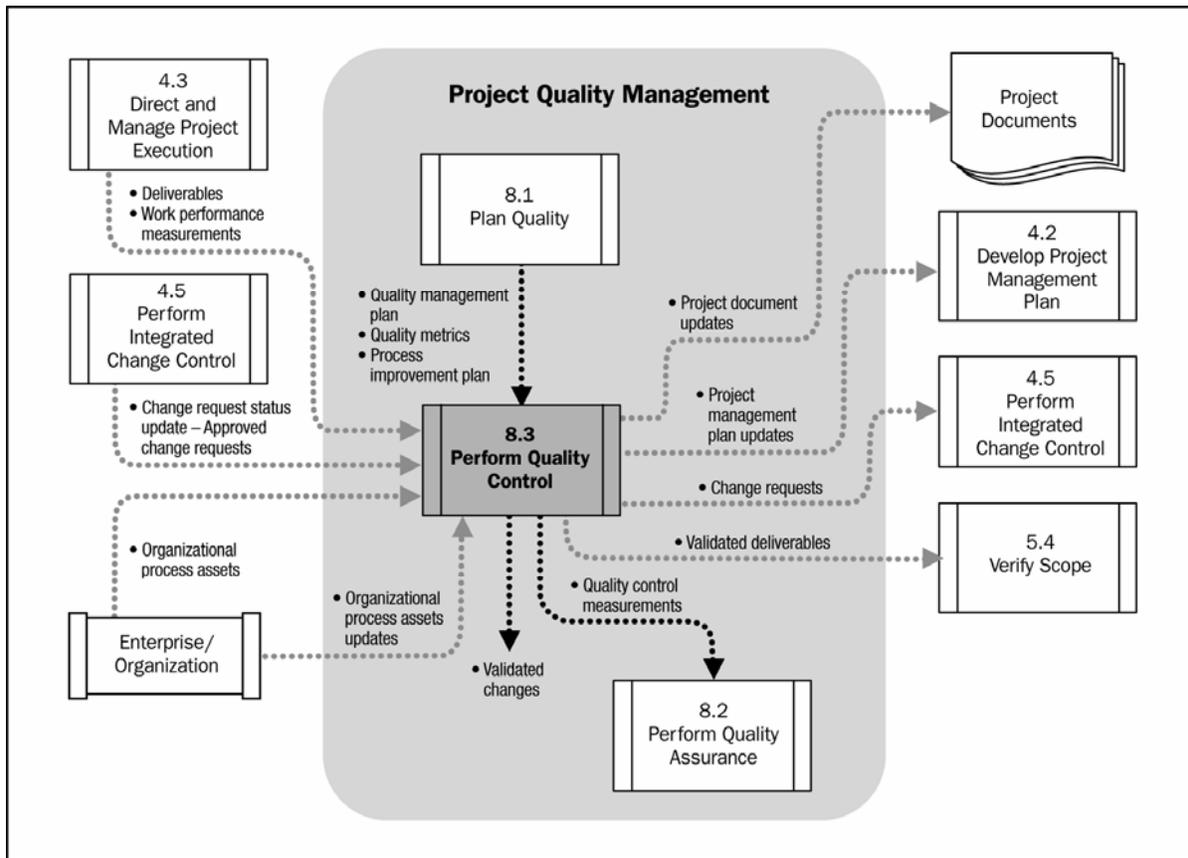


Figure 8-7. Perform Quality Control: Inputs and Outputs

8.3.1 Perform Quality Control: Inputs

.1 Quality Management Plan

The quality management plan describes how quality control will be performed within the project (Section 8.1.3.1.).

.2 Quality Metrics

Described in Section 8.1.3.2.

.3 Quality Checklists

Described in Section 8.1.3.3.

.4 Work Performance Measurements

Work performance measurements are used to produce project activity metrics to evaluate actual progress as compared to planned progress. These metrics include but are not limited to:

- Planned vs. actual technical performance,
- Planned vs. actual schedule performance, and
- Planned vs. actual cost performance.

.5 Approved Change Requests

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

.6 Deliverables

Described in Section 4.3.3.1.

.7 Organizational Process Assets

The organizational process assets that can influence the Perform Quality Control 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 Perform Quality Control: Tools and Techniques

The first seven of these are known as the seven basic tools of quality.

.1 Cause and Effect Diagram

Cause and effect diagrams, also called Ishikawa diagrams or fishbone diagrams, illustrate how various factors might be linked to potential problems or effects. Figure 8-8 is an example of a cause and effect diagram. A possible root cause can be uncovered by continuing to ask “why” or “how” along one of the lines. “Why-Why” and “How-How” diagrams may be used in root cause analysis.

.2 Control Charts

Control charts are described in Section 8.1.2.3. In this process, the appropriate data is collected and analyzed to indicate the quality status of project processes and products. Control charts illustrate how a process behaves over time and when a process is subject to special cause variation, resulting in an out-of-control condition. They graphically answer the question: “Is this process variance within acceptable limits?” The pattern of data points on a control chart may reveal random fluctuating values, sudden process jumps, or a gradual trend in increased variation. By monitoring the output of a process over time, a control chart can help assess whether the application of process changes resulted in the desired improvements. When a process is within acceptable limits it is in control and does not need to be adjusted. Conversely, when a process is outside acceptable limits, the process should be adjusted. The upper control limit and lower control limit are usually set at ± 3 sigma, where 1 sigma is one standard deviation.

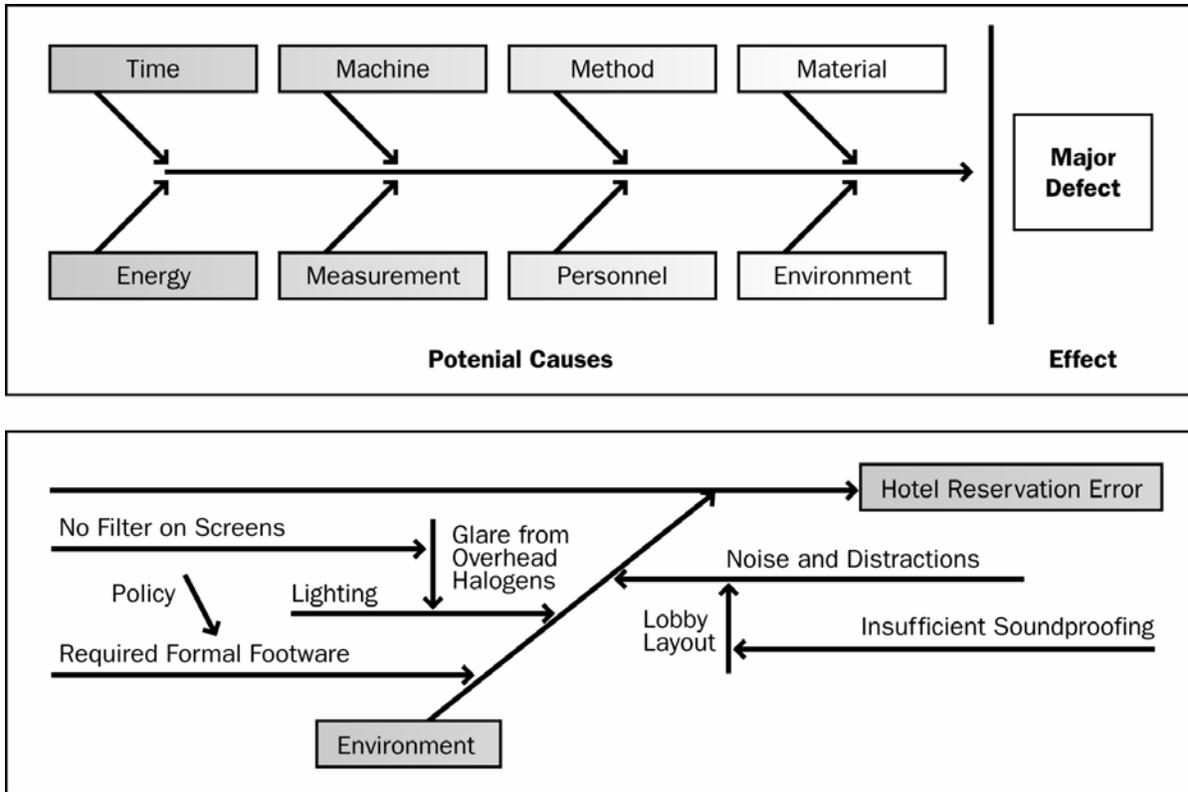


Figure 8-8. Cause and Effect Diagram with Next Level of Detail

.3 Flowcharting

Described in Section 8.1.2.7, flowcharting is used during Perform Quality Control to determine a failing process step(s) and identify potential process improvement opportunities.

.4 Histogram

A histogram is a vertical bar chart showing how often a particular variable state occurred. Each column represents an attribute or characteristic of a problem/situation. The height of each column represents the relative frequency of the characteristic. This tool helps identify the cause of problems in a process by the shape and width of the distribution. Figure 8-9 is an example of an unordered histogram showing causes of late time entry by a project team.

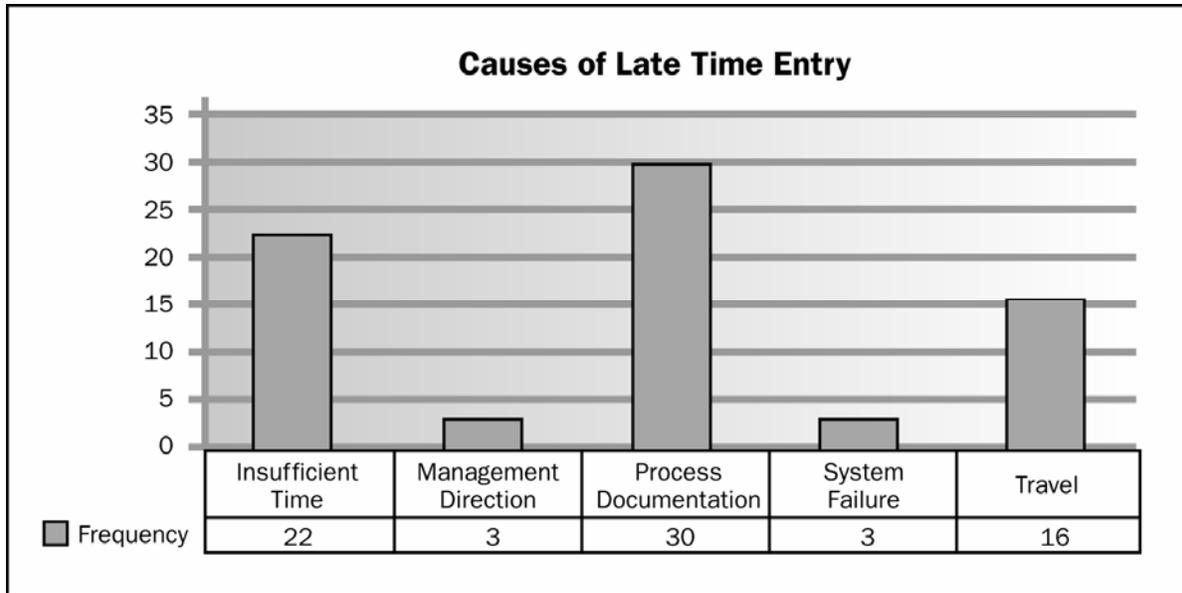


Figure 8-9. Histogram

.5 Pareto Chart

A Pareto chart is a specific type of histogram, ordered by frequency of occurrence. It shows how many defects were generated by type or category of identified cause (Figure 8-10). Rank ordering is used to focus corrective action. The project team should address the causes creating the greatest number of defects first.

Pareto diagrams are conceptually related to Pareto's Law, which holds that a relatively small number of causes will typically produce a majority of the problems or defects. This is commonly referred to as the 80/20 principle, where 80% of the problems are due to 20% of the causes. Pareto diagrams also can be used to summarize all types of data for 80/20 analyses.

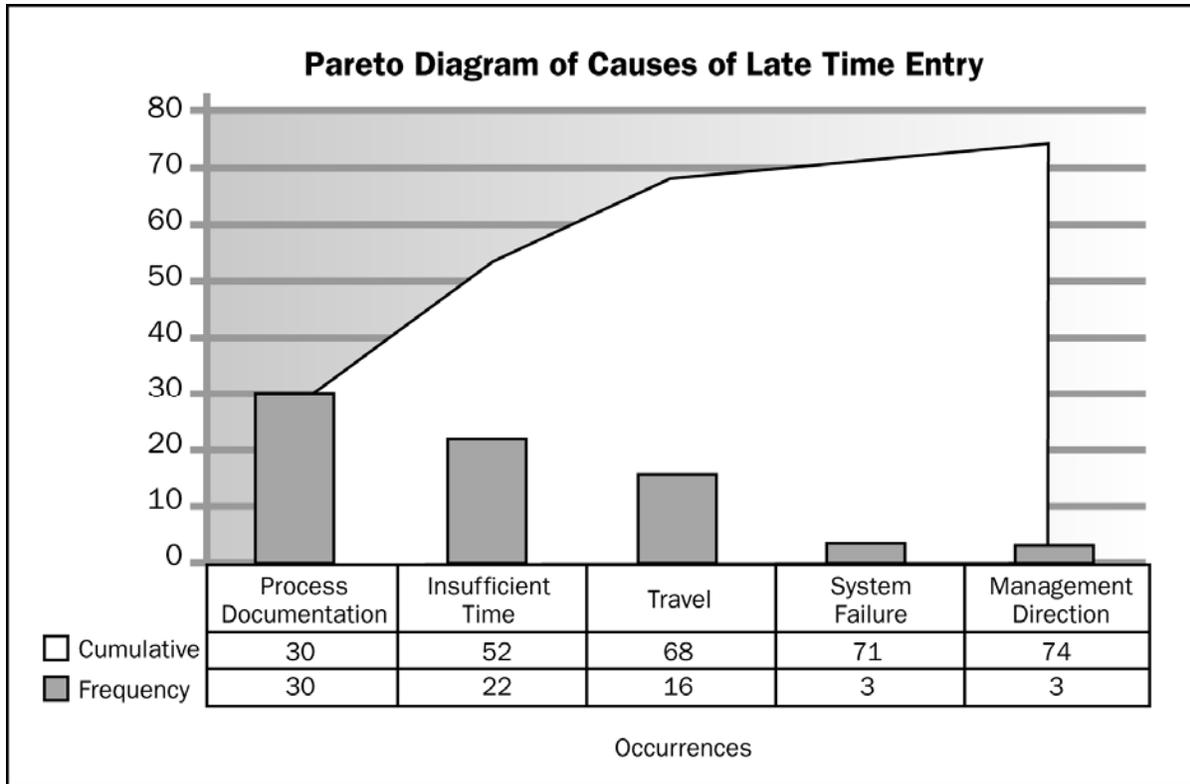


Figure 8-10. Pareto Diagram

.6 Run Chart

Similar to a control chart without displayed limits, a run chart shows the history and pattern of variation. A run chart is a line graph that shows data points plotted in the order in which they occur. Run charts show trends in a process over time, variation over time, or declines or improvements in a process over time. Trend analysis is performed using run charts. Trend analysis involves using mathematical techniques to forecast future outcomes based on historical results. Trend analysis is often used to monitor:

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

.7 Scatter Diagram

A scatter diagram (Figure 8-11) shows the pattern of relationship between two variables. This tool allows the quality team to study and identify the possible relationship between changes observed in two variables. Dependent variables versus independent variables are plotted. The closer the points are to a diagonal line, the more closely they are related. This example shows the correlation between the timecard submission date and the number of days traveling per month.

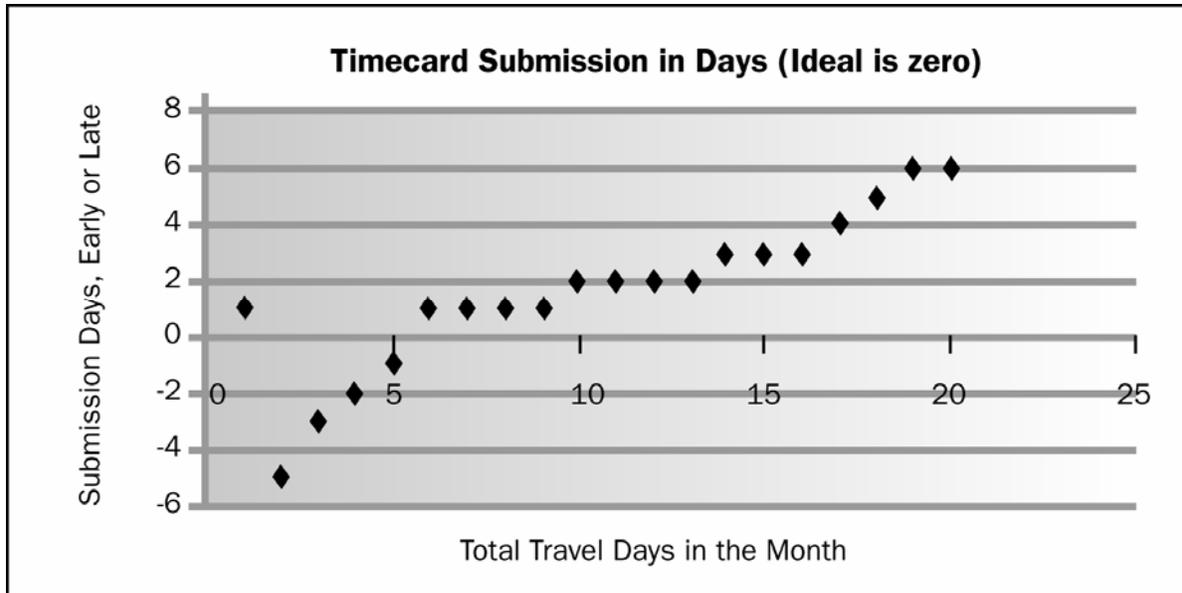


Figure 8-11. Scatter Diagram

.8 Statistical Sampling

Described in Section 8.1.2.6. Samples are selected and tested as defined in the quality plan.

.9 Inspection

An inspection is the examination of a work product to determine whether 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, and walkthroughs. In some application areas these terms have narrow and specific meanings. Inspections are also used to validate defect repairs.

.10 Approved Change Requests Review

All approved change requests should be reviewed to verify that they were implemented as approved.

8.3.3 Perform Quality Control: Outputs

.1 Quality Control Measurements

Quality control measurements are the documented results of quality control activities in the format specified during quality planning.

.2 Validated Changes

Any changed or repaired items are inspected and will be either accepted or rejected before notification of the decision is provided (Section 4.3). Rejected items may require rework.

.3 Validated Deliverables

A goal of quality control is to determine the correctness of deliverables. The results of the execution quality control processes are validated deliverables.

.4 Organization 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 should 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 quality control should be documented so they become part of the historical database for both the project and the performing organization. Lessons learned are documented throughout the project life cycle, but at a minimum, during project closure (Section 4.1.1.5).

.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.

.6 Project Management Plan Updates

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

- Quality management plan, and
- Process improvement plan.

.7 Project Document Updates

Project documents that may be updated include but are not limited to quality standards.

References

[1] American Society for Quality, 2000

[2] International Organization for Standardization. ISO 8402. *Quality Management and Quality Assurance*. Geneva: ISO Press, 1994.

Chapter 9 Project Human Resources 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 roles and responsibilities for the project team members are assigned, team member involvement 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. 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*.

Table 9-1 provides an overview of the Project Human Resource Management processes, which are as follows:

- 9.1 Develop Human Resource Plan**—The process of identifying and documenting project roles, responsibilities, required skills, reporting relationships, and creating the 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.

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, 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 can be shared by the entire team or administered solely by the project manager. The project sponsor works with the project management team, typically assisting with matters such as project funding, clarifying scope, monitoring progress, and influencing others in order to benefit the project.

Managing and leading the project team also includes, but is not limited to:

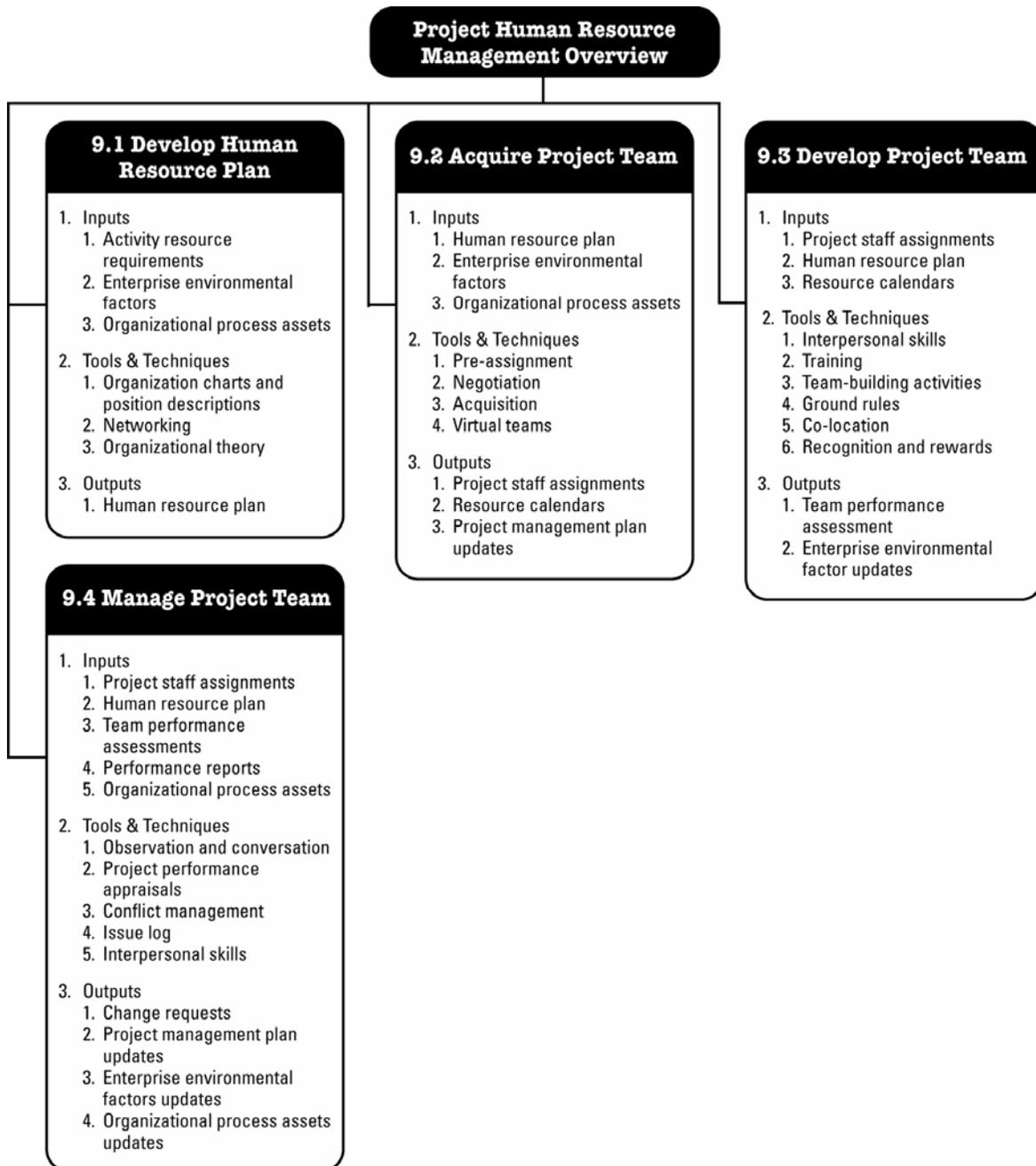
- **Influencing the project team.** Being aware of, and influencing when possible, those human resource factors that may impact the project. This includes team environment, communications among stakeholders, internal and external politics, cultural issues, organizational uniqueness, and other such people 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.

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.

Table 9-1. Project Human Resource Management Overview

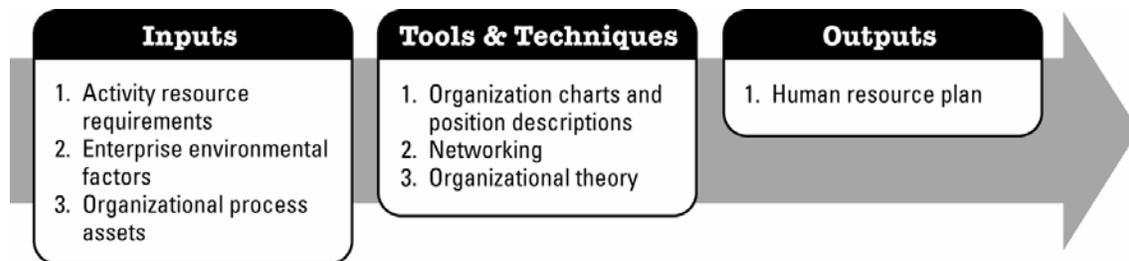


9.1 Develop Human Resource Plan

Develop Human Resource Plan is the process of identifying and documenting project roles, responsibilities, required skills, reporting relationships, and creating the staffing management plan. Human resource planning is used to determine and identify human resources with the necessary skills required for project success. The human resource plan documents project roles and responsibilities, project organization charts, and the staffing management plan including the timetable for staff acquisition and release. It may also include 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.

Important consideration should be given to 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 resources with the same competencies or skill sets. Given these factors, project costs, schedules, risks, quality and other areas may be significantly affected. Effective human resource planning should consider and plan for these factors and develop human resource options.

Table 9-2. Develop Human Resource Plan: Inputs, Tools & Techniques, and Outputs



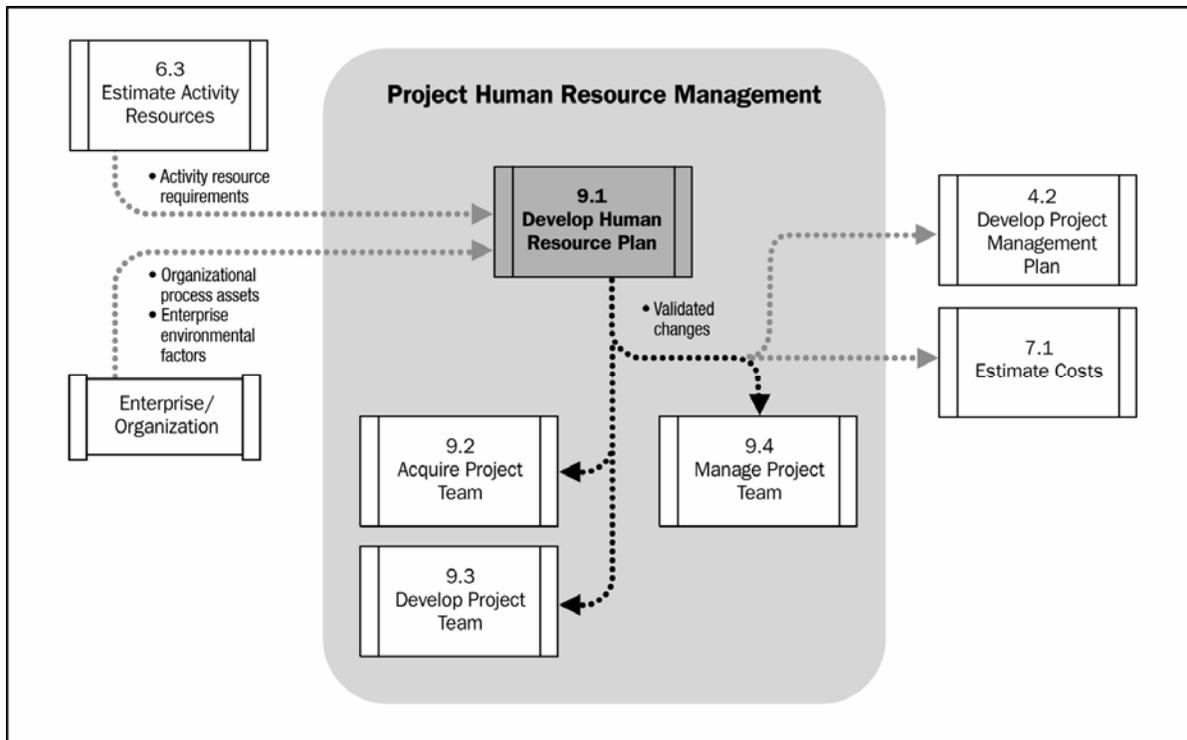


Figure 9-1. Develop Human Resource Plan Data Flow Diagram

9.1.1 Develop Human Resource Plan: Inputs

.1 Activity Resource Requirements

Human resource planning uses activity resource requirements (Section 6.3.3.1) 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.

.2 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Develop Human Resource Plan process include but are not limited to:

- Organizational, culture, and structure;
- Existing human resources;
- Personnel administration policies; and
- Marketplace conditions.

.3 Organizational Process Assets

The organizational process assets that can influence the project team with the Develop Human Resource Plan process include but are not limited to:

- Organizational standard processes and policies and standardized role descriptions,
- Templates for organizational charts and position descriptions, and
- Historical information on organizational structures that have worked in previous projects.

9.1.2 Develop Human Resource Plan: Tools and Techniques

.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 9-2): hierarchical, matrix, and text-oriented. Additionally, some project assignments are listed in subsidiary project plans such as the risk, quality, or communication 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.

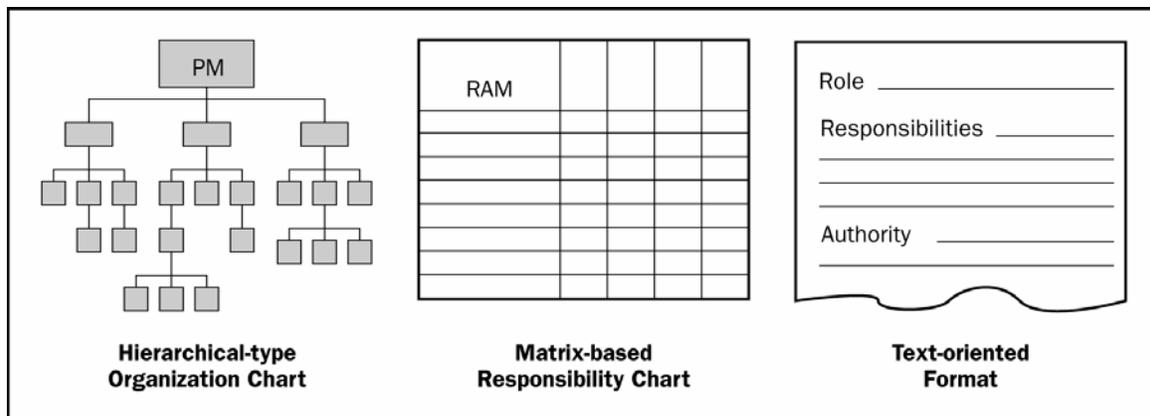


Figure 9-2. Roles and Responsibility Definition Formats

- **Hierarchical-type charts.** The traditional organization chart structure can be used to show positions and relationships in a graphic, 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 used to illustrate the connections between work packages 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 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 or all people associated with one activity. One example of a RAM is a RACI (Responsible, Accountable, Consult, and Inform) chart, shown in Figure 9-3. 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.

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 9-3. 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.
- **Other sections of the project management plan.** Some responsibilities related to managing the project are listed and explained in other sections of the project management plan. For example, the risk register lists risk owners, the communication plan lists team members responsible for communication activities, and the quality plan designates those responsible for carrying out quality assurance and quality control activities.

.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. 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.

.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.

9.1.3 Develop Human Resource Plan: Outputs

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. It is a component of the project management plan. The human resource plan should include, but not be 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 label describing the portion of a project for which a person is accountable. Examples of project roles are civil engineer, court liaison, business analyst, and testing coordinator. Role clarity concerning authority, responsibilities, and boundaries should be documented.
 - *Authority.* The right to apply project resources, make decisions, and sign approvals. 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 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, a part of the project management plan, describes when and 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, will the human resources come from within the organization or from external, contracted sources? Will team members need to work in a central location or can they work from distant locations? What are the costs associated with each level of expertise needed for the project? How much assistance can the organization's human resource department and functional managers provide to the project management team?

- *Timetable.* 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 (Section 6.5.3.2). This bar chart illustrates the number of hours a person, department, or entire project team will be needed each week or month over the course of the project. The chart can include a horizontal line that represents the maximum number of hours available from a particular resource. Bars that extend beyond the maximum available hours identify the need for a resource leveling strategy, such as adding more resources or modifying the schedule. An example of a resource histogram is illustrated in Figure 9-4.

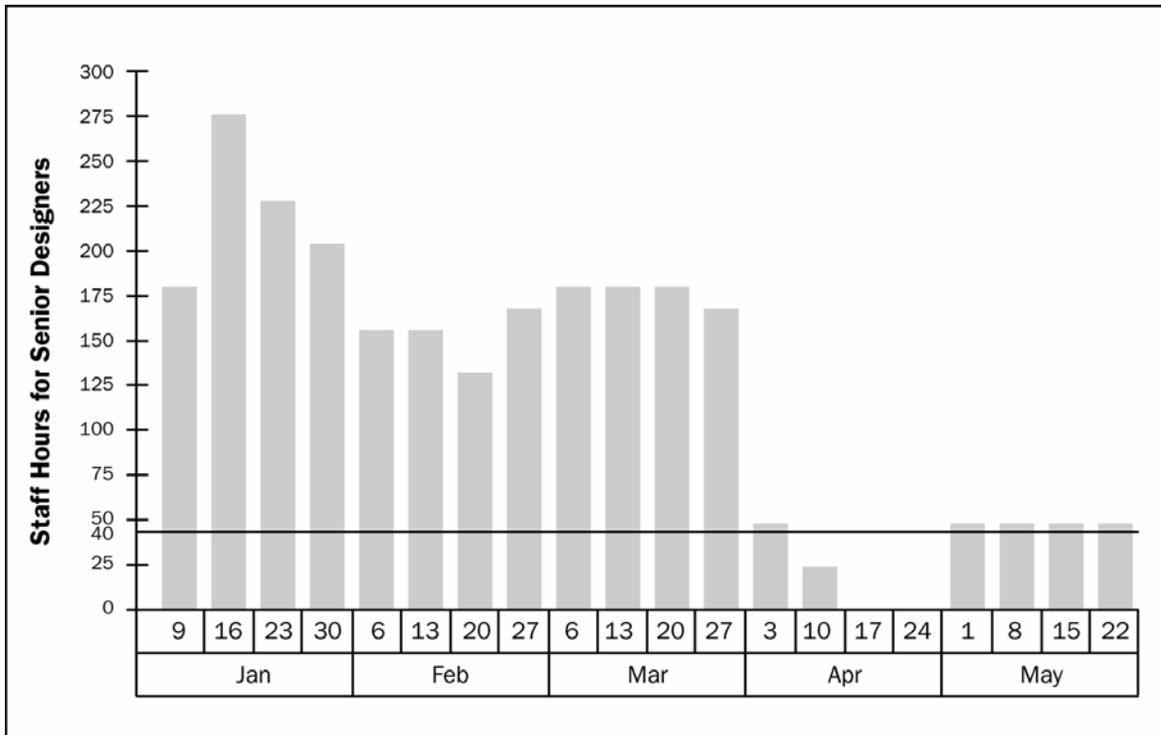


Figure 9-4. Illustrative Resource Histogram

- *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 the team members to be assigned are not expected to 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 helps 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 9.3.2.6).

- *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 the risk register.

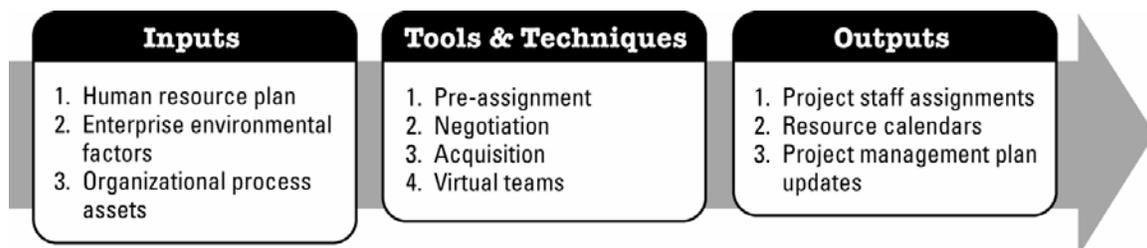
9.2 Acquire Project Team

Acquire Project Team is the process of confirming human resource availability and obtaining the team necessary to complete project assignments. The 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.

Table 9-3. Acquire Project Team: Inputs, Tools & Techniques, and Outputs



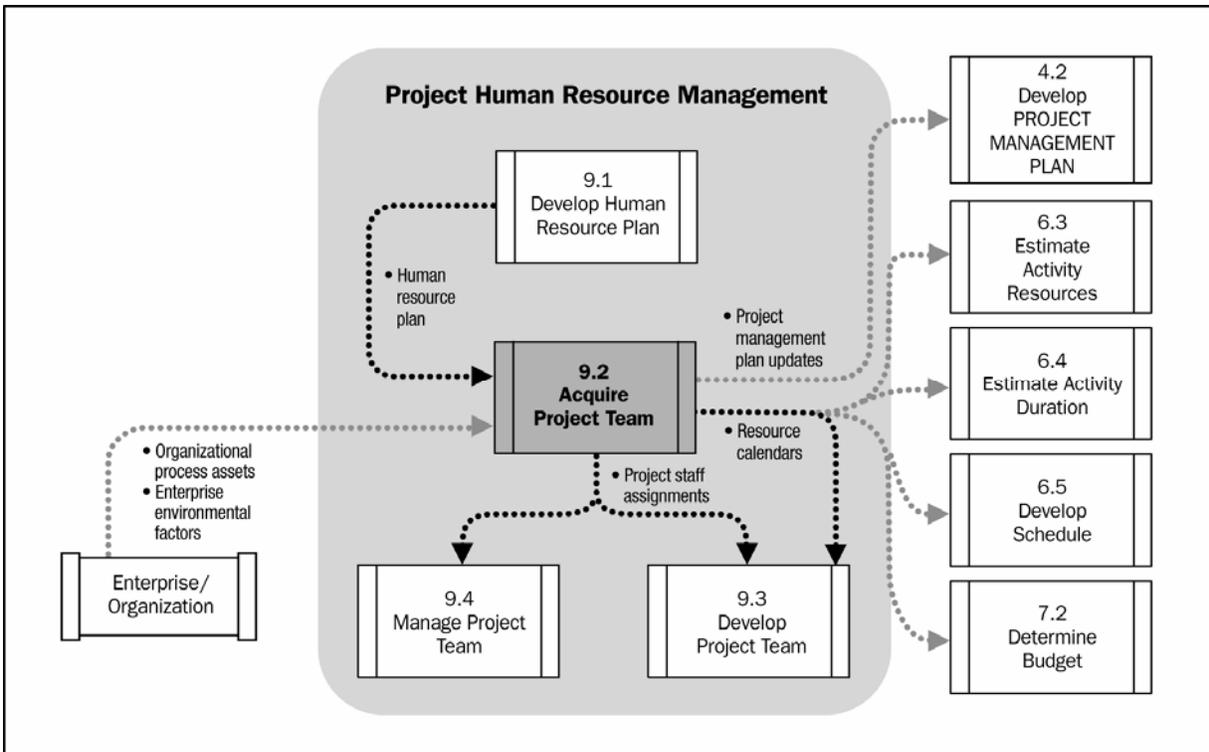


Figure 9-5. Acquire Project Team Flow Diagram

9.2.1 Acquire Project Team: Inputs

.1 Human Resource Plan

The human resource plan (Section 9.1.3.1) provides guidance on how project human resources should be defined, 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.

.2 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Acquire Project Team process include but are not limited to:

- Existing human resources such as who is available, their competency levels, their prior experience, their interest in working on the project and their cost rate;
- Personnel administration policies such as those that affect outsourcing; and
- Organizational structure as described in Section 2.1.

.3 Organizational Process Assets

The organizational process assets that can 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

.1 Pre-Assignment

When project team members are selected in advance, they are considered pre-assigned. 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.

.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.

.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.

.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 and video conferencing has made such teams feasible. The virtual team format makes it possible to:

- Form teams of people from the same company who live in widespread geographic areas;
- Add special expertise to a project team even though the expert is not in the same geographic area;
- Incorporate employees who work from home offices;
- Form teams of people who work different shifts or hours;
- Include people with mobility handicaps; 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, and share credit in successes.

9.2.3 Acquire Project Team: Outputs

.1 Project Staff Assignments

The project is staffed when appropriate people have been assigned. Documentation 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.

.2 Resource Calendars

Resource calendars document the time periods that each project team member can work on the project. Creating a reliable schedule (Section 6.5.3.1) 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.

.3 Project Management Plan Updates

Elements of the project management plan that may be updated include but are not limited to: the human resources 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. 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 [1].

Today project managers operate in a global environment and work on projects characterized by cultural diversity. Teamwork is the key to project success. 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:

- Improve knowledge and skills of team members in order to increase their ability to complete project deliverables, while lowering costs, reducing schedules, and improving quality;
- Improve feelings of trust and agreement among team members in order to raise morale, lower conflict, and increase team work; and
- Create a dynamic and cohesive team culture to improve individual and team productivity, team spirit and cooperation, allowing cross-training and mentoring between team members to share knowledge and expertise.

Table 9-4. Develop Project Team: Inputs, Tools & Techniques, and Outputs

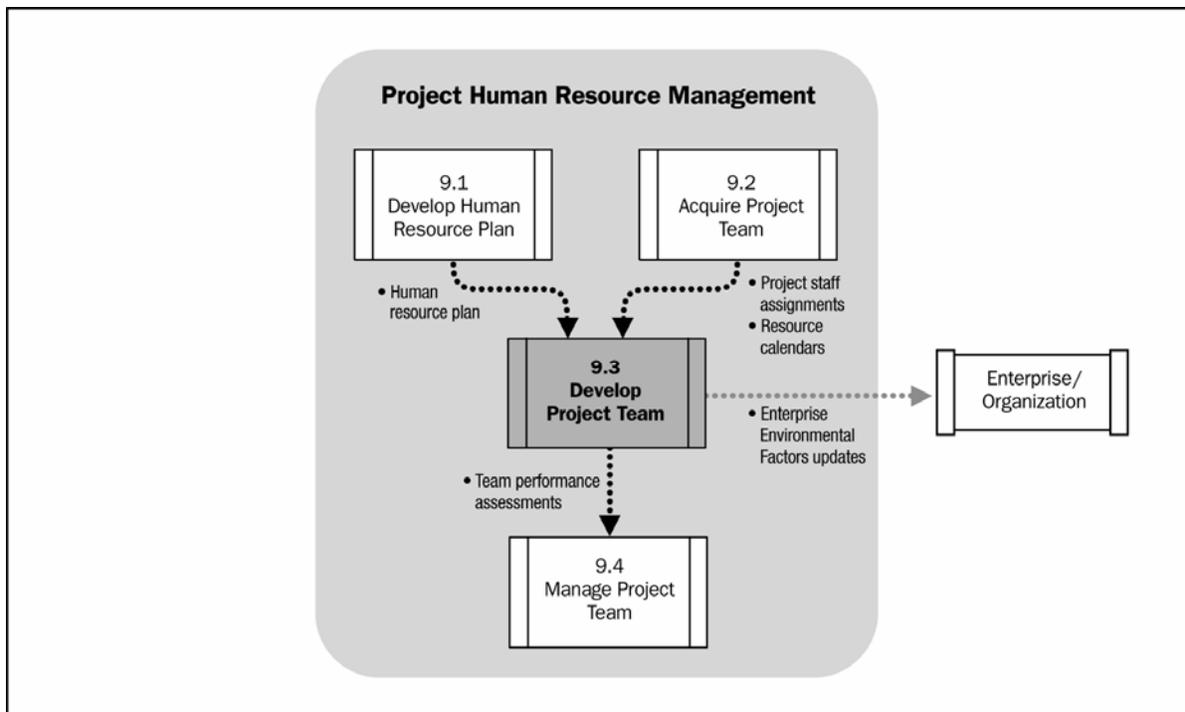


Figure 9-6. Develop Project Team Data Flow Diagram

9.3.1 Develop Project Team: Inputs

.1 Project Staff Assignments

Team development starts with a list of the project team members. Project staff assignment documents identify the people who are on the team.

.2 Human Resource Plan

The human resource plan 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.

.3 Resource Calendars

Resource calendars identify times when the project team members can participate in team development activities.

9.3.2 Develop Project Team: Tools and Techniques

.1 Interpersonal Skills

These are sometimes known as “soft skills,” 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.

.2 Training

Training includes all activities designed to enhance the competencies of the project team members. Training can be formal or informal. Examples of training methods include classroom, online, computer-based, on-the-job training from another project team member, mentoring, and coaching. If project team members lack necessary management or technical skills, such skills can be developed as part of the project work. Scheduled training takes place as stated in the human resources 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.

.3 Team-Building Activities

Team-building activities can vary from a five-minute agenda item in a status review meeting to an off-site, professionally facilitated experience designed to improve interpersonal relationships. The objective of team-building activities is to help individual team members effectively work together. 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.

One of the most important skills in developing a team environment involves handling project team problems and discussing these as team issues. The entire team should be encouraged to work collaboratively to resolve these issues. To build effective project teams, project managers should obtain top management support, obtain commitment of team members, introduce appropriate rewards and recognition, create a team identity, manage conflicts effectively, promote trust and open communication among team members, and, above all, provide good team leadership.

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 corrective actions are needed to prevent or correct various team problems.

All teams go through five stages of development:

- Forming,
- Storming,
- Norming,
- Performing, and
- Adjourning.

All stages occur naturally and in order. The duration of a particular stage depends upon team dynamics, team size, and team leadership.

.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.

.5 Co-location

Co-location involves placing many or all of the most active project team members in the same physical location to enhance their ability to perform as a team. Co-location can be temporary, such as at strategically important times during the project, or for the entire project. Co-location strategies can include a team meeting room, places to post schedules, and other conveniences that enhance communication and a sense of community. While co-location is considered a good strategy, the use of virtual teams is sometimes unavoidable.

.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 Develop Human Resource Plan 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 the most 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. For example, developing appropriate team rewards in a culture that encourages individualism can be difficult.

Only desirable behavior should be rewarded. For example, the willingness to work overtime to meet an aggressive schedule objective should be rewarded or recognized; needing to work overtime as the result of poor planning should not be rewarded. Win-lose (zero sum) rewards that only a limited number of project team members can achieve, such as team member of the month, can hurt team cohesiveness. Rewarding behavior that everyone can achieve, such as turning in progress reports on time, tends to increase support among team members.

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 important aspect of any reward system. 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.

9.3.3 Develop Project Team: Outputs

.1 Team Performance Assessment

As project team development efforts such as training, team building, and co-location 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. This is especially important in contract-related or collective bargaining projects.

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. They also exhibit specific job-related and people-related qualities that represent indirect measures of project performance.

The evaluation of a team's effectiveness may include indicators such as:

- Improvements in skills that allow a person 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 performing 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 proper 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 appropriate parties. This is especially important when team members are part of a union, involved in collective bargaining, bound by contract performance clauses, or other related situations.

.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, including updates for 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 project management team observes team behavior, manages conflict, resolves issues, and appraises team member

performance. 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.

Table 9-5. Manage Project Team: Inputs, Tools & Techniques, and Outputs

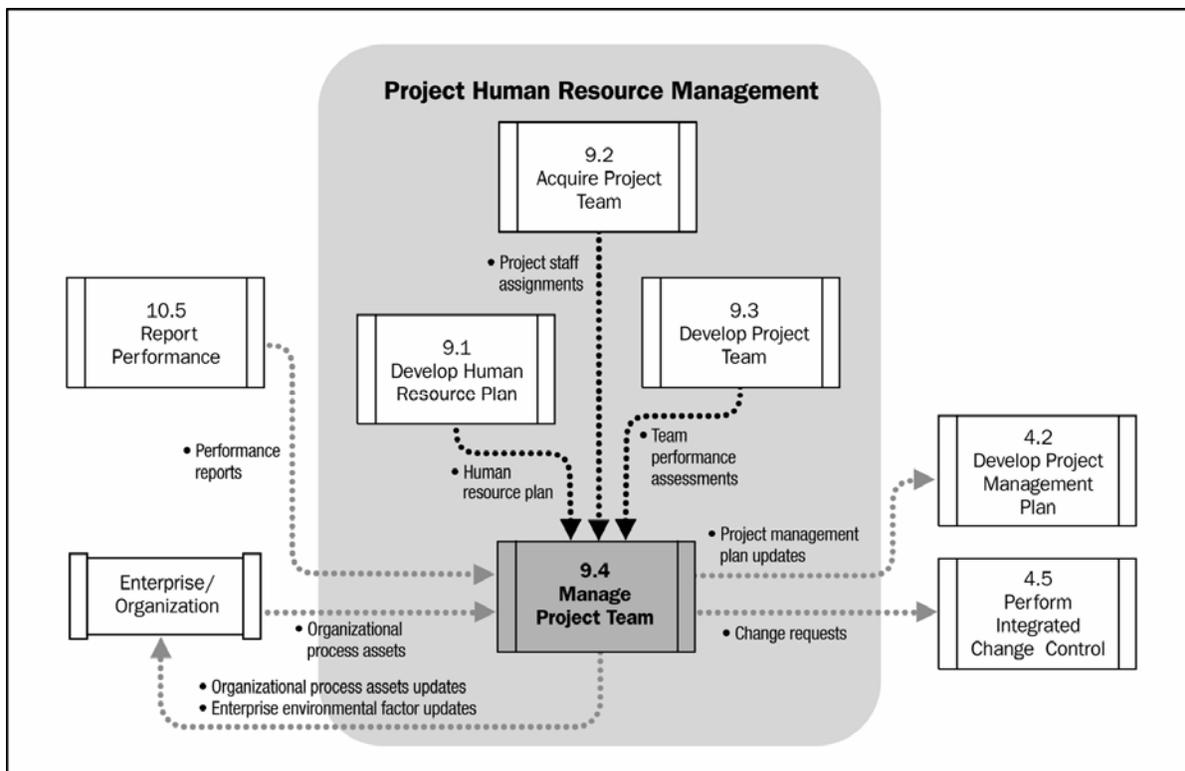
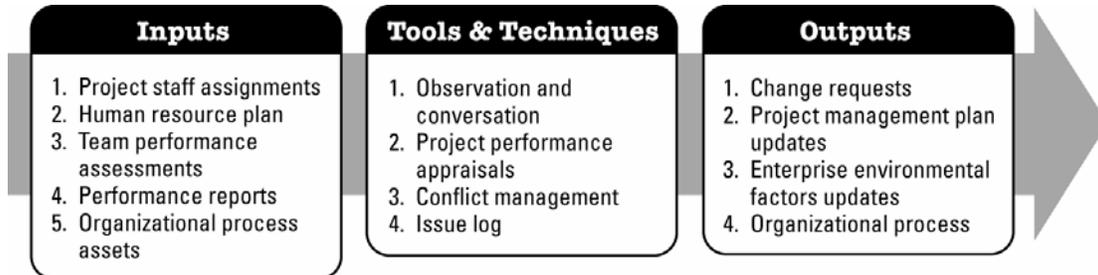


Figure 9-7. Manage Project Team Data Flow Diagram

9.4.1 Manage Project Team: Inputs

.1 Project Staff Assignments

Project staff assignments (Section 9.2.3.1) provide a list of the project team members to be evaluated during this monitoring and controlling process.

.2 Human Resource Plan

The human resource plan includes but is not limited to:

- Roles and responsibilities,
- Project organization, and
- The staffing management.

.3 Team Performance Assessments

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.

.4 Performance Reports

Performance reports (Section 10.5.3.1) provide documentation about project. Performance areas that can help with project team management include results from schedule control, cost control, quality control, and scope verification. 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.

.5 Organizational Process Assets

The organizational process assets that can influence the Manage Project Team process include but are not limited to:

- Certificates of appreciation,
- Newsletters,
- Web sites,
- Bonus structures,
- Corporate apparel, and
- Other organizational perquisites.

9.4.2 Manage Project Team: Tools and Techniques

.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.

.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.

.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.

When handling conflict in a team environment, project managers should recognize the following characteristics of conflict and the conflict management process:

- Conflict is natural and forces a search for alternatives,
- Conflict is a team issue,
- Openness resolves conflict,
- Conflict resolution should focus on issues, not personalities, and
- Conflict resolution should focus on the present, not the past.

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:

- **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 [2].

.4 Issue Log

Issues arise in the course of managing the project team, 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.

.5 Interpersonal Skills

Project managers use a combination of technical, human, and conceptual skills to analyze situations and interact appropriately with team members. Using appropriate interpersonal skills aids project managers in capitalizing on the strengths of all team members.

There is a wide body of knowledge about interpersonal skills that is appropriate to project work and non-project work. That body of knowledge is too in-depth to cover in this publication. There is expanded coverage of some of the most relevant interpersonal skills used in project management in Appendix X. In this section we briefly cover some of the interpersonal skills the project managers use most often.

- **Leadership.** Successful projects require strong leadership skills. Leadership is important through all project phases of the project life cycle. It is especially important to communicate the vision and inspire the project team to achieve high performance.
- **Influencing.** Since 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:
 - The ability to be persuasive and clearly articulate points and positions,
 - High levels of active and effective listening skills,
 - Consideration of 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.** 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 opportunity and risk.

9.4.3 Manage Project Team: Outputs

.1 Change Requests

Staffing changes, whether by choice or by uncontrollable events, can affect the rest of the project plan. When staffing issues disrupt the project 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 can include moving people to different assignments, outsourcing some work, and replacing team members who leave.

Preventive actions that can be developed to reduce the probability and/or impact of problems before they occur include cross-training in order to reduce problems during project team member absences, additional role clarification to ensure all responsibilities are fulfilled, and added personal time.

.2 Project Management Plan Updates

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

.3 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.

.4 Organizational Process Assets.

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.

References

[1] Vijay Verma, “Managing the Project Team,” PMI, Newtown Square, PA.

[2] Vijay Verma, “Human Resource Skills for the Project Manager,” PMI, Newtown Square, PA.

Chapter 10 Project Communications Management

Project Communications Management includes the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval, and 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 involved in a project, connecting various cultural and organizational backgrounds, different levels of expertise, various perspectives and interests in the project execution or outcome.

Table 10-1 provides an overview of the Project Communications Management processes which include the following:

10.1 Identify Stakeholders—The process of identifying all people or organizations impacted by the project, and documenting relevant information regarding their interests, involvement and impact on project success.

10.2 Plan Communications—The process of determining the project stakeholder information needs and defining a communication approach.

10.3 Distribute Information—The process of making relevant information available to project stakeholders as planned.

10.4 Manage Stakeholders Expectations—The process of communicating and working with stakeholders to meet their needs and addressing issues as they occur.

10.5 Report Performance—The process of collecting and distributing performance information, including status reports, progress measurements, and forecasts.

These processes interact with each other and with processes in the other Knowledge Areas. Each process occurs at least once in every project and, if the project is divided into phases, it could occur in one or more project phases. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they may overlap and interact in ways not detailed here.

Communication activity has many potential dimensions, including:

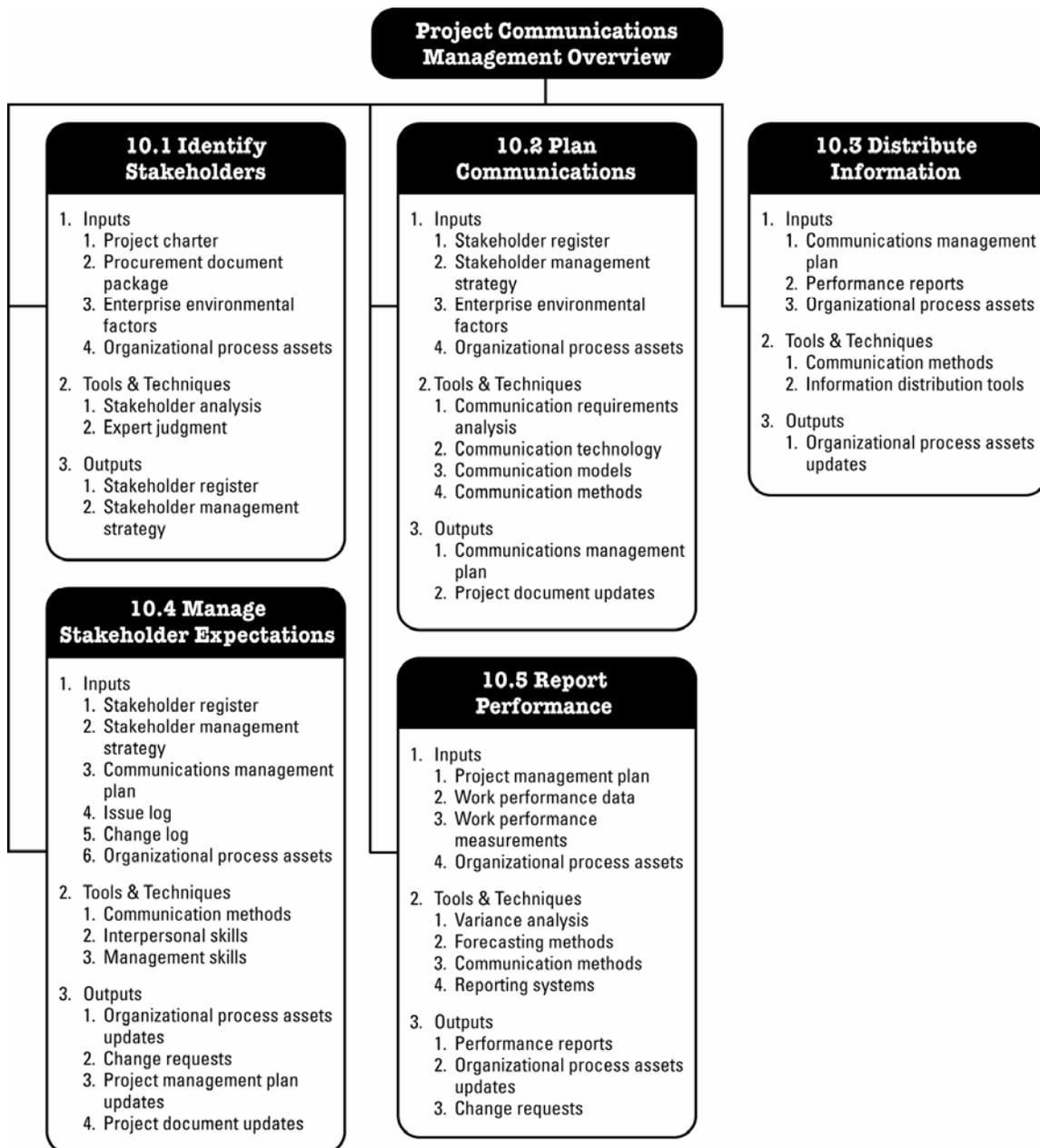
- Internal (within the project) and external (customer, other projects, the media, the public),
- Formal (reports, memos, briefings) and informal (emails, ad-hoc discussions),
- Vertical (up and down the organization) and horizontal (with peers),
- Official (news letters, annual report) and unofficial (off the record communications),
- Written and oral, and
- Verbal and non-verbal (voice inflections, body language).

Communication is a general management discipline as well as a project management discipline. There are many commonalities and some specifics for project-related communication as outlined in the next sections. Most communication skills are common for general management and project management, such as, but not limited to:

- Listening actively and effectively,

- Questioning, probing ideas and situations to ensure better understanding,
- Educating, increasing team’s knowledge so that they can be more effective,
- Fact-finding to identify or confirm information,
- Setting and managing expectations,
- Persuading a person or organization to perform an action,
- Negotiating to achieve mutually acceptable agreements between parties,
- Resolving conflict to prevent disruptive impacts, and
- Summarizing, recapping and identifying the next steps.

Table 10-1. Project Communications Management Overview



10.1 Identify Stakeholders

Identify Stakeholders is the process of identifying all people or organizations impacted by the project, and documenting relevant information regarding their interests, involvement and impact on project success. It is essential to identify all project stakeholders in order to increase the likelihood of project success, as well as to document relevant information regarding their interests, involvement, and potential impact on the definition or execution of the project. Project stakeholders are persons and organizations such as customers, sponsors, the performing organization, and the public that 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 executing organization for the project. Section 2.3 identifies various types of project stakeholders.

It is critical for project success to identify the stakeholders early on in the planning process, and to analyze their levels of interest, expectations, importance and influence. A strategy can then be developed for approaching each stakeholder and determining the level and timing of stakeholders' involvement to maximize positive influences and mitigate potential negative impacts. The assessment and corresponding strategy should be periodically reviewed during project execution to adjust for potential changes.

Most projects will have a large number of stakeholders. As the project manager's time is limited and must 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.

Table 10-2. Identify Stakeholders: Inputs, Tools & Techniques, and Outputs



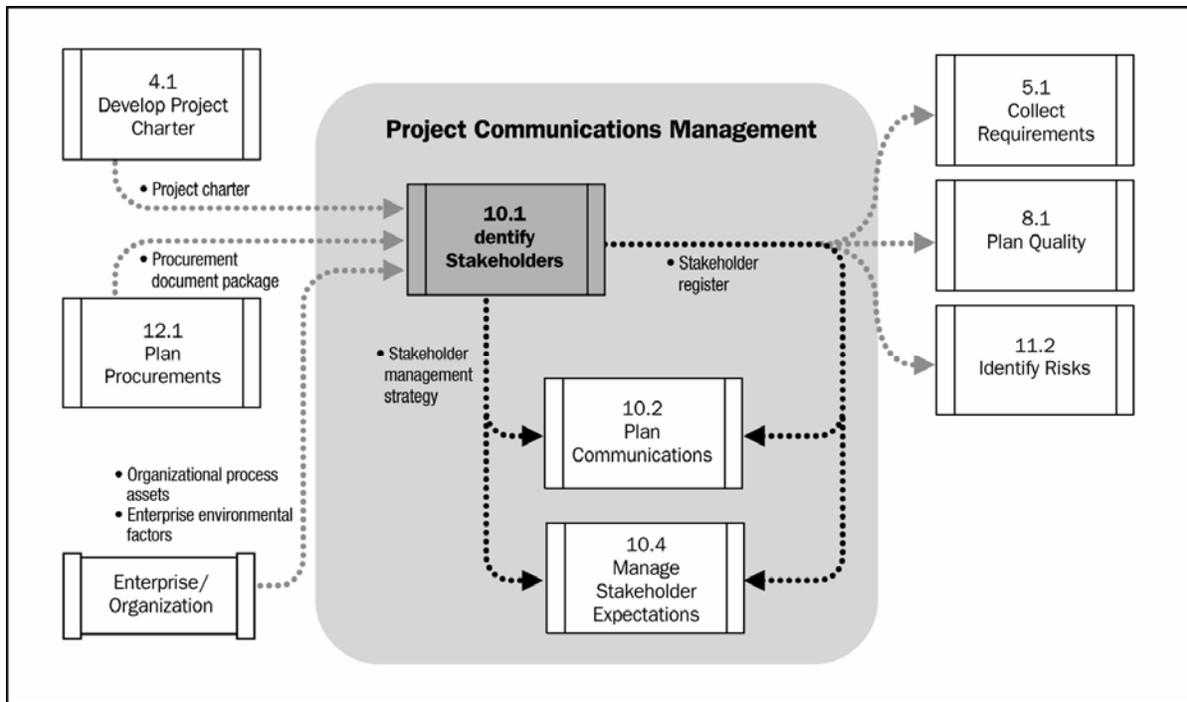


Figure 10-1. Identify Stakeholders Data Flow Diagram.

10.1.1 Identify Stakeholders: Inputs

.1 Project Charter

The Project charter can provide information about internal and external parties involved in and affected by 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.

.2 Procurement Documents

If a project is the result of procurement activity or is based on an established contract, the legal parties in that contract are key project stakeholders. Other relevant parties, such as suppliers, should also be considered as part of the project stakeholders list.

.3 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Identify Stakeholders process include but are not limited to:

- Organizational or company culture and structure, and
- Governmental or industry standards (e.g. regulations, product standards).

.4 Organizational Process Assets

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.

10.1.2 Identify Stakeholders: Tools and Techniques

.1 Stakeholder Analysis

Stakeholder analysis is a process 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:

- **Step 1.** 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.
- **Step 2:** Identify the potential impact or support each stakeholder could generate, and classify them so as to define an approach strategy. There are multiple classification models available; some of them include:
 - Power/Interest grid,
 - Will-Skill model,
 - Power/Influence grid
 - Influence/Impact grid, and
 - Salience model.

Figure 10-2 presents an example of a power/interest grid with A-H representing the placement of generic stakeholders.

- **Step 3:** Assess how key stakeholders are likely to react or respond in various situations, in order to plan how to win or enhance their support and mitigate potential negative impacts.

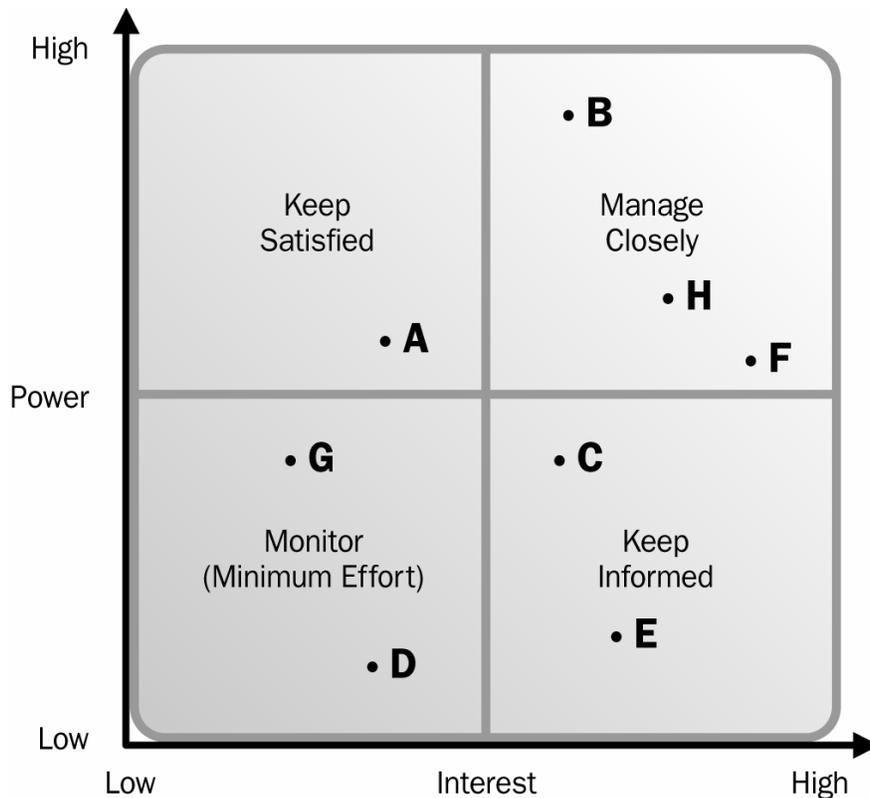


Figure 10-2. Example Power/Interest Grid with Stakeholders

.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 knowledge on the subject area 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.

Expert judgment can be obtained through individual consultations (one-on-one meetings, interviews, etc.) or through a panel format (focus groups, surveys etc).

10.1.3 Identify Stakeholders: Outputs

.1 Stakeholder Register

The main output of the Identify Stakeholders process is the stakeholder register, which includes all details related to the identified stakeholders:

- **Identification information:** Name, organizational position, role in the project, contact information;
- **Assessment information:** Major requirements, main expectations, and potential influence in the project, and
- **Stakeholder classification:** Internal/external, supporter/neutral/resistor, etc.

Some of the information related to a certain stakeholder could be too sensitive to be included in the register, which is a public document. The project manager must exercise judgment with regard to the type of information and the level of detail to be included in the stakeholder register.

.2 Stakeholder Management Strategy

The stakeholder management strategy defines an approach to increase the support and minimize negative impacts of stakeholders throughout the entire project life cycle. It includes elements such as:

- Key stakeholders who can significantly impact the project,
- Level of participation in the project desired for each identified stakeholder, and
- Stakeholder groups and their management (as groups).

A common way of representing the stakeholder management strategy is a stakeholder analysis matrix. An example of a blank matrix with column headers is provided in Figure 10-3.

Stakeholder	Stakeholder Interest(s) in the Project	Assessment of Impact	Potential Strategies for Gaining Support or Reducing Obstacles

Figure 10-3. Sample Stakeholder Analysis Matrix

10.2 Plan Communications

Plan Communications is the process of determining the project stakeholder information needs and defining a communication approach. The Plan Communications process responds to the information and communications needs of the stakeholders; for example, who needs what information, when they will need it, how it will be given to them, and by whom. While all projects share the need to communicate project information, the informational needs and methods of distribution vary widely. Identifying the information needs of the stakeholders and determining a suitable means of meeting those needs are important factors for project success.

Improper communication planning will lead to problems such as delay in message delivery, communication of sensitive information to the wrong audience, or lack of communication to some of the required stakeholders. A communication plan allows the project manager to document the approach to communicate most efficiently and effectively with stakeholders. Effective communication means that the information is provided in the right format, at the right

time, and with the right impact. Efficient communication means providing only the information that is needed. On most projects the communications planning is done very early, such as during project plan development. The results of this planning process should be reviewed regularly throughout the project and revised as needed to ensure continued applicability.

The Plan Communications process is tightly linked with enterprise environmental factors, since the organization’s structure will have a major effect on the project’s communications requirements.

Table 10-3. Plan Communications. Inputs, Tools & Techniques and Outputs

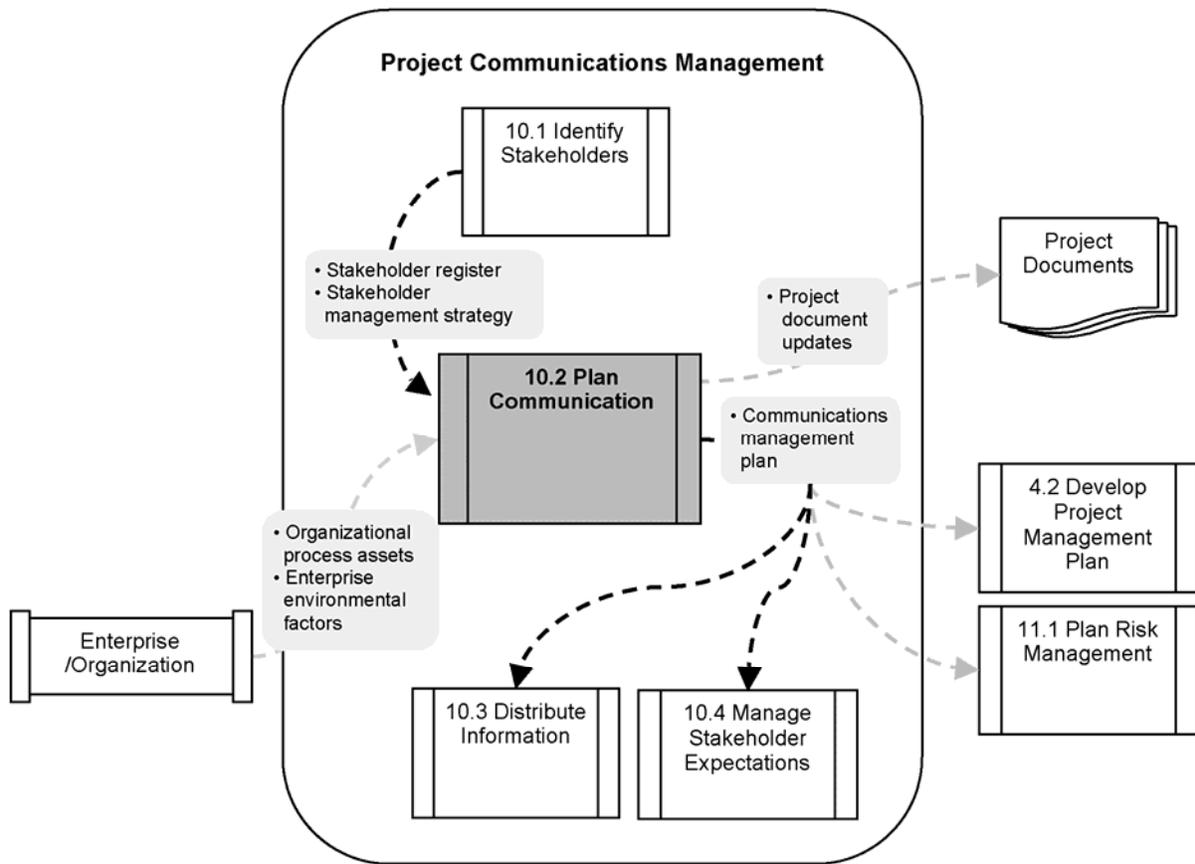
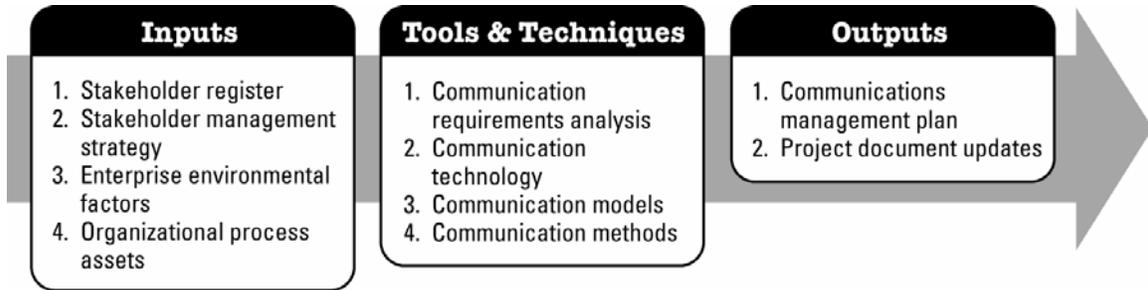


Figure 10-4. Plan Communication Data Flow Diagram

10.2.1 Plan Communications: Inputs

.1 Stakeholder Register

The stakeholder register is described in Section 10.1.3.1.

.2 Stakeholder Management Strategy

Stakeholder management strategy is described in Section 10.1.3.2.

.3 Enterprise Environmental Factors

All enterprise environmental factors are used as inputs for this process since communication must be adapted to the all the specifics of the project environment.

.4 Organizational Process Assets

All organizational process assets are used as inputs for the Plan Communications 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.

10.2.2 Plan Communications: Tools and Techniques

.1 Communications Requirements Analysis

The analysis of the communications 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 are expended only on communicating information that contributes to success, 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. Thus, a project with 10 stakeholders has $10(10-1)/2 = 45$ potential communication channels. A key component of planning the project's actual communications, therefore, is to determine and limit who will communicate with whom and who will receive what information.

Information typically used to determine project communication requirements includes:

- Organization 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., communicating across organizations),
- External information needs (e.g., communicating with the media or contractors), and
- Stakeholder information from stakeholder register and the stakeholder management strategy.

.2 Communication Technology

The methodologies used to transfer information among project stakeholders can vary significantly. For example, a project team may use techniques from brief conversations all the way through to extended meetings, or from simple written documents to material (e.g., schedules and databases) that is accessible online as methods of communication.

Communications technology factors that can affect the project include:

- **Urgency of the need for information.** Is project success dependent upon having frequently updated information available on a moment's notice, or would regularly issued written reports suffice?
- **Availability of technology.** Are appropriate systems already in place or do project needs warrant change?
- **Expected project staffing.** Are the proposed communications systems compatible with the experience and expertise of the project participants, or is extensive training and learning required?
- **Duration of the project.** Is the available technology likely to change before the project is over?
- **Project environment.** Does the team meet and operate on a face-to-face basis or in a virtual environment?

.3 Communication Models

A basic model of communication, shown in Figure 10-5, demonstrates how information is sent and received between two parties, defined as the sender and the receiver. The key components of the model include:

- **Encode.** To translate thoughts or ideas into a language that is understood by others.
- **Message and feedback-message.** The output of encoding.
- **Medium.** The method used to convey the message.
- **Noise.** Anything that interferes with the transmission and understanding of the message (e.g., distance).
- **Decode.** To translate the message back into meaningful thoughts or ideas.

Figure 10-5 is a basic communication model. Inherent in the model is an action to acknowledge a message. Acknowledgement means that the receiver signals receipt of the message, but not necessarily agreement with the message. Another action is the response to a message, which means that the receiver has decoded, understands, and is replying to the message.

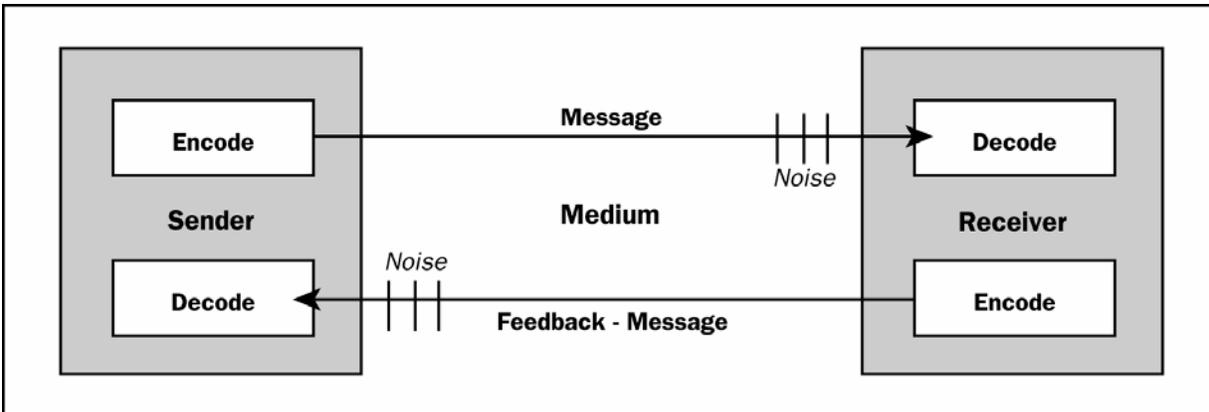


Figure 10-5. Basic Communication Model

The components in the communications model need to be taken into account when discussing project communications. As part of the communications process, the sender is responsible for making the information clear and complete so that the receiver can receive it correctly, and for confirming that it is properly understood. The receiver is responsible for making sure that the information is received in its entirety, understood correctly, and acknowledged. A failure in communication can negatively impact the project.

There are many challenges in using these components to effectively communicate with project stakeholders. Consider a highly technical, multinational project team. For one team member to successfully communicate a technical concept to another team member in a different country can involve encoding the message in the appropriate language, sending the message using a variety of technologies, and having the receiver decode the message and reply or provide feedback. Any noise introduced along the way compromises the original meaning of the message.

.4 Communication Methods

There are several communication methods used to share information among project stakeholders. These methods can be broadly classified into:

- **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, 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 etc.
- **Pull communication**, used for very large volumes of information, or for very large audiences, that requires 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 communication requirements, what, how, and when communication methods are to be used in the project.

10.2.3 Plan Communications: Outputs

.1 Communications Management Plan

The communications management plan is contained in, or is a subsidiary of the project management plan (Section 4.2). The communications management plan can be formal or informal, highly detailed or broadly framed, and based on the needs of the project.

The communications management plan usually provides:

- Stakeholder communication requirements;
- Information to be communicated, including format, content, and level of detail;
- Reason for the distribution of that 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;
- Time frame and frequency for the distribution of required information;
- 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 for project status meetings, project team meetings, e-meetings, and e-mail. The use of a project web site and project management software can also be included if they are actively used in the projects.

.2 Project Document Updates

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

- Project schedule,
- Stakeholder register, and
- Stakeholder management strategy.

10.3 Distribute Information

The process of making relevant information available to project stakeholders as planned. It is performed throughout the entire project life cycle, and in all management processes. The focus here is mainly in the execution process, which includes implementing the communications management plan, as well as responding to unexpected requests for information. Effective information distribution includes a number of techniques including:

- *Sender-receiver models*: feedback loops and barriers to communication;
- *Choice of media*: situation specifics of when to communicate in writing versus orally, when to write an informal memo versus a formal report, and when to communicate face-to-face versus by e-mail;
- *Writing style*: active versus passive voice, sentence structure, and word choice;
- *Meeting management techniques*: preparing an agenda and dealing with conflicts;
- *Presentation techniques*: body language and design of visual aids; and
- *Facilitation techniques*: building consensus and overcoming obstacles.

Table 10-4. Distribute Information. Inputs, Tools & Techniques, and Outputs

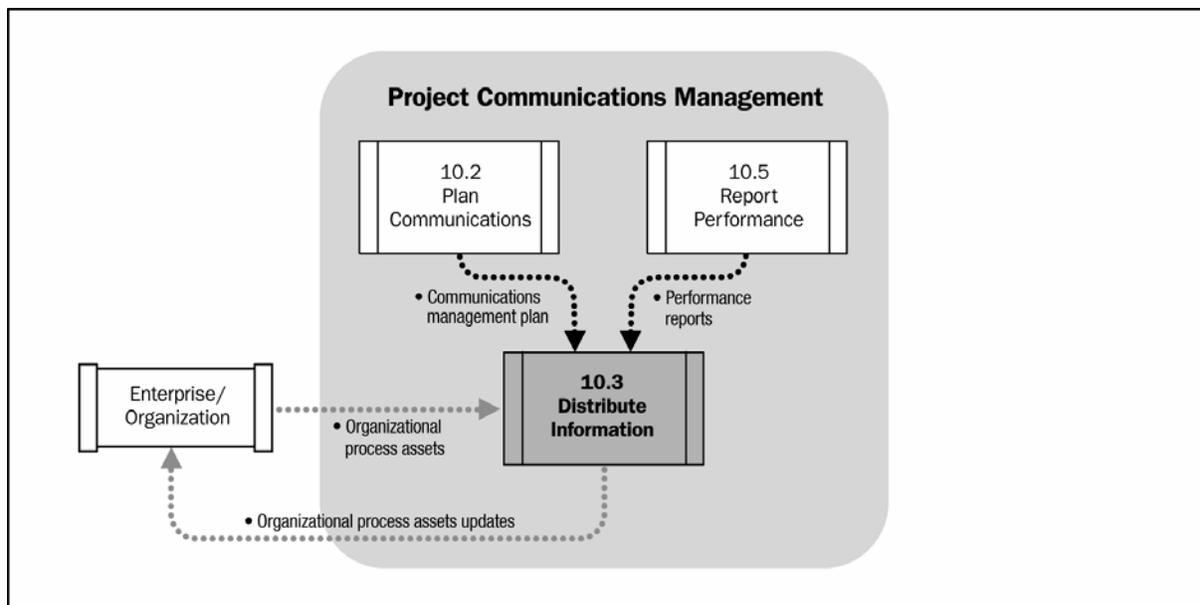
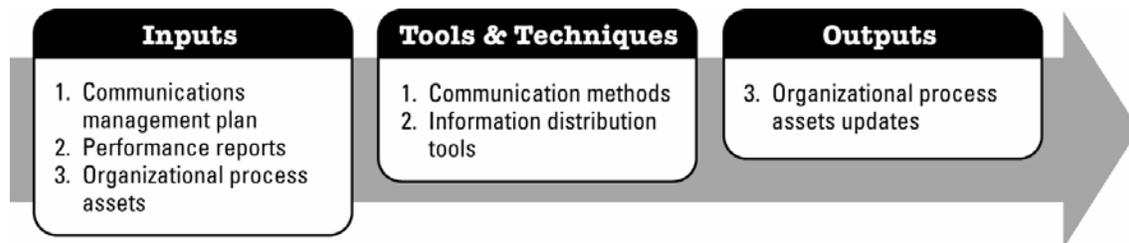


Figure 10-6. Distribute Information Data Flow Diagram

10.3.1 Distribute Information: Inputs

.1 Communications Management Plan

Described in Section 10.2.3.1.

.2 Performance Reports

Performance reports are used to distribute project performance and status information, and should be made available prior to project meetings, and should be as precise and up to date as possible.

Forecasts are updated and reissued based on work performance measurements provided as the project is executed. This information is about the project's past performance that could impact the project in the future, for example, estimates at completion and estimates to complete. Forecast information is often generated using earned value technique (see Section 7.3.2.2), but may use other methods such as analogy with past projects, re-estimating remaining work, inclusion of impact of external events in the schedule, and others. This information should be available along with performance data and other important information that must be distributed for decision-making purposes. Forecasting methods are described in Section 10.5.2.2. Additional information on performance reports is provided in Section 10.5.3.1.

.3 Organizational Process Assets

The organizational process assets that can influence the Distribute Information process include but are not limited to:

- Policies, procedures, and guidelines regarding information distribution;
- Templates; and
- Historical information and lessons learned.

10.3.2 Distribute Information: Tools and Techniques

.1 Communication Methods

Individual and group meetings, video and audio conferences, computer chats, and other remote communications methods are used to distribute information.

.2 Information Distribution Tools

Project information can be distributed using a variety of tools, including:

- Hard-copy document distribution, manual filing systems, and shared-access electronic databases.
- Electronic communication and conferencing tools, such as e-mail, fax, voice mail, telephone, video and web conferencing, and web publishing.
- Electronic tools for project management, such as web interfaces to scheduling and project management software, meeting and virtual office support software, portals, and collaborative work management tools.

10.3.3 Distribute Information: Outputs

.1 Organizational Process Asset 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 detail project status, and include lessons learned, issues logs, project closure reports, and outputs from other Knowledge Areas (Chapters 4–12).

- **Project presentations.** The project team provides information formally or informally to any or all of the project stakeholders. The information and presentation method should be relevant to the needs of the audience.
- **Project records.** Project records can include correspondence, memos, meeting acts, 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 can be 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 information distribution. Lessons learned are documented and distributed so that they become part of the historical database for both this project and the performing organization.

10.4 Manage Stakeholder Expectations

Manage Stakeholder Expectations is the process of communicating and working with stakeholders to meet their needs and addressing issues as they occur. Managing Stakeholder Expectations involves communication activities directed toward project stakeholders to influence their expectations, address concerns, and resolve issues, such as:

- Actively managing the expectations of stakeholders to increase the likelihood of project acceptance by negotiating and influencing their desires to achieve and maintain the project goals;
- Addressing concerns that have not become issues yet, usually related to the anticipation of future problems. These concerns need to be uncovered and discussed, and the risks need to be assessed; and
- Clarifying and resolving issues that have been identified. The resolution may result in a change request or may be addressed outside of the project; for example, postponed for another project or phase or deferred to another organizational entity

Managing expectations helps to increase the probability of project success by ensuring that the stakeholders understand the project benefits and risks. This enables them to be active supporters of the project and to help with risk assessment of project choices. By anticipating people's reaction to the project, preventive actions can be taken to win their support or minimize potential negative impacts.

The project manager is responsible for stakeholder expectations management. Actively managing stakeholder expectations decreases the risk that the project will fail to meet its goals and objectives due to unresolved stakeholder issues, and limits disruptions during the project.

Table 10-5. Manage Stakeholder Expectations. Inputs, Tools & Techniques and Outputs

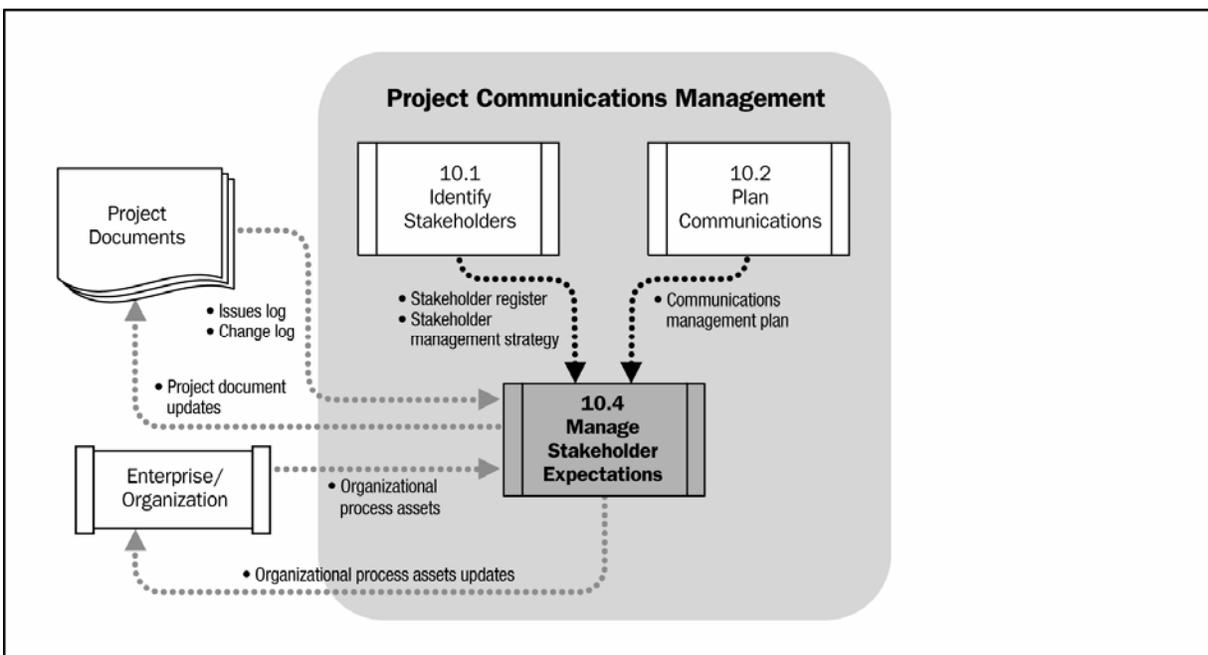
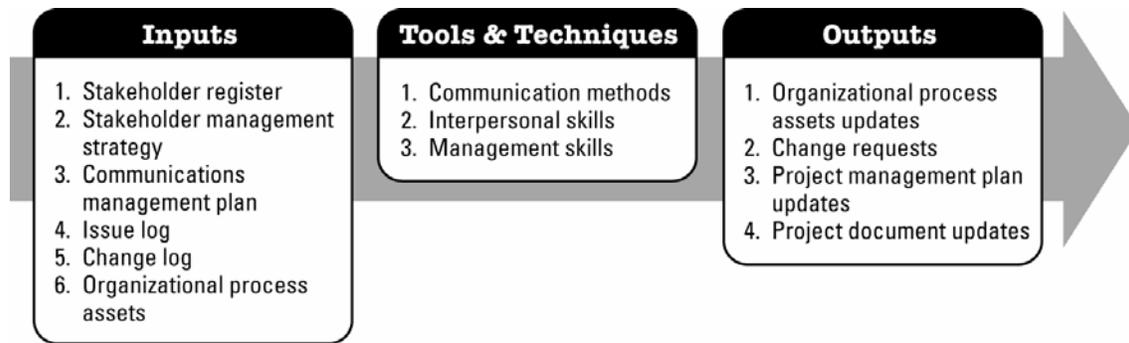


Figure 10-7. Manage Stakeholder Expectations Data Flow Diagram

10.4.1 Manage Stakeholder Expectations: Inputs

.1 Stakeholder Register

The stakeholder register is a list of the relevant stakeholders for the project. It is used to ensure that all stakeholders are included in the project communications.

.2 Stakeholder Management Strategy

An understanding of stakeholder goals and objectives is used to determine a strategy to manage stakeholder expectations. The strategy is documented in the stakeholder management strategy document.

.3 Communications Management Plan

Stakeholder requirements and expectations provide an understanding of stakeholder goals, objectives, and level of communication required during the project. The needs and expectations are identified, analyzed, and documented in the communications management plan, which is a subsidiary of the project management plan.

.4 Issue Log

An issue log or action-item log is a tool that can be used to document and monitor the resolution of issues. It can be used to facilitate communication and ensure a common understanding of issues. Issues do not usually rise to the importance of becoming a project or activity, but are usually addressed in order to maintain good, constructive working relationships among various stakeholders, including team members.

The issues are clearly stated and categorized based on urgency and potential impact. An owner is assigned and a target date is usually established for closure. Unresolved issues can be a major source of conflict and project delays.

.5 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.

.6 Organizational Process Assets

The organizational process assets that can influence the Manage Stakeholder Expectations process include but are not limited to:

- Organizational communication requirements,
- Issue management procedures,
- Change control procedures, and
- Historical information about previous projects.

10.4.2 Manage Stakeholder Expectations: Tools and Techniques

.1 Communication Methods

The methods of communication identified for each stakeholder in the communications management plan are utilized during stakeholder management.

.2 Interpersonal Skills

The project manager applies appropriate interpersonal skills to manage stakeholder expectations. For example:

- Building trust,
- Resolving conflict,
- Active listening, and
- Overcoming resistance to change.

More information on interpersonal skills is found in Appendix X.

.3 Management Skills

Management is the act of directing and controlling a group of people for the purpose of coordinating and harmonizing the group towards accomplishing a goal beyond the scope of individual effort. Management skills possibly used by the project manager include but are not limited to:

- Presentation skills,
- Writing skills, and
- Public speaking.

10.4.3 Manage Stakeholder Expectations: Outputs

.1 Organizational Process Assets Updates

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

- Causes of issues,
- Reasoning behind corrective actions chosen, and
- Lessons learned from managing stakeholder expectations.

.2 Change Requests

Managing stakeholder expectations may result in a change request to the product or the project. It may also include corrective or preventive actions as appropriate.

.3 Project Document Updates

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

- **Stakeholder management strategy.** This is updated as a result of addressing concerns and resolving issues. For example, it may be determined that a stakeholder has additional informational needs.
- **Stakeholder register.** This is updated if new stakeholders are identified or if registered stakeholders are no longer involved in or impacted by the project.
- **Issue log.** This is updated as new issues are identified and current issues are resolved.

.4 Project Management Plan Updates

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

- **Communications management plan.** This is updated with new or changed methods of communication. For example, if a current communication method is ineffective, it may be replaced by another method.

10.5 Report Performance

Report Performance is the process of collecting and distributing performance information, including status reports, progress measurements, and forecasts. The performance reporting process 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 reports need to provide information detailed enough for each audience. The format may range from a simple status report to more elaborate reports. A simple status report might show performance data, 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; current status of risks and issues; work completed during the period; work to be completed next; summary of changes approved in the period; and other relevant information which must be reviewed and discussed. A complete report should also include forecasted project

completion (including time and cost). These reports may be prepared regularly or on an exception basis.

Table 10-6. Report Performance. Inputs, Tools & Techniques and Outputs

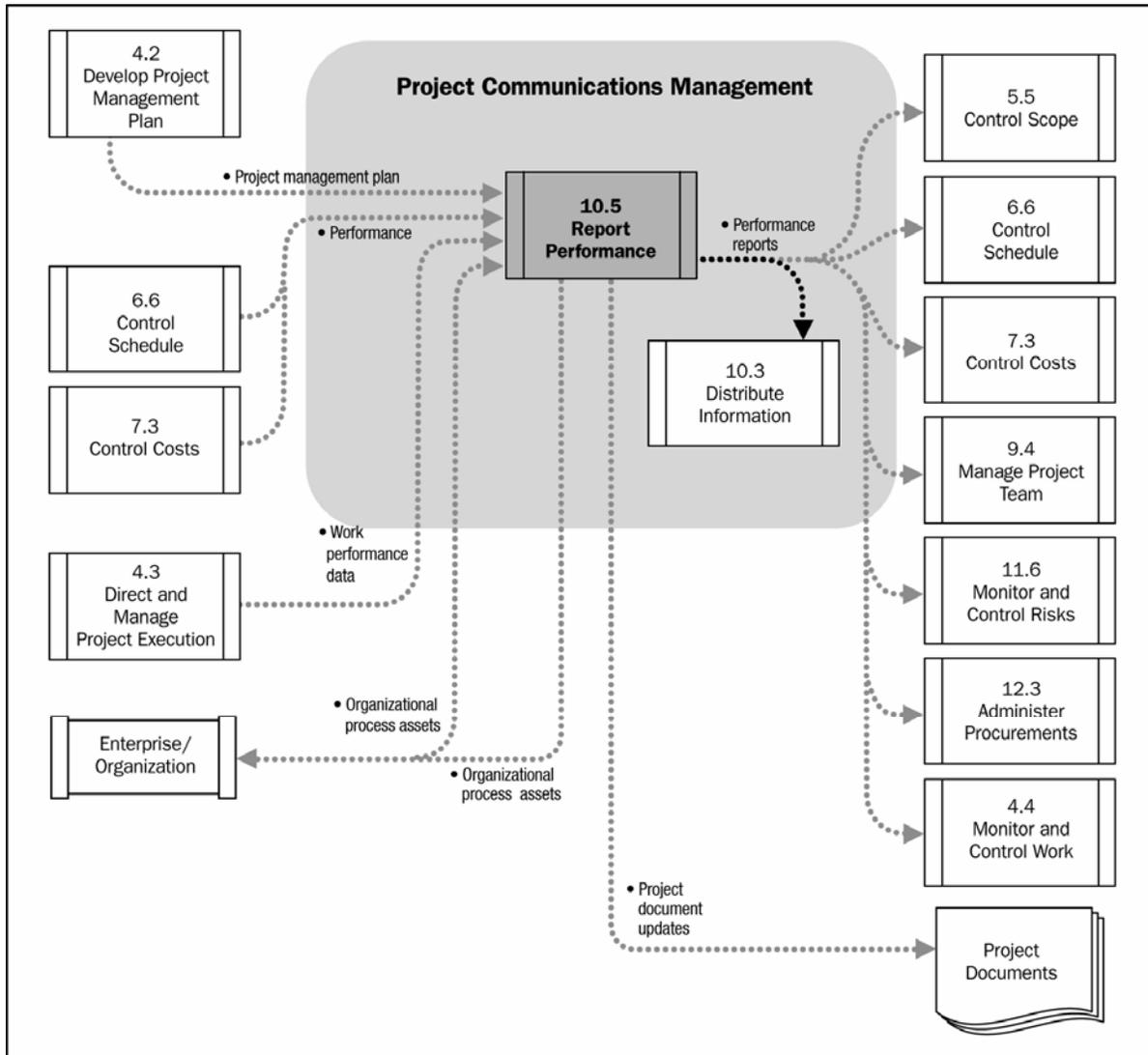
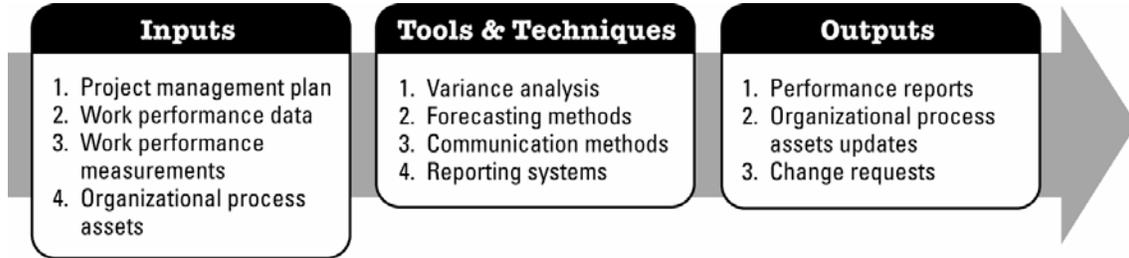


Figure 10-8. Report Performance Data Flow Diagram

10.5.1 Report Performance: Inputs

.1 Project Management Plan

The project management plan provides information on project baselines. 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.

.2 Work Performance Data

Raw data from project activities is collected on performance results such as:

- Deliverables status,
- Schedule progress, and
- Costs incurred.

.3 Work Performance Measurements

Work performance data is used to generate project activity metrics to evaluate actual progress compared to planned progress. These metrics include but are not limited to:

- Planned vs. actual schedule performance,
- Planned vs. actual cost performance, and
- Planned vs. actual technical performance.

.4 Organizational Process Assets

The organizational process assets that can influence the Report Performance process include but are not limited to:

- Report templates,
- Policies and procedures that define the measures and indicators to be used, and
- Organizationally defined variance limits.

10.5.2 Report Performance: Tools and Techniques

.1 Communications Methods

Status review meetings can be used to exchange and analyze information about the project progress and performance. The project manager generally uses a push communication technique as defined in 10.2.2.4 to distribute performance reports.

.2 Variance Analysis

Variance analysis is an after-the-fact look at what caused a difference between the baseline and the actual performance. The process for performing variance analysis may vary depending on the application area, the standard used and the industry. Common steps are:

- Verify the quality of the information collected to ensure that it is complete, consistent with past data and credible when comparing with other project or status information.

- Determine variances, comparing the actual information with the project baseline and noting all differences both favorable and unfavorable to the project outcome. Earned value technique uses specific equations to quantify variances. The technique is explained in detail in Section 7.3.2.1.
- Determine the impact of the variances in the project cost and schedule as well as in other areas of the project (i.e., quality performance adjustments and scope changes, etc.).

If applicable, analyze the trends of the variances and document any finding about the sources of variation and the impact area.

.3 Forecasting Methods

Forecasting is the process of predicting future project performance trends based on the actual performance to date. Forecasting methods may be classified in different categories:

- **Time series methods.** Time series methods use historical data as the basis for estimating future outcomes. Examples of methods in this category may include earned value, moving average, extrapolation, linear prediction, trend estimation and growth curve.
- **Causal/econometric methods.** Some forecasting methods use the assumption that it is possible to identify the underlying factors that might influence the variable that is being forecasted. For example, sales of umbrellas might be associated with weather conditions. If the causes are understood, projections of the influencing variables can be made and used in the forecast. Examples of methods in this category include regression analysis using linear regression or non-linear regression, autoregressive moving average (ARMA) and econometrics.
- **Judgmental methods.** Judgmental forecasting methods incorporate intuitive judgments, opinions and probability estimates. Examples of methods in this category are composite forecasts, surveys, Delphi method, scenario building, technology forecasting, and forecast by analogy.
- **Other methods.** Other methods may include simulation, prediction market, probabilistic forecasting, and ensemble forecasting.

.4 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. 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 data.

10.5.3 Report Performance: Outputs

.1 Performance Reports

Performance reports organize and summarize the information gathered, and present the results of any analysis as compared to the performance measurement baseline. Reports should provide the status and progress information, and the level of detail required by various stakeholders, as documented in the communications management plan. Common formats for performance reports include bar charts, S-curves, histograms, and tables. Variance analysis, earned value analysis, and

forecast data is often included as part of performance reporting. Figure 10-8 gives a tabular view of earned value data.

Performance reports are issued periodically and their format may range from a simple status report to more elaborate reports. A simple status report might show only performance data such as percent complete, or status dashboards for each area (e.g., scope, schedule, cost, and quality). More elaborate reports may include:

- Analysis of past performance,
- Current status of risks and issues,
- Work completed during the period,
- Work to be completed next,
- Summary of changes approved in the period,
- Results of variance analysis,
- Forecasted project completion (including time and cost), and
- Other relevant information to be reviewed and discussed.

	Planned	Earned	Cost					Performance Index	
WBS Element	Budget	Earned Value	Actual Cost	Cost Variance		Schedule Variance		Cost	Schedule
	(\$) (PV)	(\$) (EV)	(\$) (AC)	(\$) (EV - AC)	(%) (CV ÷ EV)	(\$) (EV - PV)	(%) (SV ÷ PV)	CPI (EV ÷ AC)	SPI (EV ÷ PV)
1.0 Pre-Pilot Plan	63,000	58,000	62,500	-4,500	-7.8	-5,000	-7.9	0.93	0.92
2.0 Checklists	64,000	48,000	46,800	1,200	2.5	-16,000	-25.0	1.03	0.75
3.0 Curriculum	23,000	20,000	23,500	-3,500	-17.5	-3,000	-13.0	0.85	0.87
4.0 Mid-Term Evaluation	68,000	68,000	72,500	-4,500	-6.6	0	0.0	0.94	1.00
5.0 Implementation Support	12,000	10,000	10,000	0	0.0	-2,000	-16.7	1.00	0.83
6.0 Manual of Practice	7,000	6,200	6,000	200	3.2	-800	-11.4	1.03	0.89
7.0 Roll-Out Plan	20,000	13,500	18,100	-4,600	-34.1	-6,500	-32.5	.075	0.68
Totals	257,000	223,700	239,400	-15,700	-7.0	-33,300	-13.0	0.93	0.87

Note: All figures are project-to-date.

*Other units of measure that may be used in these calculations may include: labor hours, cubic yards of concrete, etc.

Figure 10-9. Tabular Performance Report Sample

.1 Organizational Process Assets Updates

The organizational process assets that can be updated include, but are not limited to lessons learned documentation, including the causes of issues, reasoning behind the corrective action chosen, and other types of lessons learned about performance reporting. Lessons learned are documented so that they become part of the historical database for both this project and the performing organization.

.2 Change Requests

Analysis of project performance 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.
- Recommended preventive actions can reduce the probability of incurring future negative project performance.

Chapter 11 Project Risk Management

Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, and monitoring and control on a project. Project Risk Management objectives are to increase the probability and impact of positive events, and decrease the probability and impact of negative events in the project.

Table 11-1 provides an overview of 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 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 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 Monitor and Control Risk Responses**—The process of executing 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. Each process can involve effort from one or more persons based on the needs of the project. Each process occurs at least once in every project and occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete elements with well-defined interfaces, in practice they will overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3 on Project Management Processes for a Project.

Project risk is always in the future. Risk is an uncertain event or condition that, if it occurs, has an effect on at least one project objective. Objectives can include scope, schedule, cost, or performance. A risk may have one or more causes and, if it occurs, it may have one or more impacts. A cause may be a requirement, constraint, or condition that creates the possibility of negative or positive outcomes. For example, causes could include requiring an environmental permit to do work, or having limited personnel assigned to design the project. The risk event is that the permitting agency may take longer than planned to issue a permit, or the limited design personnel available and assigned may still be able to get the job done on time. If either of these uncertain events occurs, there may be an impact on the project cost, schedule, or performance. Risk conditions could include aspects of the project's or organization's environment that may contribute to project risk, such as immature project management practices, lack of integrated management systems, concurrent multiple projects, or dependency on external participants who cannot be controlled.

Table 11-1 Project Risk Management Overview



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 while: unknown risks cannot be managed proactively, the project team can create a contingency plan.

Organizations perceive risk as it relates to threats to project success, or to opportunities *for* efficient, effective project success. Risks that are threats to the project may be accepted if the risks are in balance with the rewards that may be gained by taking the risks. For example, adopting a fast track schedule (Section 6.5.2.7) that may be overrun is a risk taken to achieve the reward created by an earlier completion date.

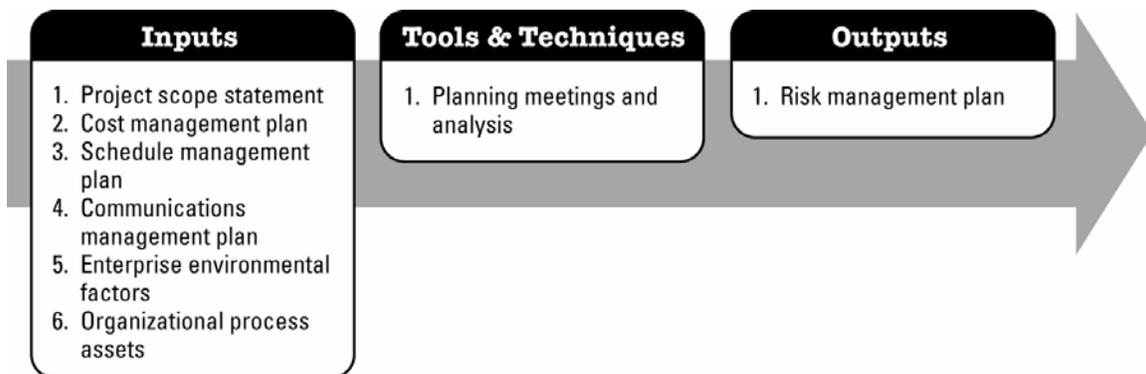
Individuals and groups adopt attitudes toward risk that influence the way they respond. These risk attitudes are driven by perception and other biases, which should be made explicit wherever possible. A consistent approach to risk that meets the organization’s requirements should be developed for each project, and communication about risk and its handling should be open and honest. Risk responses reflect an organization’s perceived balance between risk-taking and risk avoidance.

To be successful, the organization should be committed to address risk management proactively and consistently throughout the project. A conscious choice must be made at all levels of the organization to actively identify and pursue effective risk management during the life of the project. Risk exists the moment a project is conceived. Moving forward on a project without a proactive focus on risk management generates more risk to the successful conclusion of any project.

11.1 Plan Risk Management

Plan Risk Management is the process of defining how to conduct risk management activities for a project (see Table 11-2 and Figure 11-1). Careful and explicit planning enhances the probability of success for the five other risk management processes. Planning risk management processes is important to ensure that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization. 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 as a project is conceived and should be completed early during project planning.

Table 11-2. Plan Risk Management: Inputs, Tools & Techniques, and Outputs



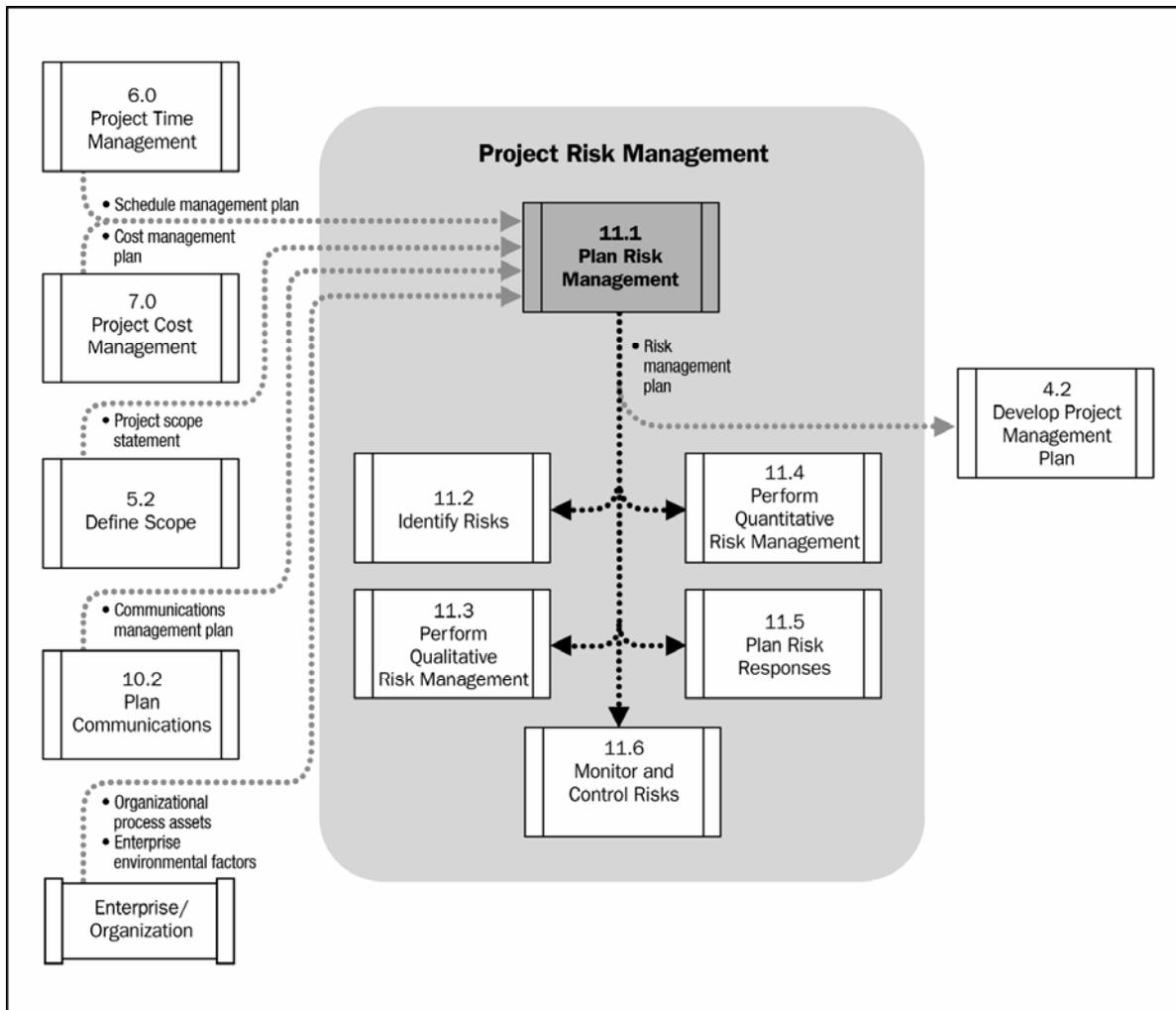


Figure 11-1. Plan Risk Management Data Flow

11.1.1 Plan Risk Management: Inputs

.1 Project Scope Statement

The project scope statement provides a clear sense of the range of possibilities associated with the project and its deliverables and establishes the framework for how significant the risk management effort may ultimately become. Described in Section 5.2.3.1.

.2 Cost Management Plan

The project cost management plan defines how risk budgets, contingencies, and management reserves will be reported and accessed. Described in Section 7.

.3 Schedule Management Plan

The schedule management plan defines how schedule contingencies will be reported and assessed. Described in Section 6.

.4 Communications Management Plan

The project communications management plan defines the interactions that will occur on the project, and determines who will be available to share information on various risks and responses at different times (and locations) Described in Section 10.2.3.1.

.5 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Plan Risk Management process include but are not limited to risk attitudes and tolerances that demonstrate organizational willingness to embrace high-threat situations or unwillingness to forego high-opportunity conditions.

.6 Organizational Process Assets

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,
- Lessons learned, and
- Stakeholder registers, which are also critical assets to be reviewed as components of establishing effective risk management plans.

11.1.2 Plan Risk Management: Tools and Techniques

.1 Planning Meetings and Analysis

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 cost elements and schedule activities will be developed for inclusion in the project budget and schedule, respectively. Risk contingency reserve application approaches may be established or reviewed. Risk responsibilities will 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 will be summarized in the risk management plan.

11.1.3 Plan Risk Management: Outputs

.1 Risk Management Plan

The risk management plan describes how risk management will be structured and performed on the project. It becomes a subset of the project management plan (Section 4.2.3.1). The risk management plan includes the following:

- **Methodology.** Defines the approaches, tools, and data sources that may be used to perform risk management on the project.
- **Roles and responsibilities.** Defines the lead, support, and risk management team membership for each type of activity in the risk management plan. Assigns people to these roles and clarifies their responsibilities.
- **Budgeting.** Assigns resources, and estimates costs needed for risk management for inclusion in the project cost baseline and establishes protocols for application of contingency reserve (Section 7.2.3.1).
- **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 to be included in the project schedule (Section 6.5.3.1).
- **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 categorization framework which might take the form of a simple list of categories or might be structured into a Risk Breakdown Structure (RBS). The RBS is a hierarchically organized depiction of the identified project risks arranged by risk category and subcategory that identifies the various areas and causes of potential risks. An example is shown in Figure 11-2.

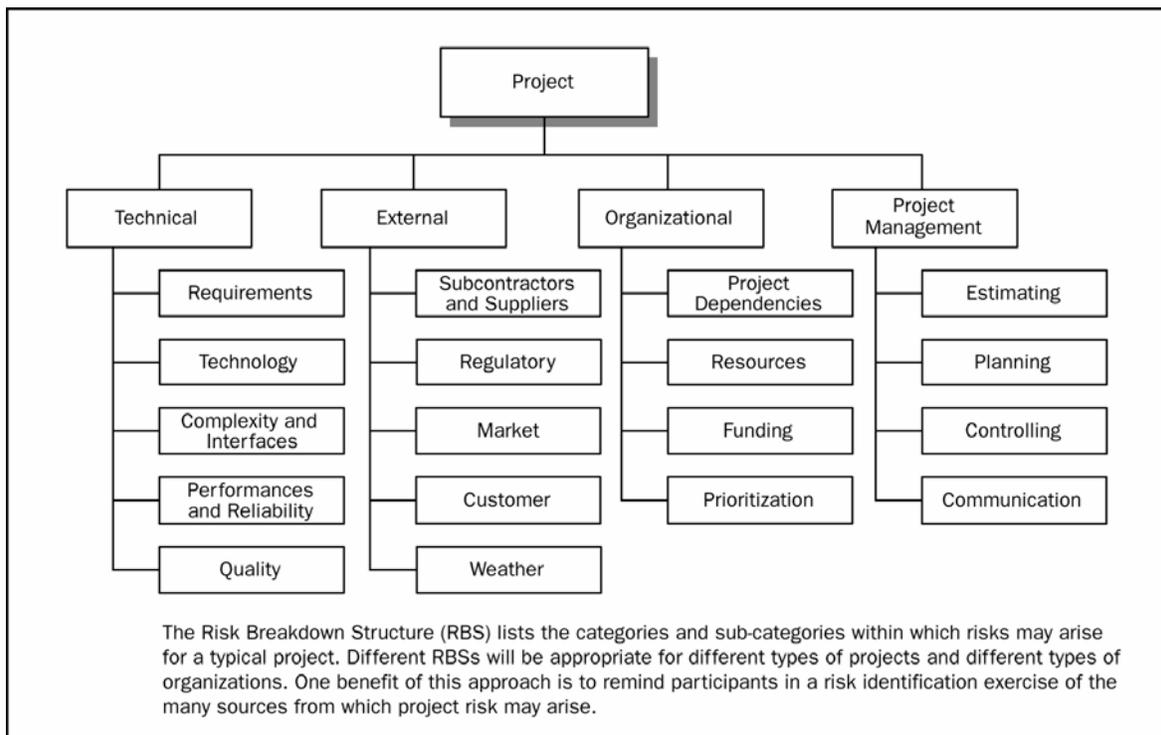


Figure 11-2. Example of a Risk Breakdown Structure (RBS)

- **Definitions of risk probability and impact.** The quality and credibility of the Perform Qualitative Risk Analysis process requires that different levels of the risks' probabilities and impacts be defined. General definitions of probability levels and impact levels are

tailored to the individual project during the Plan Risk Management process for use in the Perform Qualitative Risk Analysis process (Section 11.3). Figure 11-3 is an example of definitions of negative impacts that could be used in evaluating risk impacts related to four project objectives. (Similar tables could be established with a positive impact perspective). The figure illustrates both relative and numeric (in this case, nonlinear) approaches.

- **Probability and impact matrix.** 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 (Section 11.3.2.2). The specific combinations of probability and impact that lead to a risk being rated as “high,” “moderate,” or “low” importance, with the corresponding importance for planning responses to the risk (Section 11.5), are usually set by the organization.

Defined Conditions for Impact Scales of a Risk on Major Project Objectives (Examples are shown for negative impacts only)					
Project Objective	Relative or numerical scales are shown				
	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 11-3. Definition of Impact Scales for Four Project Objectives

- **Revised stakeholders’ tolerances.** Stakeholders’ tolerances may be revised in the Plan Risk Management process, as they apply to the specific project.
- **Reporting formats.** Defines how the outcomes of the risk management processes will be documented, analyzed, and communicated. 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, as well as for future needs and lessons learned. Documents whether and how risk management processes will be audited.

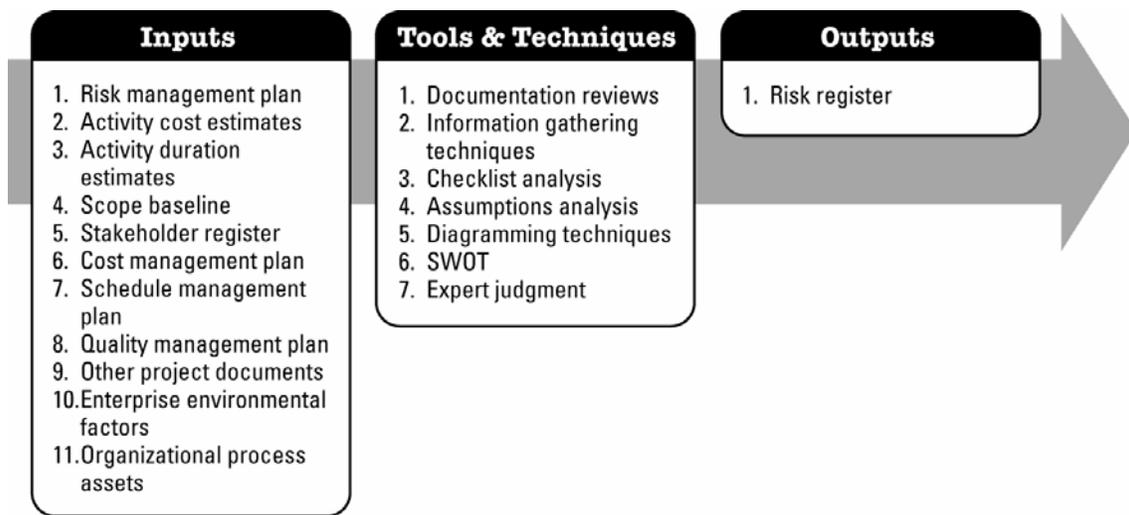
11.2 Identify Risks

Identify Risks is the process of determining which risks may affect the project and documenting their characteristics (see Table 11-3 and Figure 11-4).. Participants in risk identification activities can include the following, where appropriate: 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 who participates in each cycle will vary by situation, but the format of the risk statements should be consistent to ensure the ability to compare the relative effect of one risk event against others on the project. The project team should be involved in the process so that 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.

Table 11-3 Identify Risks: Inputs, Tools & Techniques, and Outputs



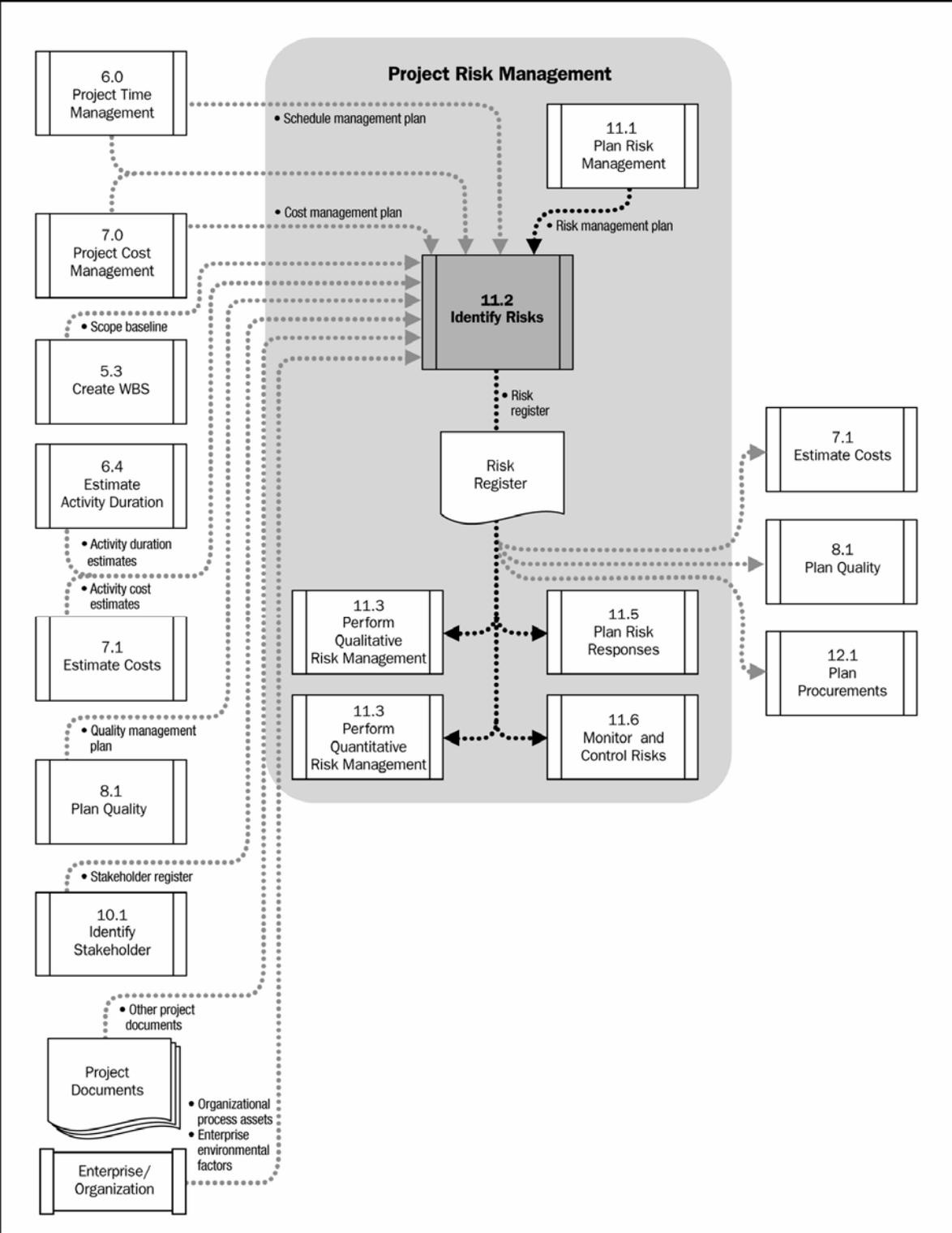


Figure 11-4 Identify Risks Data Flow Diagram

11.2.1 Identify Risks: Inputs

.1 Risk Management Plan

Key inputs from the risk management plan 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 (Section 11.1), which are sometimes expressed in an risk breakdown structure (Figure 11-2).

.2 Activity Cost Estimates

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 degrees of risk. The review may result in projections that the estimate is either sufficient or insufficient to complete the activity (and hence pose a risk to the project). (Section 7.1.3.1).

.3 Activity Duration Estimates

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. (Section 6.4.3.1)

.4 Scope Baseline

Project assumptions are found in the project scope statement (Section 5.2.3.1). 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.

.5 Stakeholder Register

Information about the stakeholders will be useful in soliciting inputs for identifying risks as this will ensure that key stakeholders, especially the customer, are interviewed or otherwise participate during the “Identify Risks” process (Section 10.1.3.1).

.6 Cost Management Plan

The risk identification process requires an understanding of the cost management plans found in the project management plan (Section 7). The project-specific approach to cost management may generate or alleviate risk by its nature or structure.

.7 Schedule Management Plan

The risk identification process also requires an understanding of the schedule management plan found in the project management plan (Section 6). The project-specific approach to schedule management may generate or alleviate risk by its nature or structure.

.8 Quality Management Plan

The risk identification process also requires an understanding of the quality management plan found in the project management plan (Section 8.1) The project-specific approach to quality management may generate or alleviate risk by its nature or structure.

.9 Other Project Documents

Other project documents include but are not limited to the following:

- Assumptions log,
- Work performance reports,
- Earned value reports,
- Baselines, and
- Other project information proven to be valuable in identifying risks.

.10 Enterprise Environmental Factors

The 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 Organizational Process Assets

The organizational process assets that can influence the Identify Risks process include but are not limited to:

- Project files, including actual data,
- Risk statement templates, and
- Lessons learned.

11.2.2 Risk Identification: Tools and Techniques

.1 Documentation Reviews

A structured review may be performed of project documentation, including plans, assumptions, previous project files, and other information. The quality of the plans, as well as consistency between those plans and with the project requirements and assumptions, can be indicators of risk in the project.

.2 Information Gathering Techniques

Examples of information gathering techniques used in identifying risk can include:

- **Brainstorming.** The goal of brainstorming is to obtain a comprehensive list of project risks. The project team usually performs brainstorming, often with a multidisciplinary set of experts not on the team. Ideas about project risk are generated under the leadership of a facilitator, either in a traditional free-form brainstorm session with ideas contributed by participants, or structured using mass interviewing techniques such as the nominal group technique or the Crawford Slip. Categories of risk (Section 11.1.3.1), such as a risk

breakdown structure, can be used as a framework. Risks are then identified and categorized by type of risk and their definitions are sharpened.

- **Delphi technique.** The Delphi technique is a way to reach a consensus of experts. Project risk experts participate in this technique anonymously. A facilitator uses a questionnaire to solicit ideas about the important project risks. The responses are summarized and are then 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 can identify risks.
- **Root cause analysis.** When root causes of a project's risks are identified, those causes can be used to identify a range of risks emanating from the single root cause or few root causes.

.3 Checklist Analysis

Risk identification checklists can be developed based on historical information and knowledge that has been accumulated from previous similar projects and from other sources of information. The lowest level of the RBS can also be used as a risk checklist. While a checklist can be quick and simple, it is impossible to build an exhaustive one. Care should be taken to explore items that do not appear on the checklist. The checklist should be reviewed during project closure to incorporate new lessons learned and improve it for use on future projects.

.4 Assumptions Analysis

Every project and every identified project risk 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, inconsistency, or incompleteness of assumptions.

.5 Diagramming Techniques

Risk diagramming techniques may include:

- **Cause-and-effect diagrams** (Section 8.3.2.1). 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 (Section 8.3.2.3).
- **Influence diagrams.** These are graphical representations of situations showing causal influences, time ordering of events, and other relationships among variables and outcomes.

.6 Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis

This technique examines the project from each of the 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 wider business. These factors are often identified using brainstorming. SWOT analysis then identifies any opportunities for the project that arise from organizational strengths, and any threats

arising from organizational weaknesses. SWOT analysis also examines the degree to which organizational strengths offset threats and opportunities may serve to overcome weaknesses.

.7 Expert Judgment

Risks can be identified directly by experts with relevant experience of similar projects or business areas. Such experts should be identified by the project manager and invited to consider all aspects of the project, suggesting 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

The main outputs from Identify Risks are typically contained in a document usually called a risk register.

.1 Risk Register

The primary outputs from Identify Risks are the initial entries into the risk register. The risk register ultimately 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 Project Risk Management processes.

- **List of identified risks.** The identified risks are described in as much detail as is reasonable, including the impact of the event that may occur and its cause. Risks can cover nearly any topic, but a few examples include the following: A few large items with long lead times are on the critical path. Industrial relations disputes at the ports may delay the delivery of those items and, subsequently, delay completion of the construction phase. Another example is a project management plan that assumes a staff size of ten, but there may be only six resources available. The lack of resources may have the positive influence of reducing costs and still accomplishing the project's goals. 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*. Such structures allow for more consistent analysis of identified risks. 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 may be identified as a byproduct of the risk identification technique used, or through analysis of risks documented in the risk register. They should be recorded and used to support future risk identification for this and other projects. Knowledge of root causes can also support development of effective risk responses, since related groups of risks might be dealt with by addressing their root cause. The process of identifying risks can also lead to identification of new risk categories being added to the list of risk categories. The RBS developed in the Plan Risk Management process may have to be enhanced or amended, based on the outcomes of the Identify Risks process.
- **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, may be useful as inputs to the Plan Risk Responses process (Section 11.5).

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 (see Table 11-4 and Figure 11-5). Organizations can improve the project's performance effectively by focusing on high-priority risks. Perform Qualitative Risk Analysis assesses the priority of identified risks using their relative probability of occurrence, the corresponding impact on project objectives if the risks do 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 attitude of the project team and other stakeholders to risk. Effective assessment therefore requires explicit identification and management of the risk attitudes of key participants in the Perform Qualitative Analysis process. Where these risk attitudes introduce bias into the assessment of identified risks, attention should be paid to evaluating 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 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. Qualitative risk analysis should be revisited during the project's life cycle to stay current with changes in the project risks. This process can lead into Perform Quantitative Risk Analysis (Section 11.4) or directly into Plan Risk Responses (Section 11.5).

Table 11-4 Perform Qualitative Risk Analysis: Inputs, Tools & Techniques, and Outputs



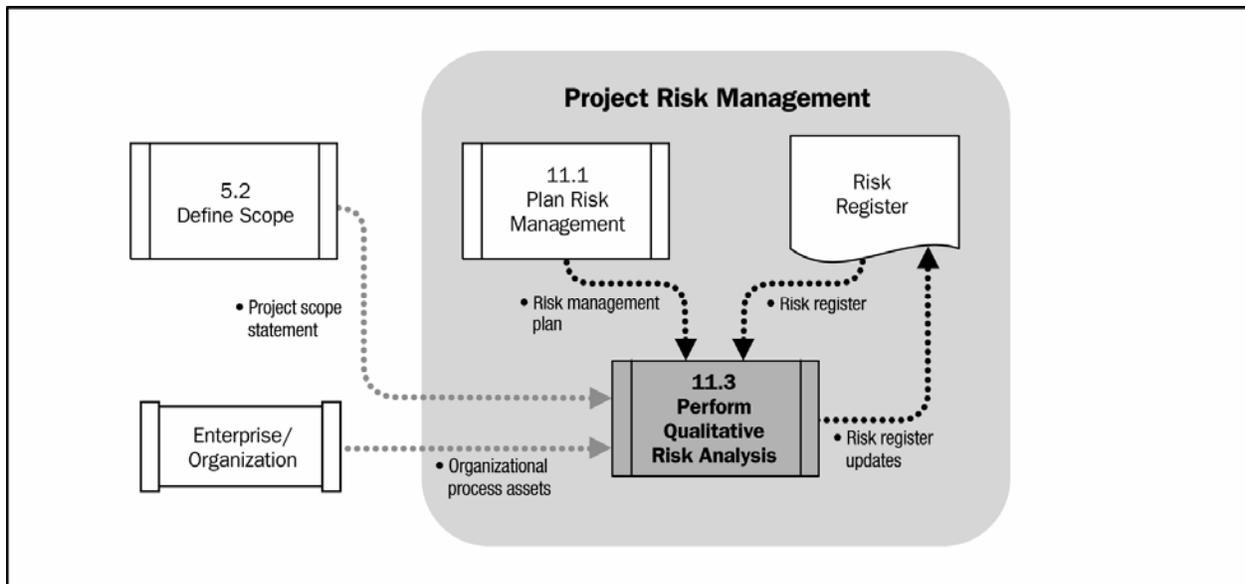


Figure 11-5. Perform Qualitative Risk Analysis Data Flow Diagram

11.3.1 Perform Qualitative Risk Analysis: Inputs

.1 Risk Register 4

See Section 11.2.3.1.

.2 Risk Management Plan

Key elements of the risk management plan for Perform Qualitative Risk Analysis include roles and responsibilities for conducting risk management, budgets, and 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 (Section 11.1). If they are not available, they can be developed during the Perform Qualitative Risk Analysis process (Section 11.3).

.3 Project Scope Statement

Projects of a common or recurrent type tend to have more well-understood risks. Projects using state-of-the-art or first-of-its-kind technology, and highly complex projects, tend to have more uncertainty. This can be evaluated by examining the project scope statement (Section 5.2.3.1).

.4 Organizational Process Assets

The Organizational process assets that can influence the Perform Qualitative Risk Analysis process include but are not limited to:

- Information on prior, similar completed projects,
- Studies of similar projects by risk specialists, and
- Risk databases that may be available from industry or proprietary sources.

11.3.2 Perform Qualitative Risk Analysis: Tools and Techniques

.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, 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, perhaps, knowledgeable persons from outside 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, is also recorded. Risk probabilities and impacts are rated according to the definitions given in the risk management plan (Section 11.1.3.1). Risks with low ratings of probability and impact will be included on a watchlist for future monitoring.

.2 Probability and Impact Matrix

Risks can be prioritized for further quantitative analysis and response based on their risk rating. 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. Evaluation of each risk's importance and, hence, priority for attention is typically conducted using a look-up table or a probability and impact matrix (Figure 11-6). Such a matrix specifies combinations of probability and impact that lead to rating the risks as low, moderate, or high priority. 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.

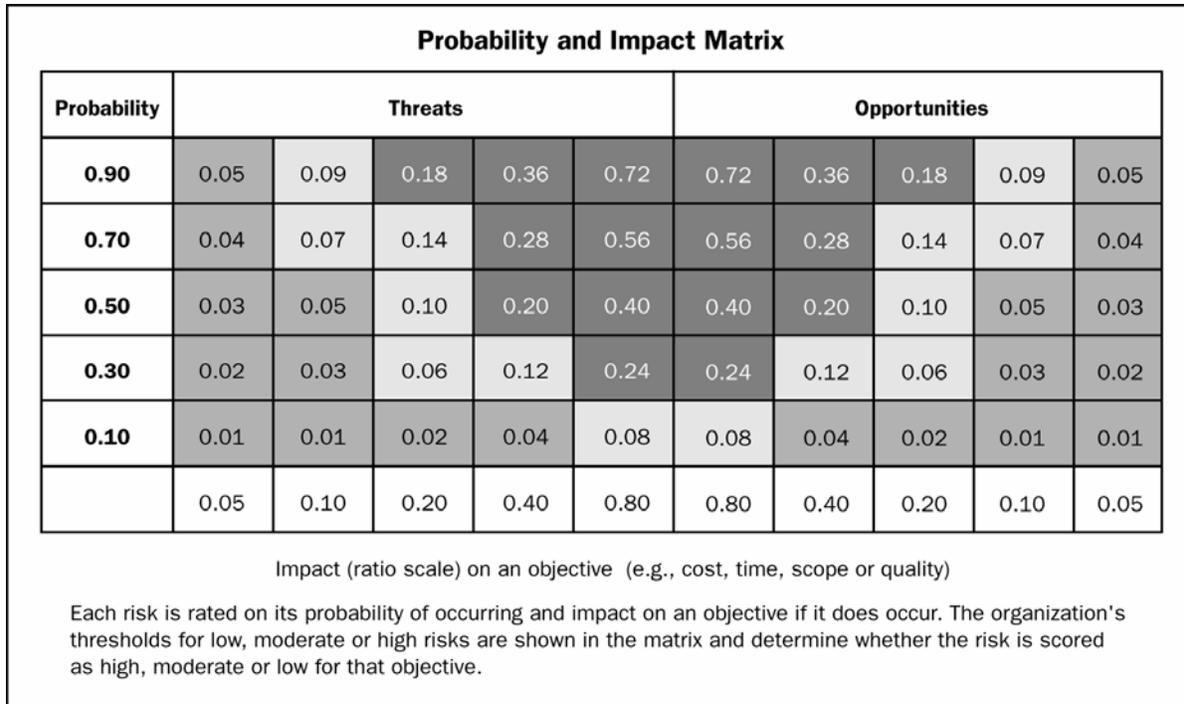


Figure 11-6. Probability and Impact Matrix

As illustrated in Figure 11-3, an organization can rate a risk separately for each objective (e.g., cost, time, and scope). In addition, it can develop ways to determine one overall rating for each risk. An overall project rating scheme is developed to reflect the organization's preference for one objective over another and using those preferences to develop a weighting of the risks that are assessed by objective. Finally, opportunities and threats can be handled in the same matrix using definitions of the different levels of impact that are appropriate for each.

The risk rating helps guide risk responses. For example, risks that have a negative impact on objectives if they occur (threats), and that are in the high-risk (dark gray) zone of the matrix, may require priority action and aggressive response strategies. Threats in the low-risk (medium gray) zone may not require proactive management action beyond being placed on a watchlist or adding a contingency reserve. Similarly for opportunities, those in the high-risk (dark gray) zone that can be obtained most easily and offer the greatest benefit should, therefore, be targeted first. Opportunities in the low-risk (medium gray) zone should be monitored. The values provided in 11.4.2.1 are representative. The number of steps in the scale is organizationally determined and organizationally dependent.

.3 Risk Data Quality Assessment

A qualitative risk analysis requires accurate and unbiased data if it is to be credible. Analysis of the quality of risk data is a technique to evaluate the degree to which the data about risks is useful for risk management. It involves examining the degree to which the risk is understood and the accuracy, quality, reliability, and integrity of the data about the risk. If data quality is unacceptable, it may be necessary to gather better data.

.4 Risk Categorization

Risks to the project can be categorized by sources of risk (e.g., using the RBS), the area of the project affected (e.g., using the WBS), or other useful category (e.g., project phase) to determine areas of the project most exposed to the effects of uncertainty. Grouping risks by common root causes can lead to developing effective risk responses.

.5 Risk Urgency Assessment

Risks requiring near-term responses may be considered more urgent to address. Indicators of priority can include time to effect a risk response, symptoms and warning signs, and the risk rating.

.6 Expert Judgment

Expert judgment is required to assess the probability and impact of each risk to determine risks' locations in the matrix shown in Figure 11-6. Experts generally are those with experience with similar projects that occurred in the not-too-distant past. In addition, those who are planning and managing the specific project are experts, particularly about the specifics of that project. Securing 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 Qualitative Risk Analysis: Outputs

.1 Risk Register Updates

The risk register is started during the Identify Risks process. The risk register is updated with information from Perform Qualitative Risk Analysis and the updated risk register is included in the project documents. The risk register updates from Perform Qualitative Risk Analysis include:

- **Relative ranking or priority list of project risks.** The probability and impact matrix can be used to classify risks according to their individual significance. Using combinations of each risk's probability of occurring and impact on objectives if it were to occur, risks will be prioritized relative to each other by sorting them into groups of "high risk," "moderate risk" and "low risk." Risks may be listed by priority separately for schedule, cost and performance, since organizations may value one objective over another. The project manager can then use the prioritized list of risks to focus attention on those items of high significance (high risk) to the most important objectives, where responses can lead to better project outcomes. A description of the basis for the assessed probability and impact should be included for risks assessed as important to the project.
- **Risks grouped by categories.** Risk categorization can reveal common root.
- **Causes of risk or project areas requiring particular attention.** Discovering concentrations of risk may improve the effectiveness of risk responses.
- **List of risks requiring response in the near-term.** Those risks that require an urgent response and those that can be handled at a later date may be put into different groups.
- **List of risks for additional analysis and response.** Some risks might warrant more analysis, including Quantitative Risk Analysis, as well as response action.
- **Watchlists of low priority risks.** Risks that are not assessed as important in the Perform Qualitative Risk Analysis process can be placed on a watchlist for continued monitoring.

- **Trends in qualitative risk analysis results.** As the analysis is repeated, a trend for particular risks may become apparent, and can make risk response or further analysis more or less urgent/important.

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 (Table 11-5 and Figure 11-7). 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 risk events and assigns a numerical rating to those risks. It also presents a quantitative approach to making decisions in the presence of uncertainty. This process uses techniques such as the Program Evaluation and Review Technique (PERT), Monte Carlo simulation and decision tree analysis to:

- Quantify the possible outcomes for the project and their probabilities
- Assess the probability of achieving specific project objectives
- Identify risks requiring the most attention by quantifying their relative contribution to overall project risk
- Identify realistic and achievable cost, schedule, or scope targets, given the project risks
- Determine the best project management decision when some conditions or outcomes are uncertain.

Perform Quantitative Risk Analysis generally follows the Perform Qualitative Risk Analysis process. In some cases, Perform Quantitative Risk Analysis may not be required to develop effective risk responses. Availability of time and budget, and the need for qualitative or quantitative statements about risk and impacts, will determine which method(s) to use on any particular project. Perform Quantitative Risk Analysis should be repeated after Plan Risk Responses, as well as part of Monitor and Control Risk Responses, to determine if the overall project risk has been satisfactorily decreased. Trends can indicate the need for more or less risk management action.

Table 11-5 Perform Quantitative Risk Analysis: Inputs, Tools & Techniques, and Outputs



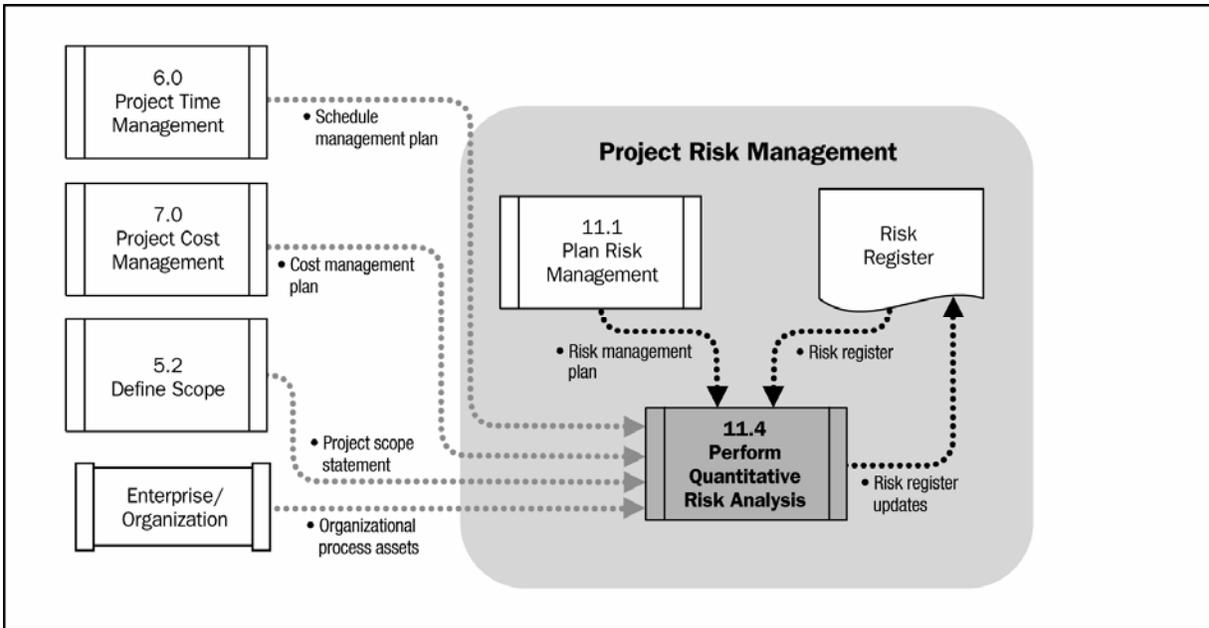


Figure 11-7 Perform Quantitative Risk Analysis Data Flow Diagram

11.4.1 Perform Quantitative Risk Analysis: Inputs

.1 Risk Register

See Section 11.2.3.1.

.2 Risk Management Plan

See Section 11.1.3.1.

.3 Cost Management Plan

The project cost management plan sets the format and establishes criteria for planning, structuring, estimating, budgeting, and controlling project costs (Section 7). Those controls may help determine the structure and/or application approach for quantitative analysis of the budget or cost plan.

.4 Schedule Management Plan

The project schedule management plan sets the format and establishes criteria for developing and controlling the project schedule (Section 6) Those controls and the nature of the schedule itself may help determine the structure and/or application approach for quantitative analysis of the schedule.

.5 Organizational Process Assets

The organization process assets that can influence the Perform Quantitative Risk Analysis process include but are not limited to:

- Information on prior, similar completed projects
- Studies of similar projects by risk specialists
- Risk databases that may be available from industry or proprietary sources

11.4.2 Perform Quantitative Risk Analysis: Tools and Techniques

.1 Data Gathering and Representation Techniques

- **Interviewing.** Interviewing techniques are used 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, and the mean and standard deviation for others. Examples of three-point estimates for cost are shown in Figure 11-8. 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.

WBS Element	Low	Most Likely	High
Design	\$4M	\$6M	\$10M
Build	\$16M	\$20M	\$35M
Test	\$11M	\$15M	\$23M
Total Project	\$31M	\$41M	\$68M

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 appearing in 11.4.2.2 (Modeling and simulation)

Figure 11-8. Range of Project Cost Estimates Collected During the Risk Interview

- **Probability distributions.** Continuous probability distributions 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 11-9. These asymmetrical 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.

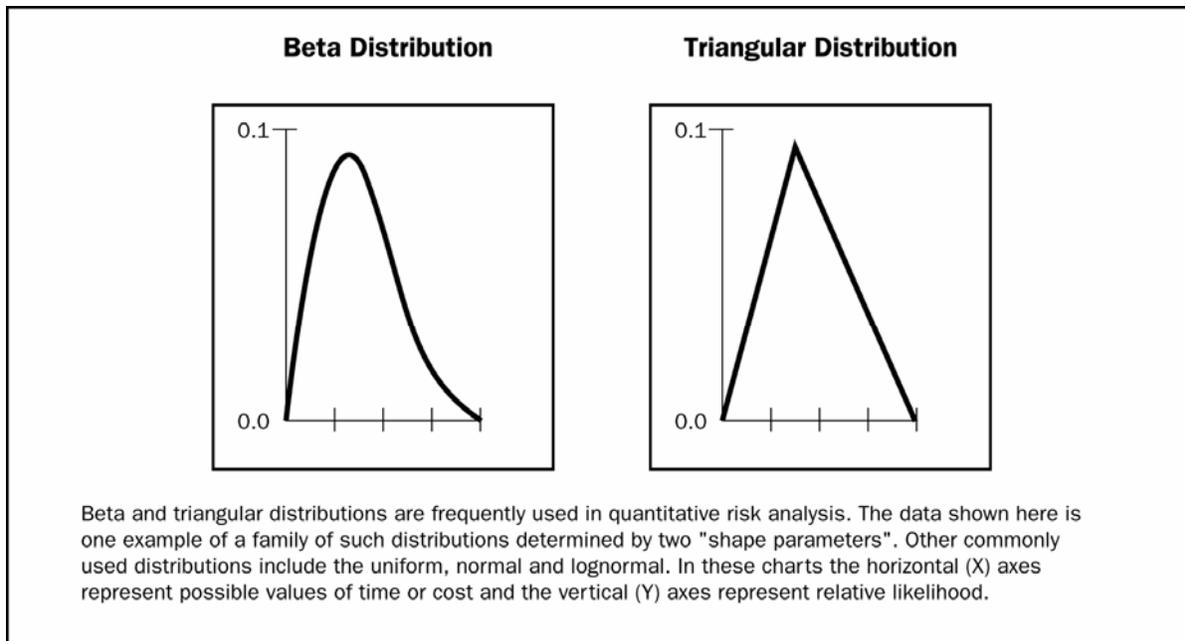


Figure 11-9. Examples of Commonly Used Probability Distributions

- **Expert judgment.** Subject matter experts internal or external to the organization, such as engineering or statistical experts, validate data and techniques.

.2 Quantitative Risk Analysis and Modeling Techniques

Commonly used techniques include both event-oriented and project-oriented analysis approaches:

- **Sensitivity analysis.** Sensitivity analysis helps to determine which risks have the most potential impact on the project. It examines the extent to which the uncertainty of each project element affects the objective being examined when all other uncertain elements are held at their baseline values. One typical display of sensitivity analysis is the tornado diagram, which is useful for comparing relative importance and impact of variables that have a high degree of uncertainty to those that are more stable.
- **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 will generally be expressed as positive values, while those of risks will be negative. 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 in decision tree analysis (Figure 11-10).
- **Decision tree analysis.** Decision tree analysis is usually structured using a decision tree diagram (Figure 11-10) that describes a situation under consideration, and the implications of each of the available choices and possible scenarios. It incorporates the cost of each available choice, the probability of each possible scenario, and the outcome (net path value) of each alternative logical path. Solving the decision tree provides the EMV (or other measure of interest to the organization) for each alternative, when all the rewards and subsequent decisions are quantified.

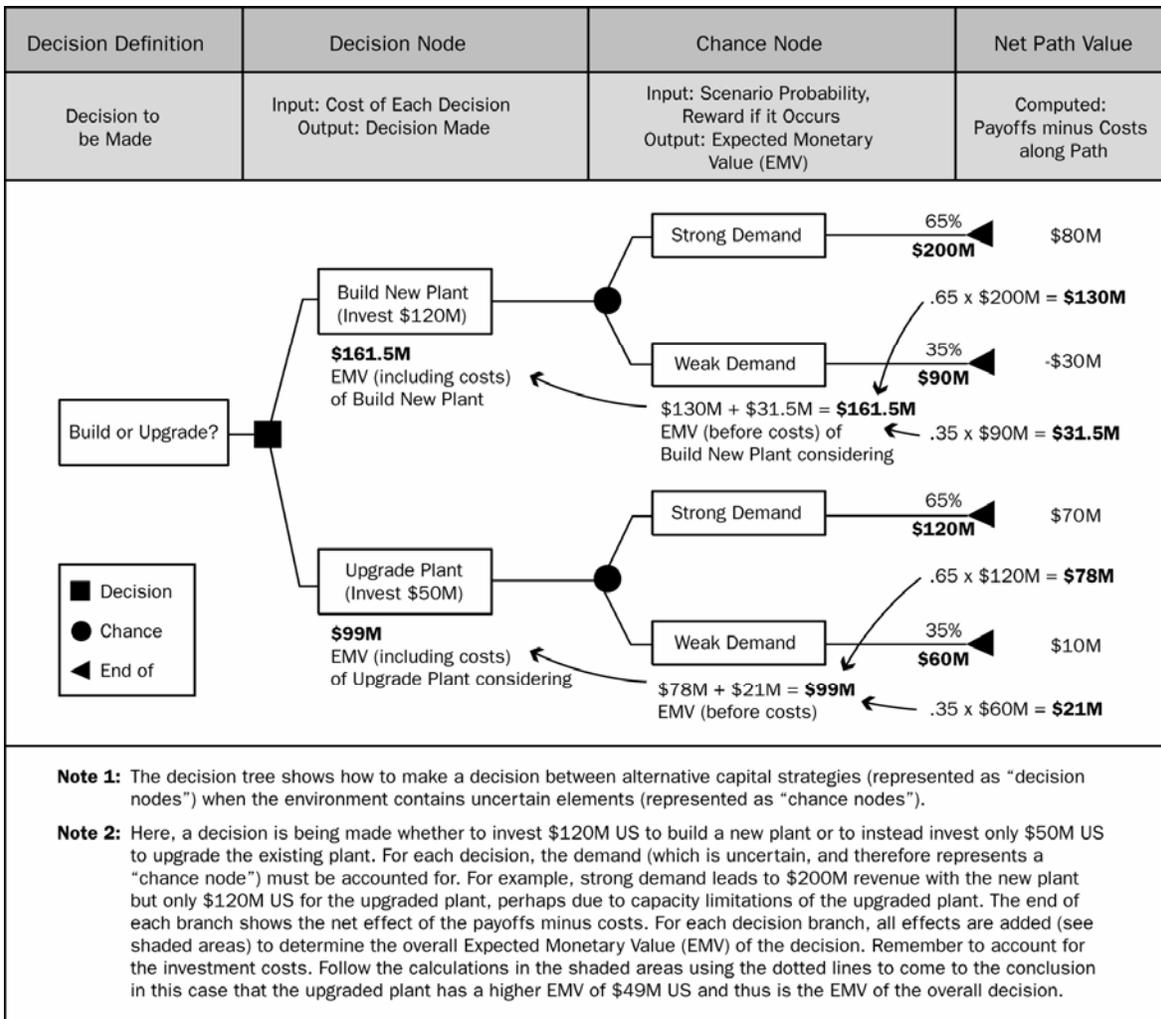


Figure 11-10. Decision Tree Diagram

- Modeling and simulation.** A project simulation uses a model that translates the uncertainties specified at a detailed level of the project into their potential impact on project objectives. Iterative simulations are typically performed using the Monte Carlo technique. In a simulation, the project model is computed many times (iterated), with the input values randomized from a probability distribution function (e.g., cost of project elements or duration of schedule activities) chosen for each iteration from the probability distributions of each variable. A probability distribution (e.g., total cost or completion date) is calculated from the iterations. For a cost risk analysis, a simulation can use source data from the traditional project WBS or a cost breakdown structure. For a schedule risk analysis, the network schedule is used. The output from a cost risk simulation is shown in Figure 11-11. Modeling and simulation are recommended for use in cost and schedule risk analysis, because they are more powerful and less subject to misuse and/or personal bias than EMV analysis.

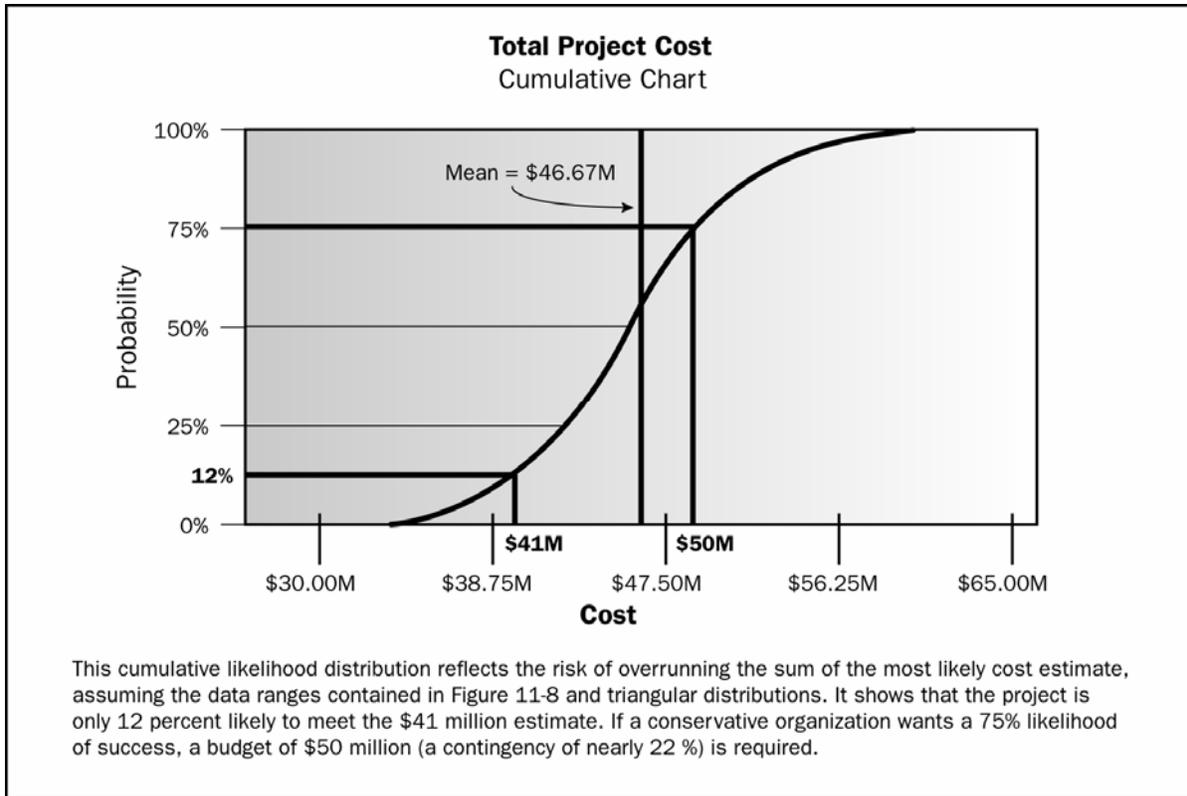


Figure 11-11. Cost Risk Simulation Results

Models are not exclusively iterative. They may also include basic mathematical derivations. The Program Evaluation and Review Technique (PERT) is a more rudimentary approach to quantitative analysis. (PERT applies a weighted average favoring the most likely outcome.):

$$\frac{O + 4M + P}{6}$$

6

While such non-iterative models do not take merge bias into account (as Monte Carlo does), they do provide alternative (and more optimistic) approaches for calculating the relative risk of a project.

.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 relative strengths. Experts may determine when a given tool may or may not be more appropriate given the organization's capabilities and culture.

11.4.3 Quantitative Risk Analysis: Outputs

.1 Risk Register Updates

The risk register is further updated to include a quantitative risk report, detailing quantitative approaches, outputs, and recommendations. Updates include the following main components:

- **Probabilistic analysis of the project.** Estimates are made of potential project schedule and cost outcomes, listing the possible completion dates and costs with their associated confidence levels. This output, often expressed as a cumulative distribution, can be 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. For instance, in Figure 11-11, the cost contingency to the 75th percentile is \$9 million US, or about 22% when compared to the \$41 million US sum of the most likely estimates shown in Figure 11-8.
- **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 11-11, the likelihood of achieving the cost estimate of \$41 million US (from Figure 11-8) is about 12%.
- **Prioritized list of quantified risks.** This list of risks includes those that pose the greatest threat or present the greatest opportunity to the project. These include the risks that may have the greatest effect on cost contingency and those that are most likely to influence the critical path. These risks may be identified, 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 history on project schedule, cost 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 or exploit opportunities and to reduce or eliminate threats to project objectives (Table 11-6 and Figure 11-12). It 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 (the “risk response owner”) to take responsibility for each agreed-to and funded risk response. Plan Risk Responses addresses the risks by their priority, inserting resources and activities into the budget, schedule, and project plan, as needed.

Planned risk responses must be appropriate to 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. They must also be timely. Selecting the best risk response from several options is often required.

The Plan Risk Responses section presents commonly used approaches to planning responses to the risks. Risks include threats and opportunities that can affect project success, and responses are discussed for each.

Table 11-6 Plan Risk Responses: Inputs, Tools & Techniques, and Outputs

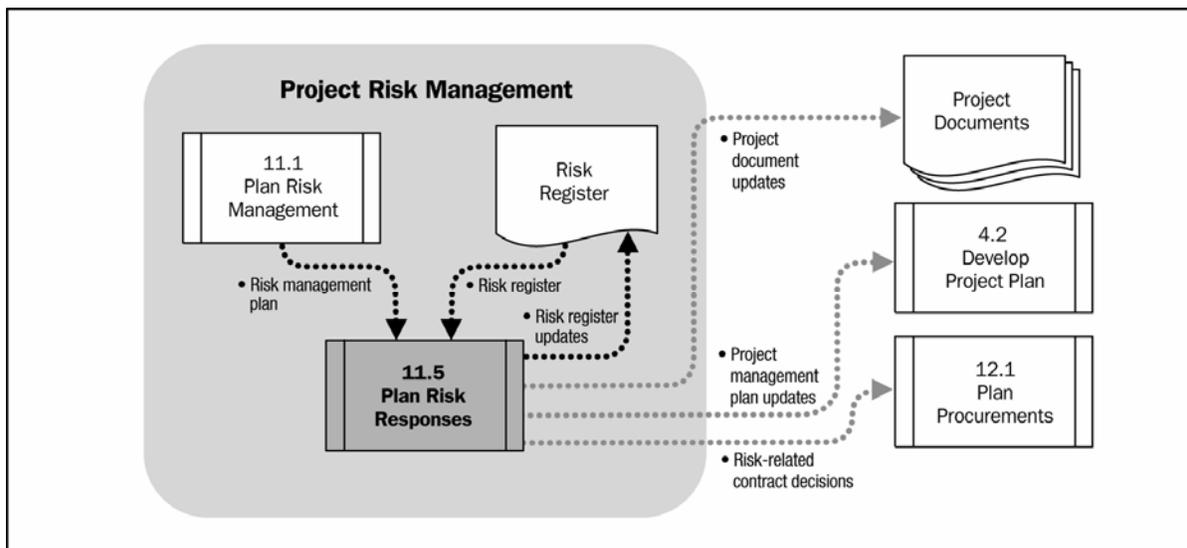


Figure 11-12 Plan Risk Responses Data Flow Diagram

11.5.1 Plan Risk Responses: Inputs

.1 Risk Register

The Plan Risk Responses 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, a list of risks requiring response in the near term, a list of risks for additional analysis and response, trends in qualitative analysis results, and a watchlist of low priority risks.

.2 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.

11.5.2 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 (11.4.2.1), can be used to choose the most appropriate responses. Then, specific actions are

developed to implement that strategy. Primary and backup strategies (as necessary) should be selected. A fallback plan can be developed for implementation (as warranted) if the selected strategy turns out not to be fully effective, or if an accepted risk occurs. Secondary risks (risks driven by the strategies) should also be reviewed. Often, a contingency reserve is allocated for time or cost. Finally, contingency plans can be developed, along with identification of the conditions that trigger their execution.

.1 Strategies for Negative Risks or Threats

Three strategies typically deal with threats or risks that may have negative impacts on project objectives if they occur. These strategies are to avoid, transfer, or mitigate:

- **Avoid.** Risk avoidance 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 transfer requires shifting some or all of the negative impact of a threat, along with ownership of the response, to a third party. Transferring the risk simply gives another party responsibility for its management—it does not eliminate it. Transferring liability for risk is most effective in dealing with financial risk exposure. Risk transference nearly always involves payment of a risk premium to the party taking on the risk. Transference tools 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, if the project's design is stable.
- **Mitigate.** Risk mitigation implies a reduction in the probability and/or impact of an adverse risk event to an acceptable threshold. 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.
- **Acceptance.** This strategy is adopted because it is seldom possible to eliminate all threat from a project. 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 threats or opportunities as they occur. The most common active acceptance strategy is

to establish a contingency reserve, including amounts of time, money, or resources to handle known, or even sometimes potential unknown, threats or opportunities.

.2 Strategies for Positive Risks or Opportunities

Three responses are suggested to deal with risks with potentially positive impacts on project objectives. These strategies are to exploit, share, or enhance.

- **Exploit.** This 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 better quality 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.** This 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 including 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.

.3 Contingent Response Strategy

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.

.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

.1 Risk Register Updates

In the Plan Risk Responses process, appropriate responses are chosen, agreed upon, and 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 "watchlist" for periodic monitoring. Components of the risk register at this point can include:

- Identified risks, their descriptions, area(s) of the project (e.g., WBS element) affected, their causes (e.g., RBS element), and how they may affect project objectives;
- Risk owners and assigned responsibilities;
- Outputs from the Perform Qualitative Analysis process (Section 11.3), including prioritized lists of project risks;
- Agreed-upon response strategies;
- Specific actions to implement the chosen response strategy;
- Symptoms and warning signs of risks' 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 analysis of the project and the organization's risk thresholds.

.2 Risk-Related Contract Decisions

Decisions to transfer risk, such as agreements for insurance, services, and other items as appropriate are selected in this process. This may result as a result of transferring part or all of the threat or sharing part or all of the opportunity. These decisions are inputs to the Plan Procurements (Section 12.1) process.

.3 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 (Section 6) 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 itself.
- **Cost management plan.** The cost management plan (Section 7) 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 and the consumption of contingency reserves.
- **Quality management plan.** The quality management plan (Section 8.1.3.1) 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 (Section 12.1.3.1) 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.

- **Staffing management plan.** The staffing management plan (Section 9.1.3.1) 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.
- **Work breakdown structure.** Because of new work (or omitted work) generated by the risk responses, the Work Breakdown Structure (WBS) (Section 5.3.3.1) may be updated to reflect those changes.
- **Schedule baseline.** Because of new work (or omitted work) generated by the risk responses, the schedule baseline (Section 6.5.3.2) may be updated to reflect those changes.
- **Cost performance baseline.** Because of new work (or omitted work) generated by the risk responses, the cost performance baseline (Section 7.2.3.1) may be updated to reflect those changes.

.4 Project Documents Updates

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

- **Assumptions log updates.** As new information becomes available through the application of risk responses, assumptions will inherently change. As such, the assumptions log must be revisited to accommodate this new information. Assumptions may be incorporated in the scope statement or in a separate assumptions log.
- **Technical documentation updates.** As new information becomes available through the application of risk responses, technical approaches, and physical deliverables may change. As such, any supporting documentation must be revisited to accommodate this new information.

11.6 Monitor and Control Risk

Monitor and Control Risk is the process of executing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project (see Table 11-7 and Figure 11-13).

Planned risk responses that are included in the project management plan are executed during the life cycle of the project, but the project work should be continuously monitored for new and changing risks.

The Monitor and Control Risk process applies techniques, such as variance and trend analysis, which require the use of performance data generated during project execution. Other purposes of the Monitor and Control Risk process are to determine if:

- Project assumptions are still valid,
- Risk, as assessed, has changed from its prior state, with analysis of trends,
- Proper risk management policies and procedures are being followed, and
- Contingency reserves of cost or schedule should be modified in line with the risks of the project.

Monitor and Control Risk can involve choosing alternative strategies, executing a contingency or fallback plan, taking corrective action, and modifying the project management

plan. The risk response owner reports periodically to the project manager on the effectiveness of the plan, any unanticipated effects, and any mid-course correction needed to handle the risk appropriately. Risk Monitoring and Control also includes updating the organizational process assets, including project lessons learned databases and risk management templates for the benefit of future projects.

Table 11-7 Monitor and Control Risks: Inputs, Tools & Techniques, and Outputs

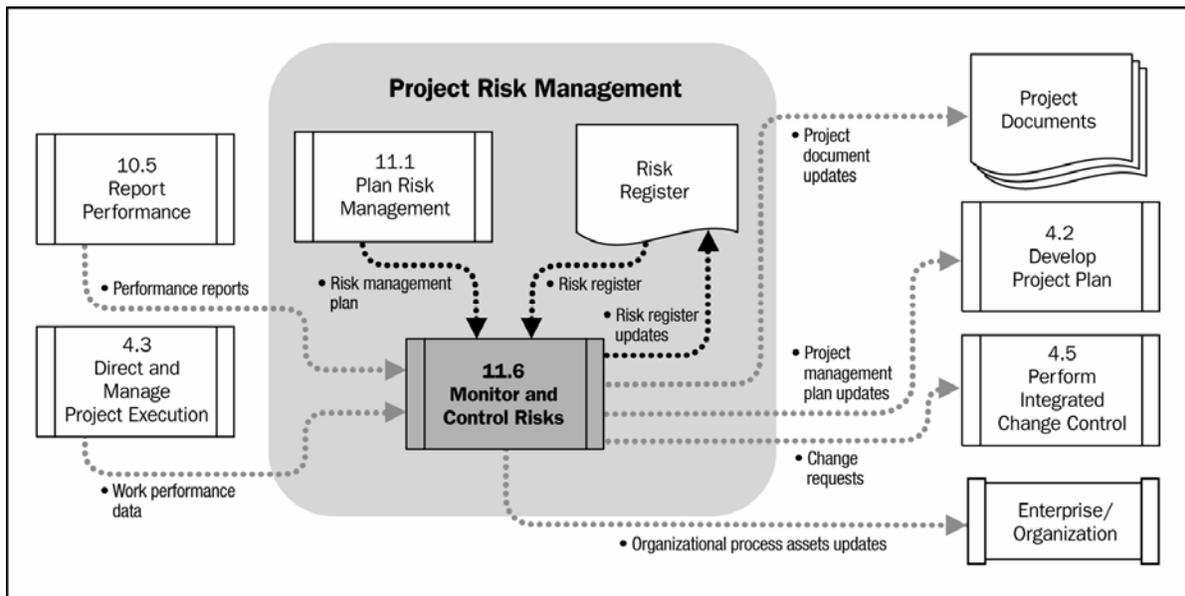
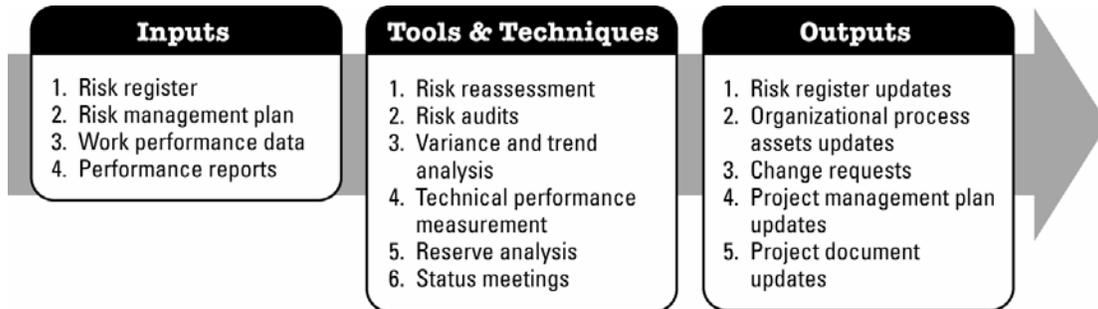


Figure 11-13. Monitor and Control Risks Data Flow Diagram

11.6.1 Risk Monitoring and Control: Inputs

.1 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 watchlist of low priority risks, and the time and cost contingency reserves.

.2 Risk Management Plan

This plan includes risk tolerances, protocols and the assignment of people (including the risk owners, time, and other resources to project risk management).

.3 Work Performance Data

Work performance data related to various performance results includes but is not limited to:

- Deliverable status,
- Schedule progress, and
- Costs incurred.

.4 Performance Reports

Performance reports (Section 10.5.3.1) takes information from performance measurements and analyzes it to provide information on project work performance, such as a variance analysis, earned value data and forecasting data.

11.6.2 Monitor and Control Risk: Tools and Techniques

.1 Risk Reassessment

Monitor and Control Risk often results in identification of new risks and reassessment of risks, using the processes of this chapter as appropriate. Project risk reassessments should be regularly scheduled. Project Risk Management should be an agenda item at project team status meetings. The amount and detail of repetition that is appropriate depends on how the project progresses relative to its objectives.

.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.

.3 Variance and Trend Analysis

Trends in the project's execution should be reviewed using performance data. Earned value analysis (Section 7.3.2.1) 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.

.4 Technical Performance Measurement

Technical performance measurement compares technical accomplishments during project execution to the project management plan's schedule of technical achievement. It requires definition of objective quantifiable measures of technical performance which can be used to compare actual results against targets. Such technical performance measures might 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, and expose the degree of technical risk faced by the project.

.5 Reserve Analysis

Throughout execution of the project, some risks may occur, with positive or negative impacts on budget or schedule contingency reserves (Section 11.5.2.3). 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.

.6 Status Meetings

Project risk management can be an agenda item at periodic status meetings. The amount of time 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, and frequent discussions about risk make talking about risks, particularly threats, easier and more accurate.

11.6.3 Monitor and Control Risk: Outputs

.1 Risk Register Updates

An updated risk register includes but is not limited to:

- Outcomes of risk reassessments, risk audits, and periodic risk reviews. These outcomes may include 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.
- 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.

.2 Organizational Process Assets Updates

The six Project Risk Management processes produce information that can 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, can be updated at project closure;
- Risk breakdown structure; and
- Lessons learned from the project risk management activities.

Final versions of the risk register and the risk management plan templates, checklists, and risk breakdown structure are included.

.3 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 4.5.1.1). Change requests can include recommended corrective and preventive actions as well.

- **Recommended corrective actions.** Recommended corrective actions include contingency plans and workaround plans. 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.** Recommended preventive actions are used to bring the project into compliance with the project management plan.

.4 Project Management Plan Updates

If the approved change requests have an effect on the risk management processes, then 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 (Section 11.5).

.5 Project Document Updates

Project documents that may be updated as a result of the Monitor and Control Risks process are the same as those in the Plan Risk Responses process (Section 11.5).

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 to perform the work. This chapter presents two perspectives of procurement. The organization can be either the buyer or seller of the product, service, or results under 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.

Table 12-1 provides an overview of the Project Procurement Management processes which include the following:

12.1 Plan Procurements—The process of documenting project purchasing decisions, 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 Administer 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 the processes in the other Knowledge Areas. Each process can involve effort from one or more persons or groups of persons, based on the requirements of the project. Each process occurs in one or more project phases, if the project is divided into phases. Although the processes are presented here as discrete components with well-defined interfaces, in practice they overlap and interact in ways not detailed here. Process interactions are discussed in detail in Chapter 3, Project Management Processes.

The Project Procurement Management processes involve 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. A contract is a legal relationship subject to remedy in the courts. The agreement can be simple or complex, and can reflect the simplicity or complexity of the deliverables and procured effort.

A procurement contract will include terms and conditions, and may incorporate other items that the buyer relies upon to establish 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 for example, an agreement, an understanding, a subcontract, or a purchase order. Most organizations will have documented policies and procedures specifically defining the procurement rules and specifically prescribing who has delegated 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 ensures 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 the disciplines of contracting, purchasing, law, and technical. 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 or 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.

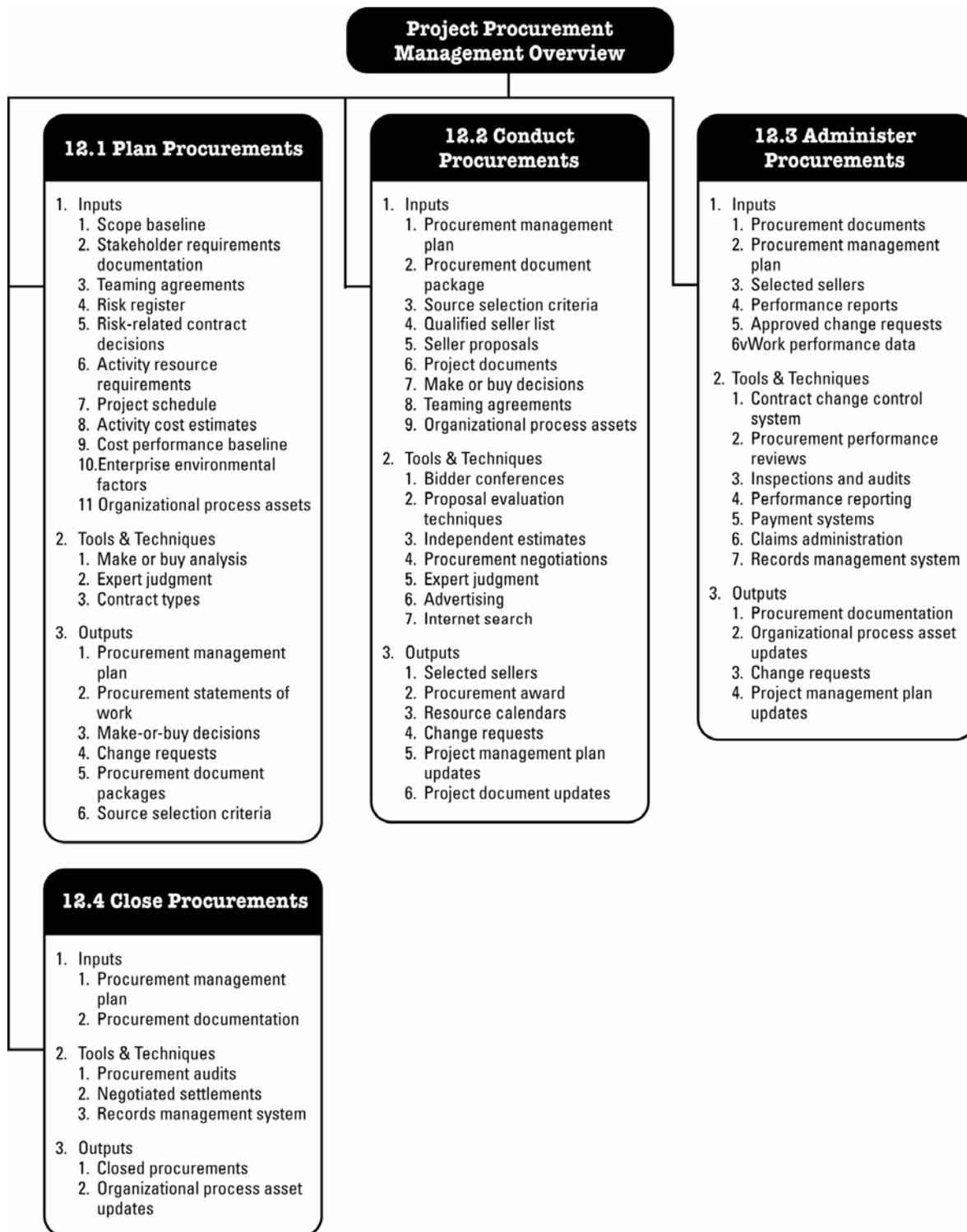
The seller will typically manage the work as a project if the acquisition is not just for shelf material, goods, or common products. In such cases:

- 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).

This chapter assumes that the buyer of items for the project is within or assigned to the project team and that the sellers are organizationally external to the project team.

It also assumes that a formal contractual relationship will be developed and exist between the buyer and the seller. However, most of the discussion in this chapter is equally applicable to non-contractual inter-divisional work, entered into with other units of the project team's organization.

Table 12-1. Project Procurement Management Overview



12.1 Plan Procurements

Plan Procurements is the process of documenting project purchasing decisions, the approach, and identifying potential sellers (see Table 12-2 and Figure 12-1). It identifies those project needs

which 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.

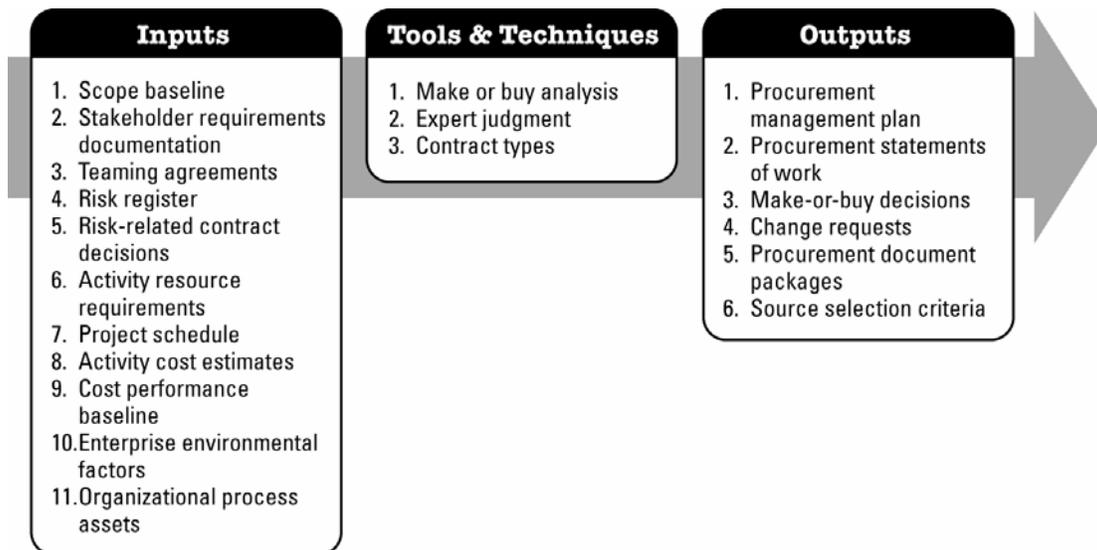
This process involves consideration of whether, how, what, how much, and when to acquire outside support. When the project obtains products, services, and results required for project performance from outside the performing organization, the processes from Plan Procurements through Close Procurements are performed for each item to be acquired.

The Plan Procurements 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 Procurements process. Decisions made in developing the procurement management plan can also influence the project schedule and are integrated with Develop Schedule (Section 6.5), Estimate Activity Resources (Section 6.3), and make-or-buy decisions (Section 12.1.3.3).

The Plan Procurements process includes consideration of the risks involved with each make-or-buy decision, and also includes reviewing the type of contract planned to be used with respect to mitigating risks, sometimes transferring risks to the seller.

Table 12-2. Plan Procurements Inputs, Tools and Techniques and Outputs.



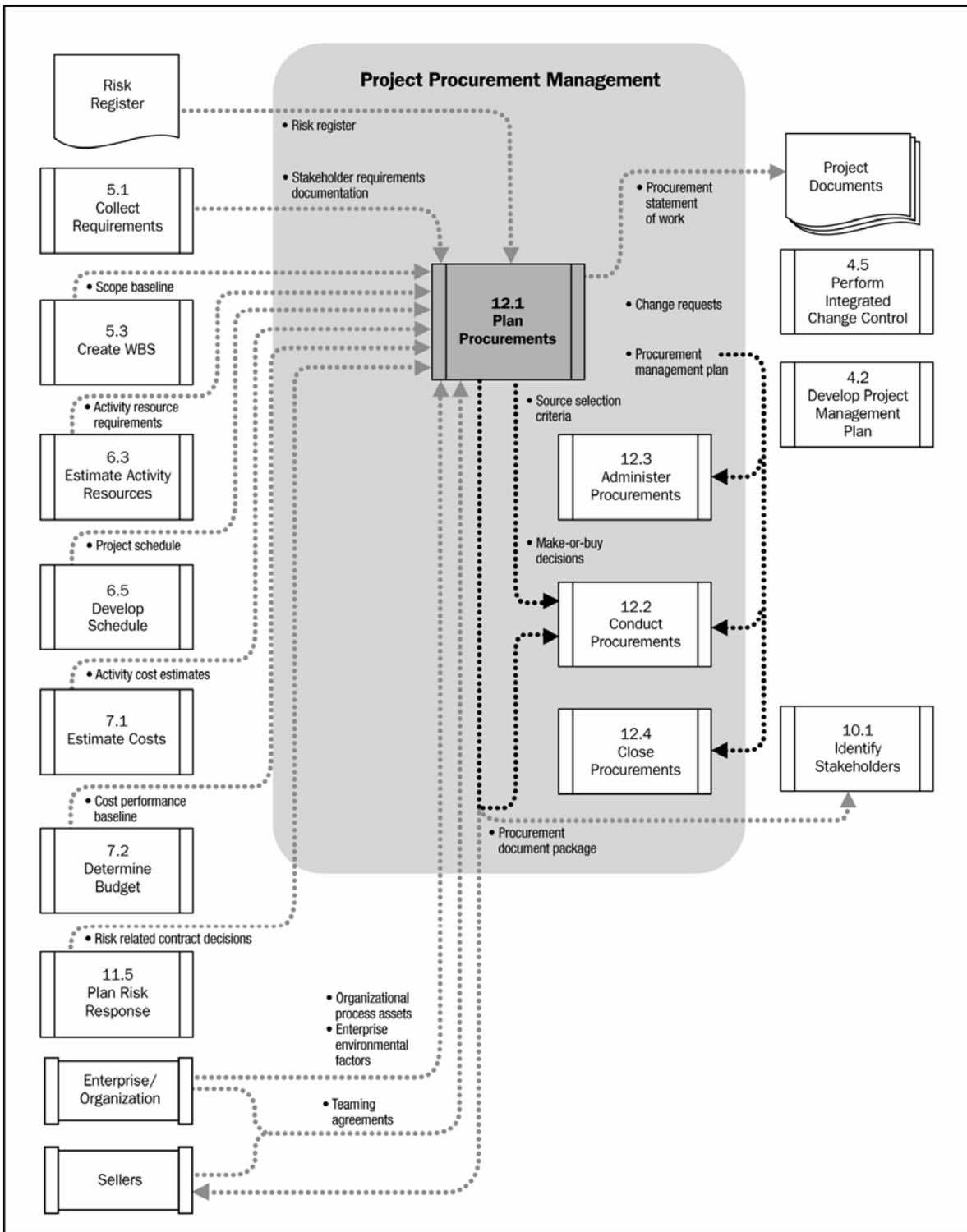


Figure 12-1 Plan Procurements Data Flow Diagram

12.1.1 Plan Procurements: Inputs

.1 Scope Baseline

The scope baseline (Section 5.3.3.3) describes the need, justification, requirements, and current boundaries for the project. It consists of the following components:

- **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. Examples of constraints are required delivery dates, available skilled resources, and organizational policies.
- **Work breakdown structure (WBS).** The project's WBS (Section 5.3.3.1) provides a pictorial display of the relationships among the components of the project and the project deliverables (Section 4.3.3.1).
- **WBS dictionary.** The WBS dictionary (Section 5.3.3.2) 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.

.2 Stakeholder Requirements Documentation

Stakeholder requirements documentation may include:

- Important information about project requirements that is considered during planning for procurements.
- Requirements with contractual and legal implications 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.

.3 Teaming Agreements

Teaming agreements are a legal contractual agreement between two or more entities to form a partnership or joint venture, or some other arrangement as defined by the parties. The agreement defines buyer-seller roles for each party. Whenever the new business opportunity ends, the teaming agreement also ends. Whenever a teaming agreement is in effect, the planning process for the project is significantly impacted. Thus whenever a teaming agreement is in place on a project, the roles of buyer and seller are predetermined, and such issues as scope of work, competition requirements, and other critical issues are generally predefined in a teaming arrangement.

.4 Risk Register

The risk register includes risk-related information such as the identified risks, risk owners, and risk responses. (Section 11.2.3.1).

.5 Risk-Related Contract Decisions

Includes agreements for insurance, bonding, services, and other items as appropriate, that are prepared to specify each party's responsibility for specific risks, should they occur. (Section 11.5.3.2).

.6 Activity Resource Requirements (Section 6.3.3.1)

Contains information on specific needs such as people, equipment, or location needs.

.7 Project Schedule (Section 6.5.3.1)

Contains information on required timelines or mandated deliverables dates.

.8 Activity Cost Estimates (Section 7.1.3.1)

Estimates are used as a basis on which to regard bids.

.9 Cost Performance Baseline (Section 7.2.3.1)

Provides detail on the planned budget over time.

.10 Enterprise Environmental Factors

The enterprise environmental factors that can influence the Plan Procurements process include but are not limited to:

- Marketplace conditions, and
- Products services and results that are available in the marketplace, the supplier, past performance of suppliers, under what terms and conditions.

.11 Organizational Process Assets

The Organizational process assets that influence the Plan Procurement 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, then the project team will have to 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 contract types to be used.
- Organizations will sometimes have an established multi-tier supplier system of pre-qualified sellers based on prior experience.

12.1.2 Plan Procurements: Tools and Techniques

.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 procure such effort from outside the organization in order to meet its schedule commitments.

Any budget constraints are factors which 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.

.2 Expert Judgment

Expert technical judgment will often be 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 procured products, services, or results and to various aspects of the procurement management processes.

.3 Contract Types

Although the firm-fixed-price type of contractual arrangement is typically the preferred type which is encouraged and often demanded by most organizations, there are times when another contract form may be in the best interests of the project when considering all factors. If a contract type other than fixed-price is intended, it is incumbent on the project team to justify its use. The type of contract to be used and the specific contract terms and conditions fix the degree of risk sharing being assumed by the buyer and seller.

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 services 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, 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 must precisely specify the product or services being procured. Changes in scope can 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 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, plus a fee representing seller profit for completed work. 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 (CFIF), and Cost Plus Award Fee (CFAF).

The cost reimbursable contract gives the project the needed 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). 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). 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 pre-negotiated cost sharing formula, e.g., an 80/20 split over/under target costs.
 - Cost Plus Award Fee Contracts (CPAF). This is a cost reimbursement contract whereby the seller is reimbursed for all legitimate costs, but the majority of fee is only earned based on the satisfaction of certain broad subjective performance criteria, as 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 type arrangements. 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 type arrangements in that they can be left open ended and may be subject to cost growth 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 type arrangements. 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 when both parties agree on the values for specific resource categories, for example senior engineers at so much per hour, or categories of materials at specified rates per unit.

12.1.3 Plan Procurements: Outputs

.1 Procurement Management Plan

The procurement management plan describes how the procurement processes will be managed from developing procurement documentation through contract closure. The procurement management plan can include guidance for:

- The types of contracts to be used;
- Whether independent estimates will be used and if they are needed as evaluation criteria;
- Those actions the project management team can take unilaterally, if the performing organization has a proscribed procurement, contracting, or purchasing department;
- Standardized procurement documents, if they are 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 pre-qualified 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 (Section 4.3.1.1).

.2 Procurement Statements of Work

Each procurement statement of work (SOW) defines for those items being purchased, only that portion of the project scope that is to be included within the related contract. The SOW for each contract is developed from the project scope baseline. The procurement SOW describes the

procurement item in sufficient detail to allow prospective sellers to determine if they are capable of providing the item. Sufficient detail can vary, based on the nature of the item, the needs of the buyer, or the expected contract form. A procurement SOW describes the products, services, or results to be supplied by the seller. Information included in a SOW can include specifications, quantity desired, quality levels, performance data, period of performance, work location, and other requirements.

The 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 contract 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.

.3 Make-or Buy Decisions

Make-or-buy documents the decisions of what project products, services, or results will be acquired from outside the project organization, or will be performed internally by the project team. This may also include decisions to buy insurance policies or performance bond contracts to address some of the identified risks. The make-or-buy decisions document can be as simple as a listing that includes a short justification for the decisions. These decisions can be altered as subsequent procurement activities indicate a requirement for a different approach.

.4 Change Requests

Change requests (Section 4.3.3.3) to the project management plan, its subsidiary plans and other components may result from the Plan Procurements process. Change requests are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).

.5 Procurement Document Packages

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 contractor 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 documentation can 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.

.6 Source Selection Criteria

Selection criteria are often included as a part of the procurement solicitation documents. Such criteria are developed and used to rate or score seller proposals, and can be objective or subjective.

Selection criteria can 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 a more complex product or service or results. Some examples are:

- **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 (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, and how much risk will be assigned to the selected seller?
- **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 documentation requirements or are they likely to provide more 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 type or category of business, such as small, women-owned, or disadvantaged small businesses, as defined by the buyer or established by governmental agency and set-forth as a condition of 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?

12.2 Conduct Procurements

Conduct Procurements is the process of obtaining seller responses, selecting a seller, and awarding a contract (Table 12.3 and Figure 12-2). In this process the team will receive bids or proposals and will apply previously defined evaluation criteria, as applicable, to select one or more sellers who are both qualified to perform the work and acceptable as a seller. Many factors can be evaluated in the seller selection decision process, for example:

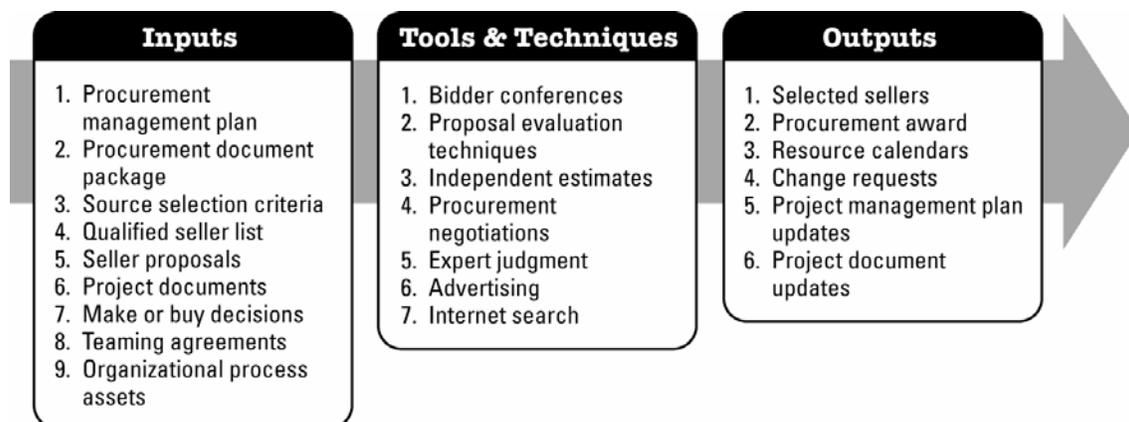
- Price or cost can be the primary determinant for a standard off-the-shelf item, but the lowest proposed price may not be the lowest cost if the seller proves unable to deliver the products, services, or results in a timely manner.
- Proposals are often separated into technical (approach) and commercial (price) sections, with each issue evaluated separately. Sometimes, management sections are required as a part of the proposal and also have to be evaluated separately.
- Multiple sources could be required for critical products, services, and results to mitigate risks that can be associated with issues such as delivery schedules and quality requirements. The potentially higher cost associated with such multiple sellers, including any loss of possible quantity discounts, and replacement and maintenance issues, are considered.

The tools and techniques described here can be used alone or in combination to 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 weighed evaluation scores assigned to each proposal.

On major procurement items, the overall process of requesting responses from sellers and evaluating sellers' 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 specific and comprehensive requirements document requested from the sellers on the short list.

Table 12-3. Conduct Procurements Inputs, Tools & Techniques, and Outputs



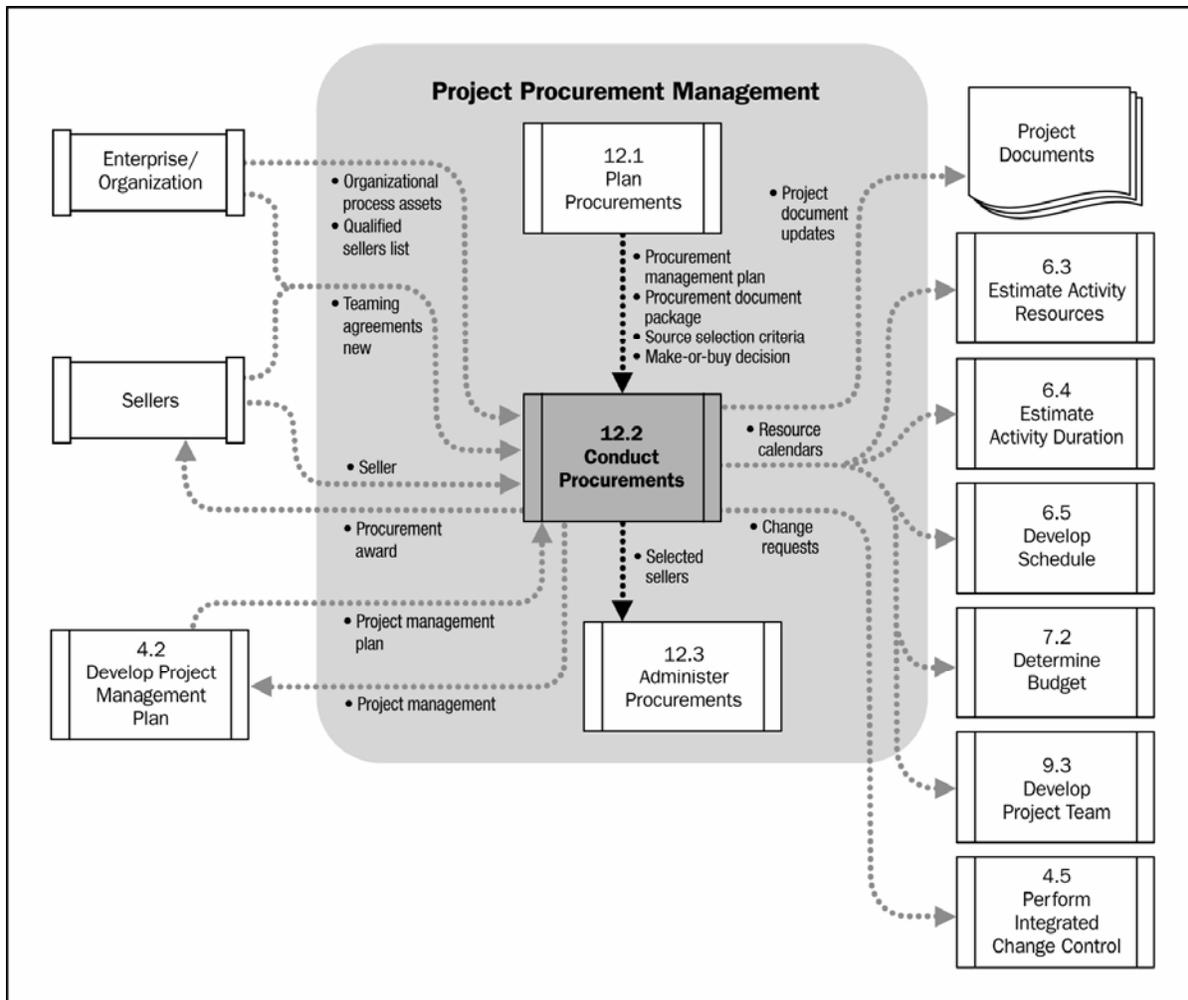


Figure 12-2. Conduct Procurements Data Flow Diagram

12.2.1 Conduct Procurements: Inputs

.1 Procurement Management Plan

Described in Section 12.1.3.1.

.2 Procurement Document Package

Described in Section 12.1.3.5.

.3 Source Selection Criteria

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.

.4 Qualified Sellers List

Described in Section 12.2.1.4.

.5 Seller Proposals

Seller proposals prepared in response to a procurement document package form the basic set of information that will be used by an evaluation body to select one or more successful bidders (sellers).

.6 Project Documents

To the extent that project documents are available, they are considered during the Select Sellers process. Other documents that are often considered include:

- Risk register (Section 11.5.1.1).
- Risk-related contract decisions (Section 11.5.3.2).

.7 Make or Buy Decisions

Described in Section 12.1.3.3.

.8 Teaming Agreements

Whenever a teaming 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 some form of interim 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 and plan which satisfies the requirements of the project. The two parties will then negotiate a final contract for award.

.9 Organizational Process Assets

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.

12.2.2 Conduct Procurements: Tools and Techniques

.1 Bidder Conferences

Bidder conferences (sometimes also called contractor conferences, vendor conferences, and pre-bid conferences) are meetings with all prospective sellers and buyers 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 and answer from any individual seller.

.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 process will be defined by the buyer's procurement policies. The evaluation committee will make their selection for approval by management prior to award.

.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.

.4 Procurement Negotiations

Negotiations clarify the structure and requirements 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 and authorities, authority to make changes, applicable terms and governing law, technical and business management approaches, proprietary rights, contract financing, technical solution, overall schedule, payments, and price. Contract negotiations conclude with a document that can be executed by both buyer and seller that constitutes the contract.

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 prefixed and non-negotiable, 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 clarifications of the project's technical, quality, and management requirements.

.5 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, law, finance, accounting, engineering, design, research, development, sales, and manufacturing.

.6 Advertising

Existing lists of potential sellers can often be expanded by placing advertisements in general circulation publications such as selected newspapers or in specialty trade publications. Some government jurisdictions require public advertising of certain types of procurement items; and most government jurisdictions require public advertising of pending government contracts.

.7 Internet Search

The Internet has a major influence on most of the project procurements and supply chain acquisitions in organizations. A vast majority of commodities, components, shelf-items can be quickly located and secured at a fixed-price on the Internet. However, while the majority of purchased items may be obtained using the Internet, the high-risk, highly complex, procured effort that must be closely monitored cannot be obtained by this means.

12.2.3 Conduct Procurements: Outputs

.1 Selected Sellers

The sellers selected are those sellers who have been judged to be in a competitive range based upon the outcome of the proposal or bid evaluation, and who have negotiated a draft contract, which 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.

.2 Procurement Award

A procurement contract is awarded to each selected seller. 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 a contract document will vary, but will sometimes include the following:

- Statement of work or deliverables,
- Schedule,
- Performance reporting,
- Period of performance,
- Roles and responsibilities,
- Sellers place of performance,
- Pricing,
- Payment terms,
- Place of delivery,
- Inspection and acceptance criteria ,
- Warranty,
- Product support,
- Limitation of liability,
- Fees and retainage,
- Penalties,
- Incentives,
- Insurance and performance bonds,
- Subordinate subcontractor approvals,
- Change request handling, and
- Termination and alternate disputes resolution mechanisms.

.3 Resource Calendars

The quantity and availability of contracted resources and those dates on which each specific resource can be active or idle are documented.

.4 Change Requests

Change request to the project management plan, its subsidiary plans and other components, such as the project schedule (Section 6.5.3.1) and procurement management plan, may result from the Select Sellers process. Requested changes are processed for review and disposition through the Perform Integrated Change Control process (Section 4.5).

.5 Project Management Plan Updates

Elements of the Project Management Plan include but are not limited to:

- Cost Baseline,
- Scope Baseline,
- Schedule Baseline, and
- Procurement Management Plan.

.6 Project Document Updates

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

- Stakeholder requirements documentation,
- Requirements Traceability Documentation, and
- Risk Register.

12.3 Administer Procurements

Administer Procurements is the process of managing procurement relationships, monitoring contract performance, and making changes and corrections as needed (see Table 12-4 and Figure 12-3). 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 Administer Procurements process ensures that the seller's performance meets procurement requirements and that the buyer performs according to the terms of their legal contract. 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 administering 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.

Administer Procurements includes application of the appropriate project management processes to the contractual relationship(s), and integration of the outputs from these processes into 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 Execution (Section 4.3) to authorize the contractor's work at the appropriate time;

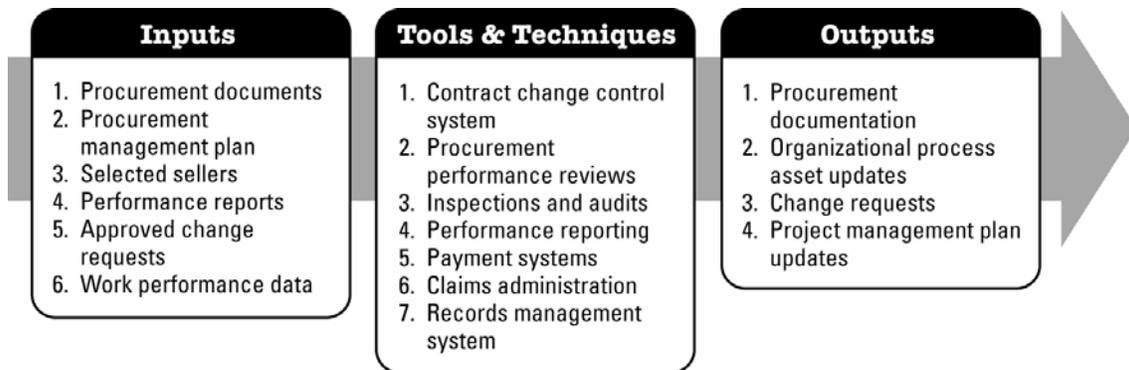
- Report Performance (Section 10.5) to monitor contractor cost, schedule, and technical performance;
- Perform Quality Control (Section 8.3) to inspect and verify the adequacy of the contractor’s product;
- Perform Integrated Change Control (Section 4.5) to assure that changes are properly approved, and that all those with a need to know are aware of such changes; and
- Monitor and Control Risks (Section 11.6) to ensure that risks are mitigated.

Procurement administration also has a financial management component that involves monitoring of 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 be some close relationship of payments made to the work accomplished.

The Administer Procurements process reviews and documents how well a seller is performing or has performed based on the contract and established corrective actions when needed. Also, the performance is documented as a basis for future relationships with the seller. Seller performance evaluation by the buyer is primarily carried out to confirm the competency or lack of competency of the seller, relative to performing similar work on the project or other projects. Similar evaluations are also carried out when it is necessary to confirm that a seller is not meeting the seller’s contractual obligations, and when the buyer contemplates corrective actions. Administer Procurements includes managing any early terminations of the contracted work (for cause, convenience, or default) in accordance with the termination clause of the contract.

Contracts 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.

Table 12-4. Administer Procurements Inputs, Tools & Techniques and Outputs



12.3.1 Administer Procurements: Inputs

.1 Procurement Documents

Described in Section 12.1.3.5.

.2 Procurement Management Plan

Described in Section 12.1.3.1.

.3 Selected Sellers

Described in Section 12.2.3.1.

.4 Performance Reports

Seller performance-related documentation includes:

- Seller-developed technical documentation and other deliverable information provided in accordance with the terms of the contract; and
- Seller performance reports (Section 10.5.3.1). The seller's performance reports indicate which deliverables have been completed and which have not.

.5 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 description of the products, services, or results to be provided. All changes are formally documented in writing and approved before being implemented.

.6 Work Performance Data

Work performance data (Section 4.3.2), including the extent to which quality standards are being satisfied, what costs have been incurred or committed, which seller invoices have been paid, are all collected as part of project execution.

12.3.2 Administer Procurements: Tools and Techniques

.1 Contract Change Control Systems

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.

.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 non-compliance which allows 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.

.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.

.4 Performance Reporting

Performance reporting provides management with information about how effectively the seller is achieving the contractual objectives.

.5 Payment Systems

Payments to the seller are typically processed by the accounts payable system of the buyer, after certification of satisfactory work by someone on the project team. All payments should be made in strict accordance with the terms of the contract.

.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 even 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 alternate disputes resolution (ADR) typically following procedures established in the contract. Settlement of all claims and disputes through negotiation is the preferred method.

.7 Records Management System

A records management system is a specific set of processes, related control functions, and automation tools that are consolidated and combined into a whole, as part of the project management information system (Section 4.3.2.2). A records management system is used by the project manager to manage contract and procurement documentation and records. The system is used to maintain an index of contract documents and correspondence, and assist with retrieving and archiving that documentation.

12.3.3 Administer Procurements: Outputs

.1 Procurement Documentation

Procurement documentation includes but is not limited to 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, warranties, financial documents including invoices and payment records, and the results of contract-related inspections.

.2 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 clarifications. 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 can form the basis for early termination of the seller's contract, or determining how contract penalties, fees, or incentives are administered. The results of these performance evaluations can also be included in the appropriate qualified seller lists (Section 12.2.1.4).

.3 Change Requests

Change requests to the project management plan, its subsidiary plans and other components, such as the project schedule (Section 6.5.3.1) and procurement management plan (Section 12.1.3.1), may result from the Administer Procurements process. Change requests are processed for review and approval through the Perform Integrated Change Control process (Section 4.5).

Requested 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.

.4 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 (Section 12.1.3.1) is updated to reflect any approved change requests that affect procurement management, including impacts to costs or schedules.
- Baseline schedule. If there are slippages that impact overall project performance the baseline schedule may need to be updated to reflect the current expectations.

12.4 Close Procurements

Close Procurements is the process of completing each project procurement. It supports the Close Project or Phase process (Section 4.6), since it involves verification that all work and deliverables were acceptable.

The Close Procurements process also involves administrative activities, such as 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 multi-phase 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, which can result from a mutual agreement of both parties, from the default of one of the parties, 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 project, for cause or convenience, at any time. 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.

Table 12-5. Plan Quality Inputs, Tools & Techniques and Outputs.

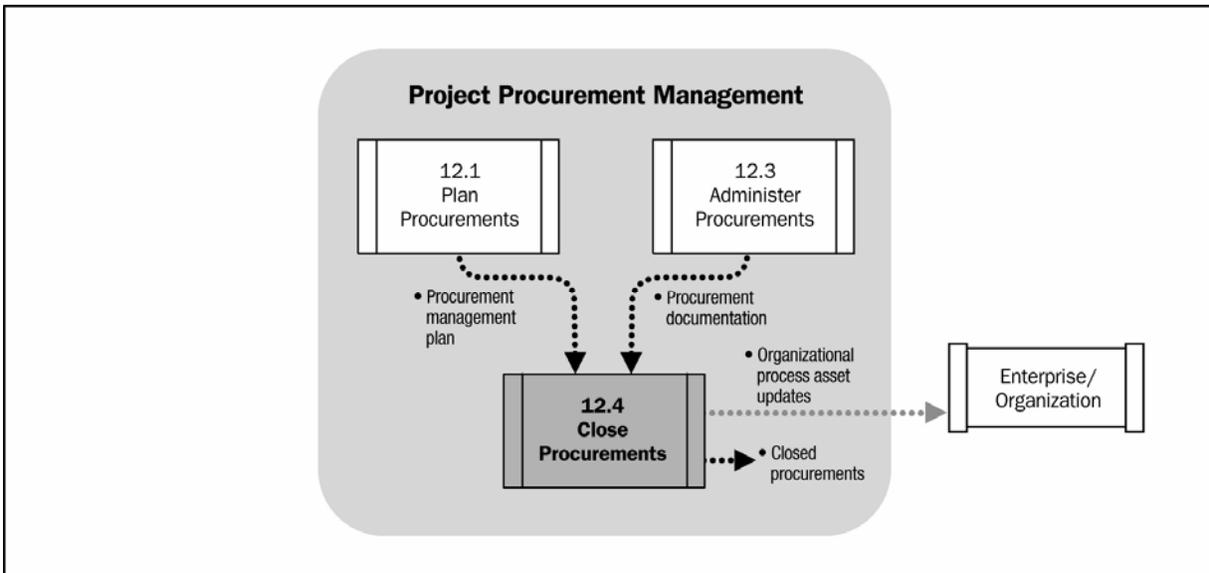


Figure 12.4 Close Procurements Data Flow Diagram

12.4.1 Close Procurements: Inputs

.1 Procurement Management Plan

Described in Section 12.1.3.1.

.2 Procurement Documentation

Described in Section 12.3.3.1.

12.4.2 Close Procurements: Tools and Techniques

.1 Procurement Audits

A procurement audit is a structured review of the procurement process originating from the Plan Procurements process (Section 12.1) through Administer Procurements (Section 12.3). The objective of a procurement audit is to identify successes and failures that warrant recognition in the

preparation or administration of other procurement contracts on the project, or on other projects within the performing organization.

.2 Negotiated Settlements

In all procurement relationships the final equitable settlement of all outstanding issues, claims, disputes, by negotiation is a primary goal of the project. Whenever settlement cannot be achieved through direct negotiation, then some form of alternate disputes resolution (ADR) like mediation or arbitration may be explored. When all else fails, litigation in the courts is the least desirable option.

.3 Records Management System

Described in Section 12.3.2.7.

12.4.3 Close Procurements: Outputs

.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.

.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 contract 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 non-conforming deliverables, are usually defined in the contract.
- Lessons learned documentation. Lessons learned analysis, what has been experienced, and process improvement recommendations, should be developed for the project file to improve future procurements.