PMP® Study Guide

Amol Kshirsagar, PMP

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PMP® Study Guide

What it covers

► Strong emphasis to cultivate PMBOK® Guide’s way of project management
► Help in remembering processes, niche tools and techniques
► Formulas, important figures, tables and diagrams

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Introduction

In this “mini-guide,” maximum efforts have been made to simplify and explain *PMBOK® Guide* concepts in layman’s terms. It has been written and organized without reinventing the wheels of *PMBOK® Guide*—Fifth Edition in terms of key concepts, pictures, diagrams, figures and tables. All of it has been presented “as is” to maintain a standard throughout studies so that learners should don’t deviate from main concepts. Explanation in this guide is also brief and to the point so anyone can understand and remember things better. Those who have already scheduled the exam and are wondering what to study can revisit learned concepts efficiently and effectively, because no one can remember each and every word by heart from *PMBOK® Guide*—and that’s where this “mini-guide” comes into play, to cover the important essence of the PMP exam and provide a perfect avenue to quickly review end-to-end project management areas with vital knowledge.

Who this is for

In today’s busy schedule, it’s not always feasible for everyone to read the complete *PMBOK® Guide* every time, but it does not imply that one should not read it at all. This “mini-guide” is designed to help those who are aspiring to learn and manage projects in the PMI way—but have a little time and want to study qualitatively prior to the exam. It focuses specifically on studying one to two weeks prior to the exam to boost understanding from the PMI perspective under one umbrella; it will help you keep the rhythm of knowledge areas and process groups intact on a separate paradigm. It will be very helpful in allowing you to connect the dots, not panic and face and pass the exam confidently with well-organized exam notes. This “mini-guide” is going to help those who have already completed reading *PMBOK® Guide* at least a few times.

This “mini-guide” includes tools and techniques, not limited to *PMBOK® Guide* but also from vast variety of project management practices used globally. This guide is also helpful for those who are already PMP certified and want to revisit or refer to processes, project skills and tools & techniques—to quickly learn them, and to implement actions in real-time project scenarios as project practitioners to enhance knowledge, performance and interpersonal skills.

We want to hear from you

Please share your valued feedback or report an error. Community feedback is a most valuable asset. Please tell us what you think of this guide at: amol.dksagar@gmail.com.
1. **What is a Project?**

A project is a temporary endeavour undertaken to create a unique product, service or result. A temporary means it has a definite beginning and end (start and end date, and progressively elaborated).

*Note: A project is not day-to-day operations, processes or strategic-based activities that support the business and systems of the organization.*

2. **What is Project Management?**

Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. Project management is accomplished through the appropriate application of systematically integrated 47 logically grouped project management processes, which are categorized into five Process Groups:

| Initiating | Planning | Executing | Monitoring & Controlling | Closing |

3. **What is Program Management?**

A program is a group of related projects, subprograms and program activities managed in a coordinated way to obtain benefits not available from managing them individually. Programs may include elements of related work outside the scope of the discrete projects in the program. **A project may or may not be** part of a program, but a program will always have projects. The program management mainly focuses on the interdependencies between the projects to resolve variety of issues, change management, constraint and conflicts and align organizational/strategic direction that affects project and program goals and objectives.

4. **What is Portfolio Management?**

A portfolio includes individual projects, programs, sub portfolios and operations managed as a group to achieve **strategic objectives**. The projects or programs of the portfolio may not necessarily be interdependent or directly related.
5. What is a Project Management Office (PMO)?

A project management office (PMO) is a management structure that standardizes the project-related governance, processes and facilitates the sharing of resources, methodologies, tools and techniques. The responsibilities of a PMO can range from providing project management support functions to actually being responsible for the direct management of one or more projects.

5.1 Types of PMO

5.1.1 Supportive:

Supportive PMOs provide a consultative role to projects by supplying policies, methodologies, templates, best practices, training, access to information and lessons learned from other projects. This type of PMO serves as a project repository. The degree of control provided by the PMO is low.

5.1.2 Controlling:

Controlling PMOs provide support and guidance and require compliance through various means. Compliance may involve adopting project management frameworks or methodologies, using specific templates, forms and tools or conformance to governance. The degree of control provided by the PMO is moderate.

5.1.3 Directive:

Directive PMOs take control of the projects by directly managing the projects. The degree of control provided by the PMO is high.

6. Types of Organizational Structures

Organization structures range from functional to projectized, with a variety of matrix structures in between.
Types of Organizational Structures

### Table 6-1 Influence of Organizational Structures on Projects

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

### 6.1 Functional Organization:

This is a common form of organization. Such organizations are grouped by areas of specialization within different functional areas also known as “silos” (marketing, accounting, and manufacturing). Each department in a functional organization will do its project work in addition to routine department work.

![Figure 6-1 Functional Organization](image)

### 6.2 Matrix Organizations
Types of Organizational Structures

Weak, balanced or strong matrix organizations reflect a blend of functional and projectized characteristics. It all depends on relative level of power and influence between functional and project manager; this is an attempt to maximize the strengths of both the functional and projectized structure. When you see word “matrix,” assume there are always “two bosses.”

Note: A tight matrix has nothing do with organization type; it one of the tool or technique used in HRMS.

6.2.1 Weak matrix

Power is with functional manager and power of project manager is comparable to that of a coordinator or expediter.

- **Project Coordinator**: This position is similar to the project expediter, except the coordinator has power to make decisions, some authority and reports to a higher-level manager.
- **Project Expediter**: The project expediter works as a staff assistance and communications coordinator. The expediter cannot personally make or enforce decisions.

![Figure 6-2 Weak Matrix Organizations](image)

6.2.2 Balanced matrix

The power is shared between the functional manager and the project manager.
6.2.3 Strong matrix

Project manager has more authority (power) than functional manager.

6.3 Projectized Organization

In a projectized organization, the entire company is organized by projects, and the project manager has control of the project with a great deal of independence and authorities. Personnel are assigned and report to a project manager. When project is over, they cannot continue to work as employee.
because teams are organized around projects, the team is released, in short do not have department to go back to.

7. Project Life Cycle

The project life cycle refers to a series of activities which are necessary to fulfil project goals or objectives. Projects vary in size and complexity, but no matter how large or small, every project has certain phases of development. A clear understanding of these phases allows managers and executives to maintain control of the project more efficiently. By definition, a project has a beginning and an end and passes through several phases of development known as life cycle phases. These phases are varied depending upon the industry involved but all follow the same basic steps.

It is important to realize that the project life cycle for each project may differ in both the number of phases it may have and the detail within each of these phases. All projects can be mapped to the following life cycle structure:

7.1 Characteristics of the Project Life Cycle

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

This generic life cycle structure is often referred to when communicating with upper management or other entities less familiar with the details of the project. It should not be confused with the project management process groups, because the processes in a group consist of activities that may be performed and recur within each phase of a project as well as for the project as a whole. The project life cycle is independent from the life cycle of the product produced by or modified by the project. However, the project should take the current life-cycle phase of the product into consideration. 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 displays the following characteristics: Cost and staffing levels are low at the start, peak as the work is carried out, and drop rapidly as the project draws to a close.

The typical cost and staffing curve above may not apply to all projects. A project may require significant expenditures to secure needed resources early in its life cycle, for instance, or be fully staffed from a point very early in its life cycle.

The generic life cycle structure generally displays the following characteristics: Risk and uncertainty (as illustrated in below Figure - Impact of Variable Based on Project Time) are greatest at the start of the project. These factors decrease over the life of the project as decisions are reached and as deliverables are accepted.

The 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 toward completion.

The below figure also illustrates the idea that the cost of making changes and correcting errors typically increases substantially as the project approaches completion. While these characteristics remain present to some extent in almost all project life cycles, they are not always present to the same degree. Adaptive life cycles, in particular, are developed with the intent of keeping stakeholder influences higher and the costs of changes lower throughout the life cycle than in predictive life cycles.
8. Levels of Management

The three levels of management typically found in an organization hierarchy: operational, middle management and strategic.

![Levels of Management](image)

9. Project Selection Methods

The following set of methods describes the most common financial criteria that can be used to determine which projects are suitable:

Project Selection Methods offer a set of time-tested techniques based on logical reasoning to arrive at a choice of project, and filter out undesirable projects with very low likelihood of success. Project selection may be carried out in a number of ways. It is best for an organization to try different methods before choosing a project to be absolutely certain that every project will need careful consideration.

<table>
<thead>
<tr>
<th>Benefit Measurement Method (Comparative Approach)</th>
<th>Constrained Optimization Method (Mathematical Approach)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Figure 7-2 Impact of Variable Based on Project Time](image)

![Figure 8-1 Levels of Management](image)
9.1 Benefit Measurement Method (Comparative Approach)

9.1.1 Scoring Model

The scoring model is an objective technique wherein the project selection committee lists relevant criteria, weighs them according to their importance and their priorities and then adds the weighted values. Once the scoring of these projects is completed, the project with the highest score is chosen.

9.1.2 Discounted Cash Flow

This is a technique to estimate the attractiveness of an investment by predicting how much money will be received in the future and discounting it to its current value. The future value of money will not be the same as it is today. For example, $15,000 will not carry the same worth 10 years down the line from today.

9.1.2 Economic Model

The Economic Value Added (EVA) is the performance metric that calculates the worth-creation of the organization while defining the return on capital. This concept is concerned with whether the project returns to the company more value than the initiative costs. It is also defined as the net profit after the deduction of taxes and capital expenditure.

9.1.2.1 Present Value

A dollar today is worth more than a dollar tomorrow.

The basis is that receiving $1,000 now is worth more than $1,000 five years from now, because if you got the money now, you could invest it and receive an additional return over the five years.

\[ PV = \frac{FV}{(1+r)^n} \]

E.g., what is the present value of $200,000 worth five years from now, for interest rate of 8%?

$200,000 is future values; when PV formula is used, we get present value figure. 

\[ PV = \frac{200,000}{(1+0.08)^5} = \frac{200,000}{1.469} = 136,147.03 \text{ is Present value} \]

**Note:** Kindly read carefully when you come across term **PV** because it’s used in project selection method as a present value, whereas **PV = Planned Value** is used as a part of Earned Value Management (EMV) in project cost Management.

9.1.2.2 Net Present Value
A positive net present value indicates that the projected earnings generated by a project (in present dollars) exceed the anticipated costs (also in present dollars).

Generally, an investment with a positive NPV will be a profitable one and one with a negative NPV will result in a net loss. This concept is the basis for the Net Present Value Rule, which dictates that the only investments that should be made are those with positive NPV values.

<table>
<thead>
<tr>
<th>If</th>
<th>It means</th>
<th>Then</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV &gt; 0</td>
<td>the investment would add value to the organization</td>
<td>the project may be accepted</td>
</tr>
<tr>
<td>NPV &lt; 0</td>
<td>the investment would subtract value from the firm</td>
<td>the project may be rejected</td>
</tr>
</tbody>
</table>

9.1.2.3 Internal Rate of Return

All cash flows (both positive and negative) from a particular investment equal to zero. The IRR is used to select the project with the best profitability.

When using the IRR as the project selection criteria, care should be taken to ensure this is not used exclusively to judge the worth of a project. This is because a project with a lower IRR might have a higher NPV and, assuming there is no capital constraint, the project with the higher NPV should be chosen as this increase the shareholders' wealth.

When picking a project, the one with the higher IRR is chosen.

*Note: Keep in mind, when selecting project using NPV, IRR and ROI, the higher the number, the better the choice*

9.1.2.4 Payback Period

In simpler terms, it is the time necessary to recover the cost invested in the project, the payback period takes into consideration the payback period of an investment. It is the time frame that is required for the return on an investment to repay the original cost that was invested. The calculation for payback is pretty simple.

The project that has the shortest payback period is the best choice, since the organization can regain the original investment faster.

If Project X has a payback period of eight months and Project Y has a payback period of 20 months, the organization is obviously going to select Project X over Project Y.

9.1.2.5 Cost/Benefit Ratio

As the name suggests, is the ratio between expected costs to the project to the potential benefits it could bring the organization, which is the value of return from the project. Projects that have a higher Benefit Cost Ratio or lower Cost Benefit Ratio are generally chosen over others.

A benefit cost ratio of greater than 1 means the benefit is greater than the cost. A benefit cost ratio of less than 1 means the costs are greater than the benefits.

9.1.2.6 Opportunity Cost

Opportunity given up by selecting one project over another (the opportunity cost is the value of the project not selected)
If there are two projects ‘ABC’ NPV = $85,000 & Project ‘XYZ’ with NPV = $90,000? What is the opportunity cost?

It’s the amount of project given up by the organization, so answer will be $85,000

9.2 Constrained optimization method (mathematical approach)

Constrained Optimization Methods, also known as the Mathematical Model of Project Selection, are used for larger projects that require complex and comprehensive mathematical calculations, although time consuming, employing these methods is essential for an effective business plan.

The selection techniques in project management help you pick a project that could provide a better return on investment as well as recognition. There are various documented methods to select a project, but a rule-of-thumb to employ is this: If it is a small project that isn’t very complex, then the benefit measurement model is useful, whereas if it is a complex and large project then the constrained optimization method is a better fit. Below is list of techniques is comprised as part of constrained optimization method.

Linear Programming, Integer Programming, Dynamic Programming, Multi-Objective Programming, Non-Linear Programming,

- **Financial, Accounting and Costing Terms**
  - **Sunk Cost**: Sunk costs are expenditures that can't be recovered. For example, if you decide halfway through project execution that Project cannot meet its objective the way it looks, you have a sunk cost.
  - **Working Capital**: This term refers to current assets minus current liabilities for an organization. It is the amount of money the company has available to invest, including investment in projects.
  - **Rough Order of magnitude (ROM) (ballpark estimate)** is estimating with very little accuracy at the beginning of a project and then refining the estimate over time (it’s got a range of -25 to + 75%)
  - **Budget Estimate**: This type of estimate is usually made during project planning and is in the range of +/- 10 percent from actual while others use -5 +/- 10 percent from actual.
  - **Lifecycle Costing**: This is concept of life cycle costing – looking at the cost of the whole life of the product, not just the cost of the project like to support the product once it’s in place and being used by the customer.

**Depreciation**

- **Straight Line Depreciation**: The straight-line depreciation method spreads the cost evenly over the life of an asset; the same amount of depreciation is taken each year.
- **Accelerated Depreciation**: This method allows greater depreciation deductions in the earlier years of the life of an asset.
- **Double declining balance**: First, the straight-line depreciation rate would be 1/5, i.e. 20% per year. Under the double-declining-balance method, double that rate, i.e. 40% depreciation rate would be used.
- **Sum of the year’s digits**: Under this method the annual depreciation is determined by multiplying the depreciable cost by a schedule of fractions.

10. Project Management Processes

The project processes are performed by the project team with stakeholder interaction and generally fall into one of two major categories:
Project Management Processes

- **Project management processes**: These processes ensure the effective flow of the project throughout its life cycle. These processes encompass the tools and techniques involved in applying the skills and capabilities described in the Knowledge Areas.

- **Product-oriented processes**: These processes specify and create the project’s product. Product-oriented processes are typically defined by the project life cycle and vary by application area as well as the phase of the product life cycle. The scope of the project cannot be defined without some basic understanding of how to create the specified product. For example, various construction techniques and tools need to be considered when determining the overall complexity of the house to be built.

### 10.1 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. Involving the sponsors, customers and other stakeholders during initiation creates a shared understanding of success criteria, reduces the overhead of involvement and generally improves deliverable acceptance, customer satisfaction and other stakeholder satisfaction.

### 10.2 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. Significant changes occurring throughout the project life cycle trigger a need to revisit one or more of the planning processes and possibly some of the initiating processes. This progressive detailing of the project management plan is called progressive elaboration, indicating that planning and documentation are iterative and ongoing activities.

### 10.3 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, managing stakeholder expectations, as well as integrating and performing the activities of the project in accordance with the project management plan. During project execution, results may require planning updates and re-baselining. This may include changes to expected activity durations, changes in resource productivity and availability, and unanticipated risks. A large portion of the project's budget will be expended in performing the Executing process group processes.

### 10.4 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. The project performance is measured and analysed at regular intervals, appropriate events, or exception conditions to identify variances from the project management plan. Controlling changes and recommending corrective or preventive action in anticipation of possible problems, Monitoring the ongoing project activities against the project management plan and the project performance measurement baselines, and Influencing the factors that could circumvent integrated change control or configuration management so only approved changes are implemented.

### 10.5 Closing Process Group:

Those processes performed to finalize all activities across all process groups to formally close the project or phase. This is to conclude all activities across all project management process groups to formally complete the project, phase, or contractual obligations. This process group also formally establishes the premature closure of the project. Prematurely closed projects may include, for example: aborted projects, cancelled projects and projects having a critical situation.

The integrative nature of project management requires the Monitoring and Controlling process group to interact with the other process groups, as shown in below Figure. Monitoring and Controlling processes occur at the same time as processes contained within other process groups. Thus, the Monitoring and Controlling process is pictured as a “background” process group for the other four process groups shown in below figure.

![Figure 11-1 Project Management Process Groups](image)

Projects are broken down into phases so that extra control can be applied to effectively manage the processes. These phases are further divided into subsets for easy management, control, and planning.

Below Figure 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.
12. Project Information

Throughout the life cycle of the project, a significant amount of data and information is collected, analyzed, transformed and distributed in various formats to project team members and other stakeholders. Project data are collected as a result of various Executing processes and are shared within the project team. The collected data are analyzed in context, and aggregated and transformed to become project information during various Controlling processes. The information may then be communicated verbally or stored and distributed as reports in various formats.

- **Work Performance data:** The raw observations and measurements identified during activities performed to carry out the project work. Examples include reported percent of work physically completed, quality and technical performance measures, start and finish dates of schedule activities, number of change requests, number of defects, actual costs, actual durations, etc.

- **Work Performance information:** The performance data collected from various controlling processes, analyzed in context and integrated based on relationships across areas. Examples of performance information are status of deliverables, implementation status for change requests, and forecasted estimates to complete.

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

The 47 project management processes identified in *PMBOK® Guide* are further grouped into 10 separate Knowledge Areas. A Knowledge Area represents a complete set of concepts, terms and activities that make up a professional field, project management field or area of specialization. These 10 Knowledge Areas are used on most projects most of the time. Project teams should utilize these ten Knowledge Areas (and others as appropriate for their specific project).


The important aspects of each Knowledge Area and how it integrates with the five process groups. As supporting elements, the Knowledge Areas provide a detailed description of the process inputs and outputs along with a descriptive explanation of tools and techniques most frequently used within the project management processes to produce each outcome.

**Figure 12-1 Project Data, Information and Report Flow**

<table>
<thead>
<tr>
<th>Project Management Process Group</th>
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### Project Integration Management

Project integration management means making sure that all of the process work together seamlessly to make the project successful. A bird’s-eye view of a project, project manager makes projects run so well, it’s all about balancing processes in knowledge areas with respect to scope, time, cost, quality, human resource, communication, risk, procurement and stakeholder management.

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</thead>
<tbody>
<tr>
<td>4. Project Integration Management</td>
<td>4.1 Develop Project Charter</td>
<td>4.2 Develop Project Management Plan</td>
<td>4.3 Direct and Manage Project Work</td>
<td>4.4 Monitor and Control Project Work 4.5 Perform Integration Change Control</td>
<td>4.6 Close Project or Phase</td>
</tr>
<tr>
<td>5. Project Scope Management</td>
<td>5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS</td>
<td>6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Duration 6.5 Estimate Activity Resource 6.6 Develop Schedule</td>
<td></td>
<td>5.5 Validate Scope 5.6 Control Scope</td>
<td></td>
</tr>
<tr>
<td>6. Project Time Management</td>
<td>7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget</td>
<td></td>
<td>6.7 Control Schedule</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Project Cost Management</td>
<td>8.1 Plan Quality Management</td>
<td>8.2 Perform Quality Assurance</td>
<td>8.3 Control Quality</td>
<td></td>
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<tr>
<td>11. Project Risk Management</td>
<td>12.1 Plan Procurement Management</td>
<td>12.2 Conduct Procurements</td>
<td>12.3 Control Procurements</td>
<td>12.4 Close Procurements</td>
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<tr>
<td>12. Project Procurement Management</td>
<td>13.1 Identify Stakeholders</td>
<td>13.2 Plan Stakeholder Management</td>
<td>13.3 Manage Stakeholder Engagement</td>
<td>13.5 Control Stakeholder Engagement</td>
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</table>
Projects are initiated due to internal business needs or external influences. These needs or influences often trigger the creation of a needs analysis, feasibility study, business case or description of the situation that the project will address.

14.1 Develop Project Charter

A document formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities. The sponsor of a project is responsible for creating the Project Charter. The project manager is not always involved in making it. Oftentimes it’s handed to project manager by the sponsor. The sponsor of a project pays for the project, the project manager manages the project. The Project Charter officially sanctions the project (without a charter, the project cannot begin). A project manager is identified and assigned as early in the project as is feasible, preferably while the project charter is being developed and always prior to the start of planning.

14.1.1 Inputs

Project Statement Of Work, Business Case, Agreements, Enterprises Environmental Factors, Organizational Process Assets

An Enterprise Environmental factor tells how company does business whereas organizational process assets tell about how your company normally runs its projects and it also includes lessons learned from past projects.

14.1.2 Tools & Techniques

Expert Judgement: Expert judgment is often used to assess the inputs used to develop the project charter. Expert judgment is applied to all 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 business units, consultants, stakeholders, industry groups, SME and PMO.

Facilitation techniques: The meeting is set up with the stakeholders to brainstorm project goals or work with them to resolve conflicts around how your project will run. All of the approaches you take to get everybody on the same page are called facilitation techniques. Brainstorming, conflict resolution, problem solving and meeting management are key techniques used by facilitators to help teams and individuals accomplish project activities.

14.1.3 Outputs

► Project Charter

A well-defined project start and project boundaries, creation of a formal record of the project and a direct way for senior management to formally accept and commit to the project, it also gives the project manager authority to spend money and use other company resources.

It contains project purpose, measurable project objectives, success criteria, high-level requirements, assumptions and constraints, high-level project description and boundaries, high-level risks, summary milestone schedule, stakeholder list, project approval requirements, assigned project manager, responsibility and authority level, and name and authority of the sponsor authorising the project charter.

14.2 Develop Project Management Plan
Develop Project Management Plan is the process of defining, preparing and coordinating all subsidiary plans and integrating them into a comprehensive project management plan. It is a central document that defines the basis of all project work. The plan is the core of integration management, it main tool for running a project successfully, it’s a formal document written and distributor among team, as and when the project manager encounters a change in the project, he/she always begins dealing with change by consulting the project management plan.

14.2.1 Inputs

Project Charter, Output from Other Processes, Enterprise Environmental Factor, Organizational Process Assets

14.2.2 Tools & Techniques

- **Expert Judgement**: Such expertise is provided by any group or individual with specialized knowledge or training and is available from many sources, including: other business units, consultants, stakeholders, industry groups, SME and PMO.
- **Facilitation techniques**: You might set up meeting with your stakeholders to brainstorm project goals or work with them to resolve conflicts around how your project will run. All of the approaches you take to get everybody on the same page are called facilitation techniques. Brainstorming, conflict resolution, problem solving, and meeting management are key techniques.

14.2.3 Outputs

- **Project Management Plan**

Project management plan is the document that describes how the project will be executed, monitored, and controlled; it integrates and consolidates all of the subsidiary plans and baselines from planning processes. Project manager always have the authority to make changes to your project if they don’t affect cost, schedule or scope.

The project management plan includes baselines: importantly Snapshots of the scope, schedule, and budget (Cost) which can be used to keep track of them as they change.

- **Baselines (Performance Measurement Baseline - PMB)**: There are three baselines in Project Management Plan as described below.
- **The scope baseline** is a snapshot of the scope, (project scope statement, work breakdown structure & WBS dictionary, which help to keep track of changes to work that you will be doing and the planned deliverables you will be building.
- **The schedule baseline** does the same for the project schedule (Agreed upon schedule--start and end date for each activity.
- **The cost performance baseline** does the same for the budget (the time phased cost budget (i.e., spending plan indicating how much money is approved for the project and when the funds are required)

In addition to three baselines, there are subsidiary plans from each knowledge area that are taken into account when overall project plan is finalized. Below is a brief description of each plan:

- **The scope management plan** - how scope changes are handled like what to do when someone needs to add & remove a feature for a service or product project produces.
- **The requirement management plan** – how you will gather, document & manage the stakeholder needs & how you will meet needs with the project deliverables.
Project Integration Management

► **The schedule management plan** – shows you how to deal with changes to the schedule, like updated deadline or milestones.

► **The cost management plan** - tells you how you will create the budget, and what to do when your project runs into money problems.

► **The quality management plan** – deals with problems that could arise when a product does not live up to the customer standards.

► **The process improvement plan** tells how processes that are used on the project to complete the work or perform project management activities will be evaluated and improved to build the product to make it better. Over period of time project manager need to make efforts to improve processes during the project cycle, if necessary.

► **The human resources management plan** – to deal with changes in staff, and to identify and handle any additional staffing needs and constraints you might have in specific project.

► **The communication management plan** – lists all of the ways that you communicate with your projects team, stakeholders, sponsors, and important contacts related to the projects.

► **The risk management plan** is about detailing all the bad and good things that might happen and coming up with a plan to address each risk when and if it occurs.

► **The procurement management plan** focuses on dealing with vendors outside your company.

► **The stakeholder management plan** focuses on managing the expectation of all of the people who are affected by the project.

► **The change management plan** tells how to manage changes and change process on the projects.

  Change control procedure (how and who), the approval level for authorizing changes, Creation of CCB changes control board, plan outlining how changes will be managed and controlled. Who should attend the meeting about changes, organization tools to use to track changes and control changes, the Emergency change processes, etc.

► **The configuration management plan** tells about managing changes to the documentation about the deliverables and processes of the project. All changes to this documentation throughout the life of the project, plan towards making sure everyone knows what version of plans are latest versions and other project specific documents.

**Note:** As soon as project planning is completed, the project kickoff meeting should be held along with key stakeholder of project (customer, seller, project team, senior management, the sponsor, etc.) as a part of project execution process: the main objective of meeting is to announce the start of the project and bring everyone on the same page.

### 14.3 Direct and Manage Project Work

Your project is ready to begin. And as the project unfolds, it provides overall management of the project work. It’s the project manager’s job is to direct and manage each activity on the project to produce deliverables, every step of the way implementing approved changes to achieve the project’s objectives. During project execution, the work performance data is collected and appropriately actioned and communicated, that’s what happens in the Direct and Manage Project Work process.

#### 14.3.1 Inputs

Project management plan, Approved change requests, Enterprise environmental factors, and Organizational process assets

#### 14.3.2 Tools & Techniques
**Expert judgment:** Expert judgment is used to assess the inputs needed to direct and manage execution of the project management plan. Such judgment and expertise are applied to all technical and management details during this process.

**Project management information system:** The project management information system, which is part of the enterprise environmental factors, provides access to tools, such as a scheduling tool, a work authorization system, a configuration management system, an information collection and distribution system, or interfaces to other online automated systems. Automated gathering and reporting on key performance indicators (KPI) can be part of this system.

**Meetings:** Meetings are used to discuss and address pertinent topics of the project when directing and managing project work. Meetings should be prepared with a well-defined agenda, purpose, objective, and time frame and should be appropriately documented with meeting minutes and action items. Meeting minutes should be stored as defined in the project management plan.

### 14.3.3 Outputs

- **Deliverables**

  A deliverable is any unique and verifiable product, result or capability to perform a service that is required to be produced to complete a process, phase, or project. The deliverables include all of the products or services that you and your team performing for client.

- **Work Performance Data**

  Work performance data are the raw observations and measurements identified during activities being performed to carry out the project work. Data are often viewed as the lowest level of detail from which information is derived by other processes. Data is gathered through work execution and passed to the controlling processes for further analysis.

- **Change Requests**

  A change request is a formal proposal to modify any document, deliverable, or baseline. An approved change request will replace the associated document, deliverable, or baseline and may result in an update to other parts of the project management plan.

  Actions for approved changes through change control mechanism

  - **Corrective action**—an intentional activity that realigns the performance of the project works with the project management plan;
  - **Preventive action**—an intentional activity that ensures the future performance of the project work is aligned with the project management plan;
  - **Defect repair**—an intentional activity to modify a nonconforming product or product component;

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

### 14.4 Monitor and Control Project Work

**Note:** Always remember, control means measure.

Monitor and Control Project Work is the process of tracking, reviewing, and reporting the progress to meet the performance objectives defined in the project management plan. In this process you find the
changes, defect repairs and correction that you may want to make. You need to stay top of any possible changes that happen throughout your project and always looking at what is happening on the project and comparing the actual and forecasted performance to what was planned. Continuous monitoring gives the project management team insight into the health of the project and identifies any areas that may require special attention. This process allows stakeholders to understand the current state of the project, the steps taken, and budget, schedule, and scope forecasts. When the team is repairing defects to deliverables, they still need to go through change control procedure. Project Manager always has authority to make changes to your project if they don’t affect cost, schedule, or scope.

14.4.1 Inputs

Project Management Plan, Schedule Forecasts, Cost Forecasts, Validated Changes, Work Performance Information, Enterprise Environmental Factors and Organizational Process Assets

14.4.2 Tools & Techniques

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

Analytical techniques: Analytical techniques are applied in project management to forecast potential outcomes based on possible variations of project or environmental variables and their relationships with other variables. Examples of analytical techniques used in projects are regression analysis, grouping methods, causal analysis, root cause analysis, forecasting methods, failure mode and effect analysis (FMEA), fault tree analysis (FTA), reserve analysis, trend analysis, earned value management and variance analysis.

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

Meetings: Meetings may be face-to-face, virtual, formal, or informal. They may include project team members, stakeholders and others involved in or affected by the project.

Change Control System: A change control system is the set of procedures that lets you make those changes in an organized way; many organizations have a change control system as part of their project management information system (PIMS). This system includes standardized forms, reports, processes, procedures, and software to track and control changes. It is part of an organization’s enterprise environmental factors.

14.4.3 Outputs

► Change Requests

As a result of comparing planned results to actual results, change requests may be issued to expand, adjust, or reduce project scope, product scope, or quality requirements and schedule or cost baselines. Change requests may necessitate the collection and documentation of new requirements. Changes that meet the project’s change control criteria should go through the integrated change control process established for the project.

Corrective, Preventing and Defect Actions
Corrective action involves dealing with actual deviations from the performance measurement baseline or other metrics. (An intentional activity that realigns the performance of the project work with the project management plan)

Preventive actions are any action taken to bring expected future project performance in line with the project management plan as a result dealing with anticipated or possible deviations from the performance measurement baseline and other metrics. (An intentional activity that ensures the future performance of the project work is aligned with the project management plan)

Defect Repair: Defect repair is another way of saying “rework”. Defect repair may be requested when a component of the project does not meet specifications. (An intentional activity to modify a nonconforming product or product component) A defect is any deliverable that does not meet its requirement (non-conformance)

► Work Performance Reports

Work performance reports are the physical or electronic representation of work performance information compiled in project documents, intended to generate decisions, actions, or awareness (e.g., status reports, memos, justifications, information notes, recommendations, and updates, etc.)

► Project Management Plan Updates
► Project Documents Updates

14.5 Perform Integrated Change Control

This is the process where you decide whether or not to make changes come through change request procedure. All change request are evaluated and accepted or rejected in this process, But you are not the one actually making that decision a big part of perform integrated change control is that you need to get your changes approved by the change control board. Key focus of integrated change control is to look at the impact of each change on all the project constraints. The Perform Integrated Change Control process is conducted from project inception through completion and is the ultimate responsibility of the project manager.

When required, the Perform Integrated Change Control process includes a change control board (CCB), which is a formally chartered group responsible for reviewing, evaluating, approving, delaying, or rejecting changes to the project, and for recording and communicating such decisions.

14.5.1 Inputs

Project Management Plan, Work Performance Reports, Change Requests, Enterprise Environmental Factors and Organizational Process Assets

14.5.2 Tools & Techniques

Expert judgment: In addition to the project management team’s expert judgment, stakeholders may be asked to provide their expertise and may be asked to sit on the change control board (CCB). Such judgment and expertise are applied to any technical and management details during this process and may be provided by various sources,

Meetings: When needed for the project, a change control board (CCB) is responsible for meeting and reviewing the change requests and approving, rejecting, or other disposition of those changes. Usually, a change control meeting will be a regularly scheduled thing, where people representing the
affected areas of the company will get together to review proposed changes and decide whether or not to make them. A change control board is never made up of just the people on your team. A change control meeting is all about getting people with different perspectives together to talk about the pros and cons of changes before deciding whether to approve or reject them.

**Change control tools:** In order to facilitate configuration and change management, manual or automated tools may be used. Tool selection should be based on the needs of the project stakeholders including organizational and environmental considerations and/or constraints. Tools are used to manage the change requests and the resulting decisions.

**Detailed Process for Making Changes:**

- Prevent the root cause of changes
- Identify change
- Look at the impact of the change within the knowledge area
- Create a change request
- Perform integrated change control
- Assess the change
- Look for option
- The change is approved or rejected
- Update the status of the change in the change log
- Adjust the project management plan, project document, and baseline as necessary
- Manage stakeholders expectation by communicating the change to stakeholder affected by the change
- Manage the project to the revised project management plan and project documents
- Get customer buy-in

### 14.5.3 Outputs

- **Approved change requests**
  
  Change requests are processed according to the change control system by the project manager, CCB or by an assigned team member. Approved change requests will be implemented through the Direct and Manage Project Work process.

- **Change log**
  
  The disposition of all change requests, approved or not, will be updated in the change log, these changes and their impact to the project in terms of time, cost, and risk, are communicated to the appropriate stakeholders

- **Project management plan updates**
- **Project documents updates**

### 14.6 Close Project or Phase

This process involves getting final formal acceptance of the project or phase as a whole form the customer, issues final lessons learned, and index and archives of all project records. No matter the circumstances under which Project stops, is terminated or is completed. It provides lessons learned, the formal ending of project work, and the release of organization resources to pursue new endeavors. In order to successfully achieve this, the project manager needs to engage all the proper stakeholders in the process.
14.6.1 Inputs

Project Management Plan, Accepted Deliverables and Organizational Process Assets

14.6.2 Tools & Techniques

Expert judgment: Expert judgment is applied when performing administrative closure activities. These experts ensure the project or phase closure is performed to the appropriate standards. Expertise may be other project managers within the organization, Project management office (PMO), and Professional & technical associations.

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

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

14.6.3 Outputs

► Final Product, Service or Result Transition

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

At project or phase closure, the following may occur: Obtain acceptance by the customer or sponsor to formally close the project or phase, conduct post-project or phase-end review, record impacts of tailoring to any process, document lessons learned, apply appropriate updates to organizational process assets, archive all relevant project documents in the project management information system (PMIS) to be used as historical data, close out all procurement activities ensuring termination of all relevant agreements and perform team members’ assessments and release project resources.

► Organizational Process Assets Updates
15. 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.

**Product Scope** means the features and functions of the product or service that you and your team are building to be delivered to client. Project scope is all of the work that needs to be done to make the product.

The term project scope is sometimes viewed as including product scope. Functional requirements are the behavior of the product and non-functional requirements are implicit expectation about product.

**Gold plating** a project is not allowed; it means doing extra work that is not part of product or project scope.

**Scope creep** means uncontrolled changes that cause the team to do extra work.

15.1 Plan Scope Management

The plan scope management process helps you think through everything you will need to do to keep your project focused on the right work from beginning to end. The scope management plan describes how you write down the scope, make sure it’s right and keep it up to date. The project scope will be defined, validated and controlled. This is where you write down the subsidiary plan where you plan out all of the work you will do to define your scope, it provides guidance and direction on how scope will be managed throughout the project.

15.1.1 Inputs

- Project Management Plan
- Project Charter
- Enterprise Environmental Factors
- Organizational Process Assets

15.1.2 Tools & Techniques

**Expert Judgment**: Expert judgment refers to input received from knowledgeable and experienced parties. Expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training in developing scope management plans.

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

15.1.3 Outputs

- **Scope Management Plan**

  The scope management plan is a component of the project or program management plan that describes how the scope will be defined, developed, monitored, controlled, and verified. How scope changes are handled like what to do when someone needs to add and remove a feature for a service or product project produces.

- **Requirement Management Plan**

  Here’s where you will find a description of the approach the team will take to planning, tracking and reporting on requirements. How you will gather document and manage the stakeholder needs & how
you will meet needs with the project deliverables and how you will build a traceability matrix for your requirement as well.

15.2 Collect Requirements

The process of determining, documenting and managing stakeholder needs and requirements to meet project objectives. It provides the basis for defining and managing the project scope including product scope. You know your requirements are complete when you have got a way to verify each of them once they are built. Requirements become the foundation of the WBS and they can be measured and tracked.

15.2.1 Inputs

Scope Management Plan, Requirements Management Plan, Stakeholder Management Plan, Project Charter and Stakeholder Register

15.2.2 Tools & Techniques

**Interviews or Experts Interviews:** By talking to people one to one to explain how to use product/services, an interview is a formal or informal approach to elicit information from stakeholders by talking to them directly. It is typically performed by asking prepared and spontaneous questions and recording the responses, but may involve multiple interviewers and/or multiple interviewees.

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

**Facilitated Workshops:** Facilitated workshops are focused sessions that bring key stakeholders together to define product requirements. It has structured group designer, end user led by moderator for brainstorming to define cross-functional requirement as well as by focusing to get misunderstanding and issues reconciled at once, even user stories may be created for functionality and feature like (role-functionality- business benefit), this techniques builds trust and foster relationship. Following are few example of facilitated workshops: joint application design/development (JAD), quality function deployment (QFD), and voice of the customer (VOC).

**Group Creativity Techniques:**

- **Idea/Mind mapping:** to visualize the ideas how they relate to each other, to help create map to know how one got there and help generate new ideas.
- **Affinity Diagram:** many ideas grouped together under specific categories and it’s tweaked and twisted until finalized under categories which help identify requirement with specific category.
- **The Nominal group technique:** brainstorming to write down ideas and group them for voting then it need to be ranked on priority (ideas) and ignore with less important ideas.
- **Multi-Criteria Decision Analysis:** another technique to rank ideas by quantifying requirement using a decision matrix decision analysis based on Risk level, time estimate, cost and benefit estimate.
- **Brainstorming:** A technique used to generate and collect multiple ideas related to project and product requirements. Although brainstorming by itself does not include voting or prioritization, it is often used with other group creativity techniques.
GDMT (Group decision making technique): These techniques can be used to generate, classify and prioritize product requirements.

- **Unanimity**: means everyone agrees on the decision
- **Majority**: means that more than half the people (more than 50%) in the group agree on the decision
- **Plurality**: means that the idea that gets the most of votes
- **Dictatorship**: when one person makes the decision for the whole group

**Delphi technique**: Everyone in the group gives their thoughts in writing answers to question requirements in product (anonymous), then idea is discussed in group by moderator; again everybody is given chance to adjust original idea accordingly.

**Context Diagram**: To show how processes and features in product scope relate to each other and user interactions, Context diagrams show inputs to the business system, the actor(s) providing the input, the outputs from the business system, and the actor(s) receiving the output.

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

**Document Analysis**: This is the way of collecting requirement by reading through all of the existing documents for the product. Example of documents that might be read, business plans, marketing literature, agreements, requests for proposal, current process flows, logical data models, business rules repositories, application software documentation, business process or interface documentation, use cases, other requirements documentation, problem/issue logs, policies, procedures, and regulatory documentation such as laws, codes or ordinances, etc.

**Questionnaire & surveys**: By sharing forms with a set of group as feedback to upgrading or creating product. Questionnaires and/or surveys are most appropriate with varied audiences, when a quick turnaround is needed, when respondents are geographically dispersed, and where statistical analysis is appropriate.

**Observation (Job shadowing)**: Observing people while they work which gives better ideas of how solve their problem, as people sometime do not understand to convey their requirements.

**Prototypes (Story Boarding)**: Prototypes are models of the product to be build that gives better idea to stakeholder and come with a brand new requirement that they never thought of before. Storyboarding is a prototyping technique showing sequence or navigation through a series of images or illustrations. In software development, storyboards use mock-ups to show navigation paths through webpages, screens, or other user interfaces.

**15.2.3 Outputs**

- **Requirements Documentation**

Requirements documentation describes how individual requirements meet the business need for the project. Requirements may start out at a high level and become progressively more detailed as more about the requirements is known.

- **Requirement Traceability Matrix**

Requirement traceability matrix links requirements to objectives and other requirement along with requirement attributes (identification number, source, and status)
15.3 Define Scope

Define Scope is the process of developing a detailed description of the project and product. It describes the product, service, or result boundaries by defining which of the requirements collected will be included in and excluded from the project and its deliverables.

15.3.1 Inputs

Scope Management plan, Project Charter, Requirement Documentation and Organizational Process Assets

15.3.2 Tools & Techniques

**Expert judgment**: Often used to analyze the information needed to develop the project scope statement. Such judgment and expertise is applied to any technical detail. Such expertise is provided by any group or individual with specialized knowledge or training, and is available from many sources.

**Product Analysis**: Remember product versus project scope? People naturally think about the product they are making when they start to define the scope. This tool is all about turning those things into project work that needs to be done, once the work is complete; you are going to have to make sure that what you are delivering matches what you put in your requirements. The better your product analysis is at the start of the project, the happier your stakeholders will be with the product, and the less likely it is that you will discover painful, last minute problems at the end. Product analysis includes techniques such as product breakdown, systems analysis, requirements analysis, systems engineering, value engineering, and value analysis.

**Alternatives Generation**: Think of other ways that you could do the work. Exploring different ways to do the work will help you find the one that is most efficient for the project. It's always possible that you might find a better way of doing things and need to change your original plan. A variety of general management techniques can be used, such as brainstorming, lateral thinking, analysis of alternatives

**Facilitated Workshops**: Structured group designer, end user led by moderator for brainstorming to define cross-functional requirement as well as by focusing to get misunderstanding and issues
reconciled at once, even user stories may be created for functionality and feature (role-functionality-business benefit), this techniques builds trust and foster relationship

15.3.3 Outputs

- Project Scope Statement

The project scope statement is the description of the project scope, major deliverables, assumptions, and constraints. The project scope statement documents the entire scope, including project and product scope. The project scope statement tells what work you are and are not going to do in the project.

- Project Scope Statement
- Product Scope Description
- Project Exclusion
- Project Deliverables
- Project Acceptance Criteria
- Project Constraints and Assumption

- Project Documents Updates

Include, but are not limited to stakeholder register, requirements documentation and requirements traceability matrix.

15.4 Create WBS

Create WBS is the process of subdividing project deliverables and project work into smaller, more manageable components like work packages, WBS includes complete scope of project, including product scope and project scope. It also provides a structured vision of what has to be delivered. It helps to ensure that nothing slips through the cracks; but it does not show the order of the work packages or any dependencies between them. Its only goal is to show the work involved in creating the product. The lowest levels of WBS components are called work packages. In the context of the WBS, work refers to work products or deliverables that are the result of activity and not to the activity itself.

A control account is established at higher level of WBS which allows for the aggregation and analysis of work performance data regarding scope, schedule, and cost, each work package should have only one control account. Project risk, cost and time are estimated at work package or activity level not for the project as a whole.

On small projects, the WBS is often broken down into work packages that involve from 4 to 40 hours of work; medium-size projects may have work packages with anywhere from 8 to 80 hours of work; on large projects, it involves 300 hours of work.

15.4.1 Inputs

Scope Management Plan, Project Scope Statement, Requirements Documentation, Enterprise Environmental Factors and Organizational Process Assets

15.4.2 Tools & Techniques

Decomposition or Deconstruction: Decomposition is a technique used for dividing and subdividing the project scope and project deliverables into smaller, more manageable parts. You create WBS by decomposing large project work/deliverables into work packages, as you decompose the work, you find new information that needs to be added to the requirements documents and project scope
statement that information treated as a change and goes to change control, on approval it can be added to scope

Figure 15-2 Sample WBS Decomposed Down Through Work Packages

Expert Judgment: often used to analyze the information needed to develop the project scope statement. Such judgment and expertise is applied to any technical detail. Such expertise is provided by any group or individual with specialized knowledge or training, and is available from many sources.

15.4.3 Outputs

► Scope Baseline

The scope baseline is the approved version of a scope statement, work breakdown structure (WBS), and its associated WBS dictionary, that can be changed only through formal change control procedures and is used as a basis for comparison any time you make a change, you need to get it approved, and then update the baseline. When WBS is Finalized, WBS Control Accounts are established for work packages, and it is also management control point.

► WBS Dictionary

It includes (Control Account, work package name, date, responsible person, WP description, work details to produce deliverables, acceptance criteria, assumption-constraints, quality metrics, technical source document, risks, resource assigned, duration, schedule milestone, cost, due date inter dependencies, approved by etc.)

► Project Documents Updates

15.5 Validate Scope

Validate scope is the process of formalizing acceptance of the completed project deliverables. It brings objectivity to the acceptance process and increases the chance of final product, service, or result acceptance by validating each deliverable. You need to gather required the stakeholders
together and have them make sure that all the work really was done. We call that validate scope process. Purpose of validate scope is to obtain formal, written acceptance of the work products.

Every deliverable should be inspected, including all project management documents and everything produced by team and has to make sure it meets acceptance criteria, the verified deliverables obtained from the control quality process are reviewed with the customer or sponsor to ensure that they are completed satisfactorily and have received formal acceptance of the deliverables by the customer or sponsor. **Interim deliverables** acceptance is also done during Validate Scope process.

The **Validate Scope** process 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.

### 15.5.1 Inputs

Project Management Plan, Requirements Documentation, Requirements Traceability Matrix, Verified Deliverables and Work Performance Data

### 15.5.2 Tools & Techniques

**Inspection also known as (reviews, product reviews, audits, and walkthroughs):** Inspection includes activities such as measuring, examining, and validating to determine whether work and deliverables meet requirements and product acceptance criteria. Once deliverables are ready for prime time, you inspect them with the stakeholders to make sure that they meet acceptance criteria.

**Group decision-making techniques:** To rank most useful ideas generated during brainstorming session.

- **Unanimity:** means everyone agrees on the decision
- **Majority:** means that more than half the people in the group agree on the decision
- **Plurality:** means that the idea that gets the most of votes
- **Dictatorship:** is when one person makes the decision for the whole group

### 15.5.3 Outputs

- **Accepted Deliverables**
  
Deliverables that meet the acceptance criteria are formally signed off and approved by the customer or sponsor. Formal documentation received from the customer or sponsor acknowledging formal stakeholder acceptance of the project’s deliverables is forwarded to the Close Project or Phase process. The Close Project or Phase process is to get final acceptance or signoff from the customer for the project or phase as a whole.

- **Change Requests**
  
The completed deliverables that have not been formally accepted are documented, along with the reasons for non-acceptance of those deliverables. Those deliverables may require a change request for defect repair. The change requests are processed for review and disposition through the Perform Integrated Change Control process.

- **Work Performance Information**
  
Work performance information includes information about project progress, such as which deliverables have started, their progress, which deliverables have finished or that have been accepted.
Project Scope Management

► Project Documents Updates

15.6 Control Scope

Control Scope is the process of monitoring the status of the project and product scope and managing changes to the scope baseline. In this process you make sure only those changes to the scope that you need to make, and that you need to make, and that everyone is clear on what the consequences of those changes are. The goal of Control Scope is updating the scope, plan, baseline, and WBS info; it allows the scope baseline to be maintained throughout the project. Controlling the project scope ensures all requested changes and recommended corrective or preventive actions are processed through the Perform Integrated Change Control process.

Note: The uncontrolled expansion to product and project scope without adjustment to time, cost and resources is referred as scope creep.

15.6.1 Inputs

Project Management Plan, Requirements Documentation, Requirements Traceability Matrix, Work Performance Data and Organizational Process Assets

15.6.2 Tools & Techniques

Variance analysis: There is only one tool in the control Scope process Variance analysis. This is where you constantly compare the information that you are gathering about the way the projects going to affect your baseline, important aspects of project scope control include determine the cause and degree of difference between the baseline and actual performance.

15.6.3 Outputs

► Work performance information

Work performance information produced includes correlated and contextualized information on how the project scope is performing compared to the scope baseline. It can include the categories of the changes received, the identified scope variances and their causes, how they impact schedule or cost and the forecast of the future scope performance. This information provides a foundation for making scope decisions.

► Change requests

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

► Project management plan updates
► Project documents updates
► Organizational process assets update
16. Project Time Management

It starts with figuring out what work you need to do, how you will do it, what resources you will use and how long it will take. From there, it’s all about developing and controlling that schedule. It’s where the deadlines are set and met. Time management is all about breaking the work down into activities, so you can put them in order and come up with estimates for each of them.

16.1 Plan Schedule Management

Plan Schedule Management is the process of establishing the policies, procedures, and documentation for planning, developing, managing, executing and controlling the project schedule. It provides guidance and direction on how the project schedule will be managed throughout the project.

16.1.1 Inputs

Project Management Plan, Project Charter, Enterprise Environmental Factors and Organizational Process Assets

16.1.2 Tools & Techniques

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

Analytical Techniques: The Plan Schedule Management process may involve choosing strategic options to estimate and schedule the project such as: scheduling methodology, scheduling tools and techniques, estimating approaches, formats and project management software.

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

16.1.3 Outputs

- Schedule Management Plan

It establishes the criteria and the activities for developing, monitoring and controlling the schedule and shows you how to deal with changes to the schedule, like updated deadline or milestones.

It includes project schedule model development, level of accuracy, units of measure to be used (calendar days, weeks, hours etc.), organizational procedures links percentage of work completion, project schedule model maintenance, control thresholds, rules of performance measurement, earned value management (EVM) rules, reporting formats process descriptions, etc.

16.2 Define Activities

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

Work packages are typically decomposed into smaller components called activities or tasks that represent the work effort required to complete the work package.
16.2.1 Inputs

Schedule Management Plan, Scope Baseline, Enterprise Environmental Factors and Organizational Process Assets

16.2.2 Tools & Techniques

**Decomposition:** This means taking work packages you defined in the scope management process and breaking them down even further into activities that can be estimated. Each work package within the WBS is decomposed into the activities required to produce the work package deliverables. Involving team members in the decomposition can lead to better and more accurate results. The important thing to remember about activities, though, is that they are broken down to the level at which they can be estimated accurately. Activities represent the effort needed to complete a work package.

**Rolling wave planning (Progressive elaboration):** When you plan this way, you decompose only the activities that you need to plan for because they are coming up soon. You leave everything else planned at the milestone level until it gets closer to the time when you will do it. Rolling wave planning is an iterative planning technique in which the work to be accomplished in the near term is planned in detail, while the work in the future is planned at a higher level. It is a form of progressive elaboration; therefore, work can exist at various levels of detail depending on where it is in the project life cycle.

**Expert judgment:** To ask someone who has done this before to give an opinion on what activities will be needed to get the job done. 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.

16.2.3 Outputs

- **Activity List**

This is a list of everything that needs to be done to complete project. This list is lower level than the WBS. It’s all the activities that must be accomplished to deliver the work package. The activity list is a comprehensive list that includes all schedule activities required on the project. The activity list also includes the activity identifier and a scope of work description for each activity in sufficient detail to ensure that project team members understand what work is required to be completed. Each activity should have a unique title that describes its place in the schedule, even if that activity title is displayed outside the context of the project schedule.

- **Activity Attributes**

Here’s where the description of each activity is kept. All of the information you need to figure out the order of the work should be here, too. So any predecessor activities, successor activities, or constrains should be listed in the attributes, along with descriptions and any other information about resources or time that you need for planning.

The initial stages of the project, attributes include the activity identifier (ID), WBS (ID), and activity label or name, and when completed, may include activity codes, activity description, predecessor activities, successor activities, logical relationships, leads and lags, resource requirements, imposed dates, constraints, and assumptions, the person responsible for executing the work, geographic area, or place where the work has to be performed, the project calendar the activity is assigned to, and activity type such as level of effort (LOE), 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.
Milestone List

All of the important checkpoints of your project are tracked as milestones. Some of them could be listed in your contract as requirements of successful completion. The milestone list needs to let everybody know which are required and which are required and which are not. Milestones are similar to regular schedule activities, with the same structure and attributes, but they have zero duration because milestones represent a moment in time.

16.3 Sequence Activities

The process of identifying and documenting relationships among the project activities. The key benefit of this process is that it defines the logical sequence of work to obtain the greatest efficiency given all project constraints. The main focus is order of the work. Logical relationships should be designed to create a realistic project schedule. Sequencing can be performed by using project management software or by using manual or automated techniques.

16.3.1 Inputs

Schedule Management Plan, Activity List, Activity Attributes, Milestone List, Project Scope Statement, Enterprise Environmental Factors and Organizational Process Assets

16.3.2 Tools & Techniques

Precedence diagramming method (PDM), Activity-on-Node (AON) and Arrow Diagramming Method (ADM)

Showing the activities in rectangles (boxes) and their relationships using arrows is called PDM, The precedence diagramming method (PDM) is a technique used for constructing a schedule model in which activities are represented by nodes and are graphically linked by one or more logical relationships to show the sequence in which the activities are to be performed. Activity-on-node (AON) is one method of representing a precedence diagram.

GERT – Graphical Evaluation and Review Technique

GERT is a modification to the network diagram drawing method. It is a computer simulation technique that allows loops between activities.

Dependency Determination: It means that one task needs to be completed before another one can start; there are few other kinds of predecessor as well.

- **Finish to start**: The first activity finish leads to into the second activity start
- **Start to Start**: We need to coordinate activities so they begin at the same time
- **Finish to Finish**: Two activities finish at the same time
- **Start to finish**: Very rare - second activity needs to start, which will end earlier activity by default
Dependency Determination:

- **Mandatory dependency (Hard Logic):** Mandatory predecessors are the kinds that have to exist just because of the nature of the work. (Hard dependencies), Mandatory dependencies are those that are legally or contractually required or inherent in the nature of the work. Mandatory dependencies often involve physical limitations.

- **Discretionary dependency (Soft logic, preferred/Preferred Logic):** It’s just matter of preference, some unusual aspect of the project where a specific sequence is desired, even though there may be other acceptable sequences. Discretionary dependencies should be fully documented since they can create arbitrary total float values and can limit later scheduling options.

- **External dependency:** External dependencies involve a relationship between project activities and non-project activities. These dependencies are usually outside the project team’s control, sometime project will depend on things outside the work you are doing. For example, the testing activity in a software project may be dependent on the delivery of hardware from an external source.

- **Internal dependency:** Internal dependencies involve a precedence relationship between project activities and are generally inside the project team’s control. Some dependencies are completely within the team’s control. For example, if the team cannot test a machine until they assemble it.

**Leads & Lags:**

- **Lead:** A lead may be used to indicate that an activity can start before its predecessor activity is completed. A lead is the amount of time whereby a successor activity can be advanced with respect to a predecessor activity. For example, on a project to construct a new office building, the landscaping could be scheduled to start two weeks prior to the scheduled punch list completion. This is example of finish-to-start dependency with two-week lead.

- **Lag:** Waiting Time – inserted between activities, a lag is the amount of time whereby a successor activity will be delayed with respect to a predecessor activity. For example, a technical writing team may begin editing the draft of a large document 15 days after they begin writing it. This is example of a start-to-start relationship with a 15-day lag.
16.3.3 Outputs

► Project Schedule Network Diagrams

Here is where you work out how all of the tasks fit together based on their predecessors and determine the critical path through the project. A project schedule network diagram is a graphical representation of the logical relationships, also referred to as dependencies, among the project schedule activities. Below Figure illustrates a project schedule network diagram. A project schedule network diagram is produced manually or by using project management software.

► Project Documents Updates

16.4 Estimate Activity Resources

This is the process of estimating the type and quantities of material, human resources, equipment, or supplies required to perform each activity. It identifies the type, quantity, and characteristics of resources required to complete the activity that allows more accurate cost and duration estimates. The goal of this process is to assign resources to each activity in the activity list. Resources are people, equipment, locations or anything else that you need in order to do all of the activities that you planned for. Every activity in your activity list needs to have resources assigned to it.
16.4.1 **Inputs**

Schedule management plan, activity list, activity attributes, resource calendars, risk register, activity cost estimates, enterprise environmental factors and organizational process assets.

16.4.2 **Tools & Techniques**

**Expert judgment:** Means considering several different options for how you assign resources. This includes varying the number of resources as well as the kind of resources you use. Any group or person with specialized knowledge in resource planning and estimating can provide such expertise.

**Alternative analysis:** Means considering several different options for how you assign resources. This includes varying the number of resources as well as the kind of resources you use. It’s like to think of other ways that you could do the work better way. Exploring different ways to do the work will help you find the one that is most efficient for the project. They include using various levels of resource capability or skills, different size or type of machines, different tools (hand versus automated) and make rent-or-buy decisions regarding the resource.

**Published estimating data:** Is something that project managers in a lot of industries use to help them figure out how many resources they need. They rely on article, books, journals, and periodicals that collect, analyse, and publish data from other people’s project.

**Bottom-up estimating:** Is a technique that you may have used before without even knowing it, it mean breaking down complex activities into pieces, and working out the resource assignments for each of those simpler pieces using the other four tools and technique. Bottom-up estimating is a method of estimating project duration or cost by aggregating the estimates of the lower-level components of the WBS.

**Project management software:** Microsoft Project will often have features designed to help project managers play around with resources and constraints and find the best combination of assignment for the projects. Software should have the capability to help plan, organize, and manage resource pools and develop resource estimates. Depending on the sophistication of the software, resource breakdown structures, resource availability, resource rates, and various resource calendars can be defined to assist in optimizing resource utilization.

16.4.3 **Outputs**

- **Activity Resource Requirement**

Activity resource requirements identify the types and quantities of resources required for each activity in a work package. The resource requirements documentation for each activity can include the basis of estimate for each resource, as well as the assumptions that were made in determining which types of resources are applied, their availability and what quantities are used.

- **Resource Breakdown Structure**

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

- **Project Documents Updates**
Estimate Activity Duration

Estimating time frame for a particular activity along with resource assigned. Estimate Activity Durations is the process of estimating the number of work periods needed to complete individual activities with estimated resources. It provides the amount of time each activity will take to complete. These estimates are used to approximate the number of work periods (activity duration) needed to complete the activity using the appropriate project and resource calendars. All data and assumptions that support duration estimating are documented for each estimate of activity duration.

Note: Padding is an extra time or cost added to an estimate because the estimator doesn't have enough information. Padding is hidden, unjustified and unprofessional.

16.5.1 Inputs


16.5.2 Tools & Techniques

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

Analogous estimating (Top-Down): This technique is used when you look at activities from previous project that were similar to this one and look at how long it took to do similar work before. This only works if the activities and the project team are similar, as the basis for estimating the same parameter or measure for a future project. Analogous duration estimating is frequently used to estimate project duration when there is a limited amount of detailed information about the project. Analogous estimating is generally less costly and less time consuming than other techniques, but it is also less accurate. Analogous estimating is most reliable when the previous activities are similar in fact and not just in appearance, and the project team members preparing the estimates have the needed expertise.

Parametric estimating: Plugging data about your project into a formula, spread sheet, database or computer program that comes up with an estimate, the software or formula that you use for parametric estimating is built on a database of actual duration from past projects. Parametric estimating is an estimating technique in which an algorithm is used to calculate cost or duration based on historical data and project parameters. Parametric estimating uses a statistical relationship between historical data and other variables (e.g. square footage in construction) to calculate an estimate for activity parameters, such as cost, budget, and duration. For example, if the assigned resource is capable of installing 25 meters of cable per hour, the duration required to install 1,000 meters is 40 hours. (1,000 meters divided by 25 meters per hour). This technique can produce higher levels of accuracy depending upon the sophistication and underlying data built into the model.

Regression analysis (scatter diagram): Diagram tracks two variables to see if they are related and creates a mathematical formula to use in future parametric estimating.

Learning curve: The 50th room painted will take less time than the first room because of improved efficiency.

Three-point estimating: When you come up with three number – Pessimistic, Most likely and Optimistic. This concept originated with the program evaluation and review technique (PERT).
Project Time Management

1. **Most likely** - This estimate is based on the duration of the activity, given the resources likely to be assigned.
2. **Optimistic** - The activity duration based on analysis of the best-case scenario for the activity.
3. **Pessimistic** - The activity duration based on analysis of the worst-case scenario for the activity.
   - Triangular Distribution (Simple Average) \( t_E = \frac{(O+M+P)}{3} \)
   - Beta Distribution (Weighted Average) \( t_E = \frac{(O+4M+P)}{6} \)

**Group decision-making techniques:** By involving a structured group of people who are close to the technical execution of work in the estimation process help the team decide on the best estimates for the activities they have to define. Technique used (brainstorming, the nominal group technique, and Delphi technique etc.) the activity duration based on analysis of the worst-case scenario for the activity.

**Reserve analysis:** Means adding more time to the schedule (called a contingency reserve or buffer to account for risk, to account for schedule uncertainty. **Contingency reserves** are associated with the “known-unknowns,” which may be estimated to account for this unknown amount of rework. The contingency reserve may be used, reduced, or eliminated. Contingency should be clearly identified in schedule documentation. Management reserves are a specified amount of the project duration withheld for management control purposes and are reserved for unforeseen work that is within scope of the project. **Management reserves** are intended to address the “unknown-unknowns” that can affect a project. Management reserve is not included in the schedule baseline, but it is part of the overall project duration requirements.

**16.5.3 Outputs**

- **Activity duration estimate**

Activity duration estimates are quantitative assessments of the likely number of time periods that are required to complete an activity.

2 weeks ± 2 days, which indicates that the activity will take at least eight days and not more than 12 (assuming a five-day workweek); and 15% probability of exceeding three weeks, which indicates a high probability—85%—that the activity will take three weeks or less.

- **Project documents updates**

**16.6 Develop Schedule**

It is the core of time management. It’s the process where you put it all together where you take everything you have done so far and combine it into one final schedule for the whole project.

Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model. The key benefit of this process is that by entering schedule activities, durations, resources, resource availabilities, and logical relationships into the scheduling tool, it generates a schedule model with planned dates for completing project activities.

**16.6.1 Inputs**

16.6.2 Tools & Techniques

Schedule Network Analysis: Schedule network analysis is a technique that generates the project schedule model. It employs various analytical techniques, such as critical path method, critical chain method, what-if analysis and resource optimization techniques, 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.

Critical Path Method: This technique is used to find out the longest duration of activities in network diagram. The critical path is the string of activities that will delay the whole project if any one of them is delayed, Float for each activity on the critical path is zero. The critical path method, which is a method used to estimate the minimum project duration and to calculate amount of scheduling flexibility. The critical path is the sequence of activities that represents the longest path through a project, which determines the shortest possible project duration.

This schedule network analysis technique calculates the early start, early finish, late start, and late finish dates for all activities without regard for any resource limitations by performing a forward and backward pass analysis through the schedule network.

![Figure 16-4 Example of Critical Path Method](image)

Near Critical Path: Near critical activities are those whose float (slack) is equal to one shift or less. These activities have a high potential of becoming critical. A near critical path can easily become a critical path if the float is exhausted.

Float/Slack: Tells you much extra time you have. The float for an activity is the amount of time that its duration can slip without causing the project to be delayed.

Total Float/Slack: Total float is the amount of time an activity can be delayed without delaying the project end date or milestone, while still adhering to any imposed schedule constraints.

Free Float: This is the amount of time an activity can be delayed without delaying the early start date of its successor while still adhering to any imposed schedule constraints.
**Project Time Management**

**Project Float**: Project float is amount of time a project can be delayed without delaying the externally imposed project completion date required by the customer or management, or the date previously committed to by the project manager.

**Start formula Float** = LS – ES  
**Finish formula Float** = LF – EF

- **Early Start**: the earliest time that an activity can start  
- **Early Finish**: the earliest time that an activity can finish

When you find the early start and early finish for each task, you know exactly how much freedom you have to move the start dates for those activities around without causing problem

- **Late Start**: the latest time that an activity can start  
- **Late Finish**: the latest time that an activity can finish

Figuring out the late start and late finish will help you see how much play you have in your schedule. An activity with a large late start or late finish means you have more options.

- **Forward Pass**: you can use a method called forward pass to add the early start and finish to each path in your network diagram  
- **Backward Pass**: to add the late start and late finish

Don’t forget that when two paths intersect, you have to decide which ES or LF value to take for the calculation in the next node. For the forward pass use the larger value; for the backward pass, use the smaller one.

**Schedule compression**:  
**Crashing schedule** means adding resources for activities on the critical path in order to compress the schedule while maintaining the original project scope. Crashing Always costs more and adds risk.

**Fast tracking** involves taking critical path activities that were originally planned in series and doing them instead in parallel for some or all of their duration this is pretty risky, though. There good chances you will need to redo some of the work you have done concurrently.

**Modeling Technique**: What-if Analysis. You can figure out how to deal with any problems that might come your way.

**Simulation**: This specific kind of what if analysis where you model uncertainty using a computer. There are some packages that will help to calculate risk using random numbers and Monte Carlo analysis algorithms: used computer software to simulate the outcome of a project on three-point estimates. This help with path convergence where multiple paths converge into one or more activities to find out quantitatively analyze risks.

**What-If Scenario Analysis**: What-if scenario analysis is the process of evaluating scenarios in order to predict their effect, positively or negatively, on project objectives.

**Scheduling Tool**: Using a project management software package to create a model of the schedule and adjusting various elements to see what might happen, if another technique for analyzing network diagrams [Milestone Chart, Bar chart (Gantt Chart) etc.]

**Leads and lags**: Adjusting leads and lags is applied during network analysis to find ways to bring project activities that are behind into alignment with the plan.
Lead: a lead may be used to indicate that an activity can start before its predecessor activity is completed.

Lag: Waiting Time – lags are used in limited circumstances where processes require a set period of time to elapse between the predecessors and successors without work or resource impact.

Critical Chain Method: Resource dependencies are used to determine the critical path, resource-constrained critical path is known as the critical chain, the critical chain method introduces the concept of buffers and buffer management. You add buffers, working backward from the delivery date into the schedule at strategic points, and managing the project so that each milestone is hit on time. The critical chain method adds duration buffers that are non-work schedule activities to manage uncertainty. One buffer, placed at the end of the critical chain, as shown in below Figure is known as the project buffer and protects the target finish date from slippage along the critical chain. Additional buffers, known as feeding buffers, are placed at each point where a chain of dependent activities that are not on the critical chain feeds into the critical chain. Feeding buffers thus protect the critical chain from slippage along the feeding chains.

Feeding buffer: Delays on paths of tasks feeding into the longest chain can impact the project by delaying a subsequent task on the Critical Chain. To protect against this, feeding buffers are inserted between the last task on a feeding path and the Critical Chain.

Project buffer: A project buffer is inserted at the end of the project network between the last task and the completion date. Any delays on the longest chain of dependent tasks will consume some of the buffer but will leave the completion date unchanged and so protect the project.

![Figure 16-5 Example of Critical Path Method](image)

Resource Optimization Techniques: Resource optimization refers to finding ways to adjust the use of resources.

Resource levelling: A technique in which start and finish dates are adjusted based on resource constraints with the goal of balancing demand for resources with the available supply. Resource levelling can be used when shared or critically required resources are only available at certain times, or in limited quantities, or over-allocate.

Note: Resource levelling can often cause the original critical path to change because it lengthens the schedule and increases cost.
**Resource Smoothing**: Resource smoothing is a modified form of resource levelling, where resources are levelled only within the limits of the float of their activities, so the completion dates of activities are not delayed.

**Note**: Resource smoothing does not change the original critical path to change.

16.6.3 Outputs

► Schedule baseline

A schedule baseline is the approved version of a schedule model that can be changed only through formal change control procedures and is used as a basis for comparison to actual results. The schedule baseline does the same for the project schedule (Agreed upon schedule - start and end date for each activity).

A milestone schedule as a milestone chart, (2) a summary schedule as a bar chart, and (3) a detailed schedule as a project schedule network diagram.

► Project Schedule

The outputs from a schedule model are schedule presentations. The project schedule is an output of a schedule model that presents linked activities with planned dates, durations, milestones and resources. At a minimum, the project schedule includes a planned start date and planned finish date for each activity.

Although a project schedule model can be presented in tabular form, it is more often presented graphically, using one or more of the following formats, which are classified as presentations:

- **Bar charts**: These charts, also known as Gantt charts, represent schedule information where activities are listed on the vertical axis, dates are shown on the horizontal axis, and activity durations are shown as horizontal bars placed according to start and finish dates.
- **Milestone charts**: These charts are similar to bar charts, but only identify the scheduled start or completion of major deliverables and key external interfaces.
- **Project schedule network diagrams**: These diagrams are commonly presented in the activity-on-node diagram format showing activities and relationships without a time scale, sometimes referred to as a pure logic diagram.
Schedule data

The schedule data for the project schedule model is the collection of information for describing and controlling the schedule. The schedule data includes the schedule milestones, schedule activities, activity attributes, and documentation of all identified assumptions and constraints. Schedule data could also include such items as resource histograms, cash-flow projections, and order & delivery schedules.
Project Time Management

► Project Calendar

A project calendar identifies working days and shifts that are available for scheduled activities after consideration of holidays and weekly offs.

► Project Management Plan Updates
► Project documents updates

16.7 Control Schedule

As the project work is happening, you can always discover new information that makes you re-evaluate your plan, and use the Control Schedule process to make the changes. The inputs to control schedule cover the various ways you can discover that information. The outputs are the changes themselves. Control Schedule is the process of monitoring the status of project activities to update project progress and manage changes to the schedule baseline to achieve the plan. It provides the means to recognize deviation from the plan and take corrective and preventive actions and thus minimize risk.

16.7.1 Inputs

Project Management Plan, Project Schedule, Work Performance Data, Project Calendars, Schedule Data and Organizational Process Assets

16.7.2 Tools & Techniques

Performance reviews: Performance reviews measure, compare and analyze schedule performance such as actual start and finish dates, percent complete, and remaining duration for work in progress.

Trend analysis: Trend analysis examines project performance over time to determine whether performance is improving or deteriorating. Graphical analysis techniques are valuable for understanding performance to date and for comparison to future performance goals in the form of completion dates.

Critical Path Method: To find out the longest duration of activities in network diagram. The critical path is the string of activities that will delay the whole project if any one of them is delayed, Float for each activity on the critical path is zero, evaluating the progress of activities on near critical paths can identify schedule risk.

Critical Chain Method: Resource dependencies are used to determine the critical path, then, you add buffers, working backward from the delivery date into the schedule at strategic points and managing the project so that each milestone is hit on time.

Earned value management: Schedule performance measurements such as schedule variance (SV) and schedule performance index (SPI) are used to assess the magnitude of variation to the original schedule baseline.

Project management software: This is software like Microsoft Project that helps you track planned dates versus actual dates, to report variances to and progress made against the schedule baseline, and to forecast the effects of changes to the project schedule model.

Tools and techniques from Develop schedule also used in Control schedule, kindly refer Tools and Techniques details in 17.6.2 for
Resource Optimization Techniques (17.6.2)

- Resource levelling
- Resource Smoothing

Modeling Technique (17.6.2)

- Simulation
- What-if scenario Analysis

Leads and lags (17.6.2)

Schedule compression: - (17.6.2)

- Crashing schedule
- fast tracking

Scheduling tool (17.6.2)

16.7.3 Outputs

- Work performance information

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

- Schedule forecasts

Schedule forecasts are estimates or predictions of conditions and events in the project’s future based on information and knowledge available at the time of the forecast. The information is based on the project’s past performance and expected future performance, and includes earned value performance indicators that could impact the project in the future.

- Change requests

Schedule variance analysis, along with review of progress reports, results of performance measures, and modifications to the project scope or project schedule may result in change requests to the schedule baseline, scope baseline, and/or other components of the project management plan. Change requests are processed for review and disposition through the Perform Integrated Change Control process.

- Project management plan updates
- Project documents updates
17. Project Cost Management

Project Cost Management encompasses several specific functions of project management including estimating, job controls, field data collection, scheduling, accounting and design. Its main goal is to complete a project within an approved budget. Many basic accounting and finance principles relate to cost project management.

No matter whether your project is big or small, and no matter how many resources and activities are in it. The process for figuring out the bottom line is always the same.

17.1 Cost estimates

Each type of estimate is done during different stages of the project life cycle, and each has a different level of accuracy.

17.1.1 Rough Order of magnitude

(ROM) or (Ballpark estimate) is estimating with very little accuracy at the beginning of a project and then refining the estimate over time (it’s got a range of -25 to + 75%)

17.1.2 Budget Estimate

This type of estimate is usually made during project planning and is in the range of +/- 10 percent from actual while others use -5 +/- 10 percent from actual.

17.1.3 Value Analysis

Value Engineering is to focus a less costly way to do the same work.

17.2 Types of Cost

17.2.1 Variable Costs

Variable costs are those costs that vary depending on production volume, these costs change with the amount of production or the amount of work (e.g., cost of material, supplies and wages)

17.2.2 Fixed Costs

A fixed cost is a cost that does not change with an increase or decrease in the amount of goods or services produced. These costs do not change as production change (e.g., cost of setup, rent, utilities)

17.2.3 Direct Costs

Direct costs can be traced directly to a cost such as a product or a department. In other words, direct costs do not have to be allocated to a product; these costs are directly attributed to the work on the project (e.g., travel, team wages, recognition and cost of material used on the project).

17.2.4 Indirect Costs (Overheads)

Indirect costs are costs that are not directly accountable to a cost object (such as a particular project, facility, function or product). Indirect costs are overhead items or costs incurred towards more than one project (taxes, fringe benefits and janitorial services, etc.).

17.3 Plan Cost Management
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. One need to plan out all of the processes, policies, procedures, documentation and methodologies you will use for cost management up front. The plan cost management process is where you plan out all the work you will do to make sure your project does not cost more than you have budgeted. You plan out all of the work you will do to figure out your budget and make sure your project stays within it.

17.3.1 Inputs

Project Management Plan, Project Charter, Enterprise Environmental Factors and Organizational Process Assets

17.3.2 Tools & Techniques

Expert Judgement: Expert judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects. Expert judgment can also suggest whether to combine methods and how to reconcile differences between them.

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

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

17.3.3 Outputs

Cost Management Plan or (Budget Management Plan)

The cost management plan describes how the project costs will be planned, structured, and controlled. The cost management processes and their associated tools and techniques are documented in the cost management plan. It will help how you will create the budget, and what to do when your project runs into money problems.

Cost Management Plan includes unit of measure, level of precision, level of accuracy, organizational procedures links, control thresholds, rule of performance measurement, reporting formats, process descriptions, etc.

17.4 Estimate Costs

Estimate Costs is the process of developing an approximation of the monetary resources needed to complete project activities. It determines the amount of cost required to complete project work.

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 may have a rough order of magnitude (ROM) estimate in the range of -25% to +75%. Later in the project, as more information is known, definitive estimates could narrow the range of accuracy to -5% to +10%.

17.4.1 Inputs
Project Cost Management

Cost management plan, human resource management plan, scope baseline, project schedule, risk register, enterprise environmental factors, and organizational process assets.

17.4.2 Tools & Techniques

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

Analogous estimating (Top-Down): This technique is used when you look at activities from previous project that were similar to this one and look at how long it took to do similar work before. This only works if the activities and the project team are similar, as the basis for estimating the same parameter or measure for a future project. Analogous duration estimating is frequently used to estimate project duration when there is a limited amount of detailed information about the project. Analogous estimating is generally less costly and less time consuming than other techniques, but it is also less accurate. Analogous estimating is most reliable when the previous activities are similar in fact and not just in appearance, and the project team members preparing the estimates have the needed expertise.

Parametric estimating: Mean plugging data about your project into a formula, spread sheet, database, or computer program that comes up with an estimate, the software or formula that you use for parametric estimating is built on a database of actual duration from past projects. Parametric estimating is an estimating technique in which an algorithm is used to calculate cost or duration based on historical data and project parameters. Parametric estimating uses a statistical relationship between historical data and other variables (e.g. square footage in construction) to calculate an estimate for activity parameters, such as cost, budget, and duration. For example, if the assigned resource is capable of installing 25 meters of cable per hour, the duration required to install 1,000 meters is 40 hours. (1,000 meters divided by 25 meters per hour).

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 to the greatest level of specified detail. The detailed cost is then summarized or “rolled up” to higher levels for subsequent reporting and tracking purposes.

Three-point estimating

• Triangular Distribution. \( cE = \frac{cO + cM + cP}{3} \)

• Beta Distribution (from a traditional PERT analysis). \( cE = \frac{cO + 4cM + cP}{6} \)

Reserve analysis: Cost estimates may include contingency reserves (sometimes called contingency allowances) to account for cost uncertainty. Contingency reserves are the budget within the cost baseline that is allocated for identified risks, which are accepted and for which contingent or mitigating responses are developed. Contingency reserves are associated with the “known-unknowns,” which may be estimated to account for this unknown amount of rework. The contingency reserve may be used, reduced, or eliminated. Management reserves are an amount of the project budget withheld for management control purposes and are reserved for unforeseen work that is within scope of the project. Management reserves are intended to address the “unknown unknowns” that can affect a project. The management reserve is not included in the cost baseline but is part of the overall project budget.

Cost of quality: What is the cost of conformance and non-conformance to quality will be on the project and creating an appropriate balance. Cost of Conformance: Training, document processes,
equipment, time to do it right, testing

**Cost of non-conformance:** rework, scrap, liabilities, warranty work, etc.

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

**Vendor bid analysis:** Analysis of what the project should cost, based on the responsive bids from qualified vendors. This tool is all about evaluating bids and choosing the one you will go with.

**Group decision-making techniques** (brainstorming, nominal group technique, Delphi, etc.): These techniques are useful for engaging team members to improve estimate accuracy and commitment to the emerging estimates. By involving a structured group of people who are close to the technical execution of work in the estimation process, additional information is gained and more accurate estimates are obtained, moreover, when people are involved in the estimation process, their commitment towards meeting the resulting estimates increases.

17.4.3 **Outputs**

- **Activity Cost Estimate**

Cost estimate for all activities in activity list, activity cost estimates are quantitative assessments of the probable costs required to complete project work. It takes into account resource rates and estimated duration of the activities [e.g., direct labor, materials, equipment, services, facilities, information technology, and special categories such as cost of financing (including interest charges), an inflation allowance, exchange rates or a cost contingency reserve].

- **Basis of Estimate**

The members of the project team, usually estimators, project managers, or cost analysts, calculate the total cost of the project. Through carefully planned equations, hierarchical listing of elements, standard calculations, checklists of project elements and other methods and the supporting documentation should provide a clear and complete understanding of how the cost estimate was derived.

- **Project documents updates**

17.5 **Determine Budget**

Determine Budget is the process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline. It determines the cost baseline against which project performance can be monitored and controlled. Project manager calculates the total cost of the project in order to determine the amount of funds the organization needs to have available for the project. The result of this calculation is called the budget. The **cost budget** is the cost baseline plus management reserve. This step entails close cooperation with the project sponsor.

17.5.1 **Inputs**

Cost management plan, scope baseline, activity cost estimates, basis of estimates, project schedule, resource calendars, risk register, agreements, organizational process assets.

17.5.2 **Tools & Techniques**
Cost aggregation: cost estimates are rolling up costs from the work package level to the control account level so that the number can be followed down through the WBS hierarchy. (Single or Multiple Activity estimates are clubbed under work package estimate, single or multiple combinations of work package estimates will have Control account estimate, combinations of multiple Control account estimates becomes Project estimates, Project estimates plus (+) contingency reserves = Cost Baseline, Cost Baseline plus (+) Management Reserves = Cost Budget (Project Budget) Below Project Budget component diagram illustrates the various components of the project budget.

Reserve analysis: Budget reserve analysis can establish both the contingency reserves and the management reserves for the project, after evaluating risk of project; certain money is set aside to deal with any issue.

Expert judgment: Expert judgment, guided by experience in an application area, Knowledge Area, discipline, industry, or similar project, aids in determining the budget. Such expertise may be provided by any group or person with specialized education, knowledge, skill, experience, or training.

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. (e.g. residential home construction is based on a certain cost per square foot of space).

Funding limit reconciliation: The expenditure of funds should be reconciled with any funding limits on the commitment of funds for the project. A variance between the funding limits and the planned expenditures will sometimes necessitate the rescheduling of work to level out the rate of expenditures. This is accomplished by placing imposed date constraints for work into the project schedule. It is applied to be sure that you can do the project within the amount that your company is willing to spend.

17.5.3 Outputs
Cost Baseline

The cost baseline is the approved version of the time-phased project budget, excluding any management reserves, which can only be changed through formal change control procedures and is used as a basis for comparison to actual results.

Below, the Project Budget component diagram illustrates the various components of the project budget and cost baseline.

Single or Multiple Activity estimate are clubbed under work package estimate, single or multiple combinations of work package estimates will have Control account estimate, combinations of multiple Control account estimated becomes Project estimates, Project estimates plus (+) contingency reserves = Cost Baseline, Cost Baseline plus (+) Management Reserves = Cost Budget (Project Budget)

Figure 17-2 Project Budget component

Project Funding Requirement

The time phased cost budget that is spending plan indicating how much money is approved for the project and when the funds are required. Total funding requirements and periodic funding requirements (e.g., quarterly, annually) are derived from the cost baseline. The cost baseline will include projected expenditures plus anticipated liabilities. Funding often occurs in incremental amounts that are not continuous, and may not be evenly distributed, which appear as steps as shown in below Figure.
17.6 Control Cost

Control means Measure

This process all about knows how you are doing compared to your plan and making adjustments when necessary, and it helps to figure out where to make changes so you don't overrun your budget. This process helps to recognize variance from the plan in order to take corrective action and minimize risk. In this step the allocated budget is reviewed and spending is tracked. The project manager takes responsibility for control spending and to ensure that the budget allocation is optimized and costs are fully covered with the planned and allocated budget.

17.6.1 Inputs

Project Management Plan, Project Funding Requirements, Work Performance Data and Organizational Process Assets

17.6.2 Tools & Techniques

**Earned value management** (EVM) is a methodology that combines scope, schedule, and resource measurements to assess project performance and progress. It is a commonly used method of performance measurement for projects. It integrates the scope baseline with the cost baseline, along with the schedule baseline, to form the performance measurement baseline (PMB), which helps the project management team assess and measure project performance and progress.

**Planned value** (PV) is the authorized budget assigned to scheduled work. It is the authorized budget planned for the work to be accomplished for an activity or work breakdown structure component, not including management reserve. This budget is allocated by phase over the life of the project, but at a given moment, planned value defines the physical work that should have been accomplished. The total of the PV is sometimes referred to as the performance measurement baseline (PMB). The total planned value for the project is also known as budget at completion (BAC). (In short planned valued means as of today, what is the estimated value of the work planned to be done?)
**Earned value (EV)** is a measure of work performed expressed in terms of the budget authorized for that work. It is the budget associated with the authorized work that has been completed. The EV being measured needs to be related to the PMB, and the EV measured cannot be greater than the authorized PV budget for a component. The EV is often used to calculate the percent (%) complete of a project. Progress measurement criteria should be established for each WBS component to measure work in progress. Project managers monitor EV, both incrementally to determine current status and cumulatively to determine the long-term performance trends. *(In short, earned value means as of today, what is the estimated value of the work actually accomplished?)*

**Actual cost (AC)** *(Total cost)* is the realized cost incurred for the work performed on an activity during a specific time period. It is the total cost incurred in accomplishing the work that the EV measured. The AC needs to correspond in definition to what was budgeted 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. *(In short, as of today, what is the actual cost incurred for the work accomplished?)*

**Schedule variance (SV)** is a measure of schedule performance expressed as the difference between the earned value and the planned value. It is the amount by which the project is ahead or behind the planned delivery date, at a given point in time. It is a measure of schedule performance on a project. It is equal to the earned value (EV) minus the planned value (PV). The EVM schedule variance is a useful metric in that it can indicate when a project is falling behind or is ahead of its baseline schedule. The EVM schedule variance will ultimately equal zero when the project is completed because all of the planned values will have been earned. Schedule variance is best used in conjunction with critical path method (CPM) scheduling and risk management. Equation: \( SV = EV - PV \). *(Negative is behind the schedule; positive is ahead of schedule and = 1 is on schedule)*

**Cost variance (CV)** is the amount of budget deficit or surplus at a given point in time, expressed as the difference between earned value and the actual cost. It is a measure of cost performance on a project. It is equal to the earned value (EV) minus the actual cost (AC). The cost variance at the end of the project will be the difference between the budget at completion (BAC) and the actual amount spent. The CV is particularly critical because it indicates the relationship of physical performance to the costs spent. Negative CV is often difficult for the project to recover. Equation: \( CV = EV - AC \). *(In short, negative is over budget; positive is under budget and = 1 is on planned cost)*

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

**Schedule performance index (SPI)** is a measure of schedule efficiency expressed as the ratio of earned value to planned value. It measures how efficiently the project team is using its time. It is sometimes used in conjunction with the cost performance index (CPI) to forecast the final project completion estimates. An SPI value less than 1.0 indicates less work was completed than was planned. An SPI greater than 1.0 indicates that more work was completed than was planned. Since the SPI measures all project work, the performance on the critical path also needs to be analyzed to determine whether the project will finish ahead of or behind its planned finish date. The SPI is equal to the ratio of the EV to the PV. Equation: \( SPI = EV/PV \). *(In short, a project is progressing at certain percent (%) of the rate originally planned, greater than one 1 is good, less than one 1 is bad and = 1 is on schedule)*

**Cost performance index** is a measure of the cost efficiency of budgeted resources, expressed as a ratio of earned value to actual cost. It is considered the most critical EVM metric and measures the cost efficiency for the work completed. A CPI value of less than 1.0 indicates a cost overrun for work completed. A CPI value greater than 1.0 indicates a cost underrun of performance to date. The CPI is
equal to the ratio of the EV to the AC. The indices are useful for determining project status and providing a basis for estimating project cost and schedule outcome. Equation: \( \text{CPI} = \frac{\text{EV}}{\text{AC}} \) [In short, project is getting money’s worth of work out of every $1 spent. Funds are or are not being used efficiently. Greater than one (1) is good; less than one (1) is bad and =1 is on planned cost]

**Forecasting**: Using current information about project to predict how close it will manage to meet its goals, it also provides preventive and corrective actions to keep project on right track

**BAC** = How much did we budget for the total project efforts?

**EAC** = What do we currently expect the total project to cost (a forecast)?

**ETC** = The expected cost to finish all the remaining project work (a forecast).

**VAC** = As of today, how much over or under budget do we expect to be at the end of the project?

As the project progresses, the project team may develop a forecast for the estimate at completion (EAC) that may differ from the budget at completion (BAC) based on the project performance. If it becomes obvious that the BAC is no longer viable, the project manager should consider the forecasted EAC. Forecasting the EAC involves making projections of conditions and events in the project’s future based on current performance information and other knowledge available at the time of the forecast. Forecasts are generated, updated, and reissued based on work performance data that is provided as the project is executed. The work performance information covers the project’s past performance and any information that could impact the project in the future.

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

The project manager’s manual EAC is quickly compared with a range of calculated EACs representing various risk scenarios. When calculating EAC values, the cumulative CPI and SPI values are typically used. While EVM data quickly provide many statistical EACs, only three of the more common methods are described as follows:

EAC forecast for ETC work performed at the budgeted rate. This EAC method accepts the actual project performance to date (whether favourable or unfavourable) as represented by the actual costs, and predicts that all future ETC work will be accomplished at the budgeted rate. When actual performance is unfavourable, the assumption that future performance will improve should be accepted only when supported by project risk analysis. Equation: EAC = AC + (BAC – EV).

EAC forecast for ETC work performed at the present CPI. This method assumes what the project has experienced to date can be expected to continue in the future. The ETC work is assumed to be performed at the same cumulative cost performance index (CPI) as that incurred by the project to date. Equation: EAC = BAC / 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. 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. Equation: EAC = AC + [(BAC – EV) / (CPI × SPI)]

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

**To-complete performance index (TCPI):** is the calculation that you can use to help you figure out how well your project needs to perform in the future in order to stay on budget.

**TCPI:** This formula divides the work remaining to be done by the money remaining to do it. It answers the question “In order to stay within budget, what rate we must meet for the remaining work?” Greater than one (1) is bad; less than one (1) is good.

The to-complete performance index (TCPI) is a measure of the cost performance that is required to be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the remaining budget. TCPI is the calculated cost performance index that is 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 should consider the forecasted EAC. Once approved, the EAC may replace the BAC in the TCPI calculation. The equation for the TCPI based on the BAC: (BAC – EV) / (BAC – AC).

The TCPI is conceptually displayed in below Figure. The equation for the TCPI is shown in the lower left as the work remaining (defined as the BAC minus the EV) divided by the funds remaining (which can be either the BAC minus the AC, or the EAC minus the AC).

If the cumulative CPI falls below the baseline as shown in Figure, all future work of the project will need to be performed immediately in the range of the TCPI (BAC) (as reflected in the top line of Figure 7-13) to stay within the authorized BAC. Whether this level of performance is achievable is a judgment call based on a number of considerations, including risk, schedule, and technical performance. This level of performance is displayed as the TCPI (EAC) line. The equation for the TCPI based on the EAC: TCPI = (BAC – EV) / (EAC – AC).
Figure 17-5 To-Complete Performance Index (TCPI)

Table 17-1 Earned Value Calculations Summary Table

| Earned Value Analysis |
### Project Cost Management

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Name</th>
<th>Lexicon Definition</th>
<th>How Used</th>
<th>Equation</th>
<th>Interpretation of Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PV</td>
<td>Planned value</td>
<td>The authorised budget assigned to schedule work.</td>
<td>The Value of the work planned to be completed to a point in time, usually the data, or project completion.</td>
<td>$EV = \text{sum of the planned value of completed work}$</td>
<td>Positive = Under planned cost&lt;br&gt;Neutral = On planned cost&lt;br&gt;Negative = Over planned cost</td>
</tr>
<tr>
<td>EV</td>
<td>Earned Value</td>
<td>The measure of work performed expressed in terms of the budget authorised that work.</td>
<td>The planned value of all the work completed (earned) to a point in time, usually the data date, without Reference to actual costs.</td>
<td>$PV = \text{Expected total cost of work until planned completion}$</td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>Actual Cost</td>
<td>The realized cost incurred for the work performed on an activity during A specific time period.</td>
<td>The actual cost of all the work completed to a point in time, usually the data date.</td>
<td>$\text{AC} = \text{Actual cost}$</td>
<td></td>
</tr>
<tr>
<td>BAC</td>
<td>Budget at Completion</td>
<td>The sum of all budgets established For the work to be performed.</td>
<td>The value of total planned work, the Project cost baseline.</td>
<td>$BAC = \text{Value of total planned cost}$</td>
<td></td>
</tr>
<tr>
<td>CV</td>
<td>Cost Variance</td>
<td>The amount by which the project is ahead or behind the planned delivery date, at a given point in time, expressed as the difference between The earned value and the actual cost.</td>
<td>The difference between the value of work completed to a point in time, usually the data date, and the actual Cost to the same point in time.</td>
<td>$CV = EV - AC$</td>
<td>Positive = Ahead of Schedule&lt;br&gt;Neutral = On schedule&lt;br&gt;Negative = Behind Schedule</td>
</tr>
<tr>
<td>SV</td>
<td>Schedule Variance</td>
<td>A projection of the amount of budget deficit or surplus, expressed as the difference between the budget at completion and the estimate at Completion.</td>
<td>The difference between the work planned to be completed to a point in time, usually the data date, and the work planned to be completed to the same point In time.</td>
<td>$SV = EV - PV$</td>
<td></td>
</tr>
<tr>
<td>VAC</td>
<td>Variance at Completion</td>
<td>A projection of the amount of budget deficit or surplus, expressed as the difference between the budget at completion and the estimate at Completion.</td>
<td>The estimated difference in cost at The completion of the project.</td>
<td>$\text{VAC} = \text{BAC} - \text{EAC}$</td>
<td>Positive = Under planned cost&lt;br&gt;Neutral = On planned cost&lt;br&gt;Negative = Over planned cost</td>
</tr>
<tr>
<td>CPI</td>
<td>Cost Performance Index</td>
<td>A measure of the cost efficiency of budgeted resources expressed as the ratio of earned Value to actual cost.</td>
<td>A CPI of 1.0 means the project is exactly on budget, that the work actually done so far is exactly the Same as the cost so far. Other values show the percentage of how much costs are over or under the budgeted Amount for work accomplished.</td>
<td>$\text{CPI} = \frac{EV}{AC}$</td>
<td>Greater than 1.0 = Under planned cost&lt;br&gt;Exactly 1.0 = On planned cost&lt;br&gt;Less than 1.0 = Over planned cost</td>
</tr>
<tr>
<td>SPI</td>
<td>Estimate At Completion</td>
<td>The expected total cost of completing all work expressed as the sum of the actual cost to date and The estimate to complete.</td>
<td>If the CPI is expected to be the same for the remainder of the project, EAC can be calculated using: If future work will be accomplished at the planned rate, use: If both the CPI and SPI influence the remaining work, use:</td>
<td>$\text{EAC} = \text{BAC/CPI}$&lt;br&gt;$\text{EAC} = \text{AC + EAC - EV}$&lt;br&gt;$\text{EAC} = \text{AC + Bottom-up ETC}$&lt;br&gt;$\text{EAC} = \text{AC + ([BAC - EV]/(CPI x SPI))]$</td>
<td>Greater than 1.0 = Harder to complete&lt;br&gt;Exactly 1.0 = Same to complete&lt;br&gt;Less than 1.0 = Easier to complete</td>
</tr>
<tr>
<td>EAC</td>
<td>Estimate At Completion</td>
<td>The expected total cost of completing all work expressed as the sum of the actual cost to date and The estimate to complete.</td>
<td>If the CPI is expected to be the same for the remainder of the project, EAC can be calculated using: If future work will be accomplished at the planned rate, use: If both the CPI and SPI influence the remaining work, use:</td>
<td>$\text{EAC} = \text{BAC/CPI}$&lt;br&gt;$\text{EAC} = \text{AC + EAC - EV}$&lt;br&gt;$\text{EAC} = \text{AC + Bottom-up ETC}$&lt;br&gt;$\text{EAC} = \text{AC + ([BAC - EV]/(CPI x SPI))]$</td>
<td>Greater than 1.0 = Harder to complete&lt;br&gt;Exactly 1.0 = Same to complete&lt;br&gt;Less than 1.0 = Easier to complete</td>
</tr>
<tr>
<td>ETC</td>
<td>Estimate to Complete</td>
<td>The expected cost to finish all the Remaining project work.</td>
<td>Assuming work is proceeding on plan, the cost of completing the remaining authorized work can be calculated using: Reestimate the remaining work from The bottom up.</td>
<td>$\text{ETC} = \text{EAC - AC}$&lt;br&gt;$\text{ETC} = \text{Reestimate}$</td>
<td>Greater than 1.0 = Harder to complete&lt;br&gt;Exactly 1.0 = Same to complete&lt;br&gt;Less than 1.0 = Easier to complete</td>
</tr>
<tr>
<td>TCPI</td>
<td>To Complete Performance Index</td>
<td>A measure of the cost performance that must be achieved with the remaining resources in order to meet a specified management goal, expressed as the ratio of the cost to finish the outstanding work to the Budget available.</td>
<td>The efficiency that must be maintained in order to complete on Plan. The efficiency that must be maintained in order to complete the Current EAC.</td>
<td>$\text{TCPI} = \frac{\text{BAC - EAC}}{(\text{BAC - EV})/(\text{EAC - AC})}$</td>
<td>Greater than 1.0 = Harder to complete&lt;br&gt;Exactly 1.0 = Same to complete&lt;br&gt;Less than 1.0 = Easier to complete</td>
</tr>
</tbody>
</table>

**Performance reviews**: Performance reviews compare cost performance over time, schedule activities or work packages overrunning and under running the budget, and estimated funds needed to complete work in progress. If EVM is being used, the following information is determined:
• **Variance analysis**: As used in EVM, is the explanation (cause, impact, and corrective actions) for cost \((CV = EV - AC)\), schedule \((SV = EV - PV)\), and variance at completion \((VAC = BAC - EAC)\) variances. Cost and schedule variances are the most frequently analyzed measurements.

• **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**: Compares the performance measurement baseline to actual schedule and cost performance. If EVM is not being used, then the analysis of the cost baseline against actual costs for the work performed is used for cost performance comparisons.

• **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.

• **Reserve analysis**: How you are spending versus the amount of reserve you have budgeted. You might find that you are using reserved money at a faster rate than you expected or that you need to reserve more as new risk are uncovered during cost control, reserve analysis is used to monitor the status of contingency and management reserves for the project to determine if these reserves are still needed or if additional reserves need to be requested. As work on the project progresses, these reserves may be used as planned to cover the cost of risk mitigation events or other contingencies.

17.6.3 **Outputs**

► **Work Performance Information**

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

► **Cost Forecasts**

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

► **Change Requests**

Analysis of project performance may result in a change request to the cost baseline or other components of the project management plan. Change requests may include preventive or corrective actions, and are processed for review and disposition through the Perform Integrated Change Control process.

► **Project Management Plan Updates**

► **Project Documents Updates**

► **Organizational Process Assets Updates**
18. Project Quality Management

Quality means making sure that you build what you said you would and that you do it as effectively as you can. (Conformance to Requirement). Quality is the measurement of how closely your product meets its requirements.

Quality and grade are not the same concepts. Quality as a delivered performance or result is “the degree to which a set of inherent characteristics fulfil requirements” (ISO 9000). Quality means that something does what you needed it to do. Grade describes how much people value it.

It may not be a problem if a suitable low-grade software product (one with a limited number of features) is of high quality (no obvious defects, readable manual). In this example, the product would be appropriate for its general purpose of use.

It may be a problem if a high-grade software product (one with numerous features) is of low quality (many defects, poorly organized user documentation). In essence, its high-grade feature set would prove ineffective and/or inefficient due to its low quality.

Precision is a measure of exactness whereas Accuracy is an assessment of correctness. An illustration of this concept is the comparison of archery targets. Arrows clustered tightly in one area of the target, even if they are not clustered in the bull’s-eye, are considered to have high precision. Targets where the arrows are more spread out but equidistant from the bull’s-eye are considered to have the same degree of accuracy. Targets where the arrows are both tightly grouped and within the bull’s-eye are considered to be both accurate and precise. (Precise measurement may not be accurate measurement, and accurate measurement may not be precise measurement.)

- Customer Satisfaction

Understanding, evaluating, defining, and managing requirements so that customer expectations are met. This requires a combination of conformance to requirements (to ensure the project produces what it was created to produce) and fitness for use (the product or service needs to satisfy the real needs): is about making sure that the product you build has the best design possible to fit the customer’s needs. You will always choose the product that fits your needs, even if its seriously limited, the product both does what it is supposed to do and does it well.

- Prevention over inspection

Quality should be planned, designed, and built into—not inspected into the project’s management or the project’s deliverables. The cost of preventing mistakes is generally much less than the cost of correcting mistakes when they are found by inspection or during usage. (Conformance to requirements)

- Continuous improvement

The PDCA (plan-do-check-act) cycle is the basis for quality improvement as defined by Shewhart and modified by Deming. In addition, quality improvement initiatives such as Total Quality Management (TQM), Six Sigma, and Lean Six Sigma could improve the quality of the project’s management as well as the quality of the project’s product. Commonly used process improvement models include Malcolm Baldrige, Organizational Project Management Maturity Model (OPM3®), and Capability Maturity Model Integration (CMMI®).

- Joseph Juran

Developed 80/20 principle, advocated top management involvement and defined quality as “fitness for use.”
- Philip Crosby

Developed concept of poor quality and advocated zero defects and Prevention over inspection, he stated that Quality is “Conformance to requirements.”

![Diagram](image)

**Figure 18-1 Fundamental Relationships of Quality Assurance and Control Quality to the IPECC, PDCA, Cost of Quality Models and Project Management Process Groups**

### 18.1 Plan Quality Management

Plan Quality Management focuses on taking all of the information available at beginning of the project and figuring out how you will measure you quality and prevent defects. Focuses on defining quality for the project, the product, and project management, and planning how it will be achieved. Plan Quality Management is the process of identifying quality requirements and/or standards for the project and its deliverables, and documenting how the project will demonstrate compliance with relevant quality requirements and/or standards. It provides guidance and direction on how quality will be managed and validated throughout the project.

#### 18.1.1 Inputs

Project Management Plan, Stakeholder Register, Risk Register, Requirements Documentation, Enterprise Environmental Factors and Organizational Process Assets

#### 18.1.2 Tools & Techniques

**Cost-benefit analysis**: It’s looking at how much your quality activities will cost versus how much you will gain from doing them. The main benefits are less rework, higher productivity and efficiency, and more satisfaction from both the team and the customer.
Cost of quality: It is what you get when you add up the cost of all of the preventions and inspection activities you are going to do on your project. Cost of quality can be a good number to check whether your project is doing well or having trouble (work like, writing standards, reviewing docs, meeting to analyze root cause of defects, doing rework to fix,) (Cost of conformance and non-conformance). Failure costs are often categorized into internal cost (found by the project) and external cost (found by the customer). Failure costs are also called cost of poor quality.

![Cost of Quality diagram](image)

**Figure 18-2 Cost of Quality diagram**

Seven basic quality tools

1. **Cause and effect, fishbone, or Ishikawa Diagrams**: This is used to figure out what caused a defect. You list all of the categories of the defects that you have identified and then write the possible causes of the defect you are analyzing form each category; it is very useful to pinpoint the root cause of defects.

2. **Flowcharts (Process Map)**: Lets you show how processes work visually. You can use a flowchart to show how the tasks in your project interrelate and what they depend on. They are also good for showing decision-making processes. The flow chart helps you to see how all of the phases relate to each other. (SIPOC MODEL)
3. Check Sheets (Tally Sheets): Allow you to collect data on the product under test. Check sheets are sometimes called checklists or tally sheets, you can use them to organize the test activities you will be performing and track whether the product passes or fails tests.

4. Pareto Charts: Help you figure out which problems need your attention right away. Displayed from most frequent to least frequent, 80/20 rule, 80% of the defects are usually caused by 20% of the causes. Pareto charts plot out the frequency of defects and sort them in descending order.

5. Histograms: Give you a good idea of how your data breaks down in order to identify which problem are worth dealing with.

6. Control Charts: Are used to determine whether or not a process is stable, this is the way of visualizing how processes are doing over time, it has lower control limit, upper control limit and mean (average).

   - **Lower control limit**: upper acceptable range
   - **Upper control limit**: lower acceptable range
   - **Mean (average)**: is indicated by a line in the middle of control chart, it shows the middle of the range of acceptable variation.
   - **Specification limits**: While control limits represent the performing organizations standards for quality, specification limit represent the customer’s expectation or contractual requirement for the performance and quality on the project.

Below are two indicators to identify, if process is out of control.

   - When data points fall above the upper limit or below the lower limit on a control chart, the process is out of control.
- **Rule of seven**: means that any time you have seven data points in a row that fall on the same side of the mean on a control chart, you need to figure out why.

7. **Scatter Diagrams**: Show how different types of data relate to each other. Plot ordered pairs (X, Y) and are sometimes called correlation charts because they seek to explain a change in the dependent variable, Y, in relationship to a change observed in the corresponding independent variable, X. E.g. Test team is created a bunch of new tests where scatter diagram can be used to see, if new test cases had any impact on the number of defects you found.

**Figure 18-4 SEVEN QUALITY TOOL Diagrams**

**Benchmarking**: Benchmarking involves comparing actual or planned project practices with those of comparable projects to identify best practices, generate ideas for improvement, and provide a basis for measuring performance. Benchmarked projects may exist within the performing organization or outside of it, or can be within the same application area. Benchmarking allows for analogies from projects in a different application area to be made.

**Design of experiments**: This is where you apply the scientific method to create a set of tests for your projects deliverables. It’s a statistical method, which means you use statistics to analyze the results of your experiments to determine how your deliverables best meet the requirement. 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.

**Statistical sampling**: This is when you look at a representative sample of something to make decisions. Statistical sampling involves choosing part of a population of interest for inspection (for example, selecting ten engineering drawings at random from a list of seventy-five). Sample frequency and sizes should be determined during the Plan Quality Management process so the cost of quality will include the number of tests, expected scrap, etc.

**Additional quality planning tools**

**Brainstorming**: This technique is used to generate ideas.
Affinity diagrams: Many ideas grouped together under specific categories and it's tweaked and twisted until finalized under categories which help identify requirement with specific category.

Force field analysis: This is how engineers analyze structure to see what forces affect their use.

Nominal Group Techniques: This technique is used to allow ideas to be brainstormed in small groups and then reviewed by a larger group.

Meetings: Project teams may hold planning meetings to develop the quality management plan. Attendees at these meetings may include the project manager; the project sponsor; selected project team members; selected stakeholders; anyone with responsibility for Project Quality Management activities namely Plan Quality Management, Perform Quality Assurance or Control Quality, and others as needed.

18.1.3 Outputs

► Quality Management Plan

The quality management plan is a component of the project management plan that describes how the organization’s quality policies will be implemented. It describes how the project management team plans to meet the quality requirements set for the project. Ultimately, it deals with problems that could arise when a product does not live up to the customer standards.

► Process improvement plan

It consists of Process boundaries, process configuration, process metrics, and target for improved performance. The process improvement plan tells you how you can change the processes you are using to build you product to make them better and how processes that are used on the project to complete the work or perform project management activities will be evaluated and improved.

► Quality metrics

A quality metric specifically describes a project or product attribute and how the control quality process will measure it. A measurement is an actual value. The tolerance defines the allowable variations to the metric. For example, if the quality objective is to stay within the approved budget by ± 10%, Quality metrics are used in the perform quality assurance and control quality processes. Some examples of quality metrics include on-time performance, cost control, defect frequency, failure rate, availability, reliability and test coverage.

► Quality Checklists

A checklist is a structured tool, usually component-specific, used to verify that a set of required steps has been performed. Many organizations have standardized checklists available to ensure consistency in frequently performed tasks. Quality checklists should incorporate the acceptance criteria included in the scope baseline.

► Project documents updates

18.2 Perform Quality Assurance

You need to make sure your project Audit is done in a way that complies with your company’s quality standards. And is all about improving the process, and its purpose is to ensure the team is following organization policies, standards and processes as planned to produce the project deliverables. The bottom line is that your project has a better chance of succeeding, if you stay involved with process improvement and keep your eye on how your project stacks up to your company’s expectations of quality and process.
18.2.1 Inputs

Quality Management Plan, Process Improvement Plan, Quality Metrics, Quality Control Measurements, Project Documents

18.2.2 Tools & Techniques

Quality management and control tools

The Perform Quality Assurance process uses the tools and techniques of the Plan Quality Management and Control Quality processes.

**Affinity Diagrams**: Many ideas grouped together under specific categories and it's tweaked and twisted until finalized under categories which help identify requirement with specific category.

**Process decision program charts (PDPC)**: It is used to understand a goal in relation to the steps for getting to the goal. The PDPC is useful as a method for contingency planning because it aids teams in anticipating intermediate steps that could derail achievement of the goal.

**Interrelationship digraphs**: An adaptation of relationship diagrams. The interrelationship digraphs provide a process for creative problem solving in moderately complex scenarios that possess intertwined logical relationships for up to 50 relevant items. The interrelationship digraph may be developed from data generated in other tools such as the affinity diagram, the tree diagram, or the fishbone diagram.

**Tree Diagrams**: Also known as systematic diagrams and may be used to represent decomposition hierarchies such as the WBS, RBS, tree diagrams are useful in visualizing the parent-to-child relationships in any decomposition hierarchy that uses a systematic set of rules that define a nesting relationship.

**Prioritization matrices**: Identify the key issues and the suitable alternatives to be prioritized as a set of decisions for implementation. Criteria are prioritized and weighted before being applied to all available alternatives to obtain a mathematical score that ranks the options.

**Activity network diagrams**: Previously known as arrow diagrams. They include both the AOA (Activity on Arrow) and, most commonly used, AON (Activity on Node) formats of a network diagram. Activity network diagrams are used with project scheduling methodologies such as program evaluation and review technique (PERT), critical path method (CPM), and precedence diagramming method (PDM).

**Matrix diagrams**: A quality management and control tool used to perform data analysis within the organizational structure created in the matrix. The matrix diagram seeks to show the strength of relationships between factors, causes, and objectives that exist between the rows and columns that form the matrix.
Quality audits: A quality audit is a structured, independent process when your company reviews your project to see if you are following its processes, organizational and project policies, processes, and procedures. The subsequent effort to correct any deficiencies should result in a reduced cost of quality and an increase in sponsor or customer acceptance of the project’s product. Quality audits may be scheduled or random, and may be conducted by internal or external auditors.

Process analysis: It is following your process improvement plan to compare your projects process data to goals that have been set for your company, in mean time also focusing on beneficial improvements. This analysis also examines problems experienced, constraints experienced, and non-value-added activities identified during process operation.

Kizen: means continuous improvement; it’s all about constantly looking at the way you do your work and trying to make it better. (Doing small improvements and measuring its impact.)

Just-in-Time (JIT): keeping only the inventory you need on hand when you need it. There is not any extra inventory to deal with mistakes.

Plan-Do-Check-Act: is one way to go about improving your process. (W. Edward Deming)

Total Quality Management: This philosophy encourages companies and their employees to focus on finding ways to continuously improve the quality of their product and their business practices at every level of the organization.

18.2.3 Outputs

Change Requests

Change requests are created and used as input into the Perform Integrated Change Control process to allow full consideration of the recommended improvements. Change requests are used to take corrective action, preventive action, or to perform defect repair.
Project Quality Management

- **Project Management Plan Updates**
  Quality plan, scope plan, schedule plan, cost plan, etc.

- **Project Documents Updates**

- **Organizational Process Assets Updates**

  Elements of the organizational process assets that may be updated include, but are not limited to, the organization’s quality standards and the quality management system.

18.3 Control Quality

This process examines the actual deliverables produced on the project; its purpose is to ensure the deliverables are correct and meet the planned level of quality and to find the source of problems and recommend ways to address them.

Quality assurance should be used during the project's planning and executing phases to provide confidence that the stakeholder’s requirements will be met and quality control should be used during the project executing and closing phases to formally demonstrate, with reliable data, that the sponsor and/or customer’s acceptance criteria have been met.

It useful to know below mentioned terms for control quality

**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).

**Tolerances:** (specified range of acceptable results) and control limits (that identify the boundaries of common variation in a statistically stable process or process performance).

18.3.1 Inputs

Project management plan, quality metrics, quality checklists, work performance data, approved change requests, deliverables, project documents and organizational process assets.

18.3.2 Tools & Techniques

Tools and techniques from Plan Quality Management also used in Control Quality, kindly refer Tools and Techniques details in 19.6.2 for

**Seven basic quality tools:** (19.6.2)

**Statistical sampling:** (19.6.2)

**Inspection (reviews, peer reviews, audits, or walkthroughs):** An inspection is the examination of a work product to determine if it conforms to documented standards. The results of an inspection generally include measurements and may be conducted at any level. For example, the results of a single activity can be inspected, or the final product of the project can be inspected.

**Approved change requests review:** All approved change requests should be reviewed to verify that they were implemented as approved.
**Six Sigma:** Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving toward six standard deviations between the mean and the nearest specification limit) in any process.

+-1 sigma (one standard deviation) is equal to 68.27%

+-3 Sigma (three standard deviation) is equal to 99.73%

+-6 Sigma (six standard deviation) is equal to 99.99999%

### 18.3.3 Outputs

- **Quality control measurements**

  Quality control measurements are the documented results of control quality activities. They should be captured in the format that was specified through the Plan Quality Management process.

- **Validated changes**

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

- **Verified deliverables**

  A goal of the Control Quality process is to determine the correctness of deliverables. The results of performing the Control Quality process are verified deliverables. Verified deliverables are an input to Validate Scope for formalized acceptance.

- **Work performance information**

  Work performance information is the performance data collected from various controlling processes, analyzed in context and integrated based on relationships across areas. Examples include information about the project requirements fulfillment such as causes for rejections, rework required, or the need for process adjustments.

- **Change requests**

  If the recommended corrective or preventive actions or a defect repair requires a change to the project management plan, a change request should be initiated in accordance with the defined Perform Integrated Change Control process.

- **Project management plan updates**

- **Project documents updates**

- **Organizational process assets updates**
19. Project Human Resource Management

Project Human Resource Management includes the processes that organize, manage, and lead the project team. The project team is comprised of the people with assigned roles and responsibilities for completing the project. Participation of team members during planning adds their expertise to the process and strengthens their commitment to the project. The project Team is responsible for the project management and leadership activities with the various project phases such as initiating, planning, executing, monitoring & controlling, and closing. This group can also be referred to as the core, executive, or leadership team.

Influencing the project team: The project manager needs to be aware of and influence, when possible, human resource factors that may impact the project. These factors include team environment, geographical locations of team members, communications among stakeholders, internal and external politics, cultural issues, organizational uniqueness, and others factors that may alter project performance.

Professional and ethical behaviour: The project management team should be aware of, subscribe to, and ensure that all team members follow professional and ethical behavior.

19.1 Plan Human Resource Management

Plan Human Resource Management is the process of identifying and documenting project roles, responsibilities, required skills, reporting relationships, and creating a staffing management plan. It establishes project roles and responsibilities, project organization charts, and the staffing management plan including the timetable for staff acquisition and release.

19.1.1 Inputs

Project Management Plan, Activity Resource Requirements, Enterprise Environmental Factors, Organizational Process Assets

19.1.2 Tools & Techniques

Organization Charts and Position Descriptions: Graphically tells everyone how your team is structured. Various formats exist to document team member roles and responsibilities. Most of the formats fall into one of three types as given in Roles and Responsibility Definition Formats diagram - hierarchical, matrix, and text-oriented. The objective is to ensure that each work package has an unambiguous owner and that all team members have a clear understanding of their roles and responsibilities.

Hierarchical-type charts: The traditional organization chart structure can be used to show positions and relationships in a graphical, top-down formats like Work breakdown structures (WBS), organizational breakdown structure (OBS), resource breakdown structure (RBS).

Matrix-based charts: A responsibility assignment matrix (RAM) is a grid that shows the project resources assigned to each work package. It is used to illustrate the connections between work packages or activities and project team members. A RACI chart is a useful tool to use when the team consists of internal and external resources in order to ensure clear divisions of roles and expectations.

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.
RACI Chart (R = Responsible, A = Accountable, C = Consult, I = Inform):

<table>
<thead>
<tr>
<th>Activity</th>
<th>Ann</th>
<th>Ben</th>
<th>Carlos</th>
<th>Dina</th>
<th>Ed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Create charter</td>
<td>A</td>
<td>R</td>
<td>I</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Collect requirements</td>
<td>I</td>
<td>A</td>
<td>R</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Submit change request</td>
<td>I</td>
<td>A</td>
<td>R</td>
<td>R</td>
<td>C</td>
</tr>
<tr>
<td>Develop test plan</td>
<td>A</td>
<td>C</td>
<td>I</td>
<td>I</td>
<td>R</td>
</tr>
</tbody>
</table>

**Networking:** Networking is the formal and informal interaction with others in an organization, industry, or professional environment. It is a constructive way to understand political and interpersonal factors that will impact the effectiveness of various staffing management options. Examples of human resources networking activities include proactive correspondence, luncheon meetings, informal conversations including meetings and events, trade conferences, and symposia. It can also be an effective way to enhance project management professional development during the project and after the project ends.

**Organizational theory:** Organization uses proven principles to guide your decisions. Organizational theory provides information regarding the way in which people, teams, and organizational units behave. Effective use of common themes identified in organizational theory can shorten the amount of time, cost, and effort needed; applicable organizational theories may recommend exercising a
flexible leadership style that adapts to the changes in a team’s maturity level throughout the project life cycle.

**Expert judgment:** It is necessary to figure out resource requirements and position descriptions, determine the preliminary effort level and number of resources, Determine reporting relationships, Provide guidelines on lead time required for staffing, etc.

**Meetings:** When planning human resource management of the project, the project management team will hold planning meetings. These meetings leverage a combination of other tools and techniques to allow for all project management team members to reach consensus on the human resource management plan.

19.1.3 Outputs

- **Human Resource Management plan**

The human resource management plan describes how the roles and responsibilities, reporting relationships, and staffing management will be addressed and structured within a project. It also contains the staffing management plan including timetables for staff acquisition and release, identification of training needs, team-building strategies, plans for recognition and rewards programs, compliance considerations, safety issues, and the impact of the staffing management plan on the organization.

- **Roles and Responsibilities** consist of: Role – Authority – Responsibility – Competency
- **Project Organization Chart:** A project organization chart is a graphical display of project team members and their reporting relationships. It can be formal or informal.
- **Staffing Management Plan:** The staffing management plan is a component of the human resource management plan that describes when and how project team members will be acquired and how long they will be needed.
- **Staff acquisition:** Whether the human resources come from within the organization or from external, contracted sources; whether the team members need to work in a central location or may work from distant locations; costs associated with each level of expertise needed for the project.
- **Resource calendars:** Calendars that identify the working days and shifts on which each specific resource is available.
- **Timetable:** Resource Histogram [number of resources and time (week, days, months, etc.)]
- **Staff release plan**: Determining the method and timing of releasing team members, this benefits both the project and team members. When team members are released from a project, it may also have Release Criteria.
- **Training needs**: If it is expected that the team members to be assigned will not have the required competencies, a training plan can be developed as part of the project.
- **Recognition and rewards**: Clear criteria for rewards and a planned system for their use help promote and reinforce desired behaviours. To be effective, recognition and rewards should be based on activities and performance under a person’s control.
- **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 hazards can be included in the staffing management plan as well as in the risk register.

### 19.2 Acquire Project Team

Acquire Project Team is the process of confirming human resource availability and obtaining the team necessary to complete project activities. The key benefit of this process consists of outlining and guiding the team selection and responsibility assignment to obtain a successful team.

#### 19.2.1 Inputs

Human resource management plan, enterprise environmental factors and organizational process assets.

#### 19.2.2 Tools & Techniques

**Pre-assignment**: When project team members are selected in advance, they are considered pre-assigned, means resources that are guaranteed to you when you start the project, so you don’t need to negotiate for them.
Negotiation: The most important tool in this process. There are resources that you need for your project, but they don’t report to you. So you need to negotiate with the functional managers, may be even other project manager for their time and External organizations, vendors, suppliers, contractors, etc.

Acquisition: When the performing organization is unable to provide the staff needed to complete a project so going outside of your company to contractors and consultants to staff your team. This can involve hiring individual consultants or subcontracting work to another organization.

Virtual teams: Is when your team members don’t all work in the same location. This is really useful when you are relying on consultants and contractors for outsourced work. Work is coordinated and executed with help of phone call, email, instant messaging, and online collaboration tools. There are some disadvantages related to virtual teams, such as possibility for misunderstandings, feeling of isolation, difficulties in sharing knowledge and experience between team members and cost of appropriate technology.

Multi-criteria decision analysis: In acquiring the project team. It’s useful to establish a set of criteria to help evaluate potential team members based on some factor like availability, Ability, cost, knowledge, experience, location, skill set, attitude, international factor, etc.

Note: Halo effect (Peter’s principal): When you put someone in a position they can’t handle, you do it just because they are good at another job. This should not be done in any projects assignments.

19.2.3 Outputs

► Project staff assignments

The project is staffed when appropriate people have been assigned to the team. The documentation of these assignments can include a project team directory, memos to team members, and names inserted into other parts of the project management plan, such as project organization charts and schedules.

► Resource calendars

Resource calendars document the time periods that each project team member is available to work on the project. Creating a reliable schedule depends on having a good understanding of each person’s availability and schedule constraints, including time zones, work hours, vacation time, local holidays, and commitments to other projects.

► Project management plan updates

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

19.3 Develop Project Team

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. Develop Project Team is the process of improving competencies, team member interaction, and overall team environment to enhance project performance. It results in improved teamwork, enhanced people skills and competencies, motivated employees, reduced staff turnover rates, and improved overall project performance.

19.3.1 Inputs

Human Resource Management Plan, Project Staff Assignments, Resource Calendars
19.3.2 Tools & Techniques

Interpersonal skills: Sometimes known as “soft skills,” are behavioural competencies that include proficiencies such as communication skills, emotional intelligence, conflict resolution, negotiation, influence, team building, and group facilitation. For example, the project management team can use emotional intelligence to reduce tension and increase cooperation by identifying, assessing, and controlling the sentiments of project team members, anticipating their actions, acknowledging their concerns, and following up on their issues.

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. It could be performed by in-house or external trainers.

Team-building activities: Team-building activities can vary from a 5-minute agenda item in a status review meeting to an off-site, professionally facilitated experience designed to improve interpersonal relationships. The objective of team-building activities is to help individual team members work together effectively. As an on-going process, team building is crucial to project success. It is a never-ending process. The project manager should continually monitor team functionality and performance to determine if any actions are needed to prevent or correct various team problems.


1. Forming: This phase is where the team meets and learns about the project and their formal roles and responsibilities. Team members tend to be independent and not as open in this phase. (This is phase where least amount of work gets done.)
2. Storming: During this phase, the team begins to address the project work, technical decisions, and the project management approach. If team members are not collaborative and open to differing ideas and perspectives, the environment can become counterproductive.
3. Norming: In the norming phase, team members begin to work together and adjust their work habits and behaviours to support the team. The team learns to trust each other.
4. Performing: Teams that reach the performing stage function as a well-organized unit. They are interdependent and work through issues smoothly and effectively.
5. Adjourning: In the adjourning phase, the team completes the work and moves on from the project. This typically occurs when staff is released from the project as deliverables are completed or as part of carrying out the Close Project or Phase process.

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 in areas such as code of conduct, communication, working together, or meeting etiquette allows team members to discover values that are important to one another. It helps you prevent problem between team members, and let you establish working conditions that everyone on the team can live with; setting ground rule can help eliminate conflict or problems with the team during the project.

Colocation (Tight Matrix): Colocation, also referred to as “tight matrix,” 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 (sometimes called War Room).

Recognition and rewards: Are the best ways to keep your team motivated, Part of the team development process involves recognizing and rewarding desirable behavior. The original plans concerning ways in which to reward people are developed during the Plan Human Resource Management process.
Personnel assessment tools: Personnel assessment tools give the project manager and the project team insight into areas of strength and weakness, this tool is used to figure out how your team approaches the work and how they like to work together. These tools include thing like focus groups, surveys etc. this information can give your insight into how to lead and guide the team.

19.3.3 Outputs

► Team Performance Assessments

The performance of a successful team is measured in terms of technical success according to agreed-upon project objectives (including quality levels), 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. As a result of conducting an evaluation of the team’s overall performance, the project management team can identify the specific training, coaching, mentoring, assistance, or changes required to improve the team’s performance. These resources and recommendations for team improvement should be well documented and forwarded to the relevant parties.

19.4 Manage Project Team

Manage Project Team is the process of tracking team member performance, providing feedback, resolving issues, and managing team changes to optimize project performance. It influences team behavior, manages conflict, resolves issues, and appraises team member performance.

19.4.1 Inputs

Human resource management plan, Project staff assignments, Team performance assessments, Issue log, Work performance reports, and Organizational process asset.

19.4.2 Tools & Techniques

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.

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 performance appraisal could be done as a 360-degree review, which would include the input of co-workers’ and subordinates, as well as supervisors.

Conflict management: Conflict is inevitable in a project environment, 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.

1. Withdrawal/Avoidance: Retreating from an actual or potential conflict situation, the parties retreat or postpone a decision on a problem.
2. **Smoothing/Accommodating**: This technique emphasizes agreement rather than differences of option. Conceding one’s position to the needs of others to maintain harmony and relationships.

3. **Compromising/Reconciling**: This technique involves finding solution that brings some degree of satisfaction to both parties. This is lose/lose situation.

4. **Forcing/Directing**: This technique involves pushing one viewpoint at the expense of another. It is a win/lose situation.

5. **Collaborating/Confronting/Problem Solving**: In this technique, the parties openly discuss differences and try to incorporate multiple viewpoints in order to lead to consensus and commitment which lead to win/win.

**Interpersonal skills**: This is all about helping the people on your team to solve problems. Project managers use a combination of technical, personal, and conceptual skills to analyze situations and interact appropriately with team members. Using appropriate interpersonal skills allows project managers to capitalize on the strengths of all team members and necessary skills.

**Leadership**: It is especially important to communicate the vision and inspire the project team to achieve high performance.

**Influencing**: Because project managers often have little or no direct authority over team members in a matrix environment, their ability to influence stakeholders on a timely basis is critical to project success.

**Effective Decision making**: This involves the ability to negotiate and influence the organization and the project management team.

**Five kinds of power Project Manager can use**:

1. **Formal/Legitimate power**: which is what you use when you assign work to someone who reports to you.
2. **Reward Power**: is what you have when you can award and recognizes team.
3. **Expert Power**: which means the team respects the project manager’s technical expertise.
4. **Referent Power**: is power that’s based on identifying with or admiring the power holder.
5. **Coercive/Punishment Power**: is the least effective form of power. The project manager should never punish a team member in front of peers or managers.

**Motivation Theory**

**McGregor’s Theories X and Y**:

- **Theory X** is based on a pessimistic view of employee motivation and behavior. Theory X Manager assumes that employees dislike work, are not ambitious, want to avoid responsibility, dislike change, and are self-centered.
- **Theory Y** is based on an optimistic view of employee motivation and behavior. Theory Y assumes that employees enjoy work that is meaningful, are willing to take on responsibility, and are willing to work for organizational goals or causes they believe in. Theory Y Manager also assumes that employees are capable of creativity, ingenuity, and self-direction.

**Note**: In short, this theory states that there are poor Theory X managers who don’t trust their teams, and good Theory Y manager who do.
Maslow’s Hierarchy of Needs: The theory that says that people can’t achieve “self-actualization” (Full potential) or esteem (feeling good and important) until lower needs like safety and security are met. Maslow used the terms “physiological”, “safety”, “belongingness” and “social”, “esteem”, “self-actualization”, to describe the pattern that human motivations generally move through.

Devin McClelland Theory of needs or Acquired needs theory:

1. **Achievement**: these people need to be given challenging but reachable project.
2. **Affiliation**: these people work best when cooperating with others. Look for approval rather than recognition.
3. **Power**: people whose need for power is socially oriented, rather than personally oriented, are effective leaders and should be allowed to manage others. These people like to organize and influence others.
Herzberg's Theory: says that it's difficult to motivate people unless hygiene factor like a pay check and job security are already in place (working condition, salary, personal life, relationship at work, security, status).

Expectancy Theory: holds that people only respond to reward that are tied to goals they feel they have a realistic chance of achieving.

19.4.3 Outputs

► Change Requests

Staffing changes, whether by choice or by uncontrollable events, can affect the rest of the project management plan. When staffing issues disrupt the project team from adhering to the project management plan such as causing the schedule to be extended or the budget to be exceeded, a change request can be processed through the Perform Integrated Change Control process. Staffing changes may include moving people to different assignments, outsourcing some of the work, and replacing team members who leave.

► Project Management Plan Updates

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

► Project Documents Updates

► Enterprise Environmental Factors Updates

► Organizational Process Assets Updates
20. Project Communication Management

Project Communications Management includes the processes that are required to ensure timely and appropriate planning, collection, creation, distribution, storage, retrieval, management, control, monitoring, and the ultimate disposition of project information. This is the knowledge area that gets everyone talking about the work that’s being done, so that they all stay on the same page. That way, everyone has information they need, it also helps to resolve any issues and keep the project moving forward. Project Manager spends about 90% of their time communicating. Communication management makes sure everybody gets the right message at the right time.

20.1 Plan Communication Management

Plan Communications Management is the process of developing an appropriate approach and plan for project communications based on stakeholder’s information needs and requirements, and available organizational assets. It identifies and documents the approach to communicate most effectively and efficiently with stakeholders. Effective communication means that the information is provided in the right format, at the right time, to the right audience, and with the right impact. Efficient communication means providing only the information that is needed.

20.1.1 Inputs

Project Management Plan, Stakeholder Register, Enterprise Environmental Factors and Organizational Process Assets

20.1.2 Tools & Techniques

Communication requirements analysis: Conducted to figure out what kind of communication your stakeholders need from the project so that they can make good decisions. Your project will produce a lot of information; you don’t want overwhelm every member of your project team with all of it. You job here is to figure out what all of them feel they need to stay informed and to be able to do their jobs properly. Project resources should be expended only on communicating information that contributes to the success of the project or where a lack of communication can lead to failure.

The project manager should also consider the number of potential communication channels or paths as an indicator of the complexity of a project’s communications. The total number of potential communication channels is \( n (n - 1)/2 \), where \( n \) represents the number of stakeholders.

For example, a project with 10 stakeholders has \( 10(10 - 1)/2 = 45 \) potential communication channels.

Communication technology: Technology has a major impact on how you can keep people in the loop. The methods used to transfer information among project stakeholders may vary significantly. For example, a project team may use techniques from brief conversations to extended meetings or from simple written documents to extensive materials. The technology available to you will definitely figure into your plan of how you will keep everyone notified of project status and issues.

Factors that can affect the choice of communication technology include: Urgency of the need for information, availability of technology, ease of use, project environment, sensitivity and confidentiality of the information.

Communication models: This model demonstrates how the various people associated with your project send and receive their information. It’s the message you send, how you encode and decode the messages, the medium you use to transmit the messages, the noise that blocks the messages, and the feedback you get.

Encode: Thoughts or ideas are translated (encoded) into language by the sender.
Transmit Message: This information is then sent by the sender using communication channel (medium). The transmission of this message may be compromised by various factors (e.g., distance, unfamiliar technology, inadequate infrastructure, cultural difference, and lack of background information). These factors are collectively termed as noise.

Decode: The message is translated by the receiver back into meaningful thoughts or ideas.

Acknowledge: Upon receipt of a message, the receiver may signal (acknowledge) receipt of the message but this does not necessarily mean agreement with or comprehension of the message.

Feedback/Response: When the received message has been decoded and understood, the receiver encodes thoughts and ideas into a message and then transmits this message to the original sender.

![Basic Communication Model diagram](image)

**Figure 20-1 Basic Communication Model diagram**

Communication methods: Explains how you actually share the information with your stakeholders.

Interactive communication: This method is reciprocal; Communication can be interactive, where everyone exchanges information with one another. It happens between two or more parties performing a multidirectional exchange of information. It includes meetings, phone calls, instant messaging, video conferencing, etc.

Push Communication: This method involves a one-way stream of information. You can push information out to your stakeholder by sending out emails, memos, letters, memos, blogs, press release, faxes, or other one-way communications. This ensures that the information is distributed but does not ensure that it actually reached or was understood by the intended audience.

Pull Communication: If you need to get a lot of information out to people, they can pull it down themselves form intranet websites, e-learning courses, lesson learned database, knowledge repositories or libraries.

Meetings: Always great for helping your team to think about communication. The Plan Communications Management process requires discussion and dialogue with the project team to
determine the most appropriate way to update and communicate project information, and to respond to requests from various stakeholders for that information, most project meetings are more formal with a prearranged time, place, and agenda.

20.1.3 Outputs

► Communications management plan

Plan describes how project communications will be planned, structured, monitored, and controlled. It consists of lists all of the ways that you communicate with your projects team, stakeholders, sponsors, and important contacts related to the projects. It also takes into account stakeholders’ need, language to be used and culture differences on the project.

► Project documents updates

20.2 Manage Communication

Manage Communications is the process of creating, collecting, distributing, storing, retrieving, and the ultimate disposition of project information in accordance to the communications management plan, it enables an efficient and effective communications flow between project stakeholders so that right information makes it to the right people.

20.2.1 Inputs

Communications Management Plan, Work Performance Reports, Enterprise Environmental Factors and Organizational Process Assets

20.2.2 Tools & Techniques

Tools and techniques from Plan Communication Management also used in Manage Communication, kindly refer to Tools and Techniques details in 21.1.2 for:

Communication technology: - (21.1.2)

Communication models: - (21.1.2)

Communication methods: - (21.1.2)

- **Formal written**: anytime you are signing a legal document or preparing formal documentation for your project, that formal written communication.
- **Informal written**: if you drop someone a quick email or leave her/him a memo or sticky note, that’s informal written communication.
- **Formal verbal**: if you ever have to give a presentation to update people on your project, that’s formal verbal communication.
- **Informal verbal**: just calling somebody up to chat about your project is informal verbal communication. (Meetings)

Effective Communication

- **Nonverbal communication**: means your gestures, facial expressions, and physical appearance while you are communicating your message. Imagine if vendor from big company negotiate the contract while wearing a dirty and unprofessional suit. They probably would not take him very seriously. You don’t always think about it, but the way you behave can say more than your words when you are trying to get your message across.
• **Para lingual Communication**: is the tone and pitch of your voice when you are talking to people. If you sound anxious or upset, that will have an impact on the way people take the news you are giving. You use para lingual communication all the time it’s a really important of how you communicate. When your tone of voice makes it clear you are really excited about something. Or if you are speaking sarcastically, that’s Para lingual communication in action.

• **Feedback**: is when you respond to communication. The best way to be sure people know you are listening to them is to give lots of feedback. Some ways of giving feedbacks are summarizing their main points back to them, letting them know that you agree with them, or asking questions for clarification, when you give a lot of feedback to someone who is speaking that called active listening.

• **Information management systems**: Project information is managed and distributed using a variety of tools, including (Hard copy- Electronic- Electronic project management tool)

• **Performance reporting**: the act of collecting and distributing performance information, including status reports, progress measurements, and forecasts. Performance reporting involves the periodic collection and analysis of baseline versus actual data to understand and communicate the project progress and performance as well as to forecast the project results. The format may range from a simple status report to more elaborate reports and may be prepared regularly or on an exception basis.

20.2.3 **Outputs**

► **Project Communications**

The Manage Communications process involves the activities that are required for information to be created, distributed, received, acknowledged, and understood. It may be consist of following reports like Analysis of past performance, Analysis of project forecasts (including time and cost), Current status of risks and issues, Work completed during the period, Work to be completed in the next period, Summary of changes approved in the period, and Other relevant information, which is reviewed and discussed, deliverables status, schedule progress, and cost incurred etc.)

► **Project Management Plan Updates**

► **Project Documents Updates**

► **Organizational Process Assets Updates (lesson learned)**

20.3 **Control Communications**

It’s not enough to plan and manage communication on your project. You need to make sure that everybody who has a stake in your project is getting accurate reports of how it’s going so they can make good decision that’s what the Control Communication process is all about. You use it to monitor the data your project is producing, and control how it is presented to your stakeholders. It ensures an optimal information flow among all communication participants at any moment in time.

The impact and repercussions of project communications should be carefully evaluated and controlled to ensure that the right message is delivered to the right audience at the right time.

20.3.1 **Inputs**


20.3.2 **Tools & Techniques**
**Information management systems**: Project information is managed and distributed using a variety of tools, including (Hard copy- Electronic- Electronic project management tool). An information management system provides a set of standard tools for the project manager to capture, store, and distribute information to stakeholders about the project’s costs, schedule progress and performance.

**Expert judgment**: Expert judgment is often relied upon by the project team to assess the impact of the project communications, need for action or intervention, actions that should be taken, responsibility for taking such actions, and the timeframe for taking action. Expert judgment may need to be applied to technical and/or management details and may be provided by any group or individual with specialized knowledge or training.

**Meetings**: The Control Communications process requires discussion and dialogue with the project team to determine the most appropriate way to update and communicate project performance, and to respond to requests from stakeholders for information.

### 20.3.3 Outputs

- **Work performance information**

  Work performance information organizes and summarizes the performance data gathered. This performance data typically provides status and progress information on the project at the level of detail required by the various stakeholders. This information is then communicated to the appropriate stakeholders.

- **Change requests**

  The Control Communications process often results in the need for adjustment, action, and intervention. As a result, change requests will be generated as an output. These change requests are processed through the Perform Integrated Change Control process.

  - **Project management plan updates**
  - **Project documents updates**
  - **Organizational process assets update**
21. Project Risk Management

No matter how well you plan, your project can always run into unexpected problems. Team members get sick or quit, resources that you were depending on turn out to be unavailable. The objectives of project risk management are to increase the likelihood and impact of positive events, and decrease the likelihood and impact of negative events in the project. To be successful, an organization should be committed to address risk management proactively and consistently throughout the project. Positive and negative risks are commonly referred to as opportunities and threats.

Organizations and stakeholders are willing to accept varying degrees of risk depending on their risk attitude. The risk attitudes of both the organization and the stakeholders may be influenced by a number of factors, which are broadly classified into three themes:

- **Risk appetite**: the degree of uncertainty an entity is willing to take on in anticipation of a reward.
- **Risk tolerance**: the degree, amount, or volume of risk that an organization or individual will withstand.
- **Risk threshold**: measures along the level of uncertainty or the level of impact at which a stakeholder may have a specific interest. Below that risk threshold, the organization will accept the risk. Above that risk threshold, the organization will not tolerate the risk.

21.1 Plan Risk Management

**Risk = uncertainty**

Plan Risk Management is the process of defining how to conduct risk management activities for a project. It ensures that the degree, type, and visibility of risk management are commensurate with both the risks and the importance of the project to the organization. A risk is any uncertain event or condition that might affect your project. Not all risks are negative.

A risk can be event (like fire), or it can be a condition like an important part being unavailable, either way, it's something that may or may not happen but if it does, you will be forced to change the way you and your team work on the project. A risk is any uncertain event or condition that might affect you project. Not all risks are negative and a negative project risk that has occurred is considered an issue.

21.1.1 Inputs

Project management plan, project charter, stakeholder register, enterprise environmental factors and organizational process assets.

21.1.2 Tools & Techniques

**Analytical techniques**: Analytical techniques are used to understand and define the overall risk management context of the project. Risk management context is a combination of stakeholder risk attitudes and the strategic risk exposure of a given project based on the overall project context. For example, a stakeholder risk profile analysis may be performed to grade and qualify the project stakeholder risk appetite and tolerance.

**Expert judgment**: To ensure a comprehensive establishment of the risk management plan, judgment, and expertise should be considered from groups or individuals with specialized training or knowledge in the subject area, such as, senior management, project stakeholders, project managers who have worked on projects in the same area (directly or through lessons learned), subject matter experts (SMEs) in business or project area, Industry groups and consultants, and professional and technical associations.
Meetings: Project teams hold planning meetings to develop the risk management plan. Attendees at these meetings may include the project manager, selected project team members and stakeholders, anyone in the organization with responsibility to manage the risk planning and execution activities, and others, as needed. High-level plans for conducting the risk management activities are defined in these meetings. Risk management cost elements and schedule activities should be developed for inclusion in the project budget and schedule respectively. Risk contingency reserve application approaches may be established or reviewed.

21.1.3 Outputs

- Risk management plan

The Risk Management Plan is about detailing with all the bad and good things that might happen and coming up with a plan to address each negative and positive risk when and if it occurs. Risk management plan may include below major areas.

- **Methodology:** Defines the approaches, tools, and data sources that will be used to perform risk management on the project.
- **Roles and responsibilities:** Defines the lead, support, and risk management team members for each type of activity in the risk management plan, and clarifies their responsibilities.
- **Budgeting:** Estimates funds needed, based on assigned resources, for inclusion in the cost baseline and establishes protocols for application of contingency and management reserves.
- **Timing:** Defines when and how often the risk management processes will be performed throughout the project life cycle, establishes protocols for application of schedule contingency reserves, and establishes risk management activities for inclusion in the project schedule.
- **Risk categories:** Provide a means for grouping potential causes of risk. Several approaches can be used, for example, a structure based on project objectives by category. A risk breakdown structure (RBS) helps the project team to look at many sources from which project risk may arise in a risk identification exercise. Categories might be technical, external, organizational and project management etc.
- **Definitions of risk probability and impact:** The quality and credibility of the risk analysis requires that different levels of risk probability and impact be defined that are specific to the project context. General definitions of probability levels and impact levels are tailored to the individual project during the Plan Risk Management process for use in subsequent processes.

The table below is an example of definitions of negative impacts that could be used in evaluating risk impacts related to four project objectives.
### Probability and impact matrix:
A probability and impact matrix is a grid for mapping the probability of each risk occurrence and its impact on project objectives if that risk occurs. Risks are prioritized according to their potential implications for having an effect on the project’s objectives. The specific combinations of probability and impact that lead to a risk being rated as “high,” “moderate,” or “low” importance are usually set by the organization.

#### 21.2 Identify Risks

This process documents existing risks and the knowledge and ability it provides to the project team to anticipate events. You can use risk planning to identify potential problems that could cause trouble for your project and analyze how likely they will be to occur, take action to prevent the risks you can avoid, and minimize the ones that you cannot. Identify risks is an iterative process, because new risks may evolve or become known as the project progresses through its life cycle. The frequency of iteration and participation in each cycle will vary by situation. RBS you created during planning will make it a lot easier to do this. All project personnel should be encouraged to identify potential risks.

Example of risk sources: resources, critical path, outside your project (law, regulation, gov’t rules, market, etc.)

The format of the risk statements should be consistent to ensure that each risk is understood clearly and unambiguously in order to support effective analysis and response development. The process should involve the project team so they can develop and maintain a sense of ownership and responsibility for the risks and associated risk response actions. Stakeholders outside the project team may provide additional objective information.

#### 21.2.1 Inputs
Risk management plan, cost management plan, schedule management plan, quality management plan, human resource management plan, scope baseline, activity cost estimates, activity duration estimates, stakeholder register, project documents, procurement documents, enterprise environmental factors and organizational process assets.

21.2.2 Tools & Techniques

Documentation reviews: A structured review of the project documentation may be performed, including plans, requirements, previous project files, agreement and documents from your organization process assets, and any other relevant documents that you can find to squeeze every possible risk out of them.

Information gathering techniques: Brainstorming, Delphi technique, Interviewing, Root cause analysis - Root-cause analysis is a specific technique used to identify a problem, discover the underlying causes that lead to it, and develop preventive action. (for details on tools and techniques kindly refer collect requirement's tools and Techniques 16.2.2)

Checklist analysis: Using checklists that you developed specifically to help you find risks. You checklist might remind you to check certain assumption, talk to certain people, or review documents you might have overlooked. Additionally, the checklist should be pruned from time to time to remove or archive related items. The checklist should be reviewed during project closure to incorporate new lessons learned and improve it for use on future projects.

Assumptions analysis: Every project and its plan is conceived and developed based on a set of hypotheses, scenarios, or assumptions. It is what you are doing when you look over you projects assumption. Remember how important assumptions were when you were estimating the project, well now it’s time to look back at the assumptions you made and make that they really are things you can assume about the project. Wrong assumptions are definitely a risk.

Diagramming techniques: Should be pretty familiar to you already Ishikawa/fishbone diagram and System or process flow charts to find complex or uncertain source of risks. Influence diagrams to graphically represent situations showing causal influences, time ordering of events, and other relationships among variables and outcomes.

SWOT analysis: Lets you analyze strengths, weaknesses, opportunities, and threats. You will start by brainstorming strengths and weaknesses, and then examine the strength to find opportunities, and you will look at the weaknesses to come up with threats to the project. The analysis also examines the degree to which organizational strengths offset threats, as well as identifying opportunities that may serve to overcome weaknesses.

Expert judgment: Risks may be identified directly by experts with relevant experience with similar projects or business areas. Such experts should be identified by the project manager and invited to consider all aspects of the project and suggest possible risks based on their previous experience and areas of expertise. The experts’ bias should be taken into account in this process.

21.2.3 Outputs

► Risk Register

The primary output from Identify Risks is the initial entry into the risk register. The risk register is a document in which the results of risk analysis and risk response planning are recorded. The preparation of the risk register begins in the Identify Risks process with the following information, and then becomes available to other project management and risk management processes.
List Identified Risk: The identified risks are described in as much detail as is reasonable. A structure for describing risks using risk statements may be applied, for example, EVENT may occur causing IMPACT, or IF CAUSE exists, EVENT may occur leading to EFFECT. In addition to the list of identified risks, the root causes of those risks may become more evident.

► Potential Response and Root Causes

Potential responses to a risk may sometimes be identified during the Identify Risks process. These responses, if identified in this process, should be used as inputs to the Plan Risk Responses process.

21.3 Perform Qualitative Risk Analysis

This is usually a rapid and cost-effective means of establishing priorities for Plan Risk Responses and lays the foundation for Perform Quantitative Risk Analysis, if required. The Perform Qualitative Risk Analysis process is performed regularly throughout the project life cycle, as defined in the project's risk management plan. Qualitative risk analysis is a subjective analysis of the risks identified in the risk register.

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. It enables project managers to reduce the level of uncertainty and to focus on high-priority risks.

21.3.1 Inputs

Risk management plan, scope baseline, risk register, enterprise environmental factors and organizational process assets.

21.3.2 Tools & Techniques

Risk probability and impact assessment: It is one of the best ways to be sure that you are handling your risk properly by examining how likely they are to happen, and how bad or good it will be if they do. This process helps you assign a probability to the likelihood of a risk occurring, and then figure out the actual cost or impact, if it does happen. You can use these values to figure out which of your risks need a pretty solid mitigation plan and which can be monitored as the project goes on.

Probability and impact matrix: Risks can be prioritized for further quantitative analysis and planning risk responses based on their risk rating. Ratings are assigned to risks based on their assessed probability and impact. It is a table where all of your risks are plotted out according to the values you assign. The organization should determine which combinations of probability and impact result in a classification of high risk, moderate risk, and low risk. It’s a good way of looking at the data so you can more easily make judgements about which risks require response. The ones with the higher numbers are more likely to happen and will have a bigger impact on your project if they do. So you would better figure out how to handle those.

Specifically in below Figure, 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. The risk score helps guide risk responses.
Risk data quality assessment: Risk data quality assessment is a technique to make sure that the information you are using in your risk assessment is accurate. Sometimes it makes sense to bring in outside experts to check out the validity of your risk assessment data. Sometimes you can even confirm the quality of the data on your own, by checking some samples of it against other data sources.

Risk categorization (Source of Risk): RBS and WBS created in Planning are useful; here it is all about grouping your risks so that you can come up with a better strategy for dealing with them. It is categorised to determine the areas of the project most exposed to the effects of uncertainty. You might group them by the phase of the project where you will see them, or by the source of the risk. Or you could come up with a bunch of additional categories that would help you to organize your response better and be ready for the risk if it should happen.

Risk urgency assessment: It is checking out how soon you are going to need to take care of a particular risk. If a risk is going to happen soon, you would better have a plan for how to deal with it soon, too. Indicators of priority may include probability of detecting the risk, time to affect a risk response, symptoms and warning signs, and the risk rating.

Expert judgment: Expert judgment is required to assess the probability and impact of each risk to determine its location in the matrix. Experts generally are those having experience with similar, recent projects. Gathering expert judgment is often accomplished with the use of risk facilitation workshops or interviews. The experts’ bias should be taken into account in this process.

21.3.3 Outputs

► Project Documents Updates
Project Risk Management

Project documents that may be updated include, but are not limited to risk register updates, assumption log updates, category, ranking, priority, urgency, watch list, non-critical risks and assumptions log updates.

21.4 Perform Quantitative Risk Analysis

Perform Quantitative Risk Analysis is the process of numerically analyzing the effect of identified risks on overall project objectives. The key benefit of this process is that it produces quantitative risk information to support decision making in order to reduce project uncertainty. This is where you assign numerical values for the probability and impact of each risk, and focus on gathering numbers to help evaluate risks and making the best decision about how to handle them. Quantitative risk analysis is a more objective or numerical evaluation.

21.4.1 Inputs


21.4.2 Tools & Techniques

Data gathering and representation techniques:

- **Interviewing**: Interviewing techniques draw on experience and historical data to quantify the probability and impact of risks on project objectives. The information needed depends upon the type of probability distributions that will be used. For instance, information would be gathered on the optimistic (low), pessimistic (high), and most likely scenarios for some commonly used distributions.

- **Probability distributions**: Continuous probability distributions, which are used extensively in modeling and simulation, represent the uncertainty in values such as durations of schedule activities and costs of project components. Sometimes taking a look at your time and cost estimate ranges in terms of their distribution will help you generate more data about them. You probably remember these distribution curves from your probability and statistics classes in school. Don’t worry, you will not be asked to remember the formal definition of probability distributions or even to be able to create them. You just need to know that they are another way of gathering data for quantitative analysis, such as the outcome of a test or a possible scenario in a decision tree.

Quantitative risk analysis and modeling techniques:

- **Sensitivity analysis**: Sensitivity analysis helps to determine which risks have the most potential impact on the project. It helps to understand how the variations in project’s objectives correlate with variations in different uncertainties. It is all about looking at the effect once variable might have if you could completely isolate it. People generally use Tornado diagram to look at projects sensitivity to just one risk factor, (data gathering and representation), a tornado diagram is a special type of bar chart used in sensitivity analysis for comparing the relative importance of the variables. In a tornado diagram, the Y-axis contains each type of uncertainty at base values, and the X-axis contains the spread or correlation of the uncertainty to the studied output. In below figure, each uncertainty contains a horizontal bar and is ordered vertically to show uncertainties with a decreasing spread from the base values.
Expected Monetary value analysis: Expected monetary value (EMV) analysis is a statistical concept that calculates the average outcome when the future includes scenarios that may or may not happen (i.e., analysis under uncertainty). The EMV of opportunities are generally expressed as positive values, while those of threats are expressed as negative values. EMV requires a risk-neutral assumption—neither risk averse nor risk seeking. Let's you examine costs of all of the paths you might take through the project depending on which risks occur and assign a monetary value to each decision. The main method of expected monetary value analysis you need to know for the test is decision tree analysis. Expected Monetary Value formula \( \text{EMV} = P \times I \).

A common use of this type of analysis is a decision tree analysis as shown in the figure below:
Modelling and simulation: It’s also good idea to run your project risks through modelling programs if you can. Monte Carlo analysis is one tool that can randomize the outcomes of your risks and the probabilities of them occurring to help you get a better sense of how to handle the risks you have identified. In a simulation, the project model is computed many times (iterated), with the input values (e.g., cost estimates or activity durations) chosen at random for each iteration from the probability distributions of these variables.

Expert judgment: Expert judgment (ideally using experts with relevant, recent experience) is required to identify potential cost and schedule impacts, to evaluate probability, and to define inputs such as probability distributions into the tools. Expert judgment also comes into play in the interpretation of the data. Experts should be able to identify the weaknesses of the tools as well as their strengths. Experts may determine when a specific tool may or may not be more appropriate given the organization’s capabilities and culture.

21.4.3 Outputs

- Project documents updates

Project documents are updated with information resulting from quantitative risk analysis. For example, risk register updates could include: Probabilistic analysis of the project, Probability of achieving cost and time objectives, Prioritized list of quantified risks, Trends in quantitative risk analysis results, etc.

21.5 Plan Risk Responses

This is where you decide whether to avoid, mitigate, transfer or accept and how you will do it. Plan risk response is figuring out what you will do if risks happen. You should be able to tell your change...
Project Risk Management

control board what your response plans are and who will be in charge of them so they can use them to evaluate changes. It also addresses the risks by their priority, inserting resources and activities into the budget, schedule and project management plan as needed.

21.5.1 Inputs

Risk Management Plan, Risk Register

21.5.2 Tools & Techniques

Several risk response strategies are available. The strategy or mix of strategies most likely to be effective should be selected for each risk. Specific actions are developed to implement that strategy, including primary and backup strategies, as necessary.

A fallback plan can be developed for implementation if the selected strategy turns out not to be fully effective or if an accepted risk occurs. Secondary risks should also be reviewed. Secondary risks are risks that arise as a direct result of implementing a risk response. A contingency reserve is often allocated for time or cost. If developed, it may include identification of the conditions that trigger its use.

Strategies for negative risks or threats:

Three strategies, which typically deal with threats or risks that may have negative impacts on project objectives if they occur, are: avoid, transfer, and mitigate. The fourth strategy, accept; can be used for negative risks or threats as well as positive risks or opportunities.

- **Avoid**: The best thing that you can do with a risk is avoid it. If you can prevent it from happening, it definitively will not hurt your project. It usually involves changing the project management plan to eliminate the threat entirely. The project manager may also isolate the project objectives from the risk’s impact or change the objective that is in jeopardy.

- **Transfer (deflect, allocate)**: One effective way to deal with a risk is to pay someone else (Third Party) to accept it for you. The most common way to do this is to buy insurance. It does not eliminate it. Transferring does not mean disowning the risk by transferring it to a later project or another person without his or her knowledge or agreement.

- **Mitigate**: If you cannot avoid the risk, you can mitigate it. This means taking some sort of action that will cause it to do as little damage to your project as possible. It implies a reduction in the probability and/or impact of an adverse risk to be within acceptable threshold limits. Taking early action to reduce the probability and/or impact of a risk occurring on the project is often more effective than trying to repair the damage after the risk has occurred.

- **Accept**: When you cannot avoid, mitigate, or transfer a risk, then you have to accept it. But even when you accept a risk, at least you have looked at the alternatives and you know what will happen if it occurs. Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs. This strategy is adopted where it is not possible or cost-effective to address a specific risk in any other way. Passive acceptance requires no action except to document the strategy, leaving the project team to deal with the risks as they occur, and to periodically review the threat to ensure that it does not change significantly.

Note:

- **Secondary Risk**: comes from a response you have already addressed for a primary risk.
- **Residual Risk**: remains after your risk response have been implemented.
- **Remember term ‘Privet’**: means a contractual relationship.
Strategies for positive risks or opportunities

- **Exploit**: The exploit strategy may be selected for risks with positive impacts where the organization wishes to ensure that the opportunity is realized, this is when you do everything you can to make sure that you take advantage of an opportunity. You could assign your best resources to it. Or you could allocate more than enough funds to be sure you get the most out of it.

- **Enhance**: The enhance strategy is used to increase the probability and/or the positive impacts of an opportunity. Identifying and maximizing key drivers of these positive-impact risks may increase the probability of their occurrence.

- **Share**: Sometimes it’s harder to take advantage of an opportunity on your own. Then you might call in another company to share in it with you. 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.

- **Accept**: Just like accepting negative risk, sometimes an opportunity just falls in your lap. The best thing to do, Accepting an opportunity is being willing to take advantage of the opportunity if it arises, but not actively pursuing it.

- **Contingent response strategies**: Risk responses identified using this technique are often called contingency plans or fallback plans and include identified triggering events that set the plans in effect. Events that trigger the contingency response, such as missing intermediate milestones or gaining higher priority with a supplier, should be defined and tracked.

- **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.

### 21.5.3 Outputs

- **Project Management Plan Updates**

  Elements of the project management plan that may be updated as a result of carrying out this process include, but are not limited to Schedule management plan, Cost management plan, Quality management plan, Procurement management plan, Human resource management plan, Scope baseline, Schedule baseline, and Cost baseline

- **Project Documents Updates**

  In the Plan Risk Responses process, several project documents are updated as needed.

### 21.6 Control Risks

Control Risks is the process of implementing risk response plans, tracking identified risks, monitoring residual risks, identifying new risks, and evaluating risk process effectiveness throughout the project. It improves efficiency of the risk approach throughout the project life cycle to continuously optimize risk responses. The risk response owner reports periodically to the project manager on the effectiveness of the plan, any unanticipated effects, and any correction needed to handle the risk appropriately.

### 21.6.1 Inputs

- Project Management Plan, Risk Register, Work Performance Data, and Work Performance Reports

### 21.6.2 Tools & Techniques
**Risk Reassessment:** Control Risks often result in identification of new risks, reassessment of current risks, and the closing of risks that are out-dated. You should have regularly scheduled reassessment meetings to go over all of the information you have to date and see if your risk register still holds true. In a reassessment, your main goal is to reassess your risk register every so often, and be sure that all of the risks in it are still the right ones.

**Risk Audits:** When you have an outside party come in and take a look at your risk response strategies to judge how effective they are. Sometimes risk audits will point out better ways of handling a specific risk so that you can change your response strategy going forward. 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 the team may choose to hold separate risk audit meetings.

**Variance and Trend Analysis:** Comparing the actual project performance to the plan is a great way to tell if a risk might be happening. If you find that you are significantly over budget or behind schedule, a risk could have cropped up that you did not take into account. Looking for trends in your defects or schedule variance, for example, it might show patterns that indicate that risks have occurred before you would have found that out on your own. Earned value analysis and other methods of project variance and trend analysis may be used for monitoring overall project performance.

**Technical Performance Measurement:** Means comparing the performance of your project with its planned performance. It requires the definition of objective, quantifiable measures of technical performance, which can be used to compare actual results against targets. So if you expected to hit a specific milestone, you could check performance information on your product at that time to see if it measure up to the plan. If not, that might indicate that there are risks you didn’t plan for.

**Reserve (Contingency) Analysis:** Just like you keep running tabs on your budget, you should always know how much money you have set aside for risk response. As you spend it, be sure to subtract it so you know if you have enough to cover all of your remaining risks. If you start to see that your reserves are running low and there are still a lot of risks being identified, you might be in trouble. Keeping tabs on your reserves means that you will always know if you need to set aside more funds or make different choices about how to handle risks as they come up.

Throughout execution of the project, some risks may occur with positive or negative impacts on budget or schedule contingency reserves. Reserve analysis compares the amount of the contingency reserves remaining to the amount of risk remaining at any time in the project in order to determine if the remaining reserve is adequate.

**Meetings:** Project risk management should be an agenda item at periodic status meetings. The amount of time required for that item will vary, depending upon the risks that have been identified, their priority, and difficulty of response. The more often risk management is practiced, the easier it becomes. Frequent discussions about risk make it more likely that people will identify risks and opportunities.

**21.6.3 Outputs**

- **Work Performance Information**

  Work performance information, as a Control Risks output, provides a mechanism to communicate and support project decision making.

- **Change Requests**
Implementing contingency plans or workarounds sometimes results in a change request.

- **Recommended corrective actions**: These are activities that realign the performance of the project work with the project management plan. They include contingency plans and workarounds.
- **Recommended preventive actions**: These are activities that ensure that future performance of the project work is aligned with the project management plan.

- Project Management Plan Updates
- Project Documents Updates
- Organizational Process Assets Updates
22. Project Procurement Management

Sometimes you need an outside company to do some of your project work. That's called procurement and the outside company is called the seller (supplier). Procurement process finds another company to do the work for you. If you find the right seller, choose the right kind of relationship, and make sure that the goals of the contract are met, you will get the job done and your project will be a success.

The project management team may seek support in early phases from specialists in contracting, purchasing, law, and technical disciplines. Such involvement can be mandated by an organization’s policies. The Project Procurement Management processes involve agreements, including contracts, which are legal documents between a buyer and a seller. A contract represents a mutually binding agreement that obligates the seller to provide something of value (e.g., specified products, services, or results) and obligates the buyer to provide monetary or other valuable compensation. Depending upon the application area, a contract can also be called an agreement, an understanding, a subcontract or a purchase order.

Depending on the application area, the seller may be identified as a contractor, subcontractor, vendor, service provider, or supplier. Depending on the buyer’s position in the project acquisition cycle, the buyer may be called a client, customer, prime contractor, contractor, acquiring organization, service requestor or purchaser.

22.1 Types of Contracts used in procurement

22.1.1 Fixed Price Contracts

**Fixed Price**: Means that you are going to pay one amount regardless of how much it costs the contractor to do the work. A fixed –price contract only makes sense in cases where the scope is very well known. Sellers under fixed-price contracts are legally obligated to complete such contracts, with possible financial damages if they do not. Under the fixed-price arrangement, buyers need to precisely specify the product or services being procured. Changes in scope may be accommodated, but generally with an increase in contract price.

**Fixed Price plus incentive fee (FPIF)**: In this type of contract that you are going to pay a fixed price for the contract and give a bonus based on some performance goal. You might set up a contract where the team gets a $50000 bonus if they manage to deliver an acceptable product before the contracted date. 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.

**Firm Fixed- Price (FFP) contract**: If the fixed price contract does not include a fee, it’s often referred to as a Firm Fixed- Price (FFP) contract. The most commonly used contract type is the FFP. It is favoured 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.

**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 economic inflation changes, or cost increases (or decreases) for specific commodities. The EPA clause needs to 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.

22.1.2 Cost-reimbursable contracts
A cost-reimbursable contract provides the project flexibility to redirect a seller whenever the scope of work cannot be precisely defined at the start and needs to be altered, or when high risks may exist in the effort.

**Costs plus fixed fee (CPFF):** In this contract, you pay the seller back for the costs involved in doing the work, plus you agree to an amount that you will pay on top of that. The seller is reimbursed for all allowable costs for performing the contract work, and receives a fixed-fee payment calculated as a percentage of the initial estimated project costs. A 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.

**Costs plus award fee (CPAF):** The seller is reimbursed for all legitimate costs, but the majority of the fee is earned only based on the satisfaction of certain broad subjective performance criteria defined and incorporated into the contract. The determination of fee is based solely on the subjective determination of seller performance by the buyer, and is generally not subject to appeals.

**Costs plus incentive fee (CPIF):** The seller is reimbursed for all allowable costs for performing the contract work and receives a predetermined incentive fee based upon achieving certain performance objectives as set forth in the contract. In CPIF contracts, if the final costs are less or greater than the original estimated costs, then both the buyer and seller share costs from the departures based upon a pre-negotiated cost-sharing formula, for example, an 80/20 split over/under target costs based on the actual performance of the seller.

**Cost plus fee (CPF) or Cost plus percentage of Costs (CPPC):** A CPF or CPPC contract requires the buyers to pay for all costs plus a percentage of costs as a fee. (For example: interior designer work contract.)

### 22.1.3 Time and materials

**Time and Materials (T&M):** Time and material contracts are a hybrid type of contractual arrangement that contain aspects of both cost-reimbursable and fixed-price contracts. They are often used for staff augmentation, acquisition of experts, and any outside support when a precise statement of work cannot be quickly prescribed. Most of the cases it issued in labour contracts. Its means that you will pay a rate for each of the people working on your project plus their materials costs. The time part means that the buyer pays a fixed rate for labour usually a certain number of dollars per hour. And the material part means that the buyer also pays for materials, equipment’s, office space, administrative overheads cost, and anything else that has to be paid for. This is really good contract to use if you don’t know exactly how long your contract will last, because it protects both the buyers and sellers.

### 22.1.4 Procurement related terms

- **Consideration** is another word for the payments in procurement process.
- **Force majeure:** This is a kind of clause that you will see in a contract. It says that if something like a war, riot, or natural disaster happens, you are excused from the terms of the contract.
- **The point of total assumption:** The point of total assumption is the point at which the supplier (seller) assumes costs. In fixed price contract, this is the point where the costs have gotten so large that the supplier (seller) basically runs out of money from the contract and has to start paying the costs.
- **Invitation for bid (IFB):** This is a document that tells sellers that you want them to submit proposal.
- **Requests for Proposal:** It is when you give a seller the opportunity to examine your procurement documents and write up a proposal of how they would do the work.
• **Requests for information**: Documents are sent to potential sellers to ask for information about their capability to do the work.

• **Requests for Quotation**: This is a way to tell sellers that you want them to give you a quote on a fixed price contract to do the work.

• **Names or terms used for Buyer** = client, customer, prime contractor, acquiring organization, service requestor and purchaser

• **Names or terms used for Seller** = contractor, sub-contractor, vendor, service provider or supplier, bidder

### 22.2 Plan Procurement Management

Plan Procurement Management identifies those project needs that can best be met or should be met by acquiring products, services, or results outside of the project organization. You take a close look at your needs, to be sure that you really need to create a contract. You figure out what kinds of contracts make sense for your project, and you try to define all of the parts of your project that will be contracted out.

Decisions made in developing the procurement management plan can also influence the project schedule and also integrated with Develop Schedule, Estimate Activity Resources, and make-or-buy analysis.

#### 22.2.1 Inputs

Project management plan, requirements documentation, risk register, activity resource requirements, project schedule, activity cost estimates, stakeholder register, enterprise environmental factors and organizational process assets.

#### 22.2.2 Tools & Techniques

**Make-or-buy analysis**: It is performed to figure out whether or not you should be contracting the work or doing it yourself. It could also mean deciding whether to build your own solution to your problem or buy one that is already available in market. Most of the same factor that help you make every other major project decision will help you with this one. How much does it cost to build it versus buy it. How will this decision affect the scope of project how about your project schedule do you have time to do the work and still meet your commitments as you plan out what you will and will not contract, you need to have thought through your reasoning pretty carefully. There are some resources (like heavy equipment) that your company can buy, rent, or lease depending on the situation. You will need to examine leasing versus buying costs and determine the best way to go forward.

**Expert judgment**: Expert judgment is often used to assess the inputs to and outputs from this process. Expert purchasing judgment can also be used to develop or modify the criteria that will be used to evaluate seller proposals. Expert legal judgment may involve the services of legal staff to assist with unique procurement issues, terms, and conditions. Such judgment, including business and technical expertise, can be applied to both the technical details of the acquired products, services, or results and to various aspects of the procurement management processes.

**Market research**: Market research includes examination of industry and specific vendor capabilities. Procurement teams may leverage information gained at conferences, online reviews and a variety of sources to identify market capabilities. The team may also refine particular procurement objectives to leverage maturing technologies while balancing risks associated with the breadth of vendors who can provide the materials or services desired.

**Meetings**: Research alone may not provide specific information to formulate a procurement strategy without additional information interchange meetings with potential bidders. By collaborating with
potential bidders, the organization purchasing the material or service may benefit while the supplier can influence a mutually beneficial approach or product.

22.2.3 Outputs

► Procurement Management Plan

It describes how the procurement processes will be managed from developing procurement documents through contract closure. The procurement management plan can include guidance for: Types of contracts to be used, risk management issues, whether independent estimates will be used or not, actions to be taken unilaterally, standardized procurement documents, managing multiple suppliers, coordinating procurement with scheduling and performance reporting, constraints and assumptions, manage lead times towards extra time needed to procure certain item and handling the make-or-buy decisions and linking them into the Estimate Activity Resources and Develop Schedule processes, setting the scheduled dates in each contract, identifying requirements for performance bonds or insurance contracts to mitigate some forms of project risk, guidelines to the sellers on developing and maintaining a work breakdown structure (WBS), form and format to be used for the procurement/contract statements of work, to track prequalified sellers, if any, to be used, and procurement metrics to be used to manage contracts and evaluate sellers.

► Procurement Statement of Work

The statement of work (SOW) for each procurement is developed from the project scope baseline and defines only that portion of the project scope that is to be included within the related contract. The procurement SOW describes the procurement item in sufficient detail to allow prospective sellers to determine if they are capable of providing the products, services, or results. Sufficient detail can vary based on the nature of the item, the needs of the buyer or the expected contract form. Information included in a SOW can include specifications, quantity desired, quality levels, performance data, period of performance, work location and other requirements.

► Procurement Documents

Procurement documents are used to solicit proposals from prospective sellers. Terms such as bid, tender, or quotation, request for information (RFI), invitation for bid (IFB), request for proposal (RFP), request for quotation (RFQ), tender notice, invitation for negotiation, and invitation for seller’s initial response.

► Source Selection Criteria

Source selection criteria are often included as a part of the procurement documents. Such criteria are developed and used to rate or score seller proposals, and can be objective or subjective. Some possible source selection criteria are: understanding of need, overall or life-cycle cost, technical capability, risk, management approach, technical approach, warranty, financial capacity, production capacity and interest, business size and type, past performance of sellers, references, intellectual property rights, proprietary rights etc.

► Make-or-Buy Decisions

A make-or-buy analysis results in a decision of whether particular work can best be accomplished by the project team or needs to be purchased from outside sources. If the decision is to make the item, then the procurement plan may define processes and agreements internal to the organization. A buy decision drives a similar process of reaching agreement with a supplier for the product or services.

► Change Requests
A decision that involves procuring goods, services, or resources typically requires a change request. Other decisions during procurement planning can also create the need for additional change requests.

► Project Documents Updates

Project documents that may be updated include, but are not limited to: Requirements documentation, Requirements traceability matrix, and Risk register.

22.3 Conduct Procurements

Conduct Procurements is the process of obtaining seller responses, selecting a seller, and awarding a contract. It provides alignment of internal and external stakeholder expectations through established agreements. This process is all about getting the word out to potential agreement or contract partners about the project and how they can help you. During the Conduct Procurements process, the team will receive bids or proposals and will apply previously defined selection criteria to select one or more sellers who are qualified to perform the work and acceptable as a seller.

22.3.1 Inputs

Procurement management plan, procurement documents, source selection criteria, seller proposals, project documents, make-or-buy decisions, procurement statement of work and organizational process assets.

22.3.2 Tools & Techniques

Bidder conference also known as (contractor conferences, vendor conferences, and pre-bid conferences): Meetings between the buyer and all prospective sellers prior to submittal of a bid or proposal. It’s really important that you make sure all of the bidder can compete in a fair, unbiased way. And the best way to do that is to get them all in room together, so that they can ask questions about your contract, that way, you don’t give any one seller an advantage by providing inside information that the other seller don’t have access to.

Proposal evaluation techniques: You are going to have to work closely with the seller to figure out if their proposal really is appropriate for the work. You need to be very careful before you choose someone to do the work. That’s what this tool is for it’s kind of “catch – all” that’s there to remind you that there is no single way to evaluate a proposal. You need to look at the whole picture – the seller, your needs, and the job. The evaluation committee will make their selection for approval by management prior to the award.

Independent estimates: A lot of the time, you don’t have the expertise in your company to figure out whether or not a seller is quoting you a fair price. That’s why you will often turn to a third party to come up with an estimate of what the work should cost. 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.

Expert judgment: Expert judgment may be used in evaluating seller proposals. The evaluation of proposals may be accomplished by a multi-discipline review team with expertise in each of the areas covered by the procurement documents and proposed contract. This can include expertise from functional disciplines such as contracting, legal, finance, accounting, engineering, design, research, development, sales, and manufacturing.

Advertising: Sometimes the best way to get in touch with seller is to place an ad. Also, sometimes you are required to take out an ad (like for some government funded projects) in order to give all
seller full notice so that existing lists of potential sellers often can be expanded by placing advertisements in general circulation publications such as selected newspapers or in specialty trade publications.

**Analytical techniques:** You will need to determine whether or not the vendor is capable of completing the project in the required time frame and understand how well it can deliver to your budget. If you check out its track record on past project, you will have a better sense of how it will perform. Analytical techniques can help organizations identify the readiness of a vendor to provide the desired end state, determine the cost expected to support budgeting, and avoid cost overruns due to changes.

**Procurement negotiations:** Procurement negotiations clarify the structure, requirements, and other terms of the purchases so that mutual agreement can be reached prior to signing the contract. Final contract language reflects all agreements reached. Subjects covered should include responsibilities, authority to make changes, applicable terms and governing law, technical and business management approaches, proprietary rights, contract financing, technical solutions, overall schedule, payments, and price. Negotiations conclude with a contract document that can be executed by both buyer and seller. The project manager may not be the lead negotiator on procurements.

### 22.3.3 Outputs

- **Selected sellers**

  The selected sellers are those who have been judged to be in a competitive range based upon the outcome of the proposal or bid evaluation, and who have negotiated a draft contract that will become the actual contract when an award is made. Final approval of all complex, high-value, high-risk procurements will generally require organizational senior management approval prior to award.

- **Agreements**

  A procurement agreement includes terms and conditions, and may incorporate other items that the buyer specifies regarding what the seller is to perform or provide. Depending upon the application area, an agreement can also be called an understanding, a contract, a subcontract, or a purchase order. A contract is a legal relationship subject to remedy in the courts.

  The major components in an agreement document will vary, but may include the following: Statement of work or deliverables, schedule baseline, performance reporting, period of performance, roles and responsibilities, seller's place of performance, pricing, payment terms, place of delivery, inspection and acceptance criteria, warranty, product support, limitation of liability, fees and retainer, penalties, incentives, insurance and performance bonds, subordinate subcontractor approvals, change request handling, and termination clause and alternative dispute resolution (ADR) mechanisms.

- **Resource calendars**

  The quantity and availability of contracted resources and those dates on which each specific resource or resource group can be active or idle are documented.

- **Change requests**

  Change requests to the project management plan, its subsidiary plans, and other components are processed for review and disposition through the Perform Integrated Change Control process.

- **Project management plan updates**

- **Project documents updates**
22.4 Control Procurement

When the contract is under way, you stay on top of the work and make sure the contract is adhered to. You monitor what the contractor is producing and make sure everything is running smoothly. Occasionally, you will need to make changes to the contract. Here’s where you will find and request those changes. It ensures that both the seller’s and buyer’s performance meets procurement requirements according to the terms of the legal agreement.

The Control Procurements process reviews and documents how well a seller is performing or has performed based on the contract and establishes corrective actions when needed. This performance review may be used as a measure of the seller’s competency for performing similar work on future projects. Agreements can be amended at any time prior to contract closure by mutual consent, in accordance with the change control terms of the agreement. Such amendments are typically captured in writing.

22.4.1 Inputs

Project Management Plan, Procurement Documents, Agreements, Approved Change Requests, Work Performance Reports and Work Performance Data

22.4.2 Tools & Techniques

**Contract change control system:** A contract change control system defines the process by which the procurement can be modified. It includes the paperwork, tracking systems, dispute resolution procedures, and approval levels necessary for authorizing changes. The contract change control system is integrated with the integrated change control system. This is just like all of the other change control systems that you have seen already. It’s a set of procedures that are set up to handle changes in the contract. You might have a different one for every contract in your project.

**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. Most contract lay out certain standards for how well the seller should do the job, is the seller doing all the work that was agreed to? Is the work being done on time? The buyer has the right to make sure this is happening and the way to do this is to go over the performance of the seller’s team. 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.

**Inspections and audits:** This tool is how the buyer makes sure that the product that the seller produces is up to snuff. This is where you will check up on the actual product or service that the project is producing to make sure that it meets your needs and the terms of the contract.

**Performance reporting:** Performance reporting provides management with information about how effectively the seller is achieving the contractual objectives, its easiest way for you to keep track of the contract work being done is to write up performance reports. These are exactly like the performance reports that you saw earlier in the book – you will use them to monitor the project work and report on the progress to your company’s management.

**Payment systems:** Your partner won’t be very happy if you don’t pay. The payment system is how your company pays its seller. It usually established by an accounting department. Payments to the seller are typically processed by the accounts payable system of the buyer after certification of satisfactory work by an authorized person on the project team. All payments should be made and documented in strict accordance with the terms of the contract.
Claims administration: When there’s a dispute between a buyer and a seller, that’s called a claim. Most contracts have some language that explains exactly how claims should be resolved – and since it’s in the contract, it’s legally binding, and both the buyer and seller need to follow it. Contested changes are variously called claims, disputes, or appeals; Claims are documented, processed, monitored, and managed throughout the contract life cycle, if necessary, alternative dispute resolution (ADR) used to follow procedures established in the contract. Settlement of all claims and disputes through negotiation is the preferred method.

Records management system: A records management system is used by the project manager to manage contract and procurement documentation and records. - There are a lot of records produced by a typical contract. Invoices, receipts, communications, memos, emails, instructions, clarification, etc. you will need to put a system in place to manage them. The system contains a retrievable archive of contract documents and correspondence.

22.4.3 Outputs

► Work performance information

Work performance information provides a basis for identification of current or potential problems to support later claims or new procurements. By reporting on the performance of a vendor, the organization increases knowledge of the performance of the procurement, which supports improved forecasting, risk management, and decision making. Performance reports also assist in the event there is a dispute with the vendor.

Work performance information includes reporting compliance of contracts, which provides procuring organizations a mechanism to track specific deliverables expected and received from vendors. Contract compliance reports support improved communications with vendors so that potential issues are addressed promptly to the satisfaction of all parties.

► Change requests

Change requests to the project management plan, its subsidiary plans, and other components, such as the cost baseline, schedule baseline, and procurement management plan, may result from the Control Procurements process. Change requests are processed for review and approval through the Perform Integrated Change Control process.

Requested but unresolved changes can include direction provided by the buyer or actions taken by the seller, which 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

► Project management plan updates

► Project documents updates

► Organizational process assets updates

22.5 Close Procurements

Close Procurements is the process of completing each procurement. It documents agreements and related documentation for future reference. You will make sure that the product that is produced meets the criteria for the contract, and that the contractor gets paid. The Close Procurements process also involves administrative activities such as finalizing open claims, updating records to reflect final
results, and archiving such information for future use. The Close Procurements process supports the Close Project or Phase process by ensuring contractual agreements are completed or terminated.

### 22.5.1 Inputs

Project Management Plan and Procurement Documents

### 22.5.2 Tools & Techniques

**Procurement audits**: Once you have closed out the contract, you go over everything that happened on the project to figure out the lesson learned and look for anything that went right or wrong. 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.

**Procurement negotiations**: You need to make sure that all of the terms of the contract have been met and there are no outstanding claims on it. If the buyer or the sellers have outstanding claims from the relationship, they need to get resolved, sometimes through legal arbitration or, in the worst case scenario in court. In all procurement relationships, the final equitable settlement of all outstanding issues, claims, and disputes by negotiation is a primary goal. Whenever settlement cannot be achieved through direct negotiation, some form of alternative dispute resolution (ADR) including mediation or arbitration may be explored.

**Records management system**: A records management system is used by the project manager to manage contract and procurement documentation and records. Contract documents and correspondence are archived through the records management system as part of the Close Procurements process.

### 22.5.3 Outputs

- **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.

- **Organizational Process Assets Updates**
23. Project Stakeholder Management

Project Stakeholder Management includes the processes required to identify the people, groups, or organizations that could impact or be impacted by the project, to analyze stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution. Every project will have stakeholders who are impacted by or can impact the project in a positive or negative way. While some stakeholders may have a limited ability to influence the project, others may have significant influence on the project and its expected outcomes. The ability of the project manager to correctly identify and manage these stakeholders in an appropriate manner can mean the difference between success and failure.

23.1 Identify Stakeholders

The identify stakeholder process is all about writing down your stakeholders names along with their goals, expectations and concerns in a documents called the stakeholder register. It allows the project manager to identify the appropriate focus for each stakeholder or group of stakeholders. Project stakeholders are individuals, groups, or organizations who may affect, be affected by, or perceive themselves to be affected by a decision, activity or outcome of a project. It is critical for project success to identify the stakeholders early in the project or phase and to analyze their levels of interest, their individual expectations as well as their importance and influence. This initial assessment should be reviewed and updated regularly.

![The Relationship Between Stakeholders and the Project](image)

23.1.1 Inputs

Project Charter, Procurement Documents, Enterprise Environmental Factor and Organizational Process Assets.

23.1.2 Tools & Techniques

**Stakeholder analysis:** A critical tool in this process. You need to interview the entire stakeholder you can find for your project, and find out the value the project has for them. As you sit with stakeholders, you will identify more people to interview. During stakeholder analysis, you can divide your stakeholders into groups based on their level of involvement and need for communication. When you
understand what motivates all of your stakeholders, you can come up with a strategy to make sure that they are told about the things that they find important, and that they are not bored with extraneous details.

Stakeholder analysis generally follows the steps described below:

1. Identify all potential project stakeholders and relevant information, such as their roles, departments, interests, knowledge, expectations, and influence levels.
2. Analyze the potential impact or support each stakeholder could generate, and classify them so as to define an approach strategy.
3. Assess how key stakeholders are likely to react or respond in various situations, in order to plan how to influence them to enhance their support and mitigate potential negative impacts.

Multiple classification models used for stakeholders’ analysis, such as:

- **Power/interest grid**, grouping the stakeholders based on their level of authority (“power”) and their level or concern (“interest”) regarding the project outcomes;
- **Power/influence grid**, grouping the stakeholders based on their level of authority (“power”) and their active involvement (“influence”) in the project;
- **Influence/impact grid**, grouping the stakeholders based on their active involvement (“influence”) in the project and their ability to effect changes to the project’s planning or execution (“impact”);
- **Salience model**, describing classes of stakeholders based on their power (ability to impose their will), urgency (need for immediate attention), and legitimacy (their involvement is appropriate).

The figure below presents an example of a power/interest grid with A-H representing the placement of generic stakeholders:

![Figure 23-2 Example Power/Interest Grid with Stakeholders](image)

**Expert Judgment**: Talking to all of the experts on your project to identify more stakeholders, and learn more about the ones you have identified.
Meetings: Profile analysis meetings are project meetings designed to develop an understanding of major project stakeholders, and they can be used to exchange and analyze information about roles, interests, knowledge, and the overall position of each stakeholder facing the project.

23.1.3 Outputs

► Stakeholder Register

Stakeholder Register contains all details related to the identified stakeholders including, but not limited to:

- **Identification**: Name, organizational position, location, role in the project, contact information
- **Assessment information**: Major requirements, main expectations, potential influence in the project, phase in the life cycle with the most interest
- **Stakeholder classification**: Internal/external, supporter/neutral/resistor, etc.

23.2 Plan Stakeholder Management

Plan Stakeholder Management is the process of developing appropriate management strategies to effectively engage stakeholders throughout the project life cycle, based on the analysis of their needs, interests, and potential impact on project success. It provides a clear, actionable plan to interact with project stakeholders to support the project's interests. Plan Stakeholder Management identifies how the project will affect stakeholders, which then allows the project manager to develop various ways to effectively engage stakeholders in the project, to manage their expectations, and to ultimately achieve the project objectives. Stakeholder management is about creation and maintenance of relationships between the project team and stakeholders, with the aim to satisfy their respective needs and requirements within project boundaries.

23.2.1 Inputs

Project Management Plan, Stakeholder Register, Enterprise Environmental Factors and Organizational Process Assets

23.2.2 Tools & Techniques

**Expert judgment**: Based on the project objectives, the project manager should apply expert judgment to decide upon the level of engagement required at each stage of the project from each stakeholder. For example, at the beginning of a project, it may be necessary for senior stakeholders to be highly engaged in order to clear away any obstacles to success. Once these have been successfully removed, it may be sufficient for senior stakeholders to change their level of engagement from leading to supportive, and other stakeholders, such as end users, may become more important. Experts involved could be senior management, Project team members, other units or individuals within the organization, identified key stakeholders, etc.

**Meetings**: Meetings should be held with experts and the project team to define the required engagement levels of all stakeholders. This information can be used to prepare the stakeholder management plan.

**Analytical techniques**: Means figuring out how engaged your stakeholder are today, and how engaged you want them to be as your project gets under way.

The engagement level of the stakeholders can be classified as follows:
Project Stakeholder Management

- **Unaware**: The stakeholder does not know that the project is happening.
- **Resistant**: The stakeholder does not want the project or decision you are making to happen.
- **Neutral**: The stakeholder is fine with the project or decision no matter how it turns out.
- **Supportive**: The stakeholder is fine with the project or decision to succeed.
- **Leading**: The stakeholder is actively helping the project to succeed.

The current engagement can be documented using Stakeholders Engagement Assessment Matrix, as shown in the figure below:

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Unaware</th>
<th>Resistant</th>
<th>Neutral</th>
<th>Supportive</th>
<th>Leading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder 1</td>
<td>C</td>
<td></td>
<td></td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Stakeholder 2</td>
<td></td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholder 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D,C</td>
</tr>
</tbody>
</table>

*Figure 23-3 Stakeholders Engagement Assessment Matrix diagram*

### 23.2.3 Outputs

- **Stakeholder Management Plan**

The stakeholder management plan identifies the management strategies required to effectively engage stakeholders. In addition to the data gathered in the stakeholder register, the stakeholder management plan often provides: Desired and current engagement levels of key stakeholders; Scope and impact of change to stakeholders; Identified interrelationships and potential overlap between stakeholders; Stakeholder communication requirements for the current project phase; Information to be distributed to stakeholders, including language, format, content, and level of detail; Reason for the distribution of that information and the expected impact to stakeholder engagement; Time frame and frequency for the distribution of required information to stakeholders; and Method for updating and refining the stakeholder management plan as the project progresses and develops.

- **Project Documents Updates**

### 23.3 Manage Stakeholder Engagement

To meet stakeholder’s needs, resolve their issues, and make sure they remain interested and active in project, as your project progresses, you will need to check in with your stakeholders regularly so that misunderstandings don’t develop. Your job is to help them to take part in the decisions the team is making, so that they can be supportive. When a stakeholder is resistant to change, you will need to negotiate with her and understand her resistance so that you can take her perspective into account. This process allows the project manager to increase support and minimize resistance from stakeholders, significantly increasing the chances to achieve project success.

#### 23.3.1 Inputs


#### 23.3.2 Tools & Techniques
Communication methods: As described in Communication Management, the methods of communication identified for each stakeholder in the communications management plan are utilized during stakeholder engagement management. Based on the stakeholders’ communication requirements, the project manager decides how, when, and which of these communication methods are to be used in the project. This is where you decide how you will keep people in the loop using push methods, interactive methods, or pull methods.

Interpersonal skills: This is where you use your soft skills to keep everybody on track and working towards the same goal. It may involve Building trust, Resolving conflict, Active listening, and Overcoming resistance to change.

Management skills: This is where you gather important information about your project and use it to make decisions about how to keep the team on track. The project manager applies management skills to coordinate and harmonize the group toward accomplishing the project objectives. Facilitate consensus toward project objectives, Influence people to support the project, Negotiate agreements to satisfy the project needs, and Modify organizational behavior to accept the project outcomes.

23.3.3 Outputs

► Issue Log

Managing stakeholder engagement may result in the development of an issue log. This log is updated as new issues are identified and current issues are resolved.

► Change Requests

Managing stakeholder engagement may result in a change request to the product or the project. It may also include corrective or preventive actions to the project itself or to the interaction with the impacted stakeholders, as appropriate.

► Project Management Plan Updates

► Project Documents Updates

23.4 Control Stakeholder

Control Stakeholder Engagement is the process of monitoring overall project stakeholder relationships and adjusting strategies and plans for engaging stakeholders. Once you know what your stakeholder’s requirements are, you can monitor how close or far away your project is from meeting them. When you run into a problem or find a place where you might be able to bring the project closer to meeting a stakeholder’s goal, you can make course corrections and changes to keep as many of your stakeholders satisfied as possible and that’s what the control stakeholder Engagement process is all about. It will maintain or increase the efficiency and effectiveness of stakeholder engagement activities as the project evolves and its environment changes.

23.4.1 Inputs

Project Management Plan, Issue Log, Work Performance Data and Project Documents

23.4.2 Tools & Techniques

Information management systems: An information management system provides a standard tool for the project manager to capture, store, and distribute information to stakeholders about the project cost, schedule progress, and performance. It also allows the project manager to consolidate reports from several systems and facilitate report distribution to the project stakeholders.
**Expert judgment**: To ensure comprehensive identification and listing of new stakeholders, reassessment of current stakeholders can be performed. Input should be sought from groups or individuals with specialized training or subject matter expertise.

**Meetings**: Status review meetings are used to exchange and analyze information about stakeholder engagement and to keep all of the stakeholders in the loop about project progress, and provide a place for everyone to share their opinions on how to keep the project on track.

### 23.4.3 Outputs

- **Work performance information**

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

- **Change requests**

  Analysis of project performance and interactions with stakeholders often generates change requests. These change requests are processed through the Perform Integrated Change Control process 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
  - **Project management plan updates**
  - **Project documents updates**
  - **Organizational process assets updates**

### 24. Project Management Formulas

<table>
<thead>
<tr>
<th>Knowledge Area</th>
<th>Title</th>
<th>Formulas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Integration Management</td>
<td>Present Value (PV)</td>
<td>[ PV = \frac{FV}{(1 + r)^n} ]</td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Expected Activity Duration (Triangular Distribution)</td>
<td>[ P + M + O ]</td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Expected Activity Duration (Beta Distribution)</td>
<td>[ P + 4M + O ]</td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Beta Activity Standard Deviation (SD)</td>
<td>[ P - O ]</td>
</tr>
<tr>
<td>Project Time Management</td>
<td>Range of an activity duration</td>
<td>[ \text{Beta EAD} \pm \text{SD} ]</td>
</tr>
</tbody>
</table>
| Project Time Management | Total Float (slack) | $LS - ES$, or $LF - EF$
|-------------------------|---------------------|------------------------|
| Project Cost Management | Cost Variances (CV)  | $EV - AC$
| Project Cost Management | Schedule Variance (SV) | $EV - PV$
| Project Cost Management | Cost Performance Index (CPI) or cumulative CPI | $\frac{EV}{AC} - \frac{EV}{AC}$
| Project Cost Management | Schedule Performance Index (SPI) | $\frac{EV}{PV}$
| Project Cost Management | Estimate at Completion (EAC) | $AC + \text{Bottom-up ETC}$
| Project Cost Management | Estimate at Completion (EAC) | $\frac{BAC}{CPIc}$
| Project Cost Management | Estimate at Completion (EAC) | $AC + (BAC - EV)$
| Project Cost Management | Estimate at Completion (EAC) | $AC + \frac{(BAC - EV)}{(CPIc \times SPIc)}$
| Project Cost Management | To-Complete Performance Index (TCPI) | $\frac{(BAC - EV)}{(BAC - AC)}$
| Project Cost Management | Estimate to Complete (ETC) | $EAC - AC$
| Project Cost Management | Variance at Completion (VAC) | $BAC - EAC$
| Project Communication Management | Communication Channels | $\frac{N(N - 1)}{2}$
| Project Risk Management | Expected Monetary Value | $EMV = P \times I$

| Project Procurement Management | Point of Total Assumption (PTA) = | $\text{Ceiling price} - \text{Target price} \times \frac{\text{Buyers share ratio}}{\text{Target cost}}$

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25. Code of Ethics and Professional Conduct

One must understand and abide by code of ethics and professional conduct: [https://www.pmi.org/about/ethics/code](https://www.pmi.org/about/ethics/code)