SCHOOL OF PROJECT MANAGEMENT

STUDY PACK

FOR

PROJECT TIME MANAGEMENT

AND

PROJECT COST MANAGEMENT

Table of Content

Chapter 1

An Introduction to Project Management

Objectives

The purpose of this training is to introduce key project management terms and concepts to provide a common language for discussion, including what is:

- ✓ A project
- ✓ Project management
- ✓ Project success
- ✓ A project manager
- ✓ A project management plan

Successful project management has several significant characteristics. To understand the value of project management, it is necessary to understand the fundamental nature of a project; the core characteristics of project management processes; how success is evaluated, the roles, responsibilities, and activities of a project manager and the expertise required; and the context in which projects are performed.

What is a Project?

The fundamental nature of a project is that it is a "temporary endeavour undertaken to create a unique product, service, or result."

Projects are distinguished from operations and from programs.

The temporary nature of projects indicates a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists. Temporary does not necessarily mean short in duration. Temporary does not generally apply to the product, service, or result created by the project; most projects are undertaken to create a lasting outcome. For example, a project to build a national monument will create a result expected to last centuries. Projects can also have social, economic, and environmental impacts that far outlast the projects themselves.

Every project creates a unique product, service, or result. Although repetitive elements may be present in some project deliverables, this repetition does not change the fundamental uniqueness of the project work.

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

Temporary Endeavour

To be temporary signifies that there is a discrete and definable commencement and conclusion; the management of a project requires tailored activities to support this characteristic, as such, a key indicator of project success is how it performs against its schedule that is, does is start and end on time.

Unique Deliverable

The uniqueness of the deliverable, whether it is a product, service, or result, requires a special approach in that there may not be a pre-existing blue print for the project's execution and there may not be a need to repeat the project once it is completed. Uniqueness does not mean that there are not similarities to other projects, but that the scope for a particular project has deliverables that must be produced within constraints, through risks, with specific resources, at a specific place, and within a certain period; therefore, the process to produce the deliverable as well as the deliverable itself is unique.

Progressive Elaboration

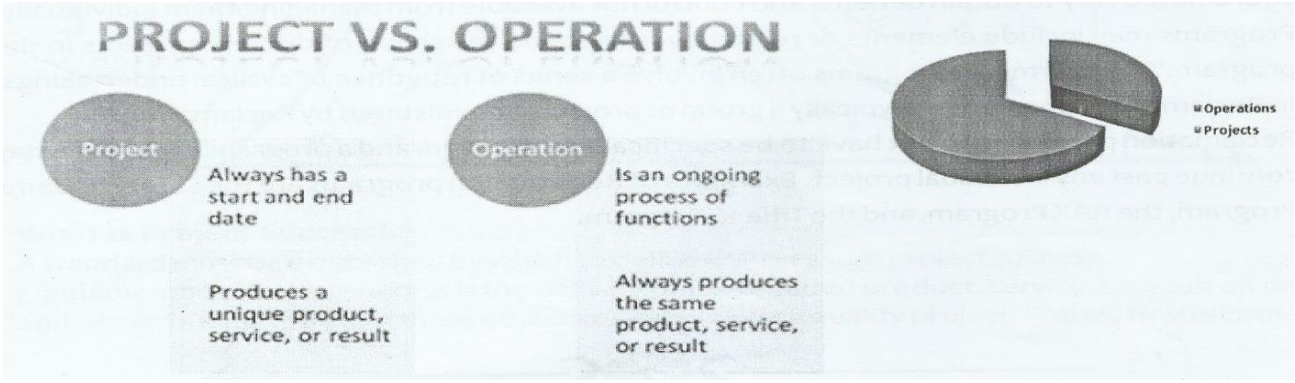
This unique process and deliverable produces the third characteristic of a project: progressive elaboration. Project management is a group of interrelated processes, implemented in a progressively elaborative manner, in which to produce the deliverable. Progressive elaboration is the revealing and focusing of details through time. For example, in the engineering design process, a general and broad concept may be a starting point for the design team; but through the design process, the concept is narrowed to a specific scope and is further elaborated to achieve the completed design; moreover, it may continue to be elaborated and not be finalized until the product, service, or result is delivered.

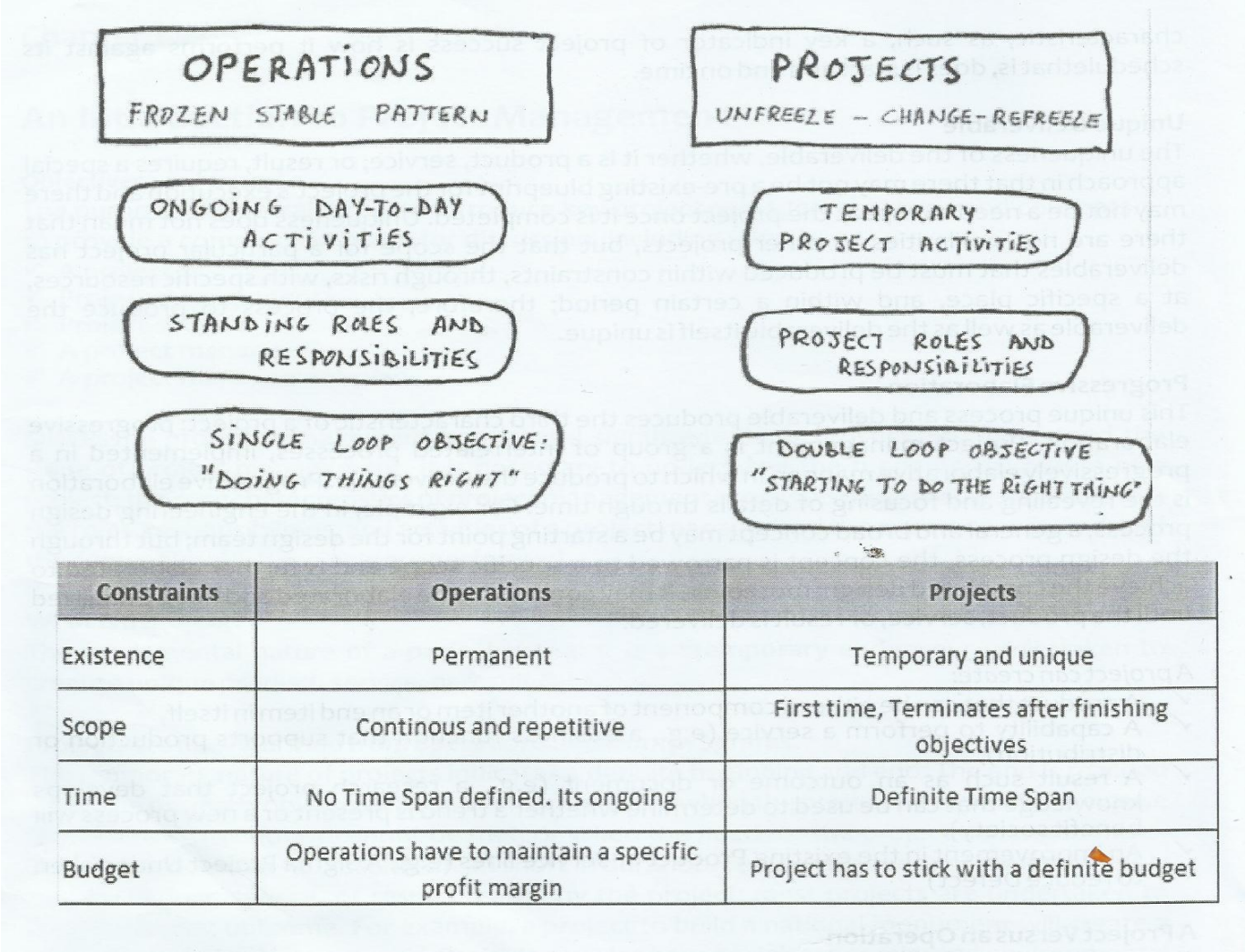
A project can create:

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

A Project versus an Operation

The operations of an organization are continuing and repetitive activities that are executed to achieve its mission and sustain the business, but without a definable end to their performance and without a unique output that is, it is not produced or provided only once.



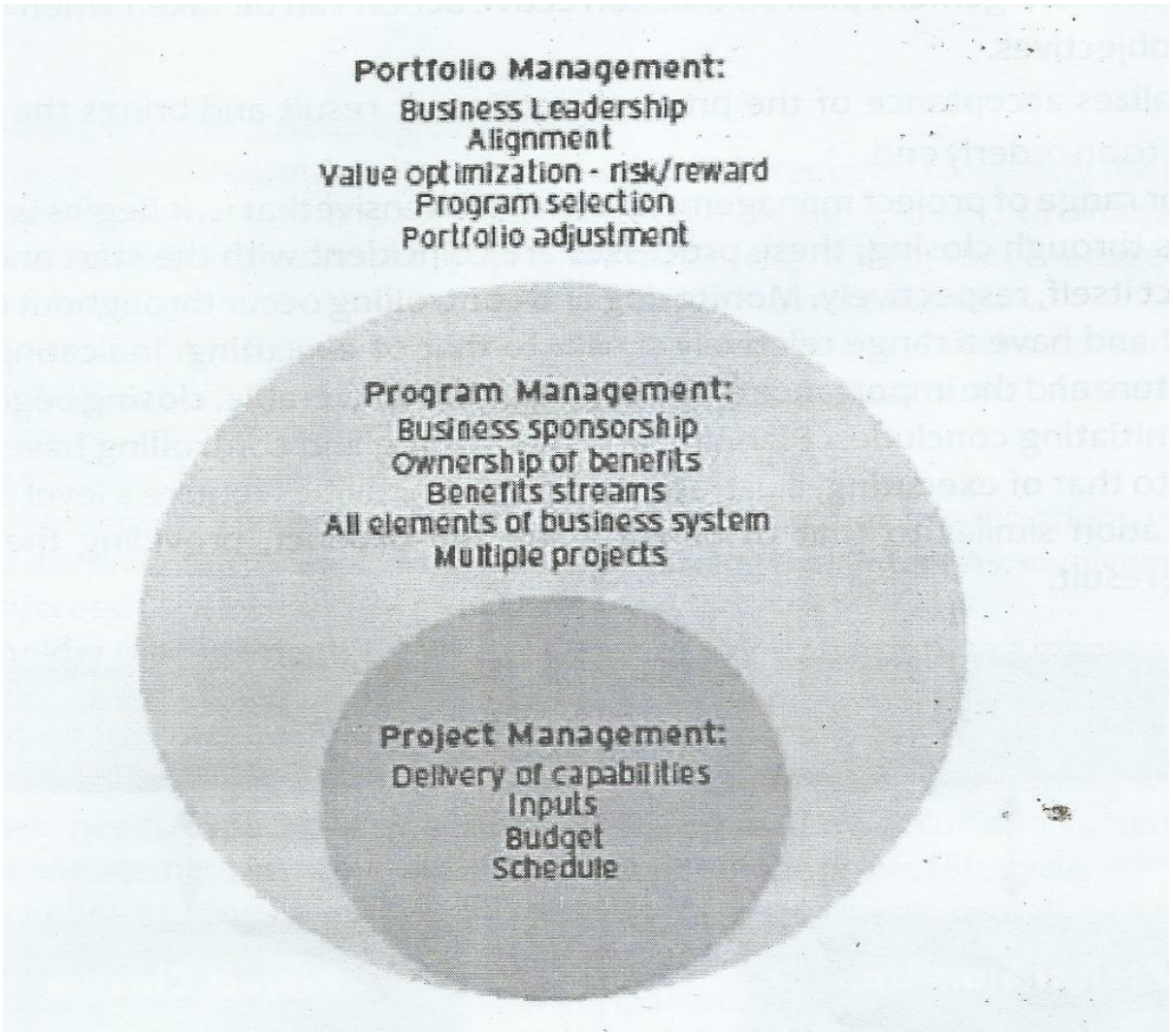


Constraints	Operations	Projects
Existence	Permanent	Temporary and unique
Scope	Continous and repetitive	First time, Terminates after finishing objectives
Time	No Time Span defined. Its ongoing	Definite Time Span
Budget	Operations have to maintain a specific profit margin	Project has to stick with a definite budget

A Project Versus a Program

A project differs from a program in that "a program is a group of related projects managed in a coordinated way to obtain benefits and control not available from managing them individually. Programs may include elements or related work outside the scope of discrete projects in the program." Furthermore, programs often involve a series of repetitive or cyclical undertakings. In Reclamation, a program is typically a group of projects administered by Reclamation.

Reclamation programs do not have to be specifically authorized, and a program's schedule may continue past any individual project. Examples of Reclamation programs are the Safety of Dams Program, the RAX Program, and the Title 16 Program.



What Is Project Management?

"Project management is the process of the application of knowledge, skills, tools, and techniques to project activities to meet project requirements." That is, project management is an interrelated group of processes that enables the project team to achieve a successful project. These processes manage inputs to and produce outputs from specific activities; the progression from input to output is the nucleus of project management and requires integration and iteration. For example, a feasibility report could be an input to a design phase; the output of a design phase could be a set of plans and specifications. This progression requires project management acumen, expertise, tools and techniques, including risk management, contingency development, and change control.

Process Groups

The project management process groups are initiating, planning, executing, monitoring and controlling, and closing.

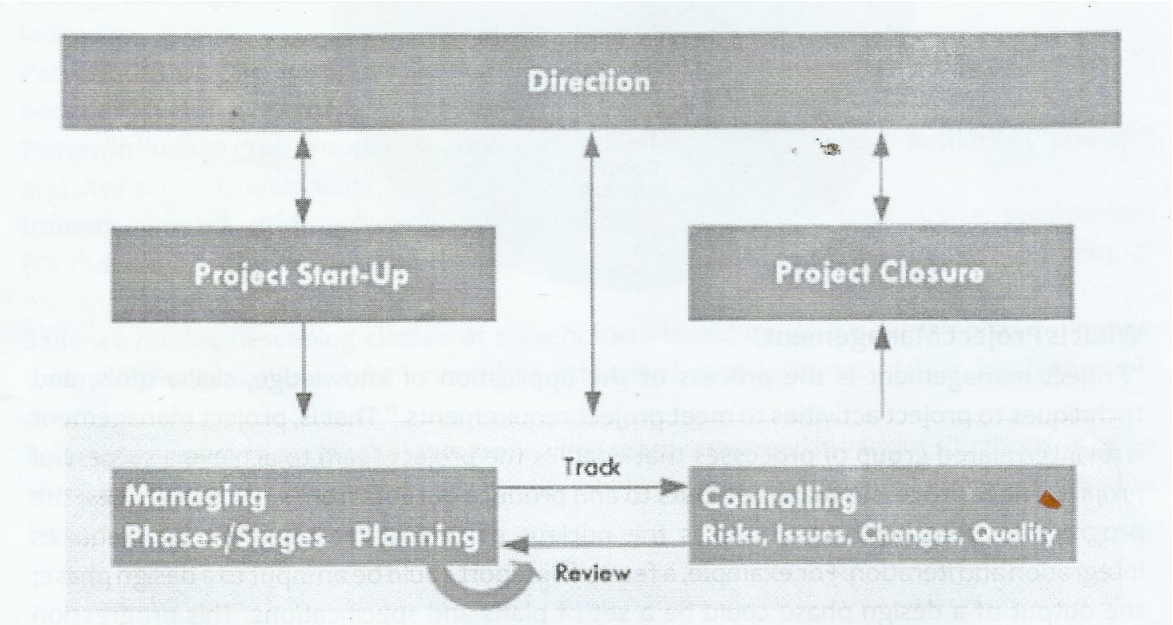
Initiating defines and authorizes the projector a project phase.

Planning defines and refines objectives and plans the course of action required to attain the objectives and scope that the project was undertaken to address. Executing integrates people and other resources to carry out the project management plan for the project.

Monitoring and controlling regularly measures and monitors progress to identify variances from the project management plan so that corrective action can be taken when necessary to meet project objectives.

Closing formalizes acceptance of the product, service, or result and brings the project or a project phase to an orderly end.

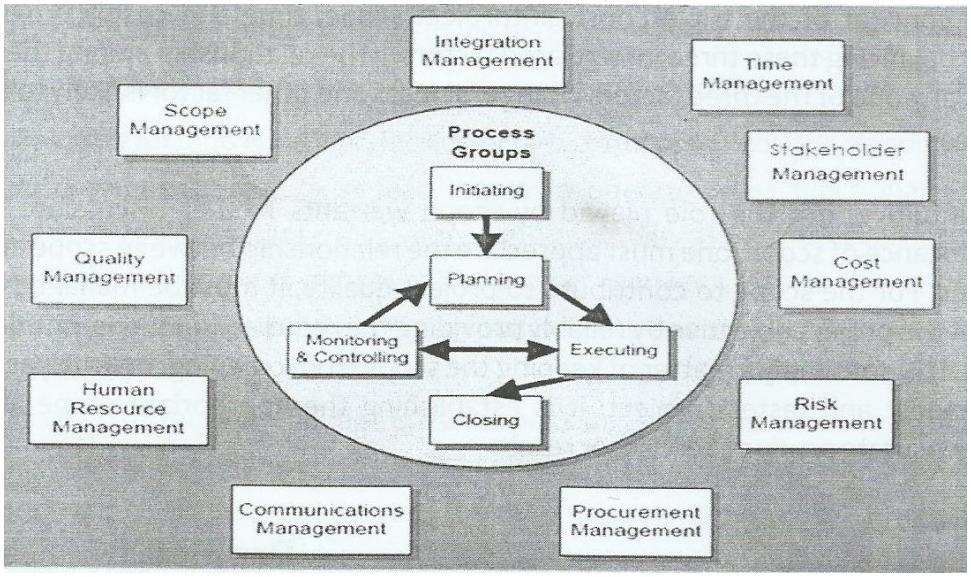
The breadth or range of project management is comprehensive that is, it begins with initiating and continues through closing; these processes are coincident with the start and end of the specific project itself, respectively. Monitoring and controlling occur throughout the duration of the project and have a range relatively similar to that of executing. Indicating a project's temporary nature and the importance of the timing of the deliverable, closing begins relatively shortly after initiating concludes. Planning and monitoring and controlling have a collective depth similar to that of executing, illustrating that these activities require a level of effort and have a implication similar to that of constructing the product, providing the service, or producing the result.



Process Group Interaction

The level of interaction of the five processes indicates a strong relational dependence not exclusive of one another. One process does not simply end and the next one begins. The presence of this interrelationship and range is a function of progressive elaboration. Projects are executed in increments and details are exposed and developed through the progression of time objectives are developed, discoveries are made; investigations, studies, and surveys are completed; analysis is performed; constraints are changed; resources are amended; contingencies are exercised; changes are managed; risks are mitigated; and Force Majeure (unforeseeable or unpreventable circumstances) occurs.

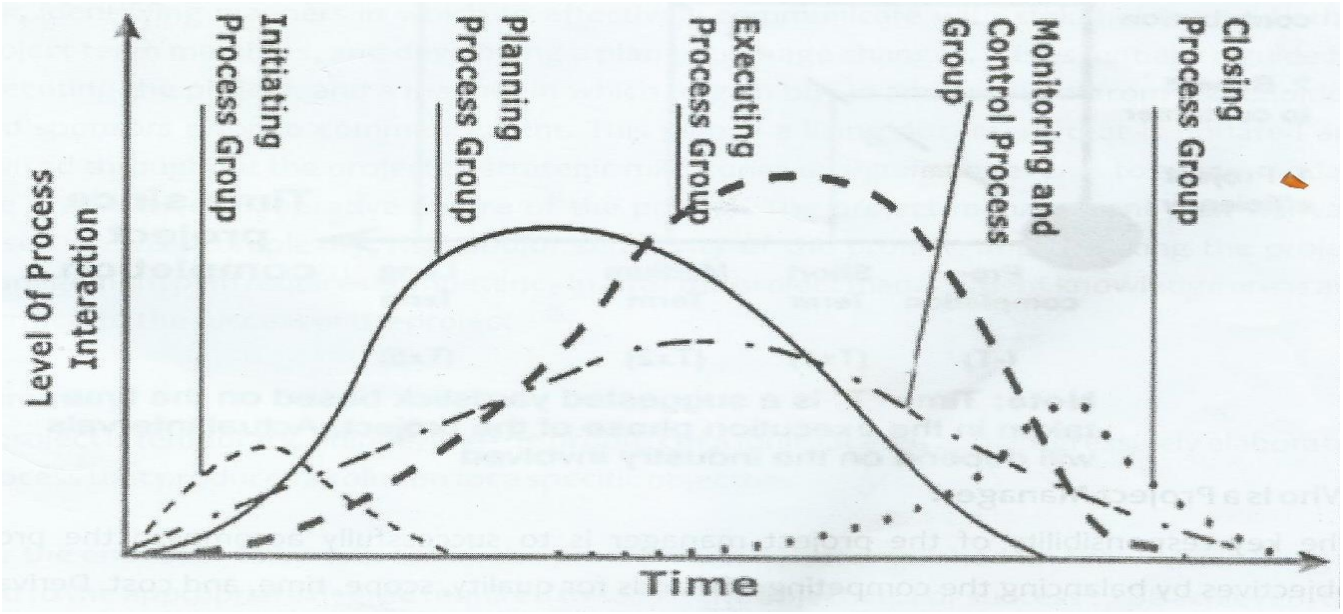
To manage the breadth or range of a project, active and proactive project management is required throughout the duration of the project. It cannot be simply initiated and/or planned and left alone; it must be continually planned and monitored and controlled. Sustained reactive project management is indicative of incomplete or absent planning and/or monitoring and controlling.



Project Phases versus Process Groups

Project management process groups are not project phases. In fact, the process groups may need to be repeated for each phase, such as study, programming engineering, procurement, construction, and commissioning. A process group or project phase is not discrete; they are interdependent and require integration.

Also, project management must ensure continuity as a project progresses through processes and phases.

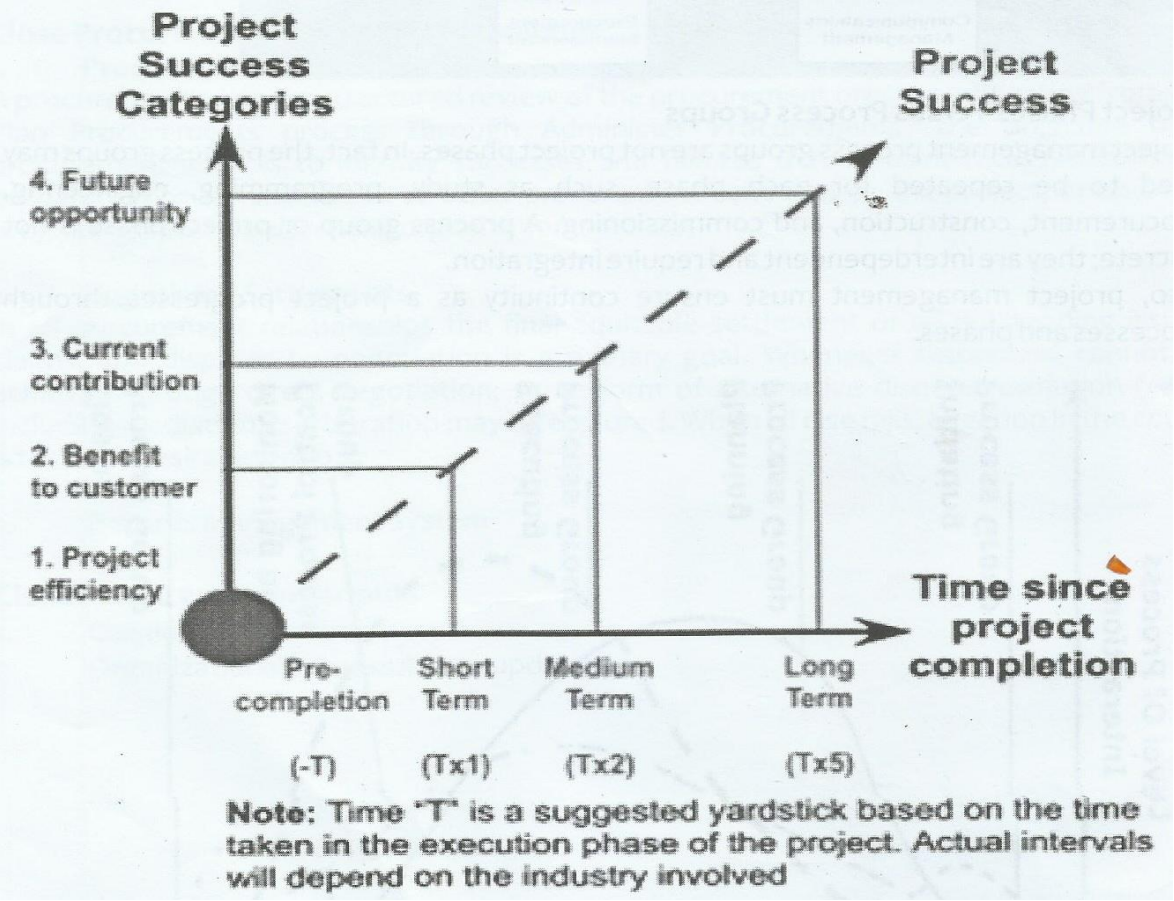


What Is Project Success?

A standard must be established by which to define and measure project success. Fundamentally, project success is the delivery of the required product, service, or result on time and within budget. To meet these objectives is to deliver a quality project. PMI illustrates project quality through the concept of the triple constraint project scope, time and cost.9 Project quality is affected by balancing these three interrelated factors. “The relationship among these factors is such that if any one of the three factors change, at least one other factor is likely to be affected.”

Cost and time are intuitive, but the role played by scope warrants further discussion. To understand the significance of scope, one must appreciate the relationship between scope and the project objectives. For the scope to

contribute to project quality, it must be managed to meet the demands of the project objective by reliably providing the required functions, nothing more or nothing less. It is not simply a matter of keeping the scope from creeping, or a matter of completing the cheapest and fastest project; it is establishing the appropriate scope and delivering the commensurate product, service, or result.



Who is a Project Manager?

The key responsibility of the project manager is to successfully accomplish the project objectives by balancing the competing demands for quality, scope, time, and cost. Derivative responsibilities include identifying the project requirements; establishing clear and achievable objectives; and adapting the specifications, plans, and approach to the different concerns and expectations of the various stakeholders. Fundamentally, the project manager must direct the project from its inputs, through its nucleus, to delivery of its outputs. In order to accomplish these multifaceted responsibilities, the roles of the project manager include that of a leader, administrator, entrepreneur, facilitator, arbitrator and mediator, liaison, and coordinator.

The project manager must lead teams to operate cross functionally towards a common objective while assuring cohesiveness and continuity as the project progresses through project processes and project phases. “The project manager acts as the key catalyst to stimulate effective communication and coordination between design, procurement and construction activities.”

In order to effectively manage these responsibilities and assume these roles, a project manager must have experience in the following project management knowledge areas: project integration, scope, time, cost, quality, human resources, communications, risk, and procurement management.

What Is a Project Management Plan (PMP)?

A project management plan is a fundamental tool for the project manager deliver the project successfully. This document is a strategic and formalized roadmap to accomplish the project’s objectives by describing how the project is to be executed, monitored and controlled, which includes creating a project work breakdown structure, identifying and planning to mitigate risk, identifying manners in which to effectively communicate with stakeholders and other project team members, and developing a plan to manage changes. It is essentially a guide for executing the project, and a manner in which to gain buy-in and approval from stakeholders and sponsors prior to commencement. This plan is a living document that is updated and revised throughout the project at strategic milestones or significant events to accommodate the progressive, elaborative nature of the project. The project management plan will vary based on size, complexity, risk, and/or sensitivity of the project. Implementing the project management plan requires competency in all of the project management knowledge areas and is critical to the success of the project

Summary

A project is temporary, unique, and the product of a multifaceted and progressively elaborated process that produces a solution for a specific objective.

For the endeavor to be successful, the project must be accomplished on time, within budget, and to the appropriate degree required to satisfy the objective. For success to be achieved, the project manager must be skilled and operate in an environment which enables a project team to function. Excellence in project management should be viewed as the positive trend in the performance of successful projects.

Chapter 2

Project Life Cycle and Organization

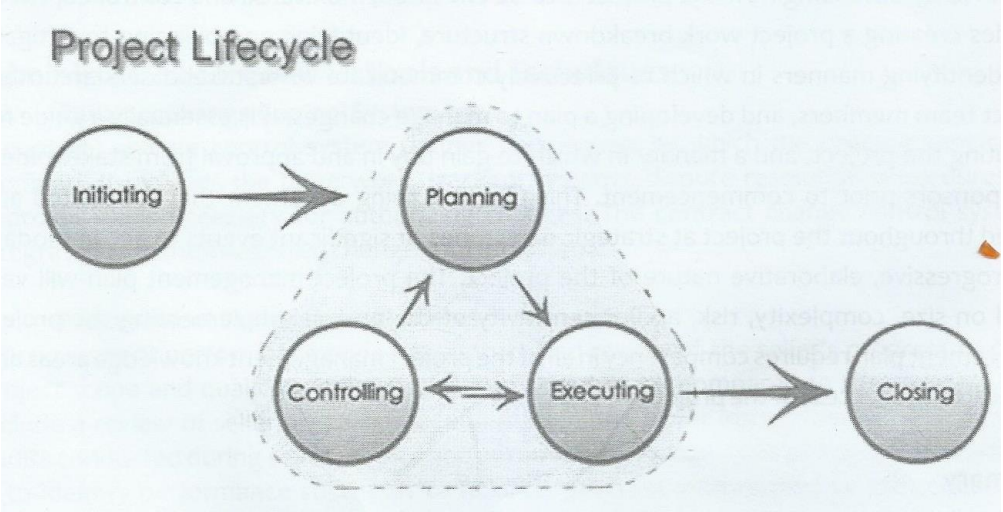
The project life cycle Overview

A project life cycle is a collection of generally sequential and sometimes overlapping project phases whose name and number are determined by the management and control needs of the organization or organizations involved in the project, the nature of the project itself, and its area of application.
Projects and project management take place in an environment that is broader than that of the project itself. It is imperative to understand these environments and structure approaches that would enhance project success.

- ✓ Divides the project into phases that provide better management
- ✓ Deliverable usually approved before the work starts on the next phase, but sometimes a subsequent phase is begun prior to approve of the previous phase (Fast Tracking)
- ✓ Cost are low at the start and higher towards the end and drop as the project closes
- ✓ Project life cycle VS Project management process

Project Life Cycle:

- ✓ Describes what you need to do to achieve the project object (to do the work for the project)
- ✓ Phases are known as project life cycle



Project Management Process

- ✓ Describe what you need to do to manage the project to achieve the project objective and meet the requirements
- ✓ Cost and Staffing Levels across the Project Life Cycle
- ✓ Impact of Variable Based on Project Time

Project Phases

- ✓ Project phases are divisions within a project where extra control is needed to effectively manage the completion of a major deliverable.
- ✓ Project phases are typically completed sequentially, but can overlap in some project situations. Project Phase is not a Project Management Process Group.

Project Governance across the Life Cycle

Project governance provides a comprehensive, consistent method of controlling the project and ensuring its success. The project governance approach should be described in the project management plan. A project's governance must fit within the larger context of the program or organization sponsoring it.

Within those constraints, as well as the additional limitations of time and budget, it is up to the project manager and the project management team to determine the most appropriate method of carrying out the project. Decisions must be made regarding who will be involved, what resources are necessary, and the general approach to completing the work. Another important consideration is whether more than one phase will be involved and, if so, the specific phased structure for the individual project.

The phase structure provides a formal basis for control. Each phase is formally initiated to specify what is allowed and expected for that phase. A management review is often held to reach a decision to start the activities of a phase. This is especially true when a prior phase has not yet completed. An example would be when an organization chooses a life cycle where more than one phase of the project progresses simultaneously. The beginning of a phase is also a time to revalidate earlier assumptions, review risks and define in more detail the processes necessary to complete the phase deliverable(s).

For example, if a particular phase does not require purchasing any new materials or equipment, there would be no need to carry out the activities or processes associated with procurement.

A project phase is generally concluded and formally closed with a review of the deliverables to determine completeness and acceptance. A phase-end review can achieve the combined goal of obtaining authorization to close the current phase and start the subsequent one. The end of a phase represents a natural point to reassess the effort underway and to change or terminate the project if necessary. A review of both key deliverables and project performance to date to a) determine if the project should continue into its next phase and b) detect and correct errors cost effectively should be regarded as good practice. Formal phase completion does not necessarily include authorizing the subsequent phase. For instance, if the risk is deemed to be too great for the project to continue or if the objectives are no longer required, a phase can be closed with the decision to not initiate any other phases.

Business Value

This Concept is unique to each organization. Business Value is defined as the entire value of the business; the total sum of all tangible and intangible elements. Examples of tangible element include monetary assets, fixtures, stakeholder utility. Examples of intangible elements include goodwill, brand recognition, public benefit, and trademarks.
Depending on the organization, business value scope can be short- medium- or long term. Value may be created through the effective management of ongoing operations. However, through the effective use of portfolio, program and project management, organizations will possess the ability to employ reliable established processes to meet strategic objective and obtain greater business value from their project investments.
Though some organizations are not business driven every organization conduct business related activities,

Stakeholders

- ✓ Stakeholders are persons or organizations who are active involved in the project or whose interests may be positively or negatively affected by the performance or completion of the projects, they may also exert influence over the project, its deliverable, and the project team members.
- ✓ The project management team must identify both internal and external stakeholders in order to determine the project requirements and expectations for all parties involved.

- ✓ The PM must manage the influence of the various stakeholders in relation to the project requirements to ensure successful outcome.

What are stakeholders?

- ✓ Project Sponsor
- ✓ Project Manager
- ✓ Project Management Team
- ✓ Project Team Members
- ✓ Program Manager
- ✓ Portfolio Manager
- ✓ Program manager

Key Stakeholders

- ✓ Customer/User
- ✓ Performing Organization
- ✓ Influences
- ✓ Stakeholder Analysis

Stakeholders must be identified, have their needs and expectations understood and managed, and be communicated with frequently in order to complete the project successfully.

Organizational Structures

Organizational Structure is an enterprise environmental factor which can affect the availability of resources and influence how projects are conducted. Organizational Structures range from functional to projectized, with a variety of matrix structures between them. The following table shows key project related characteristics of the major types of Organizational Structures.

The classic functional organization is a hierarchy which each employee has one clear superior. Staff members are grouped by specialty at the top level. Each department will do its project work independent of other departments.

Matrix Organizations are a blend of functional and projectized characteristics. Weak matrices maintain many of the c/s of a functional organizational, and the project manager role is more of a coordinator or expediter than that of a true project manager. Strong matrices have many of the c/s of the projectized organization, and can have full true project managers with considerable authority and full time project administrative staff. While the balanced matrix organization recognizes the need for a project manager, it does not provide the project manager with the full authority over the project and project funding.

At the opposite the projectized organization shown in figure , team members are often co located most of the resources are involved in project work, and project managers have a great deal of independence and authority. lt often have departments either report directly to the project manager or provide support services to the various projects.

Many organizations involve all these structures at various levels as shown in the figure (Composite Organization) to coordinate between various projects.

PROJECT ROLES & EXPECTATIONS

- Customer/Business
- Project Sponsor
- Project Manager
- Project Steering Committee
- Project Team Members
- Other Stakeholders

Customer/Business

The organization or individual receiving the final product
Responsible for business requirements that must be met

Project Sponsor

Manager/Executive with demonstrable interest in the outcome of the project
Responsible for securing spending authority and resources for the project

Ideally, highest-ranking manager possible appropriate for the project size and scope

- ✓ Champions the project.
- ✓ Ultimate decision-maker for the project.
- ✓ Provides support for the Project Manager.
- ✓ Approves major deliverables.
- ✓ Signs off on approvals to proceed to each succeeding project phase.

Project Manager

- ✓ Responsible for ensuring that the Project Team completes the project
- ✓ Develops the Project Plan with the team
- ✓ Manages the team's performance of project tasks
- ✓ Secures acceptance and approval of deliverable from the Sponsor and Stakeholders
- ✓ Monitors performance and takes corrective actions when needed

Project Steering Committee

- ✓ Representatives from stakeholders.
- ✓ Review and approve major protect decisions or deliverable.
- ✓ When escalation reaches this level, make decisions on project issues and change requests.

Project Team

Responsible for executing tasks and producing deliverable:

- ✓ As outlined in the Project Plan.
- ✓ As directed by the Project Manager.
- ✓ At the level of effort or participation defined for them.

Vendor

- ✓ Contracted to provide additional product or services the project requires.
- ✓ PM manages relationship.
- ✓ May be part of Project Team.

Other Project Stakeholders:

Individuals and organizations actively involved in the project, or with interests that may be positively or negatively affected as a result of the completion of the project.

Chapter 3

PROJECT TIME MANAGEMENT

Points to Note

The study notes explain topics that are important for PMP exam preparation, and you can expect several questions from these topics.
Pay close attention to all the terms used. It is very important to understand all the concepts discussed in this chapter.
Try to relate the concepts to real life examples.
NO process is discreet, No Tool is certain. But all the tools and techniques have been tested to be effective subject to the best practices of the project manager.

What is Project Time Management?

This is defined as the processes required managing the timely completion of the project.
Processes involved in the project time management include:

- ✓ Plan Schedule Management
- ✓ Define Activities
- ✓ Sequence Activities
- ✓ Estimate Activity Resources
- ✓ Estimate Activity Durations
- ✓ Develop Schedule
- ✓ Control Schedule

Each of these processes occurs at least once in every project and in one or more project phases (if the project is divided into phases).

Plan Schedule Management

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

Input

- ✓ Project Management Plan
- ✓ Scope Baseline
- ✓ Cost, risk and communication decision
- ✓ Project Charter
- ✓ Enterprise Environment factors
- ✓ Organization process Asset

Plan Schedule Management: Tools and Techniques

1. Expert Judgment: Expert Judgment, guided by historical information, provides valuable insight about the environment and information from prior similar projects. Expert judgment can also suggest whether to combine methods and how to reconcile differences between them
2. Analytical Techniques: The Plan Schedule management process may involve choosing strategic options to estimate and schedule the project such as: scheduling methodology, scheduling tools and techniques, estimate approaches, formats and project management software.
3. Meetings: Project team may hold planning meetings to develop the schedule management plan. Participants at these meetings may include the project manager, project sponsor, selected project team members, selected stakeholder, among others.

Plan Schedule Management: Out Put

- ✓ Schedule management Plan
- ✓ Rules of performance measurement

Define Activities

The process of identifying specific actions that needs to be performed to produce project deliverables.

The Create WBS process identifies the deliverables at the lowest level in the Work Breakdown Structure (WBS), the work package. Project work packages are typically decomposed into smaller components called activities that represent the work necessary to complete the work package.

Activities are smaller decomposed components of the project work packages, which represent the work necessary to complete the work package.

Inputs

1. **Scope Baseline**
   The project deliverables, constraints, and assumptions documented in the project scope baseline are considered explicitly while defining activities.
2. **Enterprise Environmental Factors**
3. **Organizational Process Assets**
   The organizational process assets that can influence the Define Activities process include, but are not limited to:
   Existing formal and informal activity planning-related policies, procedures, and guidelines, such as the scheduling methodology, that are considered in developing the activity definitions
   Lessons-learned knowledge base containing historical information regarding activities lists used by previous similar projects.

Define Activities: Tools and Techniques

1. **Decomposition**

   The technique of decomposition, as applied to defining activities, involves subdividing the project work packages into smaller, more manageable components called activities. Activities represent the effort needed to complete a work package. The Define Activities process defines the final outputs as activities rather than deliverables, as done in the Create WBS process.

2. **Rolling Wave Planning**

   Rolling wave planning is a form of progressive elaboration planning where the work to be accomplished in the near term is planned in detail and future work is planned at a higher level of the WBS. Therefore, work can exist at various levels of detail depending on where it is in the project life cycle.

3. **Templates**

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

4. **Expert judgments**

   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.

Output

1. **Activity List**

   The activity list is a comprehensive list including all schedule activities required on the project. The activity list 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.

2. **Activity Attributes**

   Activity attributes extend the description of the activity by identifying the multiple components associated with each activity. The components for each activity evolve over time. During the initial stages of the project they include the Act D, WBS ID, and Activity Name, and when completed may include activity codes, activity description, predecessor activities, successor activities, logical relationships, leads and tags, resource requirements, imposed dates, constraints, and assumptions. Activity attributes can be used to identify the person responsible for executing the work, geographic area, or place where the work has to be performed, and activity type such as level of effort (LOE), discrete effort, and apportioned effort (AE). Activity attributes are used for schedule development and for selecting, ordering, and sorting the planned schedule activities in various ways within reports. The number of attributes varies by application area.

3. Milestone List

A milestone is a significant point or event in the project. A milestone list identifies all milestones and indicates whether the milestone is mandatory, such as those required by contract, or optional, such as those based upon historical information.

Sequence Activities

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

Activities are sequenced using logical relationships.

Every activity and milestone except the first and last are connected to at least one predecessor and one successor.

It may be necessary to use lead or lag time between activities to support a realistic and achievable project schedule.

Sequencing can be performed by using project management software or by using manual or automated techniques.

Sequence Activities: inputs

1. Activity List
2. Activity Attributes
3. Milestone List
4. Project Scope Statement.
5. Organizational Process Assets

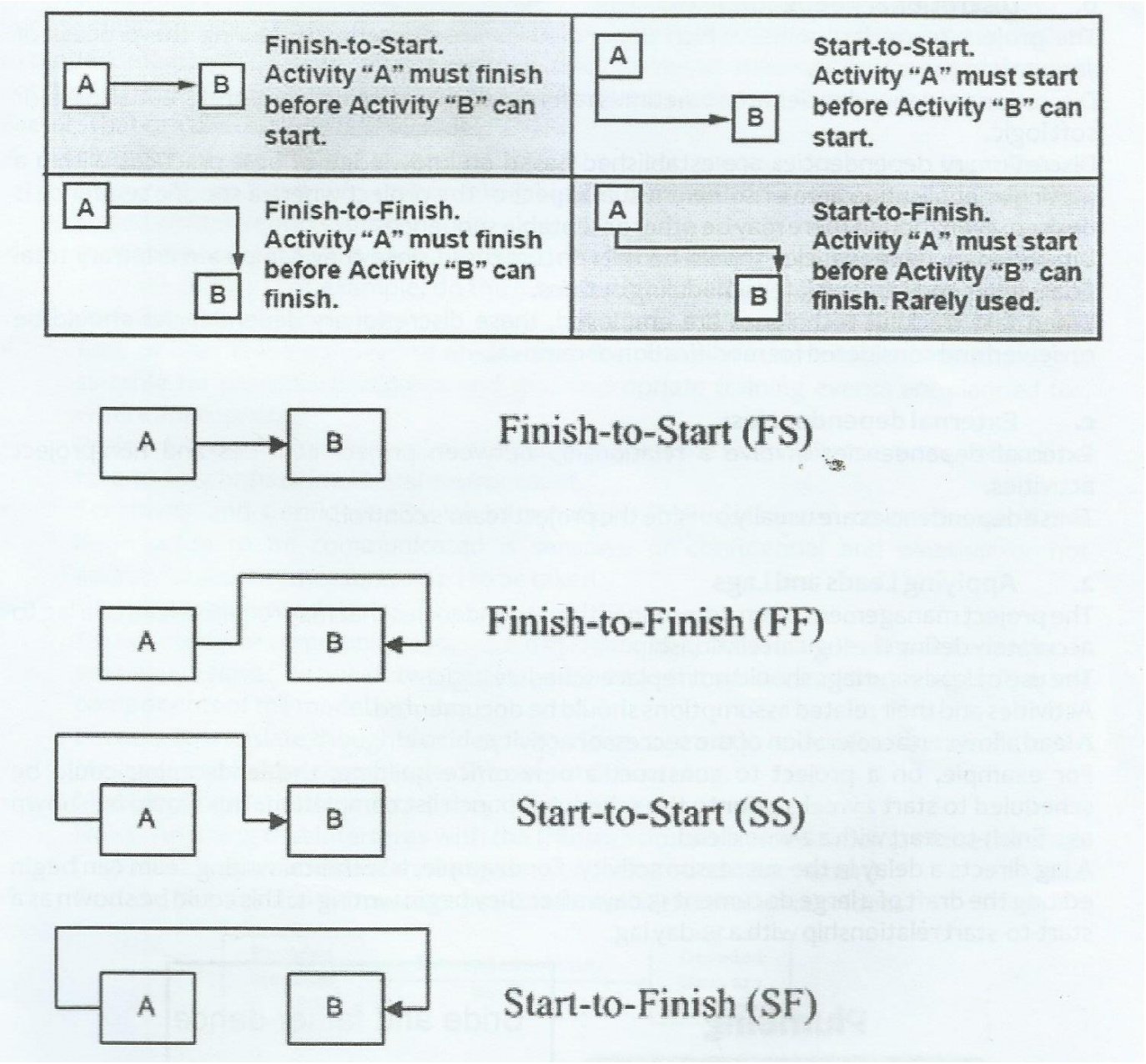
Sequence Activities: Tools and Techniques

1. Precedence Diagramming method (PDM)

PDM is a method used in Critical Path Methodology (CPM) for constructing a project schedule network diagram that uses boxes or rectangles, referred to as nodes, to represent activities, and connects them with arrows that show the logical relationships that exist between them.

PDM includes four types of dependencies or logical relationships:

a. **Finish-to-start (FS).** The initiation of the successor activity depends upon the completion of the predecessor activity.
b. **Finish-to-finish (FF).** The completion of the successor activity depends upon the completion of the predecessor activity.
c. **Start-to-start (55).** The initiation of the successor activity depends upon the initiation of the predecessor activity.
d. **Start-to-finish (SF).** The completion of the successor activity depends upon the initiation of the predecessor activity.



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

1. Dependency Determination

Types of Dependencies

a. Mandatory dependencies:

Mandatory dependencies are those that are contractually required or inherent in the nature of the work.

The project team determines which dependencies are mandatory during the process of sequencing the activities.

Mandatory dependencies are also referred to as hard logic.

b. Discretionary dependencies:

The project team determines which dependencies are discretionary during the process of sequencing the activities.

Discretionary dependencies are sometimes referred to as preferred logic, preferential logic, or soft logic.

Discretionary dependencies are established based on knowledge of best practices within a particular application area or some unusual aspect of the project where a specific sequence is desired, even though there may be other acceptable sequences.

Discretionary dependencies should be fully documented since they can create arbitrary total float values and can limit later scheduling options.

When fast tracking techniques are employed, these discretionary dependencies should be reviewed and considered for modification or removal.

c. External dependencies:

External dependencies involve a relationship between project activities and non-project activities.

These dependencies are usually outside the project team control.

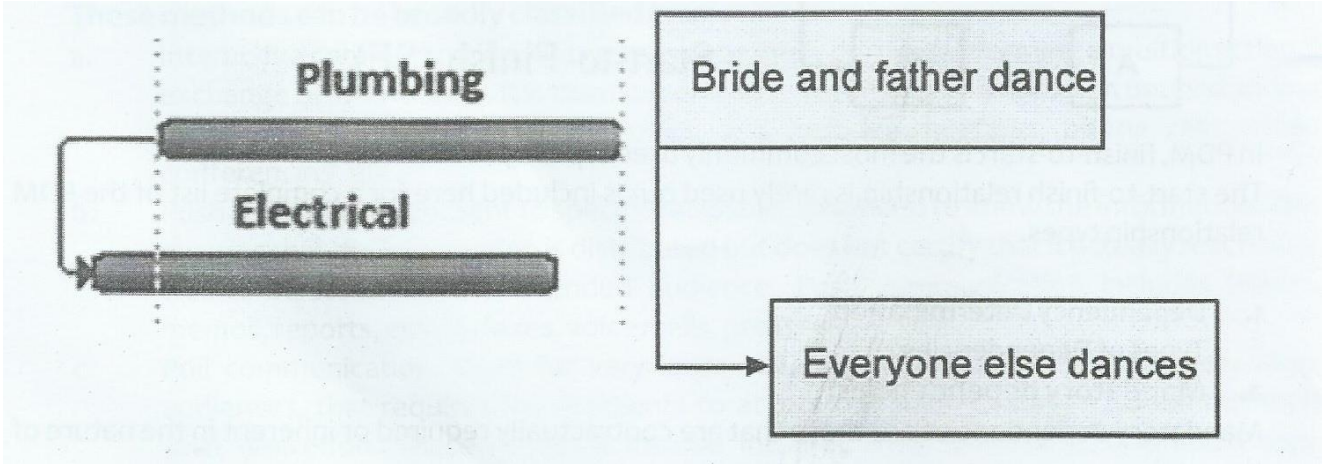
2. Applying Leads and Lags

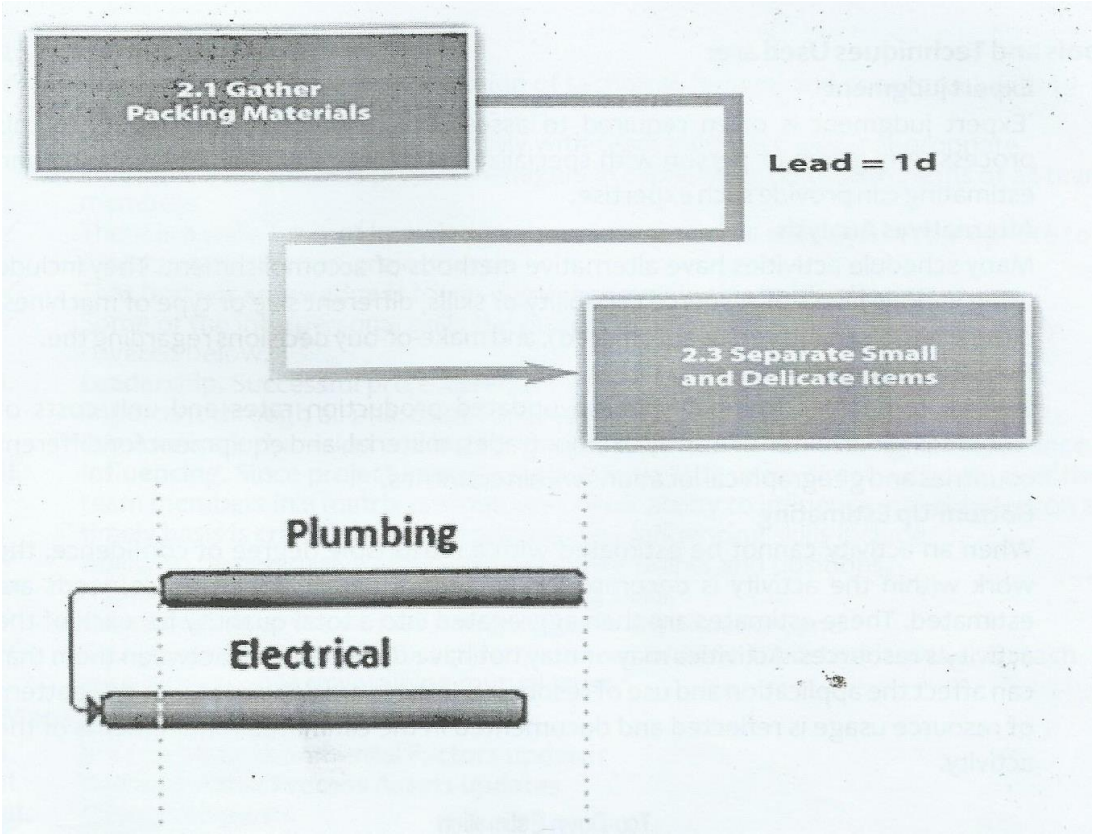
The project management team determines the dependencies that may require a lead or a lag to accurately define the logical relationship.

The use of leads and lags should not replace schedule logic. Activities and their related assumptions should be documented. A lead allows an acceleration of the successor activity.

For example, on a project to construct a new office building, the landscaping could be scheduled to start 2 weeks prior to the scheduled punch list completion. This would be shown as a finish-to-start with a 2-week lead.

A lag directs a delay in the successor activity. For example, a technical writing team can begin editing the draft of a large document 15 days after they begin writing it. This could be shown as a start-to-start relationship with a 15-day lag.





1. Schedule Network Templates

Can be used to expedite the preparation of networks of project activities

They can include an entire project or only a portion of it.

Portions of a project schedule network diagram are often referred to as a sub Network or a fragment network.

Sub Network templates are especially useful when a project includes several identical or nearly identical deliverables

OUTPUT

1. Project Schedule Network Diagrams

It's the main output of Sequence activities

Schematic displays of the project's schedule activities and the logical relationships

Among them, (also referred to as dependencies)

Can be produced manually or using project management software

Can have full project details, or have one or more summary activities

Estimate Activity Resources

Estimates the type and quantities of material, people, equipment, or supplies required toper form each activity is closely coordinated with the Estimate Costs process

Tools and Techniques Used are:

1. **Expert judgment**

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

2. **Alternatives Analysis**

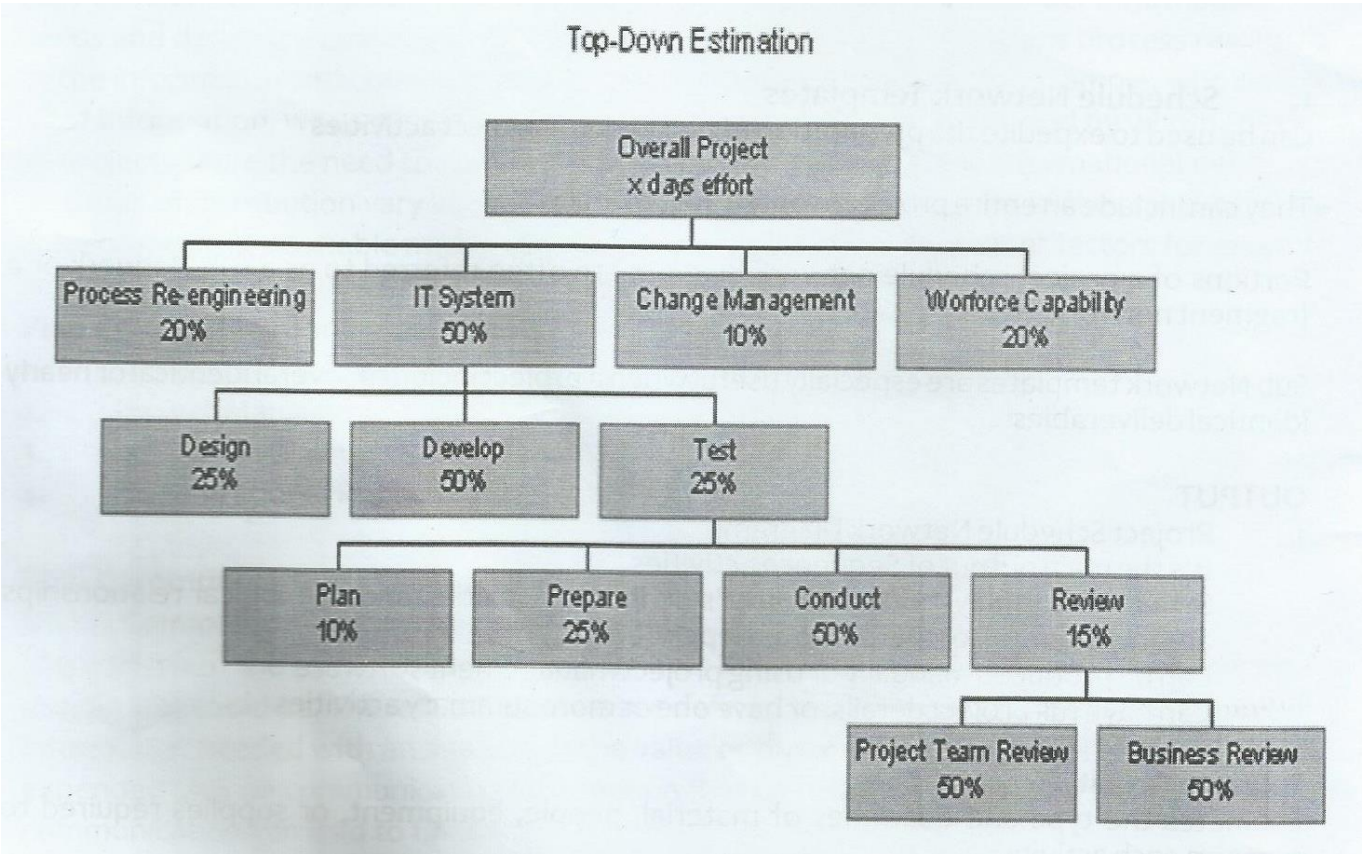
   Many schedule activities have alternative methods of accomplishment. They include using various levels of resource capability or skills, different size or type of machines, different tools (hand versus automated), and make-or-buy decisions regarding the.

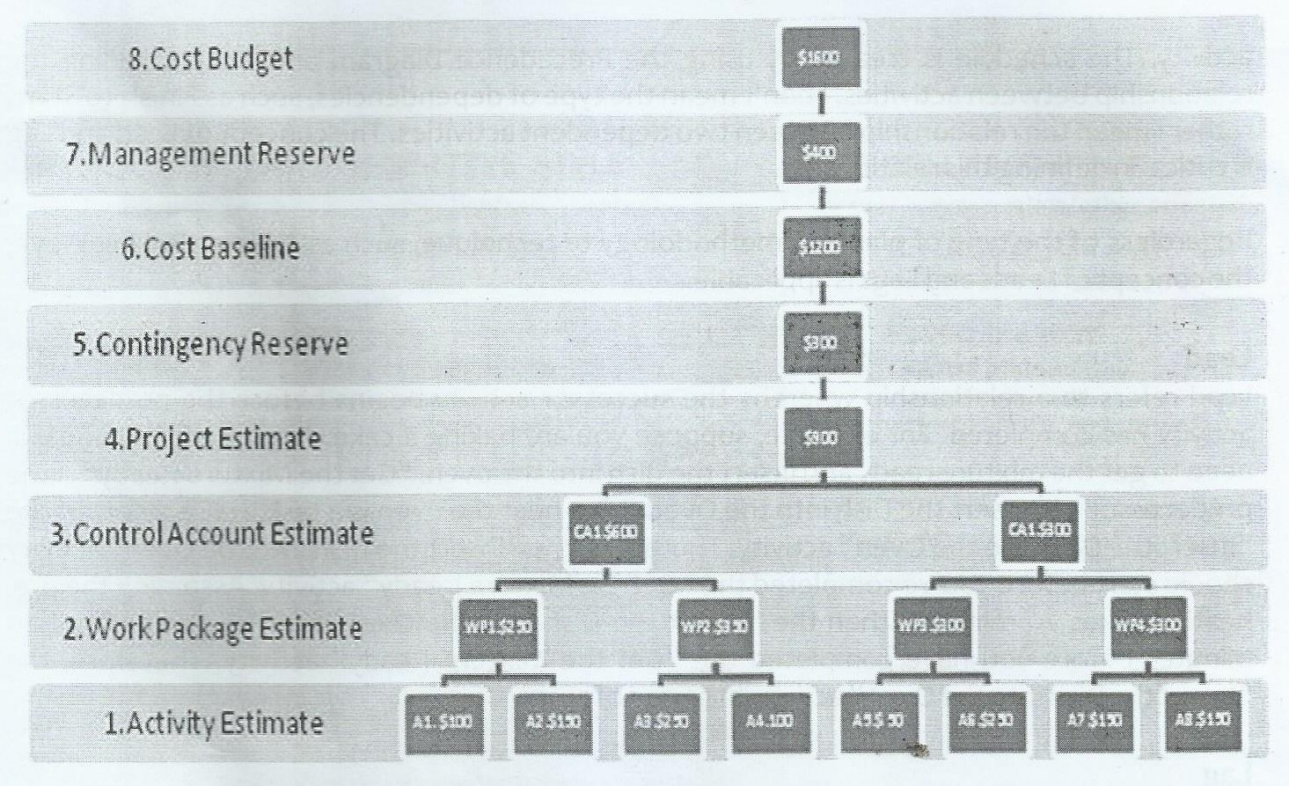
3. **Published Estimating Data**

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

4. **Bottom-Up Estimating**

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





1. Project management Software

Project management software has the capability to help plan, organize, and manage resource pools and develop resource estimates.

Depending on the sophistication of the software, resource breakdown structures, resource availability, resource rates and various resource calendars can be defined to assist in optimizing resource utilization.

Outputs of Estimate Activity Resources

1. Activity Resource Requirements

Identifies the types and quantities of resources required for each activity in a work package

Determines the estimated resources for each work package by aggregating their requirements like the types and the quantities

Will be documented by including basis of estimates and the assumptions made

2. Resource Breakdown Structure

Isa hierarchical structure of resources by type and category

Organizes and reports project schedule data with resource utilization information

3. Project Document Updates

Examples of Leads and Lags

In a Finish-to-Start dependency, does a successor activity have to start right after the completion of its predecessor? Not necessarily, it depends on the relationship they have! Gaining an Understanding

Precedence Diagrams help you to determine the project activity flow. Through the project activity flow, you can identify the critical path and compute the float of each

activity. The schedule is created by using the Precedence Diagram and understanding the relationship between activities. I don't mean the type of dependencies, such as Finish-to Start; rather I mean the relationship between two dependent activities. The concept of Lead and Lag is critical in defining this relationship.

Regardless of the type of planning methodology or technique, such as Agile or Rolling Wave, the concept of Leads and Lags is applicable.

Lead
Lead refers to a relationship whereby the successor activity begins before the predecessor activity has completed. For example, suppose you are baking a cake. As part of this, you will need to get the mixture ready and insert the dish into the oven. "Get the Mixture Ready" is the predecessor of "Insert the Dish into the Oven." Pre-heat the oven is a task that is a part of the "Insert the Dish into the Oven" activity. Therefore, the "Insert the Dish into the Oven" activity should start before you've completed the "Get the Mixture Ready" activity. Assuming the pre heating takes 20 minutes, then the "Insert the Dish into the Oven" activity should start 20 minutes before you have completed the "Get the Mixture Ready" activity. Therefore, the "Insert the Dish into the Oven" activity has Lead of 20 minutes.

Lag
Lag refers to a relationship whereby the successor activity cannot start right after the end of its predecessor. For example, after you've baked the cake, you might want to serve it cold. Therefore, before serving it to the guests you will need to put the cake into a fridge and wait for it to cool. This means that the activity "Serve Guests Cake" will not start right after its predecessor "insert the Dish into the Oven."There is a delay. This delay is called Lag.

Here's another example. Take a look at the following Precedence Diagram and identify the activity that'll most probably have a Lag.

If you identified the "Harden Foundation Cement" activity, then you are correct! Well done. There is a lag between "Lay Foundation" and "Harden Foundation Cement" because the latter activity would only start after the cement has matured. Only then can the construction workers start the "Harden Foundation Cement" activity.

Ensure you understand Leads and Lags before creating a schedule and for your PMP preparation.

Estimate Activity Durations
Process that requires the estimate of the amount of work effort required and the amount of resources to be applied for approximating the work periods needed to complete the activity.
Uses information on the activity scope of work, required resource types, estimated resource quantities, and resource calendars, as well as historical information

Is progressively elaborated with duration estimates becoming progressively more accurate and of better quality
Should take into consideration the input data's quality and availability
All assumptions and data used for supporting the duration estimating are documented

Estimate Activity Durations: inputs

1. Activity List
2. Activity Attributes
3. Activity Resource Requirements
4. Resource Calendars
5. Project Scope Statement
6. Enterprise Environmental Factors
7. Organizational Process Assets

Tools and Techniques used are:

1. Expert judgment
2. Analogous estimating
3. Parametric estimating
4. Three-Points estimating Reserve analysis

Historical Information
Available from:
Project files: Records of previous project results that are detailed enough to help in duration estimating.
Commercial duration estimating databases: Available for standard tasks
Team members' past experience: Individual members of the project team, who worked on prior similar projects, and who might be able to recollect details of estimates from those projects for possible application in the current project

ANALOGOUS ESTIMATION
(Top Down Estimation)
An estimating technique
Uses the parameters from a previous, similar project as the basis for estimating the same
Parameter for a future project
It is a gross value estimating approach
Uses historical information and expert judgment
Less costly and time consuming than other techniques, but it is also generally less accurate
Generally less accurate
Most reliable when:

- ✓ When the previous activities are similar in fact and not just in appearance
- ✓ Project team members preparing the estimates have the needed expertise

Parametric Estimating

Uses a statistical relationship between historical information and other variables to calculate an estimate for activity parameters

Determines how many times the specific work category is going to be performed in the given activity

Can be applied to a total project or segments of a project

Activity durations=Quantity of work to be performed x Labor hours per unit of work

Three-Point Estimates

The accuracy of activity duration estimates can be improved by considering estimation uncertainty and risk. This concept originated with the Program Evaluation and Review Technique (PERT).

PERT uses three estimates to define an approximate range for an activity's duration:

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

PERT analysis calculates an Expected (tE) activity duration using a weighted average of these three estimates:

$$t_E = \frac{t_O + 4t_M + t_P}{6}$$

Reserve Analysis

Duration estimates may include contingency reserves, (sometimes referred to as time reserves or buffers) into the overall project schedule to account for schedule uncertainty. The contingency reserve may be a percentage of the estimated activity duration, a fixed number of work periods, or may be developed by using quantitative analysis methods.

As more precise information about the project becomes available, the contingency reserve may be used, reduced, or eliminated. Contingency should be clearly identified in schedule documentation.

Estimate Activity Durations: outputs

Activity Duration Estimates

Project Document Updates

Develop Schedule

Analyzes activity sequences, durations, resources requirements, and schedule constraints to create the project schedule
Iterative process
Determines the project activities' scheduled start and finish dates
Determines the milestones' scheduled start and finish dates

Develop Schedule: inputs

- ✓ Activity List
- ✓ Activity Attributes
- ✓ Project Schedule network Diagrams
- ✓ Activity Resource Requirements
  - ✓ Resource Calendars
  - ✓ Activity Duration Estimates
  - ✓ Project Scope Statement
  - ✓ Enterprise Environmental Factors
  - ✓ Organizational Process Assets

Tools and Techniques used are:

- ✓ Schedule network analysis
- ✓ Critical path method
- ✓ Critical chain method
- ✓ Resource leveling
- ✓ What-if scenario analysis
- ✓ Applying leads and lags
- ✓ Schedule compression
- ✓ Scheduling tool

Schedule network Analysis

A technique that generates the project schedule.
It employs various analytical techniques, such as critical path method critical chain method, what-if analysis, and resource leveling to calculate the early and late start and finish dates for the uncompleted portions of project activities.
Some network paths may have points of path convergence or path divergence that can be identified and used in schedule compression analysis or other analyses.

Critical Path method

Calculates the theoretical early start and finish dates and late start and finish dates, for all activities without regard for any resource limitations, by performing a forward and backward pass analysis through the schedule network.
The resulting early and late start and finish dates are not necessarily the project schedule; rather, they indicate the time periods within which the activity could be scheduled, given activity durations, logical relationships, leads, lags, and other known constraints Calculated early start and finish dates, and late start and finish dates, may be affected by activity total float, which provides schedule flexibility and, may be positive, negative, or zero. On any network path, the schedule flexibility is

measured by the positive difference between early and late dates, and is termed "total float."
Critical paths have either a zero or negative total float, and schedule activities on a critical path are called **"critical activities."**
A critical path is normally characterized by zero total float on the critical path.
Networks can have multiple near critical paths.
Adjustments to activity durations, logical relationships, leads and lags, or other schedule constraints may be necessary to produce network paths with a zero or positive total float, Once the total float for a network path has been calculated then the free float, the amount of time that an activity can be delayed without delaying the early start date of any immediate successor activity within the network path, can also be determined.

Critical Chain method
Critical chain is a schedule network analysis technique that modifies the project schedule to account for limited resources.
Initially, the project schedule network diagram is built using duration estimates with required dependencies and defined constraints as inputs.
The critical path is then calculated. After the critical path is identified, resource availability is entered and the resource-limited schedule result is determined.
The resulting schedule often has an altered critical path.
The resource-constrained critical path is known as the critical chain. 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, is known as the project buffer and protects the target finish date from slippage along the critical chain.
Additional buffers, known as feeding buffers, are placed at each point that a chain of dependent tasks not on the critical chain feeds into the critical chain.
Feeding buffers thus protect the critical chain from slippage along the feeding chains.
The size of each buffer should account for the uncertainty in the duration of the chain of dependent tasks leading up to that buffer.
Once the buffer schedule activities are determined, the planned activities are scheduled to their latest possible planned start and finish dates.
Consequently, in lieu of managing the total float of network paths, the critical chain method focuses on managing remaining buffer durations against the remaining durations of task chains.

Resource Leveling
Resource leveling is a schedule network analysis technique applied to a schedule that has already been analyzed by the critical path method.
Resource leveling can be used when shared or critical required resources are only available at certain times, are only available in limited quantities, keep resource usage at a constant level. Resource leveling is necessary when resources have been over-allocated, such as when a resource has been assigned to two or more activities during

the same time period, when shared or critical required resources are only available at certain times or are only available in limited quantities.
Resource leveling can often cause the original critical path to change.

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

Applying Leads and Lags
Leads and lags are refinements applied during network analysis to develop a viable schedule.

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

Crashing: A schedule compression technique in which cost and schedule tradeoffs are analyzed to determine how to obtain the greatest amount of compression for the least incremental cost. Crashing does not always produce a viable alternative and may result in increased risk and/or cost.
Fast tracking: A schedule compression technique in which phases or activities normally performed in sequence are performed in parallel.
Fast tracking may result in rework and increased risk.
Fast tracking only works if activities can be overlapped to shorten the duration.

Constraints and Milestones
Constraints:

Factors that will limit a management team's options for a defined course of action An internal or external restriction that will affect the project's performance
Internal to the project- Dates imposed on any planned activity, used to restrict the start to finish dates imposed on any planned activity, used to restrict the start to finish dates for the tasks start no earlier than and finish no later than types

External to the project - Market window on a technology project, weather restrictions on outdoor activities, government-mandated compliance requirements, etc.

Key event or major milestone schedule:

Summarizes schedules that identify significant or major milestones in the project Denotes identified deliverables and their specified dates of completion, as requested by project sponsor, customer, or other stakeholders
Once scheduled, the milestones may be difficult to shift Simulation, Resource Leveling and Critical Chain Method
Simulation
Involves calculating multiple project durations with different sets of activity assumptions to assess the feasibility of the project schedule under adverse conditions, such as delay in major component delivery, strike, etc.

Common techniques:
Monte Carlo analysis

What-if analysis (using logic network to compute different scenarios)
Resource Leveling Heuristics

Done because mathematical analysis produces a preliminary early-start schedule that requires more than the allocated resources during certain time periods e.g., Rule of thumb - “allocate scarce resources to critical path activities first.”

Often results in a project duration that is longer than the preliminary schedule. (Also called “resource based method”).

Critical Chain Method:
A schedule network analysis technique that modifies the project schedule to account for limited resources

Chapter 4

PROJECT COST MANAGEMENT

Project Cost Management includes the processes involved in estimating, budgeting, and controlling costs so that the project can be completed within the approved budget.

Cost Management processes

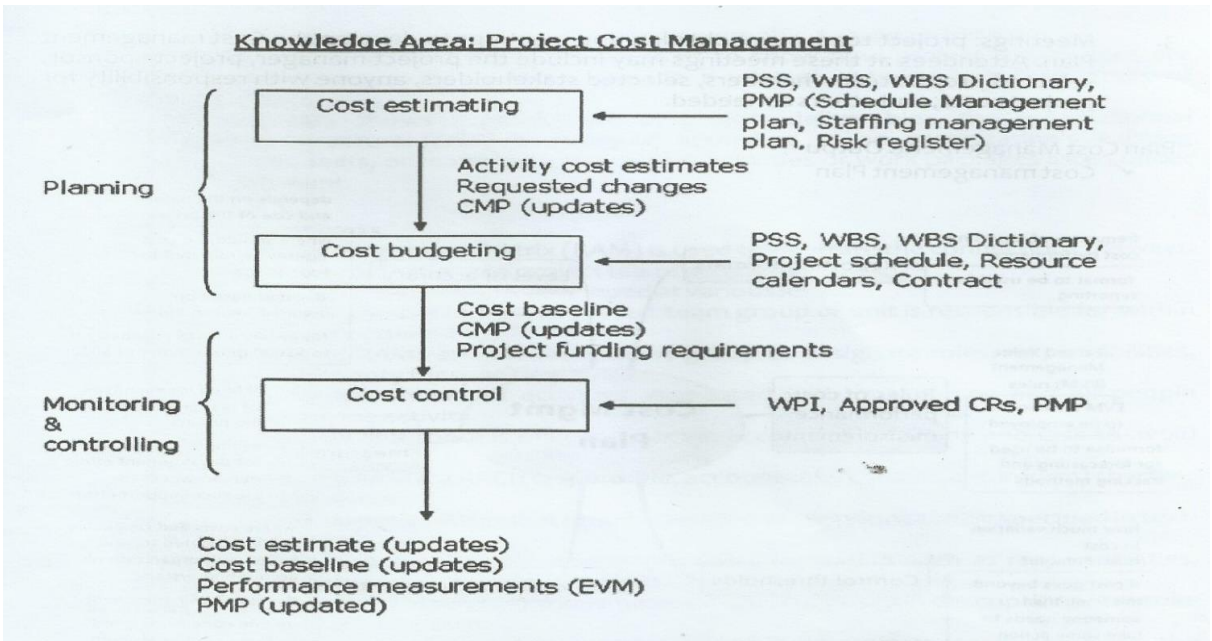
Plan Cost Management: The process that establish the policies, procedures and documentation for planning, managing, expanding and controlling project cost.

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

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

Control Costs: The process of monitoring the status of the project to update the project budget and managing changes to the cost baseline.

On some projects, especially ones of smaller scope, cost estimating and cost budgeting are so tightly linked that they are viewed as a single process that can be performed by a single person over a relatively short period of time.



Plan Cost Management

This process helps establish policies, procedures and documentation for planning, managing, expending, controlling project costs.

Advantage: helps provide guidance and direction on how the project cost will be managed throughout the project.

Plan Cost Management: Input

- ✓ Project Management Plan
- ✓ Project Charter
- ✓ Enterprise Environmental Factors
- ✓ Organizational process Assets

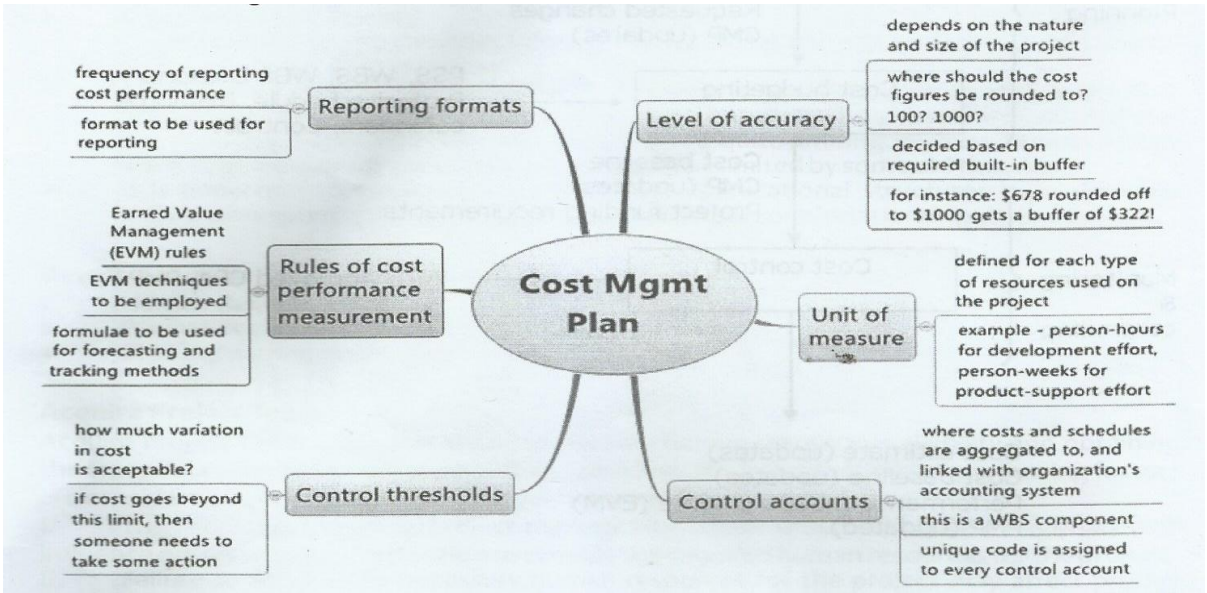
Plan Cost Management: Tools and Techniques

1. **Expert Judgment:** guided by historical information, provides valuable insight about the environment and information from prior similar projects. This method also in turn suggest if methods should be combined and how to reconcile differences between them.
2. **Analytical techniques**: Developing 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.

3. Meetings: project team may hold planning meetings to develop the Cost management Plan. Attendees at these meetings may include the project manager, project sponsor, selected project team members, selected stakeholders, anyone with responsibility for project costs, and others as needed.

Plan Cost Management: Output

- ✓ Cost management Plan



Estimate Costs

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

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

Cost estimates should be refined during the course of the project to reflect additional detail as it becomes available. The accuracy of a project estimate will increase as the project progresses through the project life cycle. Hence cost estimating is an iterative process from phase to phase.

For example, a project in the initiation phase could have a rough order of magnitude (ROM) estimate in the range of ±50%. Later in the project, as more information is known, estimates could narrow to a range of ±10%. In some organizations, there are guidelines for when such refinements can be made and the degree of accuracy that is expected.

Estimate Costs: Inputs

1. **Cost Management plan**
2. **Scope Baseline**

Scope statement. The scope statement provides the product description, acceptance criteria, key deliverables, project boundaries, assumptions, and constraints about the project.

- ✓ **Work breakdown structure.** The project WBS provides the relationships among all the components of the project and the project deliverables.
- ✓ **WBS dictionary.** The WBS dictionary and related detailed statements of work provide an identification of the deliverables and a description of the work in each WBS component required to produce each deliverable.

3. Project schedule

The type and quantity of resources and the amount of time which those resources are applied to complete the work of the project are major factors in determining the project cost.

Schedule activity resources and their respective durations are used as key inputs to this process.

4. Human Resource Plan

Project staffing attributes, personnel rates, and related rewards/recognition are necessary components for developing the project cost estimates.

5. Risk Register

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

6. Enterprise Environmental Factors

- ✓ Market conditions
- ✓ Published commercial information

7. Organizational Process Assets

Estimate Costs: Tools and Techniques

1. **Expert judgment**

   Cost estimates are influenced by numerous variables such as labor rates, material costs, inflation, risk factors, and other variables. 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.

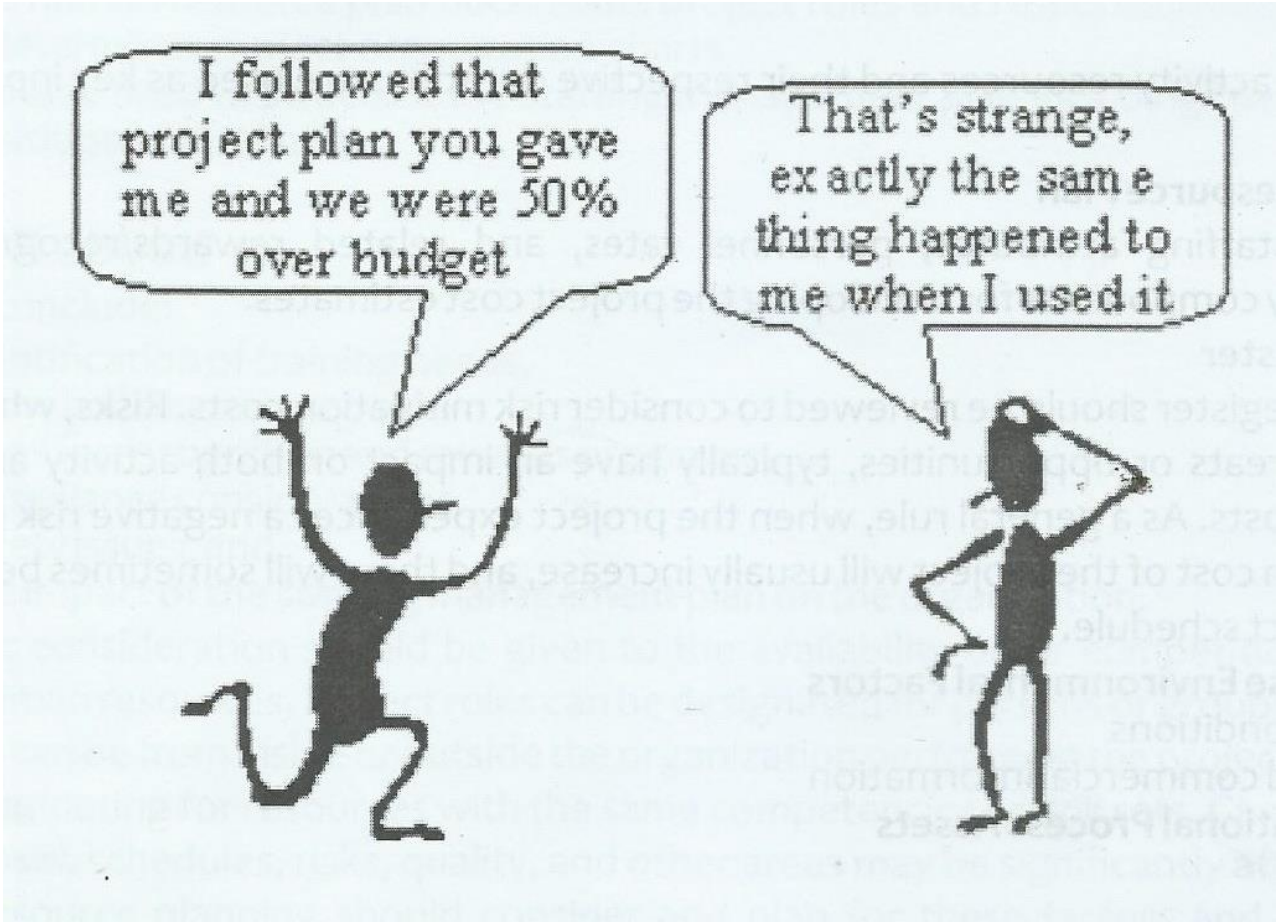
2. **Analogous Estimating**

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

   Analogous cost estimating is frequently used to estimate a parameter when there is limited amount of detailed information about the project, for example, in the early phases of a project.

Analogous cost estimating uses historical information and expert judgment.

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



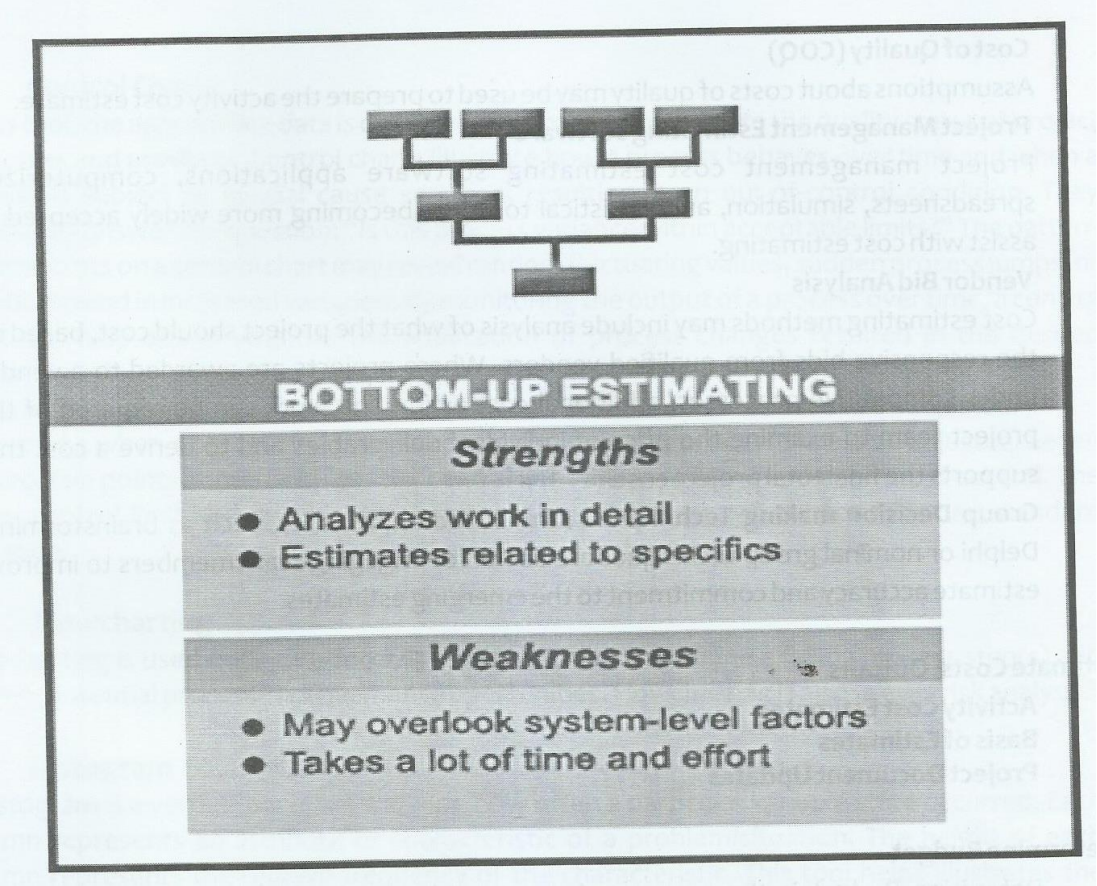
1. Parametric Estimating

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

Bottom-Up Estimating

Bottom-up estimating is a method of estimating a component of work. The cost of individual work packages or activities is estimated with the greatest level of specified detail. The detailed cost is then summarized or "rolled up" to higher levels for subsequent reporting and tracking purposes.

The cost and accuracy of bottom-up cost estimating is typically influenced by the size and complexity of the individual activity or work package.



1. Three-Point Estimates

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

a) **Most likely (cM).** The cost of the activity, based on realistic effort assessment for the required work and any predicted expenses.

b) **Optimistic (cO).** The activity cost based on analysis of the best-case scenario for the activity.

c) **Pessimistic (cP).** The activity cost based on analysis of the worst-case scenario for the activity.

PERT analysis calculated an expected (cE) activity cost using a weighted average of these three estimates:

$$\underline{cE = cO \div 4CM + cP}$$
$$6$$

Cost estimates based on this equation (or even on a simple average of the three points) may provide more accuracy, and the three points clarify the range of uncertainty of the cost estimates.

2. Reserve Analysis

Cost estimates may include contingency reserves (sometimes called contingency allowances) to account for cost uncertainty. The contingency reserve may be a

percentage of the estimated cost, a fixed number, or may be developed by using quantitative analysis methods.

3. **Cost of Quality (COQ)**

Assumptions about costs of quality may be used to prepare the activity cost estimate.

4. **Project Management Estimating software**

Project management cost estimating software applications, computerized spreadsheets, simulation, and statistical tools are becoming more widely accepted to assist with cost estimating.

5. **Vendor Bid Analysis**

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

6. **Group Decision making Technique:** team- based approaches, such as brainstorming, Delphi or nominal group techniques are useful for engaging team members to improve estimate accuracy and commitment to the emerging estimates.

Estimate Costs: Outputs

1. **Activity Cost Estimates**
2. **Basis of Estimates**
3. **Project Document Updates**

Determine Budget

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

Project budgets constitute the funds authorized to execute the project. Project cost performance will be measured against the authorized budget.

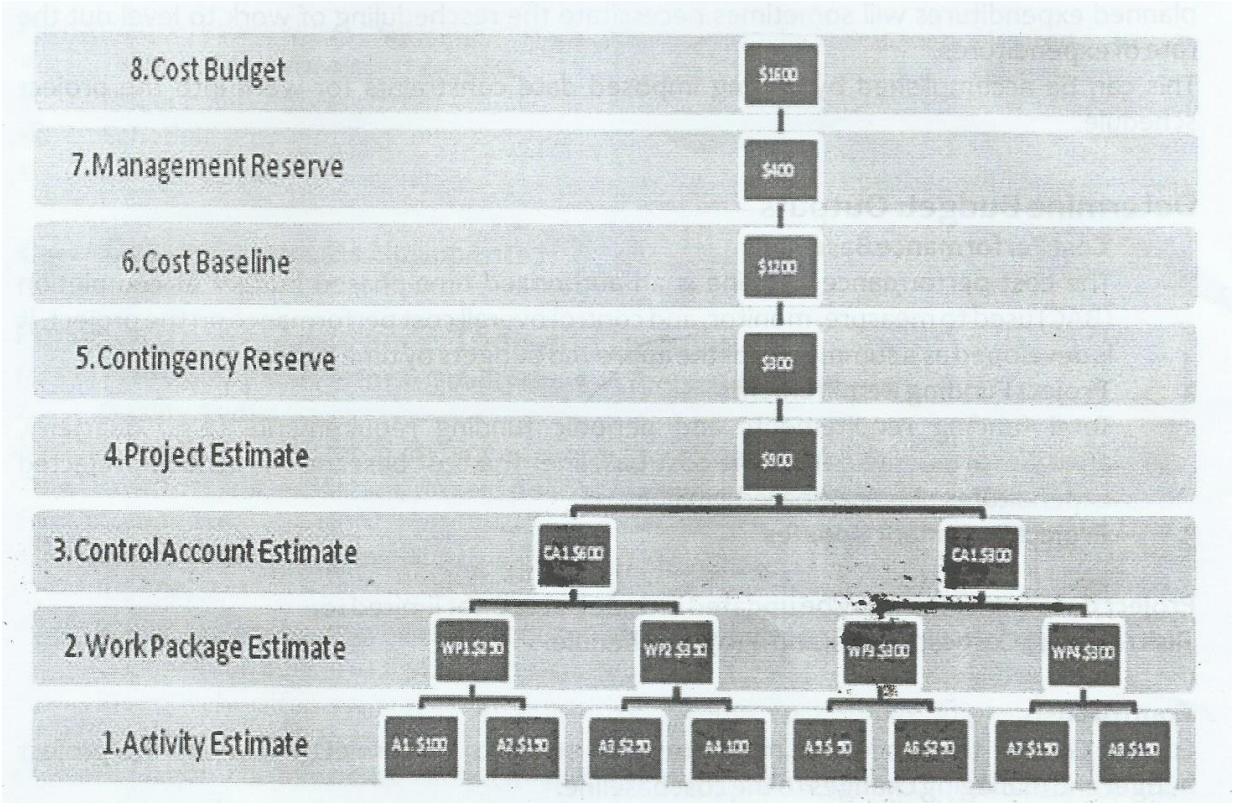
Determine Budget: Inputs

1. **Activity Cost Estimates**
2. **Basis of Estimates**
3. **scope Baseline**
4. **Project schedule**
5. **Resource Calendars**
6. **Contracts**
7. **Organizational Process Assets**

Determine Budget: Tools and Techniques

1. Cost Aggregation

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



1. Reserve Analysis

Budget reserve analysis can establish both the contingency reserves and the management reserves for the project. Contingency reserves are allowances for unplanned but potentially required changes that can result from realized risks identified in the risk register. Management reserves are budgets reserved for unplanned changes to project scope and cost.

The project manager may be required to obtain approval before obligating or spending management reserve. Management reserves are not a part of the project cost baseline, but may be included in the total budget for the project.

2. Expert judgment

Judgment provided based upon expertise in an application area, Knowledge Area, discipline, industry, etc., as appropriate for the activity being performed should be used in determining the budget.

3. Historical Relationships

Any historical relationships that result in parametric estimates or analogous estimates involve the use of project characteristics (parameters) to develop

mathematical models to predict total project costs. Such models can be simple (e.g., residential home construction is based on a certain cost per square foot of space) or complex (e.g., one model of software development costing uses multiple separate adjustment factors, each of which has numerous points within it).

4. 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 can be accomplished by placing imposed date constraints for work into the project schedule.

Determine Budget: Outputs

1. Cost Performance Baseline

The cost performance baseline is an authorized time-phased budget at completion (BAC) used to measure, monitor, and control overall cost performance on the project. It is developed as a summation of the approved budgets by time period.

2. Project Funding Requirements

Total funding requirements and periodic funding requirements (e.g., quarterly, annually) are derived from the cost baseline. The cost baseline will include projected expenditures plus anticipated liabilities.

3. Project Document Updates

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

Risk register, Cost estimates, and Project schedule.

Control Costs

Control Costs is the process of monitoring the status of the project to update the project budget and managing changes to the cost baseline.

Updating the budget involves recording actual costs spent to date. Any increase to the authorized budget can only be approved through the Perform Integrated Change Control process.

Monitoring the expenditure of funds without regard to the value of work being accomplished for such expenditures has little value to the project other than to allow the project team to stay within the authorized funding.

Thus much of the effort of cost control involves analyzing the relationship between the consumption of project funds to the physical work being accomplished for such expenditures.

The key to effective cost control is the management of the approved cost performance baseline and the changes to that baseline.

Project cost control includes:

Influencing the factors that create changes to the authorized cost baseline, Ensuring that all change requests are acted on in a timely manner, Managing the actual changes when and as they occur, Ensuring that cost expenditures do not exceed the authorized funding, by period and in total for the project, Monitoring cost performance to isolate and understand variances from the approved cost baseline,

Monitoring work performance against funds expended, preventing unapproved changes from being included in the reported cost or resource usage, informing appropriate stakeholders of all approved changes and associated cost, and Acting to bring expected cost overruns within acceptable limits.

Project cost control seeks out the causes of positive and negative variances and is part of the Perform

Control Costs: Inputs

1. **Project Management Plan**
2. **Project Funding Requirements**
3. **Work Performance Information**
4. **Organizational Process Assets**

Control Costs: Tools and Techniques

1. **Earned Value Management**

Earned value management (EVM) in its various forms is a commonly used method of performance measurement. It integrates project scope, cost, and schedule measures to help the project management team assess and measure project performance and progress. It is a project management technique that requires the formation of an integrated baseline against which performance can be measured for the duration of the project. The principles of EVM can be applied to all projects, in any industry.

EVM develops and monitors three key dimensions for each work package and control account:

✓ **Planned value.** Planned value (PV) is the authorized budget assigned to the work to be accomplished for an activity or work breakdown structure component. It includes the detailed authorized work, plus the budget for such authorized work, allocated by phase over the life of the project. The total of the PV is sometimes referred to as the performance measurement baseline (PM B). The total planned value for the project is also known as Budget At Completion (BAC).

✓ **Earned value.** Earned value (EV) is the value of work performed expressed in terms of the approved budget assigned to that work for an activity or work breakdown structure component. It is the authorized work that has been completed, plus the authorized budget for such completed work. The EV being measured must be related to the PV baseline (PM B), and the EV measured cannot be greater than the authorized PV budget for a component. The term EV is often used to describe the percentage completion of a project. A progress measurement criterion should be established for each WBS component to measure work in

progress. Project managers monitor EV, both incrementally to determine current status and cumulatively to determine the long-term performance trends.

✓ **Actual cost.** Actual cost (AC) is the total cost actually incurred and recorded in accomplishing work performed for an activity or work breakdown structure component. It is the total cost incurred in accomplishing the work that the EV measured. The AC has to correspond in definition to whatever was budgeted for in the PV and measured in the EV (e.g., direct hours only, direct costs only, or all costs including indirect costs). The AC will have no upper limit; whatever is spent to achieve the EV will be measured.

Variances from the approved baseline will also be monitored:

✓ **Schedule variance.** Schedule variance (SV) is a measure of schedule performance on a project. It is equal to the earned value (EV) minus the planned value (PV). The EVM schedule variance is a useful metric in that it can indicate a project falling behind its baseline schedule. The EVM schedule variance will ultimately equal zero when the project is completed because all of the planned values will have been earned. EVM SVs are best used in conjunction with critical path methodology (CPM) scheduling and risk management.

Equation: SV = EV PV.

✓ **Cost variance.** Cost variance (CV) is a measure of cost performance on a project. It is equal to the earned value (EV) minus the actual costs (AC). The cost variance at the end of the project will be the difference between the budget at completion (BAC) and the actual amount spent. The EVM CV is particularly critical because it indicates the relationship of physical performance to the costs spent. Any negative EVM CV is often non-recoverable to the project.

Equation: CV= EV AC.

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

The variances and indices are useful for determining project status and providing a basis for estimating project cost and schedule outcome.

✓ **Schedule performance index.** The schedule performance index (SPI) is a measure of progress achieved compared to progress planned on a project. It is sometimes used in conjunction with the cost performance index (Cr1) 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, w planned. Since the SPI measures all project work, the performance on the critical path must also be analyzed to determine whether the project will finish ahead of or behind its planned finish date. The SPI is equal to the ratio of the EV to the PV.

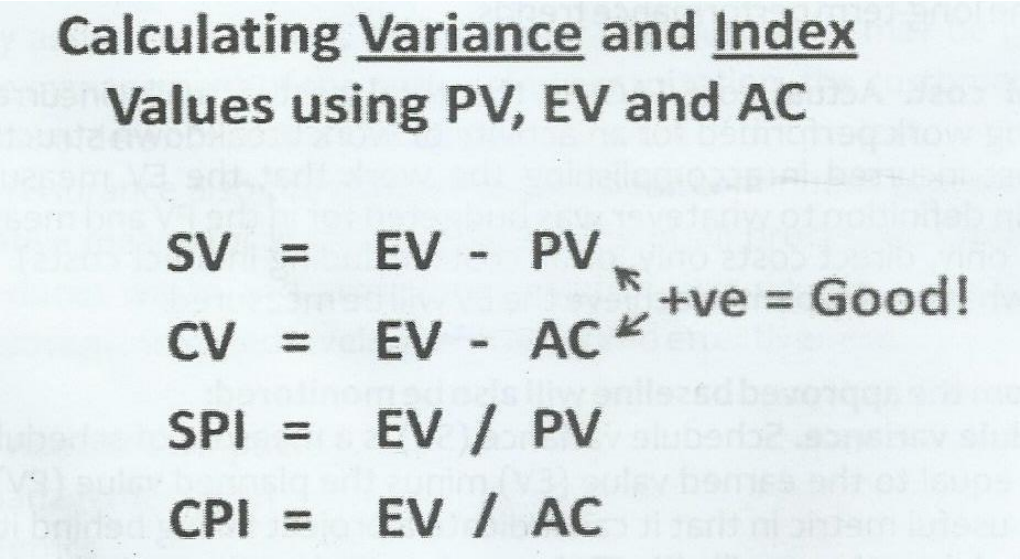
Equation: SPI = EV/PV.

✓ **Cost performance index.** The cost performance index (Cr1) is a measure of the value of work completed compared to the actual cost or progress made on the project. It is considered the most critical EVM metric and measures the cost

efficiency for the work completed. A CPI value less than 1.0 indicates a cost overrun for work completed. A CPI value greater than 1.0 indicates a cost under run of performance to date. The CPI is equal to the ratio of the EV to the AC.

Equation: (P1= EV/AC.

The three parameters of planned value, earned value, and actual cost can be monitored and reported on both a period-by-period basis (typically weekly or monthly) and on a cumulative basis.



Forecasting

As the project progresses, the project team can develop a forecast for the estimate at completion (EAC) that may differ from the budget at completion (BAC) based on the project performance. If it becomes obvious that the BAC is no longer viable, the project manager should develop a forecasted EAC. Forecasting the EAC involves making estimates or predictions of conditions and events in the project's future based on information and knowledge available at the time of the forecast.

Forecasts are generated, updated, and reissued based on work performance information provided as the project is executed. The work performance information covers the projects 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 actual costs and experience incurred for the work completed, and requires a new estimate to complete the remaining project work.

This method may be problematic in that it interferes with the conduct of project work. The personnel who are performing the project work have to stop working to provide a detailed bottom-up ETC of the remaining work. Typically there is no separate budget to perform the ETC, so additional costs are incurred for the project to conduct the ETC. Equation: EAC=AC+ bottom-up ETC.

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

- ✓ **EAC forecast for ETC work performed at the budgeted rate.** This EAC method accepts the actual project performance to date (whether favorable or unfavorable) as represented by the actual costs, and predicts that all future ETC work will be accomplished at the budgeted rate. When actual performance is unfavorable, the assumption that future performance will improve should be accepted only when supported by project risk analysis.

Equation: EAC = AC + BAC EV

- ✓ **EAC forecast for ETC work performed at the present CP1.** This method assumes what the project has experienced to date can be expected to continue in the future. The

ETC work is assumed to be performed at the same cumulative cost performance index

(CPI) as that incurred by the project to date. Equation:

EAC = BAC/cumulative CPI

- ✓ **EAC forecast for ETC work considering both sPI and CPI factors.** In this forecast, the ETC work will be performed at an efficiency rate that considers both the cost and schedule performance indices. It assumes both a negative cost performance to date, and a requirement to meet a firm schedule commitment by the project. This method is most useful when the project schedule is a factor impacting the ETC effort. Variations of this method weigh the CPI and SPI at different values (e.g., 80/20, 50/50, or some other ratio) according to the project manager judgment.

Equation: AC + [EV)/(cumulative CPI x cumulative SPI)]

1. To-Complete Performance Index (TCPI)

The to-complete performance index (TCPI) is the calculated projection of cost performance that must be achieved on the remaining work to meet a specified management goal, such as the BAC or the EAC. If it becomes obvious that the BAC is no longer viable, the project manager develops a forecasted estimate at completion (EAC). Once approved, the EAC effectively supersedes the BAC as the

cost performance goal. Equation for the TCPI based on the BAC: (BAC EV)/(BAC AC).

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 plan, all future work of the project will need to immediately be performed in the range of the TCPI (BAC) to stay within the authorized BAC. Whether this level of performance is achieve is a judgment call based on a number of considerations, including risks, schedule, and technical performance. Once management acknowledges that the BAC is no longer attainable, the project manager will prepare a new estimate at completion (EAC) for the work, and once approved, the project will work to the new EAC value, this level of performance is displayed as the TCPI (EAC) line.

The equation for the TCPI based on the EAC: (BAC EV)/(EAC AC).

2. 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.** Variance analysis as used in EVM compares actual project performance to planned or expected performance. Cost and schedule variances are the most frequently analyzed.
- ✓ **Trend analysis.** Trend analysis examines project performance over time to determine if performance is improving or deteriorating. Graphical analysis techniques are valuable for understanding performance to date and for comparison to future performance goals in the form of BAC versus EAC and completion dates.
- ✓ **Earned value performance.** Earned value management compares the baseline plan to actual schedule and cost performance.

4. Variance Analysis

Cost performance measurements (CV, CPI) are used to assess the magnitude of variation to the original cost baseline. Important aspects of project cost control include determining the cause and degree of variance relative to the cost performance baseline and deciding whether corrective or preventive action is required. The percentage range of acceptable variances will tend to decrease as more work is accomplished. The larger percentage variances allowed at the start of the project can decrease as the project nears completion.

5. 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.

Control Costs: Outputs

1. **Work Performance Measurements**
2. **Budget Forecasts**
3. **Organizational Process Assets Updates**
4. **change Requests**
5. **Project Management Plan Updates**
6. **Project Document Updates**