PROJECT MANAGEMENT

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PMP® Certification Training

Lesson 07: Project Schedule Management

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PROJECT MANAGEMENT

Objectives

- Define Project Schedule Management
- Explain project schedule, Gantt charts, and network diagrams
- Identify the key terms used in Project Schedule Management
- Describe the Project Schedule Management processes
- Explain various schedule network analysis techniques

Project Schedule Management

The definition of *Project Schedule Management is as follows:

> Project Schedule Management includes processes required to manage timely completion of the project.

Project Scheduling provides a detailed plan that represents how and when the project will deliver the products, services, and results defined in the project scope. It serves as a tool for communication, managing stakeholders' expectations, and as a basis for performance reporting.

> ! Schedule management plan defines how schedule contingencies will be reported and assessed.

*Definition taken from the Glossary of the Project Management Institute, *A Guide to the Project Management Body of Knowledge, (PMBOK® Guide)* – Sixth Edition, Project Management Institute, Inc., 2017, Page 173

Project Schedule Management Activities

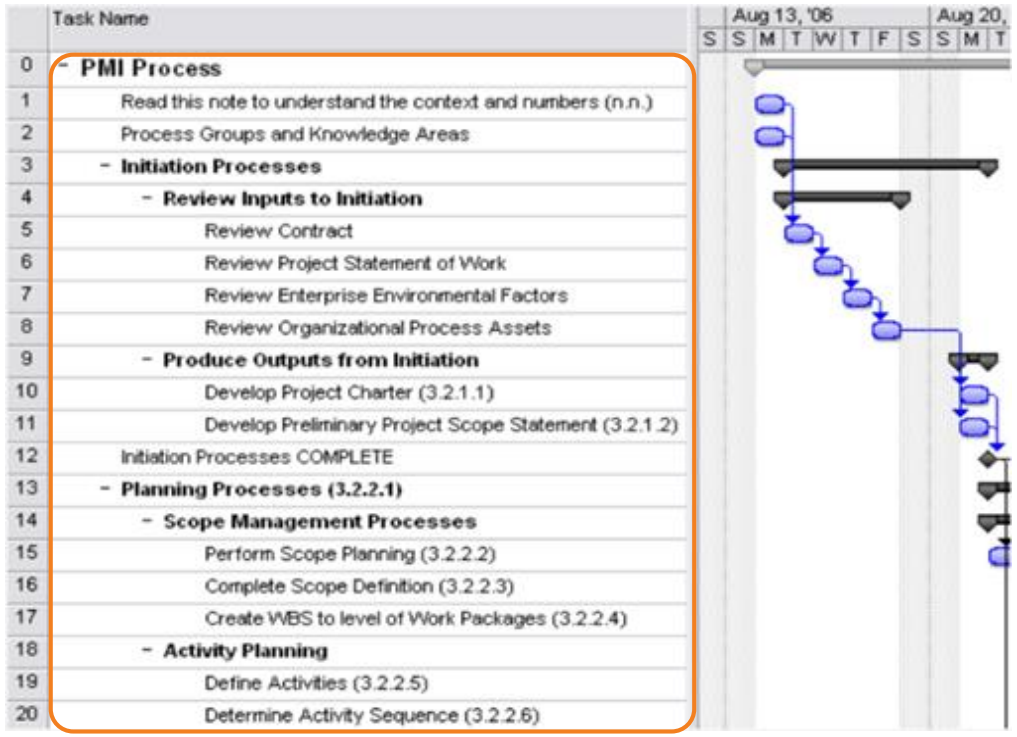
The key activities of Project Schedule Management are as follows:

Identifying Activities	A list of activities to be included in the project will be identified.
Estimating Time and Resources	Time and resources for each of the identified activities will be estimated.
Sequencing Activities	All the activities will be sequenced as per the dependencies.

Project Schedule

Project schedule assigns a duration to the project activities, and the activities are sequenced in a logical order.

- Project schedule defines the start and end dates of the project and its activities.
- Each task is assigned a resource, duration, and, when appropriate, a predecessor task.
- Scheduling software is used to develop the project schedule. Microsoft Project is the most popular tool used for project schedule development.



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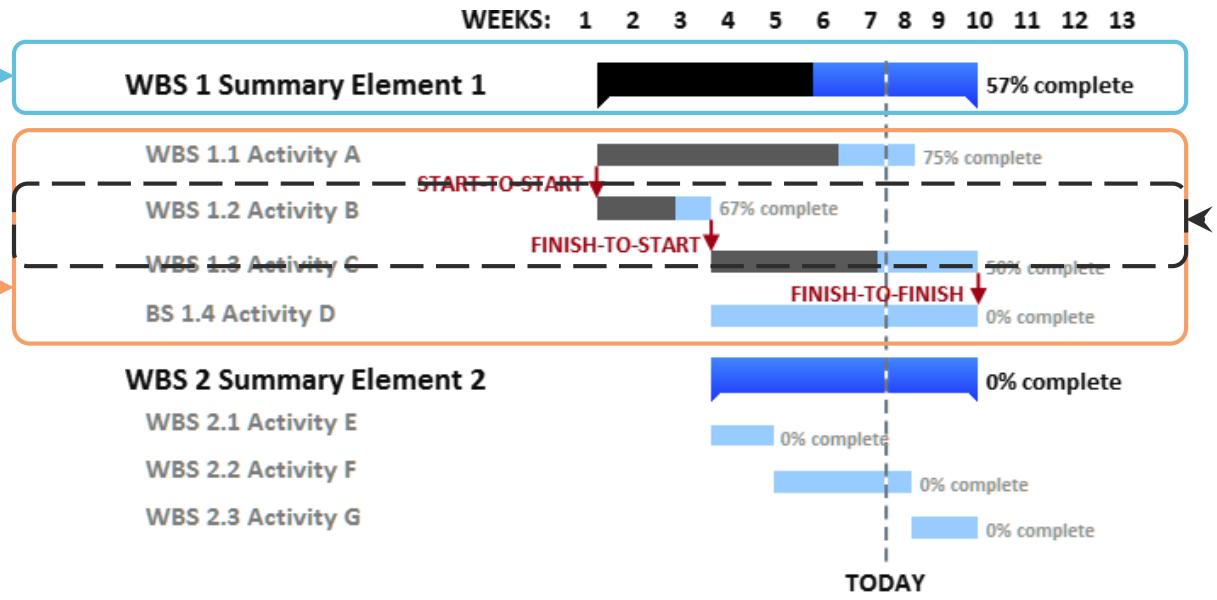
A project management plan is not a project schedule. It is more comprehensive and contains various project related plans such as risk management plan, cost management plan, etc. It may also include a schedule.

Gantt Chart

Gantt chart is a type of bar chart that displays the start and end dates for project activities and the overall project schedule. They can also show logical task relationships and indicate the task completion percentage.

Summary elements of the work breakdown structure

Number of activities under summary elements



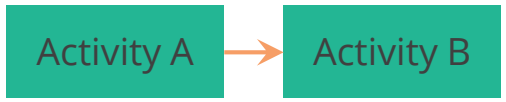
E.g., Activity B and Activity C. Activity C can start only when Activity B is completed

Create tasks and work with the Gantt chart. Each task has a duration, and the Gantt chart facilitates a graphical representation of the overall project schedule, with path to completion.

Gantt Chart: Relationships

Project activities are related to each other. The relationships among project activities can be classified as follows:

Finish to Start
An activity must finish before the next activity can start.



Finish to Finish
An activity must finish before the next activity can finish.

Start to Start
An activity must start before the next activity can start.

Start to Finish
An activity must start before the next activity can finish.

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Charts are generally laid out with finish-start and then time/resource adjusted by changing the relationship of tasks (start-start, finish-finish, start-finish)

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Gantt Chart Relationships: Examples

Finish to Start

An activity that cannot be started until its predecessor is completed. For example, the foundation for a building cannot be poured until it has been excavated.

Finish to Finish

An activity must finish before the next activity can finish. For example, an old system must be retired before a new system can go into production.

Start to Start

An activity must start before the next activity can start. For example, The project request must be submitted before work can start on the project charter.

Start to Finish

An activity must start before the next activity can finish. For example, Billing for a service must be started until the service task can be finished.

Gantt Chart: Dependencies

Dependency suggests that the project activities are interdependent. Dependencies can be classified as follows:

Classification 1

Mandatory Dependencies	These dependencies are inherent in the nature of the work and cannot be passed by. Example: The foundation of a civil structure must be laid before working on pillars and slabs.
Discretionary Dependencies	These dependencies are based on the preference of the team and can be changed if required. Example: Painting activities can be started only after all the electrical and plumbing work is done.

Classification 2

External Dependencies	These dependencies involve an external entity that may impact the project. Example: Approval by a government authority for the structural design of a building.
Internal Dependencies	These dependencies are within the control of project team. Example: Commencement of the slab work depends on the availability of ready-mix concrete.

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Network Diagram

Network diagram is used to plot the activity dependencies. Project activities are represented in the form of a network. Network diagrams can be drawn in one of the following two ways:

Precedence Diagramming Model (PDM) or Activity on Node (AON)

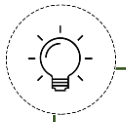
In precedence diagramming model:

- Boxes represent activities
- Arrows indicate dependencies
- Relationships can be of four types:
  - Finish to Start
  - Start to Start
  - Finish to Finish
  - Start to Finish

Arrow Diagramming Model (ADM) or Activity on Arrow (AOA)

In arrow diagramming model:

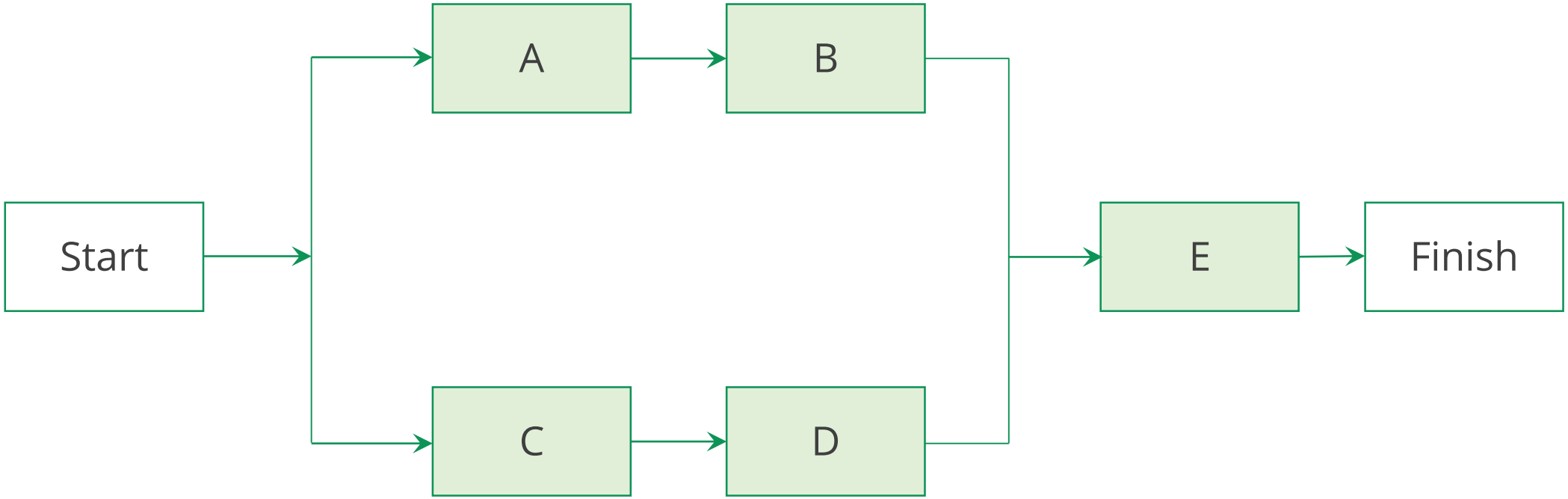
- Arrows are used to represent activities
- Direction of the arrows indicates the relationships and sequences
- Only Finish to Start relationships can be shown
- Dummy activities may be required to show a dependency



There may be questions in the PMP exam based on the Network diagram. So create and work with diagram network diagrams to ensure that you understand the value. This will make answering questions based on Network diagram easier.

Network Diagram: Example

Given below is an Activity on Node diagram:



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Hammock activities are used to show a comprehensive summary activity, which can be used for control and reporting purposes.

Key Terms

Given below are the key terms used in Project Schedule Management:

Leads and Lags

A successor activity is said to have a lead when it can start before the predecessor.
Example: Activity B can start 2 days before the completion of activity A.

A successor activity is said to have a lag when it needs to be delayed with respect to the predecessor.
Example: Activity B can start 2 days AFTER activity A is completed.

*Rolling Wave Planning

Rolling wave planning is an iterative planning technique in which the work to be accomplished in the near term is planned in detail while the work in the future is planned at a higher level. It is a form of ***progressive elaboration***.

Analogous Estimating

This estimating is based on data from previous projects (or activities). For example, if the last 5 similar projects took 6 months, this one will also take 6 months.

*Definition taken from the Glossary of the Project Management Institute, *A Guide to the Project Management Body of Knowledge, (PMBOK® Guide)* – Sixth Edition, Project Management Institute, Inc., 2017, Page 192

Key Terms

Given below are the key terms used in Project Schedule Management:

Parametric Estimating

This uses a mathematical model to calculate projected times for an activity based on historical records from the previous projects and other information.

*Effort

Effort is the total amount of work required to complete the activity.

*Duration

Duration is the calendar (elapsed) time required to complete an activity.
Example: An activity requires 10 people to work for 5 days; total effort is 50 person days, and duration is 5 days.

*Decomposition

Decomposition is the technique of breaking a task into smaller pieces.
Note: Decomposition should continue until there is no further value from decomposing the task further or until it can be estimated accurately.

*Definitions taken from the Glossary of the Project Management Institute, *A Guide to the Project Management Body of Knowledge, (PMBOK® Guide)* – Sixth Edition, Project Management Institute, Inc., 2017, Page 200 and 201

Project Schedule Management Processes

Knowledge Areas		Project Integration Management	Project Scope Management	Project Schedule Management	Project Cost Management	Project Quality Management	Project Resource Management	Project Communications Management	Project Risk Management	Project Procurement Management	Project Stakeholder Management
Project Management Process Groups	Initiating	4.1 Develop Project Charter									13.1 Identify Stakeholders
	Planning	4.2 Develop Project Management Plan	5.1 Plan Scope 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS	6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Durations 6.5 Develop Schedule	7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget	8.1 Plan Quality Management	9.1 Plan Resource Management 9.2 Estimate Activity Resources	10.1 Plan Communications Management	11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perorm Quantitative Risk Analysis 11.5 Plan Risk Response	12.1 Plan Procurement Management	13.2 Plan Stakeholder Engagement
	Executing	4.3 Direct and Manage Project Work 4.4 Manage Project Knowledge				8.2 Manage Quality	9.3 Acquire Resources 9.4 Develop Team 9.5 Manage Team	10.2 Manage Communications	11.6 Implement Risk Response	12.2 Conduct Procurments	13.3 Manage Stakeholder Engagement
	Monitoring and Controlling	4.5 Monitor and Control Project Work 4.6 Perform Integrated Change Control	5.5 Validate Scope 5.6 Control Scope	6.6 Control Schedule	7.4 Control Costs	8.3 Control Quality	9.6 Control Resource	10.3 Monitor Communications	11.7 Monitor Risks	12.3 Control Procurements	13.4 Monitor Stakeholder Engagements
	Closing	4.7 Close Poject or Phase									

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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 belongs to the Planning Process Group.

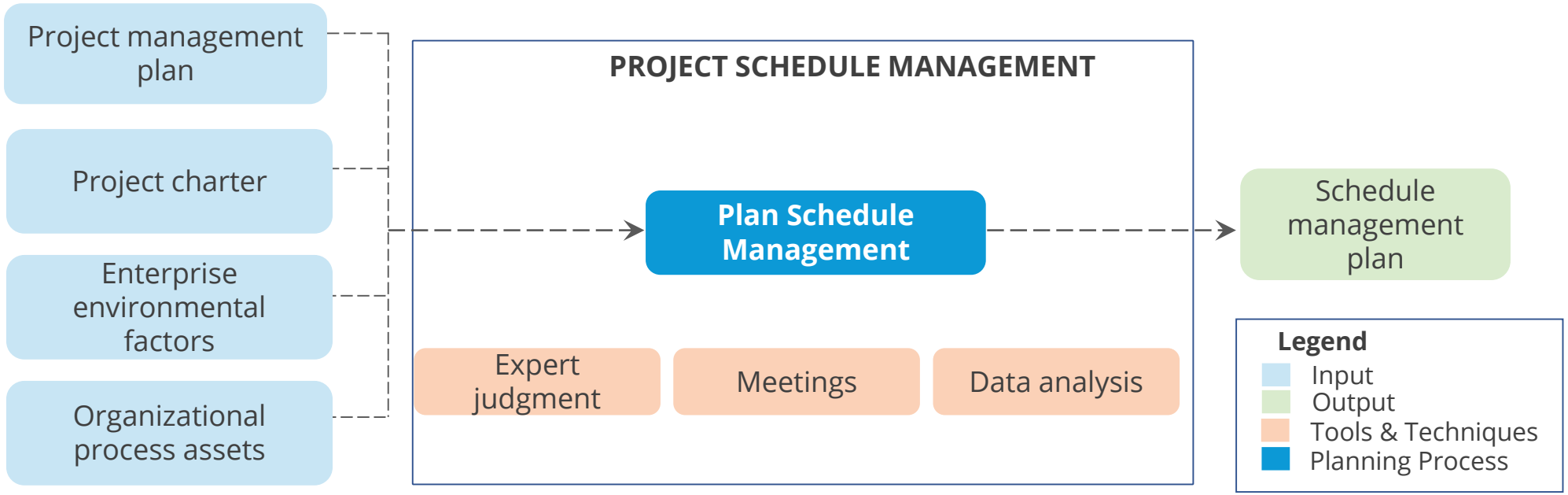

Figure 6-3. Plan Schedule Management: Inputs, Tools & Techniques, and Outputs

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Define Activities

"Define Activities is the process of identifying and documenting the specific actions to be performed to produce the project deliverables." It belongs to the Planning Process Group.

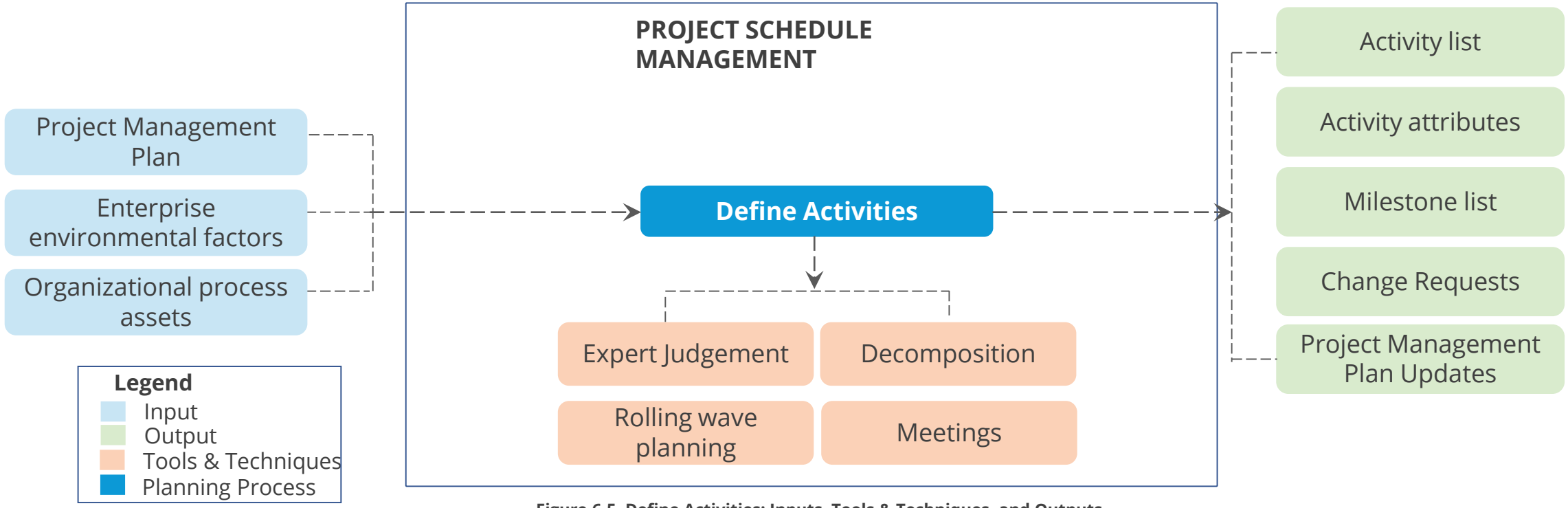

Figure 6-5. Define Activities: Inputs, Tools & Techniques, and Outputs

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Sequence Activities

"Sequence Activities is the process of identifying and documenting relationships among the project activities." It belongs to the Planning Process Group.

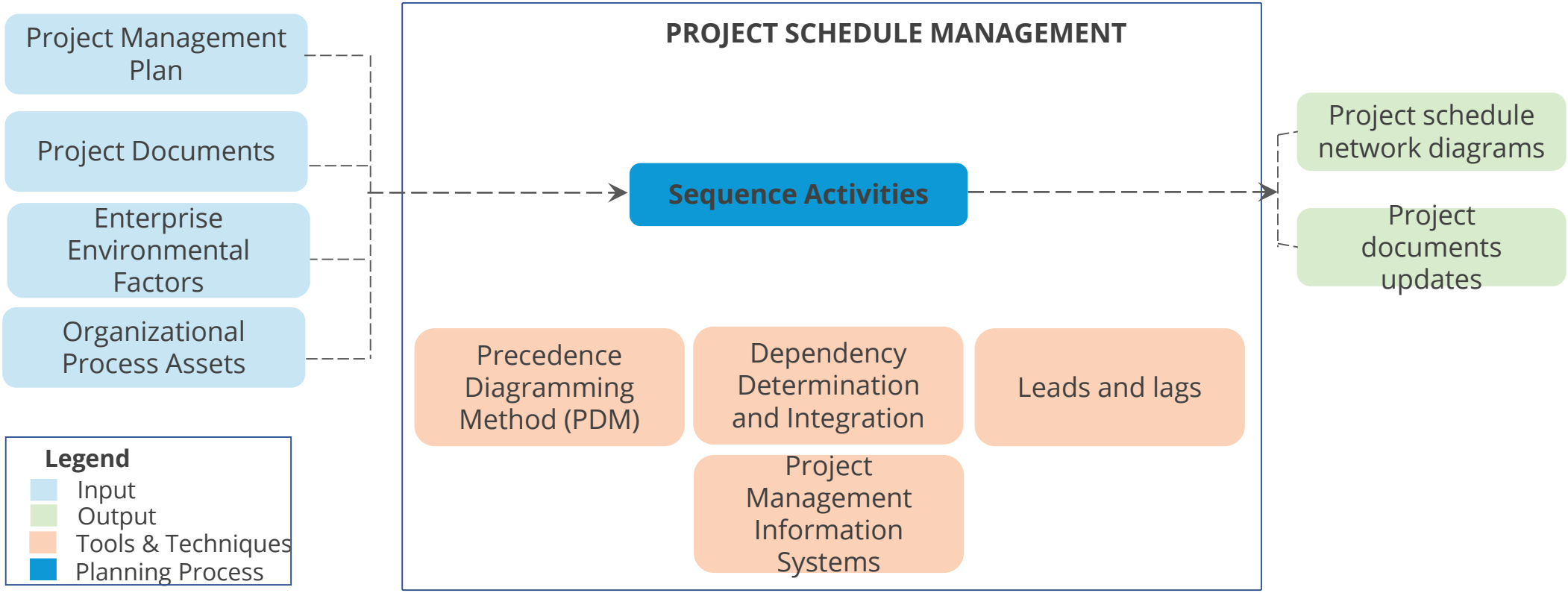

Figure 6-7. Sequence Activities: Inputs, Tools & Techniques, and Outputs

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Estimate Activity Durations

"Estimate Activity Durations is the process of estimating the number of work periods needed to complete individual activities with estimated resources. The key benefit of this process is that it provides the amount of time each activity will take to complete, which is a major input into the Develop Schedule process." It belongs to the Planning Process Group.

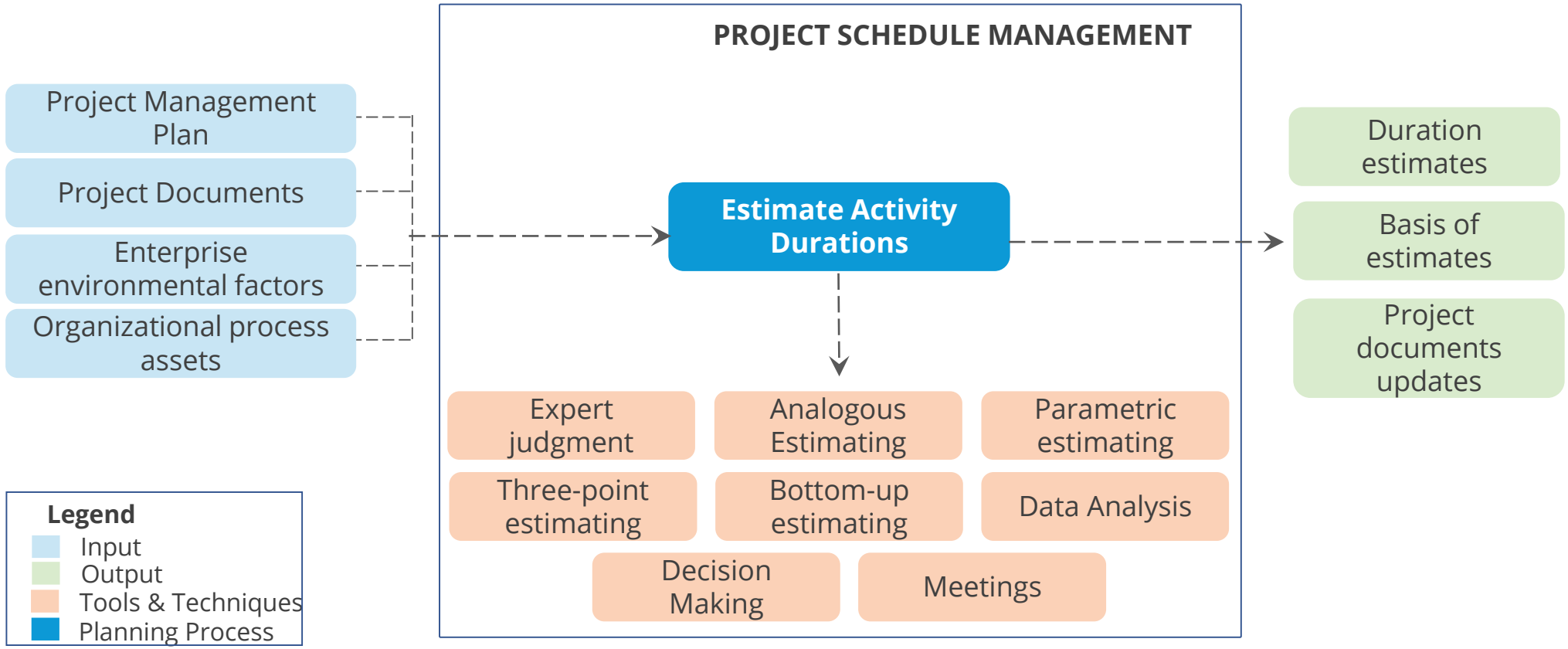

Figure 6-12. Estimate Activity Durations: Inputs, Tools & Techniques, and Outputs

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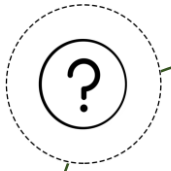
Business Scenario: Problem Statement



Jan, the EVP of the manufacturing division, has commissioned Jack to lead a project initiative in her area of responsibility because of his attention to detail. Jack is working with his team to estimate activity durations so they can map out the schedule for the project. After a successful decomposition process of the scope statement of work, Jack is confident in his team's ability to capture the true work effort that needs to be estimated and scheduled.

In reviewing the activities to be estimated, Jack realizes that a large number of the activities could benefit from some historical data and the use of mathematical parameters. This minimizes his estimating risk for 60% of the activities. For the remaining activities, the team is able to research past practices and industry standards to come up with a range of estimates based on optimistic, pessimistic and realistic durations. What approach are Jack and his team likely to take to determine their estimates?

Business Scenario: Solution

Jack and his team have decided to use parametric estimation technique for a large number of activities and have decided to use three-point estimate for the remaining activities. This is also known as PERT.

Develop Schedule

"Develop Schedule is the process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model." It belongs to the Planning Process Group.

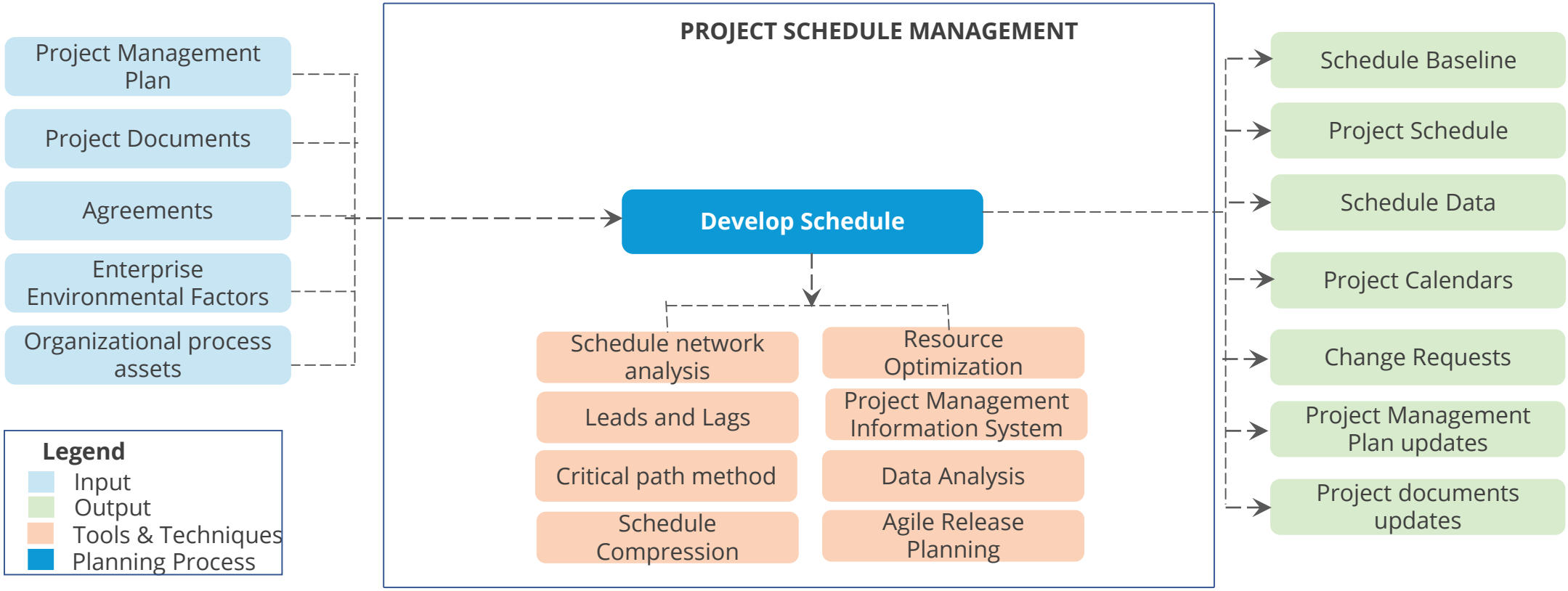


Figure 6-14. Develop Schedule: Inputs, Tools & Techniques, and Outputs

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Schedule Network Analysis

Along with the time estimate, it is necessary to know if the required resources are available at a given time.

Schedule network analysis technique generates project schedule. Various schedule network techniques are as follows:

Critical Path Method	It determines a critical path on a project schedule.
Critical Chain Method	Critical chain method is determined based on the resources required to execute project tasks. It reflects delays that occur due to task switching, Parkinson's Law (work grows to fill the available time), and lack of prioritization.
What-If Scenario Analysis	It varies a certain parameter and observes the impact on the schedule.
Resource Optimization Techniques	They arrive at the optimal utilization of the resources used on a project.

Program Evaluation and Review Technique (PERT)

Program Evaluation and Review Technique (PERT) uses three-point estimates for an activity.

- Pessimistic (P) estimate refers to the duration an activity would take in the worst case scenario.
- Most likely (M) estimate refers to the duration an activity would take in a realistic scenario.
- Optimistic (O) estimate represents the duration an activity would take in the best case scenario.

Given below are the key formulae used in PERT:

To calculate the expected duration of the estimate, based on the three estimates	$(\mu) = (P+4M+O)/6$
To calculate the standard deviation of an activity	$(\sigma) = (P-O)/6$
To calculate the variance of the activity	$\sigma \wedge 2$

Concept-based questions on PERT can be expected in the exam.

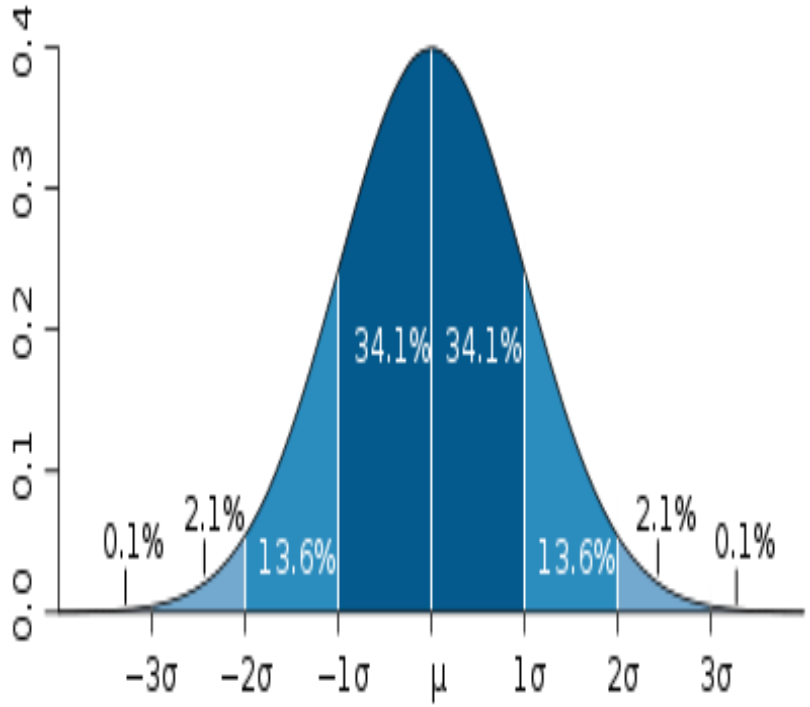
PERT: Example

The values of expected deviation and standard deviation can be applied to derive useful information about the likely range for values.

Given: O = 20; P = 70; M = 30
Now, μ = (70 + 30 * 4 + 20)/6 = 35
And σ = (70 – 20)/6 = 8 (approx.)

Using the normal curve:
Likelihood of actual time lying between:
1 σ, i.e., 27 and 43 is 68.2%
2 σ, i.e., 19 and 51 is 95.4%
3 σ, i.e., 11 and 59 is 99.7%

Six Sigma:
Six Sigma is reaching a level of confidence where 3.4 times out of a million would fall outside the stated range.



PERT allows you to plan based on the intended level of confidence in the outcome and determine buffers accordingly.

Critical Path Method

Critical path is the longest duration path through a network diagram, which determines the shortest time to complete the project. Float, also called slack, is calculated in a network diagram.
The three types of float are as follows:

*Total Float (Slack)

The amount of time that a schedule activity can be delayed or extended from its early start date without delaying the project finish date or violating a schedule constraint[7]

*Free Float (Slack)

The amount of time that a schedule activity can be delayed without delaying the early start date of any successor or violating a schedule constraint[7]

Independent Float (Slack)

The amount of time an activity can be delayed if all the immediate predecessors finish at their latest finish dates and all the immediate successors are to be started on the earliest start dates.

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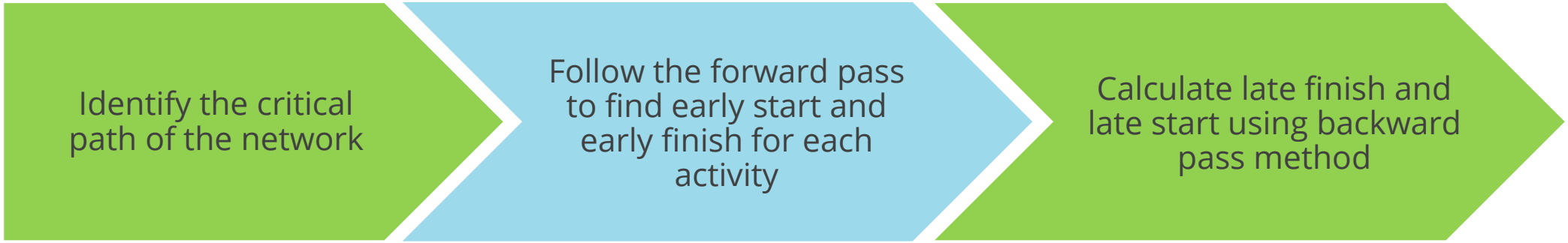
The slack of activities on the critical path is zero (0) as the activities on critical path cannot be delayed.

*Definitions taken from the Glossary of the Project Management Institute, *A Guide to the Project Management Body of Knowledge, (PMBOK® Guide)* – Sixth Edition, Project Management Institute, Inc., 2017, Page 210

Calculation of Float

Steps to calculate float are as follows:



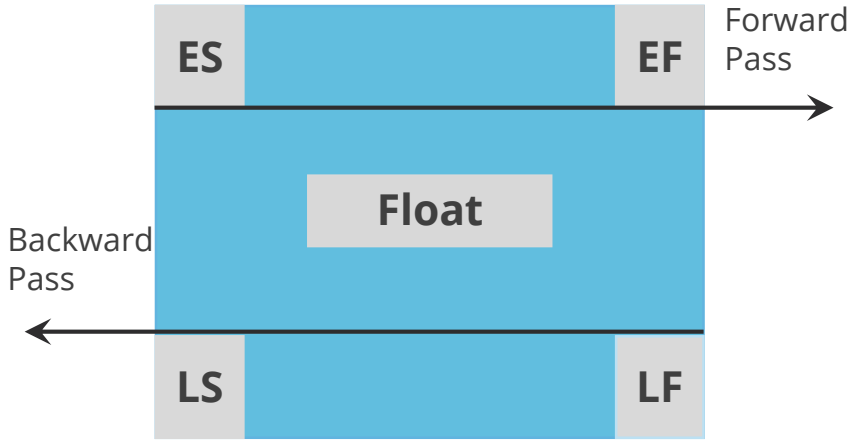
Total Float = **Late Start – Early Start** or **Late Finish – Early Finish**

Before the start of exam, please make a note of the total float formula.

Calculation of Float (Contd.)

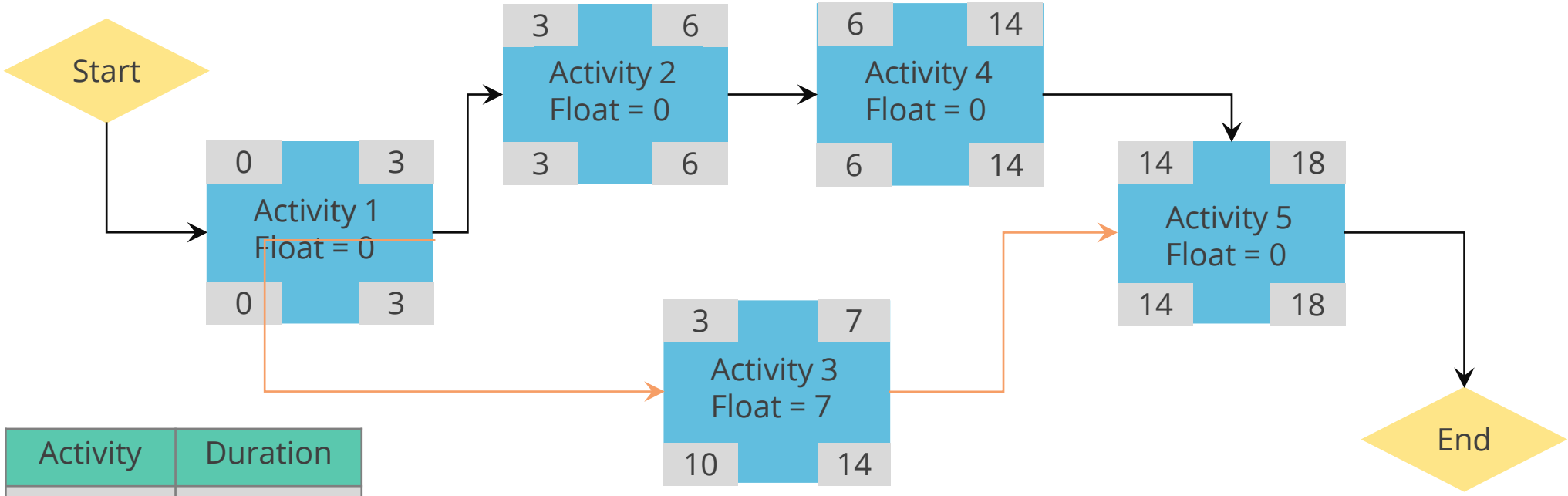
In forward pass, travel through the network starting with time zero and calculate the time required for each activity until the last activity of the project. The starting time of each activity is known as early start (ES) and the end time is known as early finish (EF).

In backward pass, travel through the network from project end date and calculate the time required for each activity. The end date is called the late finish (LF) and start date is called the late start (LS).



Critical Path: Example

Given below is the calculation of a critical path:



Activity	Duration
Activity 1	3
Activity 2	3
Activity 3	4
Activity 4	8
Activity 5	4

Paths	Duration
Start, 1, 2, 4, 5, End	18
Start, 1, 3, 5, End	11

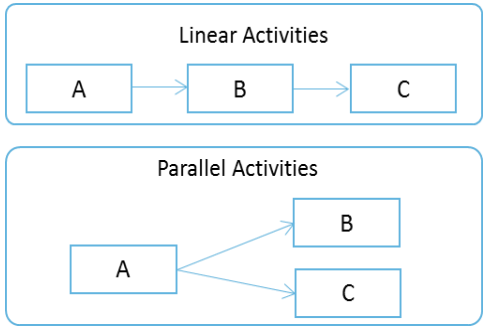
Start, 1, 2, 4, 5, End is the longer (critical) path

Schedule Compression

Schedule compression is done to see if the desired completion date can be met and what will have to change to meet that date. The two techniques of schedule compression are as follows:

Fast Tracking

Linear activities are checked if they can happen in parallel, thereby reducing the project cycle time



Crashing

This involves increasing resources on critical path activities while making cost and schedule tradeoffs. You must determine how to obtain the greatest amount of schedule compression for the least incremental cost while maintaining project scope.

Concept-based questions on schedule compression can be expected in the exam.

Schedule Compression: Example

The table summarizes the project activity details. Which activity would you crash to reduce the project time by 1 day?

Activity	Original Duration (in Days)	Crash Duration (in Days)	Time Savings	Original Cost in Dollars	Crash Cost	Extra Cost	Crash Cost per Day
A	10	8	2	10,000	12,000	2,000	1,000
B	14	10	4	14,000	24,000	10,000	2,500
C	5	4	1	15,000	17,000	2,000	2,000
D	9	7	2	12,000	18,000	6,000	3,000

Activity A, as it has the minimum crash cost per day.

Impact of Schedule Compression

Impact of schedule compression on projects are as follows:

Schedule Compression Technique	General Impact to the Project
Fast track	• Adds risks • Increases management time for the project manager
Crash	• Adds costs • Increases management time for the project manager
Reduce scope	• Saves time and cost • Increases customer dissatisfaction
Cut quality	• Saves cost and resources • Increases risks
Resource reallocation	• Does not add cost or increase risks

Other Scheduling Techniques

The techniques used in project scheduling:

What-If Scenario Analysis	In this method, the following questions are asked to produce a realistic schedule: What if a particular scenario changed on the project? Would that produce a shorter schedule?
Monte Carlo Analysis	In this method, a computer modelling program is used to simulate the outcomes of a project by making use of input values selected at random from probability distributions.
Resource Optimization Technique	In this technique, a resource-limited schedule is produced. Resource optimization results in more stable number of resources used in the project by resource leveling their effort.
Critical Chain Method	Critical chain method is determined based on the resources required to execute project tasks. It reflects delays that occur due to task switching, Parkinson's Law (work grows to fill the available time), and lack of prioritization.

Control Schedule

"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 is part of the Monitoring and Controlling Process Group.

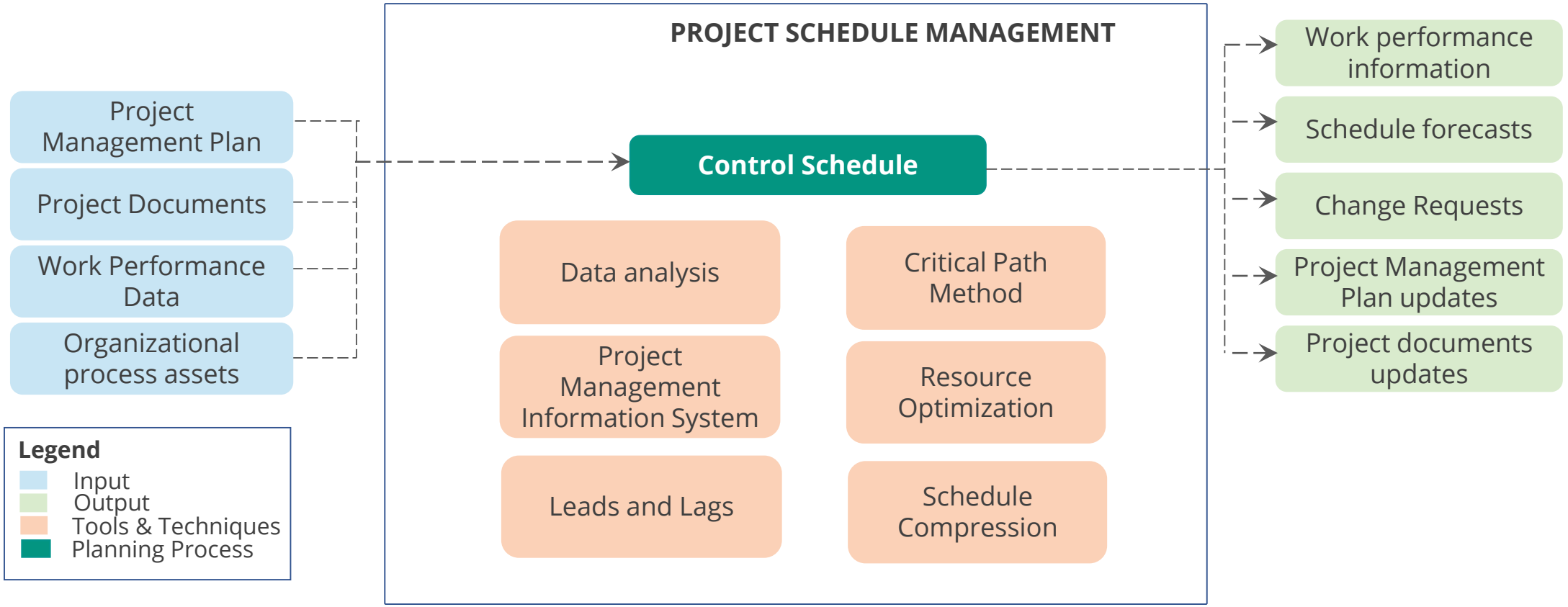


Figure 6-22. Control Schedule: Inputs, Tools & Techniques, and Outputs

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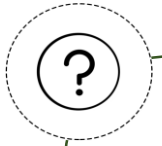
Business Scenario: Problem Statement



In one of Janice's project team meetings, her team is reporting the status of their assigned activities defined on the project schedule. About halfway through the meeting, a problem with the schedule is discovered as several activities are behind schedule.

After all activities for this phase of the project are reported, the overall schedule is determined to be progressing at about 75% of what had been planned. Janice has to figure out how she can get the schedule back on track. How can Janice go about solving this schedule problem?

Business Scenario: Solution

To aid in the decision making process, Janice needs to schedule a follow-up meeting with her team to evaluate the impact of this delay to the triple constraint. The delivery of the scope, budget, and schedule, along with quality expectations, resource availability, and risks, has to be evaluated so that she can present a strategy for correcting the project's schedule delay to the Project Sponsor.

Due to the team's assessment, Janice can make the decision to add additional resources to the scheduled activities on the critical path. Before crashing the critical path, the team can identify a series of sequenced activities that can be re-arranged and completed in parallel to free up more resources that can be re-allocated to the critical path activities. By utilizing these schedule compression techniques, Janice was able to increase the project's productivity rate to 95%.