Project Time Management
Objective

- Managing Project Time
- Planning and Monitoring and Controlling of Project Time
- Developing Schedule Management Plan
What is Project Time Management

- Project Time Management is the processes of ensuring timely completion of the Project.

- It includes processes that are required to deal with
  - Defining Project activities,
  - Sequencing Project activities using the Precedence Diagramming Method, and
  - Estimating the resources needed to complete these activities.
  - Estimating the duration needed to complete the project activities.
  - Planning and monitoring the schedule of the project.
Key Terms

- **Activity**
  Activity is the component of work performed during the course of the Project.

- **Milestone**
  A significant point or event in the Project.

- **Lead**
  A modification of a logical relationship that allows an acceleration of the successor activity.

- **Lag**
  A modification of logical relationship that directs a delay in the successor activity.

- **Float**
  The amount of time that a schedule activity can be delayed without delaying the Project finish date.
Key Terms

- **Buffer**
  A provision in the Project Management plan to mitigate schedule risk.

- **Variance**
  A quantifiable deviation, departure or divergence away from known baseline or expected value.

- **Schedule Variance**
  It is the difference between the earned value (EV) to planned value (PV).
  \[ SV = EV - PV \]

- **Critical Path Method (CPM)**
  A schedule network analysis technique used to determine the amount of scheduling flexibility (the amount of float) on various logical network paths.

- **Schedule**
  The planned dates for performing schedule activities and the planned dates for meeting schedule milestones.
Key Terms

- **Late Start Date (LS)**
  In the CPM, the latest possible date that a schedule activity may begin based upon the schedule network logic.

- **Late Finish Date (LF)**
  In the CPM, the latest possible date that a schedule activity may be completed based upon the schedule network logic.

- **Early Start Date (ES)**
  In the critical path method, the earliest possible date that a schedule activity may begin based upon the schedule network logic.

- **Early Finish Date (EF)**
  In the CPM, the earliest possible date that a schedule activity may finish based upon the schedule network logic.

- **Rolling Wave planning**
  A form of progressive elaboration planning where the work to be accomplished in the near term.
Project Time Management

Key processes:
- Plan Schedule Management
- Define Activities
- Sequence Activities
- Estimate Activity Resources
- Estimate Activity Durations
- Develop Schedule
- Control Schedule
PLAN SCHEDULE MANAGEMENT

Planning Process Group

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

- The Objective of establishing Schedule Management Process is to provide a consistent approach/guideline at organizational level for planning, creation, baseline, and manage the schedule throughout the Project lifecycle. It includes (but not limited to) Policies, Procedures, Guidelines, Templates, Thresholds and Contingencies.

- The Plan provides (high level or detailed) approach for defining and managing the schedule. This may depend on the type and size of the Project and will be largely be driven by Organizational Scheduling Guidelines.
Plan Schedule Management

**INPUTS**
- Project Charter
- Project Management Plan
- Enterprise environmental factors
- Organisational process assets

**TOOLS and TECHNIQUES**
- Expert judgment
- Analytical Techniques
- Meetings

**OUTPUTS**
- Schedule Management Plan

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Plan Schedule Management - Inputs, Tools and Techniques and Outputs
Plan Schedule Management

Input

- Project Charter
  - High-level milestones
- Project Management Plan
  - Project Scope statement
  - Assumptions
  - Risks
  - Scope Baseline
  - WBS
  - WBS dictionary
  - High Level Duration Estimates
Plan Schedule Management

Input

- **Enterprise Environmental Factor**
  
The Project Management information system (PMIS) and work authorization systems used in an organization

  Published benchmark data such as throughput factors, Resource and skill availability

- **Organizational Process Assets**

  Organizational planning related Policies, Procedures, Standards, Templates, Guidelines for Schedule Management, Project Historical information and lessons learned
Plan Schedule Management
Tools and Techniques

- **Expert Judgment**
  - Subject matter experts on schedule Management from within the Project or external to the Project who can validate the approach vis-à-vis the Project to assess adequacy of controls and accuracy of data available from Project Scope, WBS and Work Packages

- **Analytical Techniques**
  - Scheduling Methods, Schedule Management Tool, Parameters setting, Approach for Crashing and Fast Tracking and associated Risks and Project Contingencies

- **Meetings**
  - Formal review of the scheduling approach by relevant Stakeholders to obtain commitment on the thresholds and reporting requirements
Plan Schedule Management Outputs

Schedule Management Plan

- **Project Schedule Model**
  - The scheduling tool and applicable standards for the Project

- **Level of Accuracy**
  - Standards in terms of manageable units of work and control specifications including contingencies

- **Units of Measure**
  - Organizations stands for units of measure for various types of parameters like resources, effort and duration (Days or Hours, Date Formats etc)

- **Organizational Procedures**
  - Procedures to adopted while translating estimates into schedule including schedule optimization
Plan Schedule Management

- **Control Thresholds**
  - Project Level threshold for managing variations and triggers for updating the schedule baseline

- **Rules for Performance Measurements**
  - Methods for measuring schedule performance, such as EVM based metrics. Defining the applicable ways of measuring work completion, including in-flight Project activities, and reporting progress vis-à-vis the budget (effort, cost, duration etc.)

- **Reporting Formats**
  - Organizational Standard Reporting Formats that are applicable for the Project, including the frequency and Stakeholders to whom the reports should be provided

- **Process Description**
  - Schedule Management Process as applicable to the Project (Project Defined Process) including approved tailoring and any re-usable components from organizational repository
DEFINE ACTIVITIES

Planning Process Group

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

- Defining the activity is the first step in Project Time Management.
- This is the process of identifying and documenting specific activities.
- The activities are usually defined at the work package level.
- Defining specific activities that help team to
  - Estimate & Schedule,
  - Execute
  - Monitor and Control
  - Create a comprehensive list called the activity list
- Is an element of Planning Process Group
Define Activities

**INPUTS**
- Schedule Management Plan
- Scope baseline
- Enterprise environmental factors
- Organisational process assets

**TOOLS and TECHNIQUES**
- Decomposition
- Rolling wave planning
- Expert judgment

**OUTPUTS**
- Activity list
- Activity attributes
- Milestone list

**Define Activities - Inputs, Tools and Techniques and Outputs**
Define Activities

Inputs

- Schedule Management Plan
- Scope Baseline
- Enterprise Environmental Factor
- Organizational Process Assets
Decomposition

- Decomposition is a technique used to break down the work packages in a WBS into smaller, more manageable components called activities.

- Activities are the work or effort required to complete a work package that can be realistically estimated, scheduled, executed and managed by the Project Manager.

- Decomposition takes a top-down approach

- Involving the Project team helps in defining accurate list of activities.
Rolling Wave Planning
- In some cases, decomposition may not be possible for a deliverable as it will be finished in future.
- Rolling wave planning is a form of progressive elaboration planning
- Future work is planned for WBS components that are at a relatively high level of the WBS.
- In rolling wave planning WBS components may exist in different level of detail in the structure.

Expert Judgment
- The skills and knowledge of subject matter experts, from within the Project or external to the Project.
- who has experience on creating Project Scope statement, WBS and schedule development can be utilized in defining the activities.
Define Activities

**Outputs**

- **Activity List**
  - A list of Activities encompassing all the work those are to be performed in order to produce Project deliverables.

- **Milestone list**
  - Milestones are the major event or a significant point in the Project lifecycle.

- **Activity attributes**
  - Activity attributes provides additional information related to each activity
  - Activity attributes helps the Project team in schedule development.
  - The number of activity attributes used by the Project Management team varies with the Project.
Define Activities
Outputs

- Activity attributes are Name of the activity, Activity ID, WBS ID at the start of the Project and may expand to include
  - Activity codes
  - Predecessor Activity
  - Successor Activity
  - Its logical relationships
  - Activity leads and lags
  - Resource requirements
  - Imposed dates
  - Assumptions
  - Constraints
  - Activity owner
  - Geographic area where the activity is to be done
  - Level of effort required (LOE)
  - Discrete or Apportioned effort etc…
SEQUENCE ACTIVITIES

Planning Process Group

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

- The process of identifying the logical relationship among the activities and the succession in which those are to be executed in the Project.
- Leads and lags are applied for each activity to achieve realistic Project schedule.
- The Activity sequencing may be done by using Project Management software.
- Is an element of Planning Process Group
Sequence Activities

**Inputs**
- Schedule Management Plan
- Activity list
- Activity attributes
- Milestone list
- Project Scope statement
- Enterprise environmental factors
- Organisational process assets

**Tools and Techniques**
- Precedence diagram method (PDM)
- Dependency Determination leads and Lags

**Outputs**
- Project Schedule
- Network Diagram
- Project Documents
- Updates

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Sequence Activities - Inputs, Tools and Techniques and Outputs
Sequence Activities

Inputs

- Schedule Management Plan
- Activity List
  - A list of Activities encompassing all the work those are to be performed in order to produce Project deliverables.
- Activity attributes
  - Activity attributes provides additional information related to each activity
  - Activity attributes helps the Project team in schedule development.
  - The no. of activity attributes used by the Project Management team varies with the Project.
- Milestone List
  - Milestones are the major event or a significant point in the Project lifecycle.
- Project Scope Statement
  - Sequencing related inputs like predecessors, successors and external dependencies
  - Deliverables list and Project/Product Acceptance criteria
- Enterprise Environmental Factor
- Organizational Process Assets
Sequence Activities

- Precedence Diagramming Method (PDM)
  - A method of constructing a logical network using boxes to represent the activities and connecting them by lines that show dependencies.
  - The PDM is also called as Activity on Node (AON) diagramming method.
  - In PDM it is also necessary to define the relationship between the predecessor activity and the successor activity.
    - There are 4 types of relationship, namely:
      1. Finish to Start (FS)
      2. Finish to Finish (FF)
      3. Start to Start (SS)
      4. Start to Finish (SF)
**Sequence Activities**

**Tools and Techniques**

- **Finish to Start (FS)** – which means the successor activity cannot start until its predecessor has been completed.

- **Start to Start (SS)** - which means that the successor activity cannot start until after its predecessor has started.
- **Finish to Finish (FF)** - which means the successor activity cannot be completed before its predecessor has been completed.

- **Start to Finish (SF)** — which means the successor activity cannot be finished until before its predecessor has been started.
Sequence Activities
Tools and Techniques

- Dependency determination
  - Dependency determination is a method to determine how each activity in a Project depends on the predecessors or successor activity.
  
  There are four types of dependency
  - Mandatory dependencies (Hard Logic)
  - Discretionary dependencies (preferred logic, preferential logic, or soft logic)
  - External dependencies
  - Internal dependencies

- Lead and Lags
  - Lead time represents the time duration by which the succeeding activity can start before the completion of the preceding activity.
  - Lags time represents the time delay between the preceding activity and the commencement of the succeeding activity.
Sequence Activities

Outputs

- Project schedule network diagram
  - Project network diagrams are generated on performing the Sequence Activity process.
  - Project network diagram are the graphical representation of the Project schedule activities, showing their logical relationships.
  - The Project Management team can develop the Schedule network diagram either manually or using a PMS.

- Project document updates
  - Activity lists, Activity attributes and risk register are some of the documents that may get updated on performing the sequence activity process.
Network analysis is a system which plans Projects both large and small by analyzing the Project activities.

Activities are arranged in logical sequence, which presents visually, the relationship between all the activities involved.

Helps designing, planning coordinating, controlling Project economically in the minimum available time with the limited resources.
Sequence Activities

Outputs

Precedence Diagram Method (PDM)
Network Models

- **Critical Path Method (CPM)**
  - DuPont and Remington-Rand (1956)
  - **Deterministic** task times
  - **Activity-on-node (AON)** network construction

- **Program Evaluation and Review Technique (PERT)**
  - US Navy, Booz, Allen and Hamilton (1950’s)
  - **Multiple (Probabilistic)** task time estimates
  - **Activity-on-arrow (AOA)** network construction
Project Network

- Activity-on-node (AON)
  - nodes represent activities, and arrows show precedence relationships
- Activity-on-arrow (AOA)
  - arrows represent activities and nodes are events for points in time
- Event
  - completion or beginning of an activity in a Project
Six Steps in PERT/CPM

- Define the Project and all of its significant activities or task.
- Develop the relationships among the activities. Decide which activities must precede and which must follow others.
- Draw the network connecting all activities.
- Assign time and/or cost estimates to each activity
- Complete the longest time path through the network. This is called the Critical Path (CP).
- Use the network to plan, schedule, monitor and control the Project.
# Example – House Construction

<table>
<thead>
<tr>
<th>Activity Description</th>
<th>Duration (Months)</th>
<th>Immediate Predecessors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design house and Obtain financing</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>2. Lay Foundation</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. Order and Receive Materials</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4. Build House</td>
<td>3</td>
<td>2, 3</td>
</tr>
<tr>
<td>5. Select Paint</td>
<td>1</td>
<td>2, 3</td>
</tr>
<tr>
<td>6. Select Carpet</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>7. Finish Work</td>
<td>1</td>
<td>4, 6</td>
</tr>
</tbody>
</table>
Network for House Building Project

<table>
<thead>
<tr>
<th>Activity No.</th>
<th>Activity Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

- **Start**
- Lay foundations
- Build house
- Finish work
- Design house and obtain financing
- Order and receive materials
- Select paint
- Select carpet
Activity Start Times

- Start at 3 months
- Start at 5 months
- Finish at 9 months
- Start at 6 months

Activity No.
Activity Time

Start

1
3

2
2

3
1

5
1

6
1

4
3

7
1

Finish

40
Mode Configurations

Activity number

Earliest start

Earliest finish

Activity duration

Latest finish

Latest start

1 0 3
3 0 3
Start at the beginning of CPM/PERT network to determine the earliest activity times

- **Earliest Start Time (ES)**
  - Earliest time an activity can start
  - \( ES = \text{maximum } \text{EF of immediate predecessors} \)

- **Earliest finish time (EF)**
  - Earliest time an activity can finish
  - Earliest start time plus activity time
  \[
  EF = ES + t
  \]
Backward Pass

- Determines latest activity times by starting at the end of CPM/PERT network and working backward
- Latest finish time (LF)
  - Latest time an activity can be completed without delaying critical path time
  - $LF = \text{minimum LS of immediate successors}$
- Latest Start Time (LS)
  - Latest time an activity can start without delaying critical path time
  - $LS = LF - t$
Earliest Activity Start and Finish Time

Earliest time an activity can start
- ES = maximum EF of immediate predecessors

Latest time an activity can be completed without delaying critical path time
- LF = minimum LS of immediate successors

\[ EF = ES + t \]
\[ LS = LF - t \]

- **Earliest Activity Start and Finish Time**

- **Earliest Start Time (ES) -** The earliest start time of an activity is the maximum earliest finish time of all its predecessors.

- **Earliest Finish Time (EF) -** The earliest finish time of an activity is computed as the earliest start time plus the duration of the activity.

- **Latest Start Time (LS) -** The latest start time of an activity is the minimum latest finish time of all its successors.

- **Latest Finish Time (LF) -** The latest finish time of an activity is computed as the latest start time minus the duration of the activity.
How does a Network Diagram Help?

- Helps justify time estimate on a Project
- Aids in effective planning, organizing and controlling a Project
- Shows interdependencies of all activities
- Shows workflow to know what will happen in a sequence
- Identifies opportunities to compress the schedule
Project Crashing

- Crashing
  - reducing Project time by expending additional resources

- Crash time
  - an amount of time an activity is reduced

- Crash cost
  - cost of reducing activity time

- Goal
  - reduce Project duration at minimum cost
### Activity Slack

<table>
<thead>
<tr>
<th>Activity</th>
<th>LS</th>
<th>ES</th>
<th>LF</th>
<th>EF</th>
<th>Slack S</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>*2</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>*4</td>
<td>5</td>
<td>5</td>
<td>8</td>
<td>8</td>
<td>0</td>
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<tr>
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<tr>
<td>*7</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>0</td>
</tr>
</tbody>
</table>

* Critical Activity

Slack = LS – ES or Slack = LF-EF
Crashing Project Time

- Determine if critical path (CP) falls within targeted time. If yes, stop
- If no, compute crash cost per time period for each activity
- Select activity on CP with lowest crash cost and crash the Project
- Recomputed CP and check to see if within targeted time
- Repeat as necessary
Project Crashing (example)

- Crash cost
- Normal cost
- Crash time
- Normal time
- Slope = crash cost per week

<table>
<thead>
<tr>
<th>Normal activity</th>
<th>Normal time</th>
<th>Crash cost</th>
<th>Normal cost</th>
<th>Crash time</th>
<th>Normal activity</th>
<th>Normal time</th>
</tr>
</thead>
<tbody>
<tr>
<td>₹7,000</td>
<td>₹6,000</td>
<td>₹5,000</td>
<td>₹4,000</td>
<td>₹3,000</td>
<td>₹2,000</td>
<td>₹1,000</td>
</tr>
</tbody>
</table>
## Normal Activity and Crash Data

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>NORMAL TIME (WEEKS)</th>
<th>CRASH TIME (WEEKS)</th>
<th>NORMAL COST</th>
<th>CRASH COST</th>
<th>TOTAL ALLOWABLE CRASH TIME (WEEKS)</th>
<th>CRASH COST PER WEEK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td>7</td>
<td>₹3,000</td>
<td>₹5,000</td>
<td>5</td>
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<td>2</td>
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<td>5</td>
<td>₹2,000</td>
<td>₹3,500</td>
<td>3</td>
<td>500</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>3</td>
<td>₹4,000</td>
<td>₹7,000</td>
<td>1</td>
<td>3,000</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>9</td>
<td>₹50,000</td>
<td>₹71,000</td>
<td>3</td>
<td>7,000</td>
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<tr>
<td>5</td>
<td>4</td>
<td>1</td>
<td>₹500</td>
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<td>200</td>
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<tr>
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<td>₹1,100</td>
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<td>200</td>
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<td>7</td>
<td>4</td>
<td>3</td>
<td>₹15,000</td>
<td>₹22,000</td>
<td>1</td>
<td>7,000</td>
</tr>
</tbody>
</table>

₹75,000  ₹110,700
Project Duration: 36 weeks

Additional Cost:
- ₹2000
- ₹15000
- ₹500

Project Duration: 31 weeks

Additional Cost:
- ₹3000
Time-Cost Relationship

- Crashing costs increase as Project duration decreases
- Indirect costs increase as Project duration increases
- Reduce Project length as long as crashing costs are less than indirect costs
CPM - Summary

- CPM—Initially apply forward pass and find early-start and early-finish of various activities, provided the Initial Start date and duration for all activities
- CPM uses most likely duration
- Forward pass can calculate early start and early finish dates
- Backward pass can calculate late finish and late start dates
- Float/Slack = late start date – early start date
- If float = 0, then the activity is on the critical path
PERT—Program Evaluation and Review Technique. PERT is used when multiple probabilistic duration estimates are available. Expected Value = (Optimistic + Pessimistic + (4 * most likely)) / 6. Standard Deviation = (pessimistic – optimistic) / 6. Applying normal probability (bell curve),
  - Work will finish within + or – 3 standard deviation (SD) 99.73% of time
  - Work will finish within + or – 2 SD 95.44% of time
  - Work will finish within + or – 1 SD 68.26% of time
ESTIMATE ACTIVITY RESOURCES

Planning Process Group

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

- Having identified the activities and the sequence in which it is to be performed, the next step in Project Time Management is the estimation of the resources required to perform each activity.

- The resources include human resource, material, machine / equipment's or suppliers to perform these activities.

- The Estimate Activity Resource process is closely coordinated with the Estimate Cost process.

- Is an element of Planning Process Group
Estimate Activity Resources

**Inputs**
- Schedule Management Plan
- Activity list
- Activity attributes
- Resource calendars
- Risk Register
- Activity Cost Estimate
- Enterprise environmental factors
- Organisational process assets

**Tools and Techniques**
- Expert judgment
- Alternative analysis
- Published estimating data
- Bottom up estimating
- Project Management software

**Outputs**
- Activity resource requirements
- Resource breakdown structure
- Project document updates

Estimate Activity Resources - Inputs, Tools and Techniques and Outputs
Estimate Activity Resources

Inputs

- Schedule Management Plan
- Activity List
  - A list of Activities encompassing all the work those are to be performed in order to produce Project deliverables.
- Activity attributes
  - Activity attributes provides additional information related to each activity
  - Activity attributes helps the Project team in schedule development.
  - The no. of activity attributes used by the Project Management team varies with the Project.
- Resource Calendars
  - Information on the human resources, equipment's and material availability, experience and skill set of the resources, their availability and geographical location
- Risk Register
  - The resources availability and the skill availability
Estimate Activity Resources

Inputs

- Activity Cost Estimates
  - Trade-off with respect to resources availability and cost of resources, constraints, accuracy of estimates

- Enterprise Environmental Factors
  - The resources availability and the skill availability, location where available

- Organizational Process Assets
  - The organizational policies, procedures with respect to staffing, outsourcing, Renting, Leasing and the lessons learned from previous Projects
Estimate Activity Resources
Tools and Techniques

- Expert judgment
  - The skills and knowledge of SME from within the Project or external to the Project

- Alternative analysis
  - Different approaches or methods
    - Different levels of resource capability or skills,
    - Different size or type of machines,
    - Different type of tools like automated or manual and
    - Make or buy decisions
Published Estimating data
- Many organizations routinely publish the production rate for various tasks and also the costs of various tradeoff human resources, machines and material

Bottom up estimating
- the activity can be decomposed to more detailed tasks. Then the Project team can estimate the resource required to perform each task and aggregate.

Project Management software
- There is Project Management Software available which has the capability to help plan, organize, manage resource pools and develop resource estimates.
Estimate Activity Resources

Outputs

- **Activity Resource Requirements**
  - The required resources for performing each activity are aggregated to arrive at the total resource requirement for the performing the work package.

- **Resource Breakdown Structure**
  - The resources identified for the Project is arranged in a hierarchical structure by resource category (labor, material, equipment, and resource type).

- **Project Document Updates**
  - Activity list, activity attributes and resource calendars are some of the Project documents that may get updated.
ESTIMATE ACTIVITY DURATION

Planning Process Group

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

- Estimate Activity duration is the act of determining the effort and the no. of resources required.
- In this process the Project Management team estimates the time it takes to complete an activity.
- Estimating Activity Duration is dependent on the Scope of the activity, activity resource estimates, resource availability, resource calendars etc....
- The Assumption, Constraints used for estimating the activity duration will be documented by the Project team.
Estimate Activity Duration

**INPUTS**
- Schedule Management Plan
- Activity list
- Activity attributes
- Activity resource requirements
- Resource calendars
- Project Scope statement
- Risk Register
- Resource Breakdown Structure
- Enterprise environmental factors
- Organisational process assets

**TOOLS and TECHNIQUES**
- Expert judgment
- Analogous estimating
- Parametric estimating
- Three-point estimates
- Group decision-making techniques
- Reserve analysis

**OUTPUTS**
- Activity duration estimates
- Project document updates

Fig: Estimate Activity Durations - Inputs, Tools and Techniques and Outputs
Estimate Activity Duration

Input

- **Schedule Management Plan**
- **Activity List**
  - A list of Activities encompassing all the work those are to be performed in order to produce Project deliverables.
- **Activity attributes**
  - provides additional information related to each activity
  - helps the Project team in schedule development.
  - The no. of activity attributes used varies with the Project.
- **Activity Resource Requirements**
  - The required resources for performing each activity are aggregated to arrive at the total resource requirement for the performing the work package.
- **Resource Calendars**
  - information on the human resources, equipment's and material availability, experience and skill set of the resources, their availability and geographical location
Project Scope statement
- which list the Project Constraints and Assumptions, when estimating the activity duration.
- Some of the examples for Assumptions are
  - Existing Conditions
  - Availability of information
  - Length of reporting period
- Some of the examples of Constraints are
  - Available Skilled resources
  - Contract terms and requirements
Estimate Activity Duration

Input

- Risk Register
  - Actions identified as part of risk response along with the owner and target date for closure
- Resource Breakdown structure
- Enterprise Environmental Factors
  - Any published industry benchmark data by for comparing the estimates
  - Resource/Skill availability at the market place
- Organizational Process Assets
  - Any internal benchmark or capability baseline information available within the organization for estimation
  - Reusable components from Organizational repository to enhance throughput and decrease cost
Estimate Activity Duration
Tools and Techniques

- **Expert judgment**
  - The skills and knowledge of SME from within the Project or external to the Project

- **Analogous Estimating**
  - Also known as top-down estimating, it is a form of expert judgment or historical estimation.
  - Analogous Estimating is used in the early phase
  - Analogous Estimating is less costly and time consuming than other estimating technique.
  - Analogous estimating is generally less accurate and unreliable.
Parametric Estimating
- based on the historical information but it uses a statistical relationship between the variables to calculate the estimate parameters such as cost, duration and budget.
- For example if you are estimating the duration required to Plaster a wall of 100 sq. meters, if the productivity rate of the resource is 1 sq. meters /hour. Then the duration required to complete the plastering of 100 sq. meters is 100 ÷1 = 100 hours.
- Parametric estimating can produce higher accurate results than analogues estimates
Three point Estimating
- estimating is done by taking in to account the estimation uncertainty and the risk while estimating the duration.
- This estimating technique originated from the Program Evaluation and Review Technique (PERT).
- Three-point estimates are based on determining three types of estimates, namely optimistic estimates, most likely estimates and pessimistic estimates.
- Most likely ($t_M$): The duration of the schedule activity, given the resources likely to be assigned, their productivity, realistic expectations of availability for the schedule activity, dependencies on other participants, and interruptions.
Estimate Activity Duration
Tools and Techniques

- Optimistic \((t_O)\) : The activity duration is based on a best-case scenario of what is described in the most likely estimate.

- Pessimistic \((t_P)\) : The activity duration is based on a worst-case scenario for the activity.

- PERT analysis calculates the Expected \((t_E)\) activity duration using a weighted average of these estimates.
  
  Beta Distribution - \(t_E = (t_O+4t_M+t_P) / 6\) (Traditional PERT Estimate)
  
  Triangular Distribution - \(t_E = (t_O+t_M+t_P) / 3\)

- To calculate the standard deviation of an activity; the following formula helps

  \[ SD = (t_P - t_O) / 6 \]
Estimate Activity Duration
Tools and Techniques

- **Group Decision Making Techniques**
  - Involves review by Subject Matter Experts and key Stakeholders to validate accuracy and obtain commitment for deliverables

- **Reserve Analysis**
  - To take care of the schedule uncertainties buffer time also known as time reserves or contingency reserve are added to the overall Project schedule.
  - The Contingency should be clearly identified in the Project schedule documents.
Role of Project Manager in Estimation

- Provide the team with enough information for properly estimating each activity
- Let those doing the estimation know how refined their estimation needs to be
- Complete sanity check of estimates
- Prevent padding
- Formulate a reserve
- Make sure assumptions made during estimates are recorded for review later.
Activity Duration Estimates
- contains information about the number of work period that is required to complete each activity.

For example
- 2 weeks ±2 days to indicate that the activity can take at least eight days and no more than 12 days to complete. (calculated@5 working days/week)
- 15% probability that the activity may take more than three weeks.

Project Document Updates
- Some of the Project documents that may get updated include
  - Activity attributes
  - Assumptions made in developing the duration estimates such as skill levels and availability.
### Exercise

Calculate the expected activity duration using triangular distribution and Beta distribution. Also calculate the standard deviation and range for Beta distribution.

<table>
<thead>
<tr>
<th>Activity</th>
<th>P</th>
<th>M</th>
<th>O</th>
<th>Expected activity duration (Triangular)</th>
<th>Expected activity duration (Beta)</th>
<th>Standard Deviation (Beta)</th>
<th>Range of estimate</th>
</tr>
</thead>
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<td>24</td>
<td>14</td>
<td></td>
<td></td>
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<td>44</td>
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<td>24</td>
<td>14</td>
<td>28.333</td>
<td>26.167</td>
<td>5.5</td>
<td>20.667 to 31.667</td>
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<td>89</td>
<td>60</td>
<td>41</td>
<td>63.333</td>
<td>61.677</td>
<td>8.0</td>
<td>53.667 to 69.667</td>
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<tr>
<td>3</td>
<td>48</td>
<td>44</td>
<td>39</td>
<td>43.666</td>
<td>43.833</td>
<td>1.5</td>
<td>42.333 to 45.333</td>
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DEVELOP SCHEDULE

Planning Process Group

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

- Is the process of analyzing activity sequences, durations, resource requirements and schedule constraints to create Project schedule
- Is an element of Planning Process Group
Develop Schedule - Inputs, Tools and Techniques and Outputs

**INPUTS**
- Schedule Management Plan
- Activity list
- Activity attributes
- Project schedule network diagrams
- Activity resource requirements
- Resource calendars
- Activity duration estimates
- Project Scope statement
- Risk Register
- Project Staff Assignments
- Resource breakdown structure
- Enterprise environmental factors
- Organisational process assets

**TOOLS and TECHNIQUES**
- Schedule network analysis
- Critical path method
- Critical chain method
- Resource optimization techniques
- Modeling Techniques
- leads and lags
- Schedule compression
- Scheduling tool

**OUTPUTS**
- Schedule baseline
- Project schedule
- Schedule data
- Project Calendars
- Project Management Plan Updates
- Project document updates
Develop Schedule

Inputs

- Schedule Management Plan
- Activity List
- Activity attributes
- Project schedule network diagrams
- Activity resource requirements
- Resource calendars
- Activity duration estimates
- Project Scope statement
Develop Schedule

Inputs

- Risk Register
- Project Staff Assignments
- Resource breakdown structure
- Enterprise Environmental Factors
  - Scheduling tools/Models, Communication channels.
- Organizational Process Assets
  - Scheduling guidelines
  - Standard Scheduling Templates
  - Project calendar
Schedule Network Analysis
- is a technique in which the Project Management uses various analytical techniques such as critical path method, critical chain method, what –if analysis and resource leveling techniques.

Critical path method
- A critical path is the sequence of Project network activities which add up to the longest overall duration. This determines the shortest time possible to complete the Project. Any delay of an activity on the critical path directly impacts the planned Project completion date.
Critical Chain Method

- a network analysis tool, in which the resource limitations are taken into account while developing the project schedule

- In critical chain method you do deterministic and probabilistic approaches to schedule network analysis
  - Project buffers
    - Project buffers are the non work schedule activities added to the end of the critical chain to manage uncertainties.
  - Feeding buffer
    - Feeding buffers are the non work schedule activity added to the feeding point of the non dependent activities that are not on the critical path but feeds in to the critical path, to protect the critical chain from slippage along the feeding chains.
Resource Optimization Techniques

- **Resource Leveling**
  - When shared or critical resources required are available only at a
    - Certain time or
    - In limited quantity
  - When you want to keep the resource usage at constant level
  - When resources have been over allocated
  - Resource leveling will be applied to a schedule that is already analyzed by the critical path method. Resource leveling often cause the original critical path to change.

- **Resource Smoothing**
  Technique to adjust resource assignments to optimize resource carrying costs through managing activities within the available slack. This is not likely to impact Critical Path
Modeling Techniques

What-if Scenario Analysis and Simulations
- in which schedule analysis is performed using different scenarios such as what will happen to the Project schedule;
  - If there is a delay in delivery of a major component
  - If there is a labor strike
  - If there is an unexpected delay in an activity
  - If there is an influence of external factors
- This analysis helps to assess the feasibility of the Project schedule under adverse conditions and preparing for the contingency response plans. The simulation will be done under various assumptions.
- Monte Carlo analysis is a most common simulation technique used to do What-if scenario analysis.
Develop Schedule
Tools and Techniques

- Leads and Lags
  - Applying leads and lags during network analysis are to develop a viable schedule.

- Schedule Compression
  - Technique which will help the Project team to shorten the Project duration without any changes to the Project Scope.
  - Schedule compression can be done in two ways, they are
    - Crashing
    - Fast tracking
Scheduling Tool

- Scheduling tool helps the Project Management team to expedite the scheduling process by generating start finish dates based on the inputs of activities, network diagrams, resources and activity durations.
- This can be used in conjunction with other Project Management software application as well as manual methods.
Schedule Baseline
- A schedule baseline is a specific version of the Project schedule developed from the schedule network analysis, which is accepted and approved by the Project Management team as the schedule baseline.

Project Schedule
- The Project schedule is the one where the Project activities are shown in a logical sequence with the start date, finish date and the duration for each activity. The duration of all the activities adds up to the Project duration.
- The Project schedule can be presented in tabular form or in graphical form using any of the following formats
  - Milestone charts
  - Bar charts
  - Project schedule network diagram
Develop Schedule Output

The following fig shows a Project Gantt diagram from MS Project:
Schedule Data

- The schedule data for the Project includes the schedule milestones, Schedule Activities, Activity attributes and all the documented assumptions and constraints.

- The information frequently supplied as supporting details to the schedule are:
  - Resource requirements by time period
  - Alternative schedules, such as best case scenario or worst case scenario, Resource leveled or not resource leveled, with or without imposed dates.
  - Scheduling contingency reserves
  - Schedule data can include items such as resource histogram, cash flow Projections and order and delivery schedules.
• Project calendars
  - Working hours and shift that are available for schedule activities

• Project Management plan Updates
  - Schedule baseline
  - Schedule Management plan

Develop Schedule
Output
Project Documents update

- The Project documents that may get updated on performing the Develop Schedule process may include

  - Activity resource requirements
    - If the resource leveling analysis change the Project resource requirements, then the Project resource requirements will get updated.

  - Activity attributes
    - The activity attributes may get updated due to changes in resource requirements or due to any changes to the schedule.

  - Calendar
    - The calendar for each Project may use different calendar units as the basis for scheduling the Project.

  - Risk register
    - The risk register may get updated to reflect any changes to the opportunities and threats because of the Develop Schedule Process
CONTROL SCHEDULE

Monitor and Control Process Group

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

- Control Schedule is the process of monitoring the Project progress;
- Compare it with the schedule baseline and managing the schedule delays to ensure that the Project is completed in time.
- The Control Schedule is a component of the perform Integrated Change Control process.
- The focus of the Schedule Control process is
  - Determine the current status of the Project schedule
  - Influencing the factors that create schedule changes
  - Determining that the Project schedule has changed
  - Managing the actual changes as they occur.
- Is an element of Monitoring and Controlling Process Group
Control Schedule - Inputs, Tools and Techniques and Outputs

**Inputs**
- Project Management plan
- Project schedule
- Work performance data
- Project Calendars
- Schedule Data
- Organizational process assets

**Tools and Techniques**
- Performance review
- Project Management software
- Resource Optimization Techniques
- Modeling Techniques
- leads and lags
- Schedule compression
- Scheduling tool

**Outputs**
- Work performance information
- Schedule Forecasts
- Change requests
- Project Management plan updates
- Project document updates
- Organizational process assets updates
Control Schedule

Inputs

- **Project Management Plan**
  - The schedule Management plan and the schedule baseline is part of the Project Management Plan
  - The schedule baseline is used to compare the actual performance and to determine any corrective actions or preventive actions are necessary.

- **Project Schedule**
  - The Project Management team requires the recent version of the schedule with notations to indicates updates, completed activities and started activities as of the indicated data date, to monitor and control the Project schedule.
Control Schedule

Inputs

- Work Performance data
  - Information of the Project performance with respect to the Project schedule like which activities have started, their progress and which activities are completed, remaining duration for work in progress activities etc.

- Project Calendars
  - Updated information for holidays, resource availability, work time. Required for effective forecasting of Project status

- Schedule Data

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Organizational Process Assets

- Some of the organizational process assets that can influence the Control Schedule process are
  - The organization’s existing Schedule control policies, procedures and guidelines
  - The Schedule control tools available in the organization
  - The monitoring and the reporting methods that must be used
Performance Reviews

- Performance reviews is about measuring, comparing, and analyzing the Projects schedule performance such as start dates, finish dates, percent complete and remaining duration of work in progress.

- When Earned Value Management (EVM) is employed, the performance review focuses on schedule variance and schedule performance index to assess the magnitude of schedule variation.

- If the Project Management team has employed critical chain method for schedule development, then the amount of remaining buffer to the amount of buffer required to protect the delivery date can determine whether corrective action is required or not.
Control Schedule
Tools and techniques

- **Project Management Software**
  - Project Management Software will help the Project Management team to track the planned dates of the activities versus the actual dates

- **Resource Optimizing Techniques**

- **Modeling Techniques**
  - What-If Scenario Analysis
  - Simulation

- **Leads and Lags**
  - The Project Management team can revisit the leads and lags applied to the Project activities which are behind and adjust them to bring it back into alignment with the plan.
Schedule Compression

Scheduling Tool
- Schedule tool helps the Project Management team in controlling the Project schedule.
- The schedule data are updated into the schedule to reflect the actual progress of the Project and remaining work to be completed.
- The Scheduling tool can be used in conjunction with manual methods or other Project Management software to perform a schedule network analysis to generate an updated Project schedule.
Control Schedule Outputs

- **Work performance information**
  - The SV and SPI are calculated from the Project work performance for the WBS components, in particular work packages and control accounts and these data are documented and communicated to the Project stakeholders.

- **Schedule Forecast**
  - Predict Project Completion status basis the current performance and remaining work using EVM while taking into consideration Projects expected performance level for completing the remaining work.
Control Schedule

Outputs

- Organizational process assets updates
  - Some of the organization process assets that may get updated as part of performing the Control Schedule process are
  - Causes of variance
  - Corrective action chosen with reasons
  - Other types of lessons learned from Project schedule control

- Change requests
  - The Schedule variance analysis along with the review of progress reports, results of performance measures and modifications to the Project schedule can result in Change request to the schedule baseline or to any other component of the PM plan.
  - These change request are to be processed, reviewed and disposed through integrated change control process.
Project Management plan updates
- The Control Schedule process will result in updates to some components of the Project Management Plan. The components of PM plan that may get updated are
  - Schedule baseline
    - The changes to schedule baseline are incorporated in response to the approved change requests.
  - Schedule Management plan
    - The schedule Management plan may get updated to reflect a change in the way the schedule is managed.
  - Cost baseline
    - The schedule compression may lead to changes to the Project cost baseline.
Project document updates

- Some of the documents that may get updated as a result of Control Schedule process are
  - Schedule Data
    - New Project schedule network diagrams may be developed to display approved remaining durations and modifications to the work plan.
  - Project Schedule
    - An updated Project will be prepared from the updated schedule data to reflect the schedule changes and manage the Project.
  - Risk Register
    - Update risk register for mitigated risk, identified new risks and risk responses
Summary

- Discuss topics
- Q and A