TOPIC 4

Project Schedule Management

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LEARNING ASPECTS

1) **Project Schedule**
2) **Project Schedule Management Process**
3) **Project Dependencies**
4) **Project Schedule Tools and Techniques**
   - *Gantt Chart*
   - *Project Network Diagram*
   - *Critical Path Method (CPM)*
   - *Programme Evaluation Review Technique(PERT)*

PROJECT SCHEDULE

Projects are generally complex endeavors that require decomposing projects into manageable phases or groupings.

Project Schedule is a detailed plan that represents how and when the project will deliver the products, services, and results defined in the project scope.

Project Schedule serves as a tool for communication, managing stakeholder expectations, and as a basis for performance reporting.

Project Schedule Process

1. Plan Schedule Management—The process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule.

2. Define Activities—The process of identifying and documenting the specific actions to be performed to produce the project deliverables.

3. Sequence Activities—The process of identifying and documenting relationships among the project activities.

Project Schedule Process

4. Estimate Activity Durations—The process of estimating the number of work periods needed to complete individual activities with the estimated resources.

5. Develop Schedule—The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model for project execution and monitoring and controlling.

6. Control Schedule—The process of monitoring the status of the project to update the project schedule and manage changes to the schedule baseline.

PROJECT ACTIVITY DEPENDENCIES

Dependency; A logical relationship between two or more activities where the timing, sequencing, or completion of one activity is dependent upon another activity.

There are four types of dependencies:

1) Finish-to-Start

2)Start-to-Start

3)Finish-to-Finish

4)Start-to-Finish

Types of Project Dependencies

1)Finish-to-Start : FS

A logical relationship in which a successor activity cannot start until a predecessor activity has finished.

Illustrative example:

2) Finish-to-finish (FF).

A logical relationship in which a successor activity cannot finish until a predecessor activity has finished.

Illustrative example:

3) Start-to-start (SS)

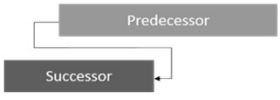
A logical relationship in which a successor activity cannot start until a predecessor activity has started.

Illustrative example:

4) Start-to-finish (SF).

A logical relationship in which a successor activity cannot finish until a predecessor activity has started.

Illustrative example:



Dependency Attributes

Mandatory Dependency

These are required based on the nature of the work involved or are required by contract, legal restrictions or regulation

Example:

Rough electrical work has to be done before you can hook up the switches, lights and outlets

Discretionary Dependency

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

- Example:

It's recommended to gather all requirements before designing the solution but you can do some design before the requirements are complete and finalized.

Dependency Attributes

External Dependency

External dependencies involve a relationship between project activities and non project activities. These dependencies are usually outside of the project team's control.

- ***Example***
- *Requiring a permit*
- *Waiting on a vendor delivery*

Internal Dependency

Internal dependencies involve a precedence relationship between project activities and are generally inside the project team's control.

Example;

- For example, if the team cannot test a machine until they assemble it, there is an internal mandatory dependency.

Mandatory & External dependencies are constraints on how you schedule a project

Discretionary and internal dependencies have the greatest schedule flexibility

Project Scheduling Tools & Techniques

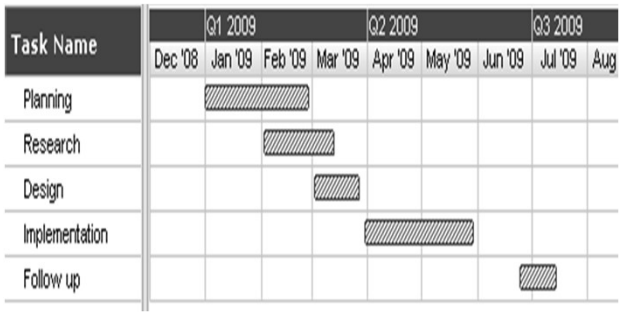
GANTT CHART

A Gantt chart chart used to visually illustrate a project schedule, including start and finish dates of the different required elements, activities and a summary of activities of a project.

Gantt charts are most commonly used for tracking project schedules.

Gant chart can also be able to show additional information about the various tasks for example how the tasks relate to each other, how far each task has progressed, what resources are being used for each task and so on.

A Simple Gantt Chart



Characteristics of the Gantt Chart

It usually includes (or allows one to see at a glance):

- the various (or major) activities and tasks of the project
- when each activity begins and ends
- how long each activity is scheduled to last
- where activities overlap with other activities, and by how much
- the start and end date of the whole project
- the project milestones

Characteristics of the Gantt Chart

- The interdependencies between activities.
- a unique identifier for each activities.
- a timeline
- the person or resource responsible for each item

Advantages of Gantt Chart

- It **creates a picture of complexity.** We think in pictures. Therefore, if we can see complex ideas as a picture, this will help our understanding.
- Used as a baseline for reporting
- Assist with delegation and managing of team workloads
- Assists in reminding team members of the project activities, objectives and when certain things are going to happen.

Advantages of Gantt Chart

- Assist in determining how long the project will take, including in analyzing the effect on the overall timeframe of activities going overtime.
- Assist with identification of project risks by showing areas of uncertainty.
- Confirm a common understanding of the project timeline among Project Sponsor, Steering Committee/Senior Management and Project Team
- Demonstrates that you know what you're doing. A nicely presented Gantt chart with high level tasks properly organized and resources allocated to those tasks.

Disadvantages of Gantt Chart

- **The size of the bar does not indicate the amount of work.** Each bar on the chart indicates the time period over which a particular set of tasks will be completed.
- **They need to be constantly updated.** As you get into a project, things will change. If you're going to use a Gantt chart you must have the ability to change the chart easily and frequently.
- **Difficult to see on one sheet of paper.** . It then becomes difficult to show the details of the plan to an audience. Further, you can print out the chart, but this will normally entail quite a large "cut and paste" exercise. If you are going to do this frequently, it can be very time-consuming.
- Gantt chart with percent-complete shading may actually miscommunicate the true schedule performance status.

CRITICAL PATH METHOD

Critical Path Method is a schedule technique used to estimate the minimum project duration and determine the amount of schedule flexibility on the logical network paths within the schedule model.

It is an important tool for effective project management.

Commonly used with all forms of projects, including construction, software development, research projects, product development, engineering, and plant maintenance, among others

Any project with interdependent activities can apply this method of scheduling.

CRITICAL PATH METHOD

Critical path is the longest path through a network, which determines the shortest possible time to complete the project.

Or

Critical path is the shortest possible path from the first activity to the last and will show the shortest amount of time that the project could be completed in.

Identifying task dependencies is essential in identifying the critical path for the project.

As a guide, a task will be on the critical path if changing the duration of the tasks changes the duration of the project by the same amount.

Key Steps in Critical Path Method

Step 1: Activity specification

The Work Breakdown Structure (WBS) can be used to identify the activities involved in the project. This is the main input for CPM. In activity specification, only the higher-level activities are selected for CPM. When detailed activities are used, CPM may become too complex to manage and maintain.

Step 2: Activity sequence establishment

Determine that the correct activity sequence is established. For that, 3 questions need to be asked for each task on the list:

1. *Which activities should take place before this activities happens.*
2. *Which activities should be completed at the same time as this activities.*
3. *Which activities should happen immediately after this activities.*

Step 3: Network diagram

Once the activity sequence is correctly identified, the network diagram can be drawn.

Step 4: Estimate durations for each activity

This could be a direct input from the WBS based estimation sheet.

Step 5: Identification of the critical path

For this, four parameters of each activity of the network need to be determined.

1) Earliest start time (ES) — The earliest time an activity can start once the previous dependent activities are over.
2) Earliest finish time (EF) — ES + activity duration.
3) Latest finish time (LF) — The latest time an activity can finish without delaying the project.
4) Latest start time (LS) — LF - activity duration

Step 5: Identification of the critical path

The float time for an activity is the time between the earliest (ES) and the latest (LS) start time or between the earliest (EF) and latest (LF) finish times.

During the float time, an activity can be delayed without delaying the project finish date.

The critical path is the longest path of the network diagram. The activities in the critical path have an effect on the deadline of the project. If an activity of this path is delayed, the project will be delayed.

Step 6: Critical path diagram to show project progresses

Critical path diagram is a live artifact. Therefore, this diagram should be updated with actual values once the task is completed.

This gives a more realistic figure for the deadline and the project management can know whether they are on track regarding the deliverables.

PROJECT NETWORK DIAGRAM

A project schedule network diagram is a graphical representation of the logical relationships/dependencies, among the project schedule activities

Network Diagram is based on tasks and their dependencies.

Network Diagram is also refered to as Precedence Diagramming Method a non computerized approach to graphic representation

Network Diagram Types

There are two types of network diagrams:

a) ***activity on arrow*** (***AOA***)

b) ***activity on node*** (***AON***). Activity on node diagrams are generally easier to create and interpret.

A Comparison of AON & AOA Networks Conventions

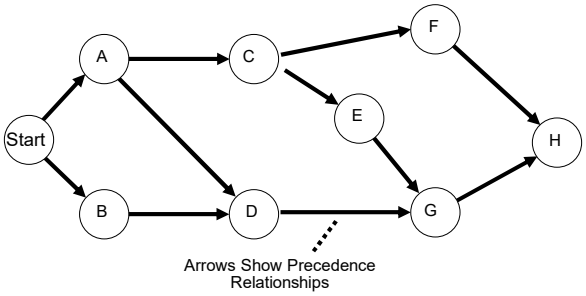
Activity on Node (AON)	Activity Meaning	Activity on Arrow (AOA)
(a) A → B → C	A comes before B, which comes before C	A → B → C
(b) A, B → C	A and B must both be completed before C can start	A, B → C
(c) A → B, C	B and C cannot begin until A is completed	A → B, C

Example of AON

Milwaukee Paper Manufacturing's Activities and Predecessors

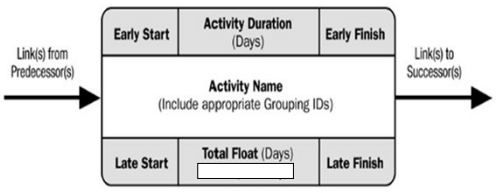
Activity	Description	Immediate Predecessors
A	Build internal components	—
B	Modify roof and floor	—
C	Construct collection stack	A
D	Pour concrete and install frame	A, B
E	Build high-temperature burner	C
F	Install pollution control system	C
G	Install air pollution device	D, E
H	Inspect and test	F, G

AON Network for Milwaukee Paper



Activity On Node (AON).

Node: can be used to display information;



Critical Path Example

Activity	Predecessors	Duration
A	_	7
B	A	8
C	A	9
D	A	6
E	B,C	4
F	D,E	9
G	E	7
H	G	3
I	F	5
J	H,I	10

Required

a) Construct a network diagram

b) Perform a forward & backward pass

c) Determine Project completion time

d) Calculate Slack/Float values

e) State the critical path

Advantages of Critical Path Method

- Offers a visual representation of the project activities.
- Presents the time to complete the tasks and the overall project
- Offers tracking of critical activities.
- It enables to calculate The Earliest Start/Finish and The Latest Start/Finish dates in order to manage activities and procurement tasks.
- It helps to determine which activities can be delayed without delaying the project.
- It improves decision making within the project team

Disadvantages of Critical Path Method

- It is hard to manage activities in large and complex projects without software.
- It does not consider resource allocations.
- Activity durations should be determined correctly otherwise, the critical path of the project will be wrong.
- It will be hard to determine the critical path if there are many other similar duration paths in the project.
- Constant updating with actual information where the project progresses in order to refine activity/project duration

Project Evaluation & Review Technique- PERT

PERT is a statistical tool, used in project management, that is designed to analyse and represent the tasks involved in completing a given project.

It is commonly used in conjunction with the CPM**.**

Mainly used in research projects where you cannot predict the duration of an activity.

Therefore, you plan your work based on the milestones. It helps you develop the project schedule for large, complex, and one time projects when no records are available..

PERT Conventions

- Two consecutive events in a PERT chart are linked by activities, which are conventionally represented as arrows.
- The events are presented in a logical sequence and no activity can commence until its immediately preceding event is completed.
- The planner decides which milestones should be PERT events and also decides their ***proper*** sequence.
- PERT activity: the actual performance of a task which consumes time and requires resources. It can be understood as representing the time, effort, and resources required to move from one event to another.

PERT Terminology

- PERT event: a point that marks the start or completion of one or more activities. It consumes no time and uses no resources. When it marks the completion of one or more tasks, it is not reached (does not occur) until all of the activities leading to that event have been completed.
- Predecessor event: an event that immediately precedes some other event without any other events intervening.
- Successor event: an event that immediately follows some other event without any other intervening events.

- **Optimistic time (O):** the minimum possible time required to accomplish a task, assuming everything proceeds better than is normally expected.
- **Pessimistic time (P):** the maximum possible time required to accomplish a task, assuming everything goes wrong (but excluding major catastrophes).
- **Most likely time (M):** the best estimate of the time required to accomplish a task, assuming everything proceeds as normal.
- **Expected time (TE):** the best estimate of the time required to accomplish a task, accounting for the fact that things do not always proceed as normal (the implication being that the expected time is the average time the task would require if the task were repeated on a number of occasions over an extended period of time).

$TE = (O + M + P) \div 3$

Sources of the 3 Point Estimates

- Furnished by an experienced person
- Extracted from standard time data
- Obtained from historical data
- Obtained from forecasting
- Generated by simulation
- Dictated by customer requirement

PERT Terminology

- **Float or Slack**: a measure of the excess time and resources available to complete a task.
- **Critical path**: the longest possible continuous pathway taken from the initial event to the terminal event.
- **Critical activity**: An activity that has total float equal to zero. An activity with zero float is not necessarily on the critical path since its path may not be the longest.

PERT Terminology

- **Lead** time is the amount of time it should take to complete a task without impacting the following activities.
- **Lag time**: the earliest time by which a successor event can follow a specific PERT event.
- **Fast tracking**: is when tasks and activities are performed simultaneously.
- **Crashing critical path**: Shortening duration of critical activities.

PERT

Activity	Predecessor	Time estimates			Expected time
		Optimistic (O)	Normal (M)	Pessimistic (P)	
A	—	2	4	6	
B	—	3	5	9	
C	A	4	5	7	
D	A	4	6	10	
E	B, C	4	5	7	
F	D	3	4	8	
G	**E**	**3**	**5**	**8**	

Advantages of PERT

- PERT chart explicitly defines and makes visible dependencies (precedence relationships) between the WBS elements.
- PERT facilitates identification of the critical path and makes this visible.
- PERT facilitates identification of early start, late start, and slack for each activity,
- PERT provides for potentially reduced project duration due to better understanding of dependencies leading to improved overlapping of activities and tasks where feasible.
- The large amount of project data can be organised and presented in diagram for use in decision making.

Disadvantages of PERT

- There can be potentially hundreds or thousands of activities and individual dependency relationships.
- The network charts tend to be large and unwieldy requiring several pages to print and requiring special size paper.
- The lack of a timeframe on most PERT/CPM charts makes it harder to show status although colours can help (e.g., specific colour for completed nodes)

Project Evaluation Review Technique (PERT) and Critical Path Method (CPM)

- ☑ Network techniques
- ☑ Consider precedence relationships and interdependencies
- ☑ Each uses a different estimate of activity times

CPM EXAMPLE

ACTIVITY	PREDECESSORS	DURATION
A	start	7
B	A	10
C	A	8
D	C	5
E	B,D	11
F	E	5
G	F	4
H	E	7
I	E	3
J	H,I	6
K	J	24
L	J	19
M	G,H	21
N	G,L	7
O	K	3
P	N,O	2
Q	M,P	2

Required

a) Construct a network diagram

b) Perform a forward & backward pass

c) Determine Project completion time

d) Calculate Slack values

e) State the critical path