Manage Operations

Handout 4

Sequential Steps for Planning

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Planning is one of the most important project management and time management techniques. Planning is preparing a sequence of action steps to achieve some specific goal. If a person does it effectively, they can reduce much the necessary time and effort of achieving the goal.

Develop a Work Breakdown Structure (WBS):

The WBS is a valuable tool in assisting the project team to organise the many work elements and to keep track of what is happening on the project. It describes all the work that needs to get done to complete the project, and forms the basis for costing, scheduling, diagramming and work assignments. The purpose of the WBS is to identify all the key activities and related tasks and sub-tasks that must be undertaken and completed.

The starting point will be to make a list of these activities in the sequence in which they will occur (Level 1). The next step will be to break each of these Level 1 activities down into various tasks (Level 2). Each task can then in turn be broken down into sub-tasks (Level3).

Continue the procedure until all meaningful tasks have been identified and each task can be individually planned, budgeted, scheduled, monitored and controlled. Remember that each activity has an outcome (event) associated with it. It should also be noted that the WBS does not show dependencies, just a task grouping under each key activity and that it is not time based.

Activity	Description of Activity or Task
a	
b	
c	
d	
e	
f	
g	
h	
i	
j	

Sequence The Key Activities:

Once the key activities have been identified in the WBS, they should be organised in a logical sequence to maximize concurrency. The duration of and people responsible for each activity should be disregarded at this stage, because it may result in errors in the project logic. An easy way to organise the activities in a logical sequence is to create a project logic diagram, whereby each key activity is written on a separate small card or self-adhesive note sheets. These cards can then be used to build a picture of the entire project, from start to finish. By making it visual (arranging cards on a table, or arranging the notelets on a wall), the project team can question and debate the validity of the logic as it grows. The notelets/cards can be connected with arrows to show the logical flow of the project. Provision should be made for both series activities and concurrent activities, focusing on the dependencies between activities.

Activity	**Description of Activity / Task**	**Immediate predecessor activities**
a		-
b		-
c		-
d		A
e		b,c
f		b,c
g		b,c
h		c
i		g,h
j		d,e

Assign Responsibility:

The project manager needs to ensure that the work is done on time and according to quality specifications. Responsibility for the implementation of each key activity should be assigned in a fair and even way to the various team members, whereby:

- The work to be done is identified at the detailed task level
- The dependencies are clearly identified
- The time estimates are accurate and subject to constant scrutiny
- The work gets done on time in accordance with the quality specifications
- Regular monitoring is maintained
- Regular accurate status reports are issued
- Problems and issues are alerted promptly to the project manager.

Determine the Duration Of Activities:

The next step is to estimate and forecast the duration of each key activity. An estimate is a decision about how much time is required to complete an activity at an acceptable standard of performance. The "size" of the activity and the amount of "effort" required in completing the work need to be determined. Duration is the conversion of effort taking into account the number of people involved, their capacities and an allowance for non-productive time.

Duration is never the same as the schedule, since it is measured in real working days that take non-available days, weekends, public and staff holidays into account.

In forecasting duration, it is also essential to make provision for contingencies. Murphy's Law requires that a buffer be built into the estimated duration of each activity. This can be done by developing four time estimates for each activity:

- the most likely time (estimated time required if normal problems and interruptions occur),
- the optimistic time (estimated time required if virtually no problems occur),
- the pessimistic time (estimated time required if problems and interruptions of an unusual nature occur)
- and the expected time (some form of weighted average of the most likely, optimistic and pessimistic time estimates).

Schedule the Project:

Project scheduling is in essence the conversion of the WBS into an operating timetable. It serves as a basis for monitoring and controlling project activity and, taken together with the plan and budget, is probably the major tool for the management of projects.

The basic approach to all scheduling techniques is the development of a network diagram that graphically portrays the sequential relations between the tasks in the project.

Such networks are powerful tools to ensure the timeous implementation and control of the various project activities and have the following benefits:

It is a consistent framework for planning, scheduling, monitoring and controlling the project

- It illustrates the interdependence of all activities, tasks, work packages and work elements
- It denotes the times when specific individuals must be available for work on a given task
- It aids in ensuring that the proper communications take place between departments and functions
- It determines an expected project completion date
- It identifies so-called critical activities that, if delayed, will delay the project completion time
- It also identifies activities with slack time that can be delayed for specific periods without penalty or from which resources may be temporarily borrowed without harm
- It determines the dates on which tasks may be started – or must be started if the project is to stay on schedule
- It illustrates which tasks must be coordinated to avoid resource or timing conflicts
- It also illustrates which tasks may be run, or must be run, in parallel to achieve the predetermined project completion date
- It relieves some interpersonal conflict by clearly showing task dependencies
- It may, depending on the information used, allow an estimate of the probability of project completion by various dates or the date corresponding to a particular priority probability.

In order to create a network diagram, the following steps must be followed:

Make a list of all the activities that have to be performed (use the WBS).

- Establish the interrelationships between activities: determine which activity starts the project and which activity ends the project; determine which activity precedes and which one follows a given activity; determine which activities can run concurrently.
- Identify the milestones you would like to specify.
- Lay out the activities and milestones on a network.
- Review the logic and practicality of the network.

Common networking techniques include the Program Evaluation Review Technique (PERT) and the Critical Path Method (CPM). We will discuss these techniques first and then look at a simple way to convert PERT/CPM data into a graphic format that is easier to work with and understand.

PERT/CPM:

PERT and CPM are quite similar and will be discussed in a combined way. Originally, PERT primarily focused on the time element of projects and used probabilistic activity time estimates to determine the probability that a project could be completed by some given date. CPM though, used deterministic activity time estimates and was designed to control both the time and cost elements of a project, in particular time/cost trade-offs. In CPM, activities can be "crashed" (expedited) at extra cost to speed up the completion time.

Both techniques identified a project critical path whose activities could not be delayed and also indicated activities with slack (or float) that could be somewhat delayed without lengthening the project completion time. These techniques are similar in the sense that one can estimate probabilistic CPM times and one can "crash" PERT networks.

PERT/CPM is based on representing the activities in a project by boxes (nodes) and showing the interdependencies between the boxes/nodes by means of arrows. All the nodes are connected, providing a visual picture of the flow of the project through its various paths. The PERT/CPM diagram or network is identical to the logic diagram we discussed earlier: each card/notelet for a key activity will be represented in the network by a node. This format for developing a network is known as the AON (activity-on-node) network.

Another format is an AOA (activity-on-arrow) network, where arrows represent activities and nodes represent events.

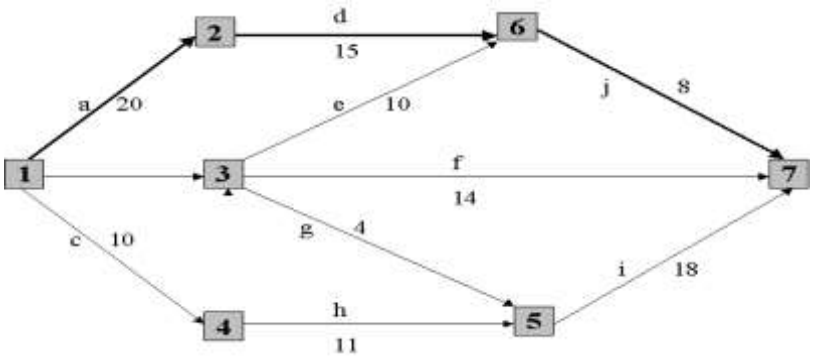
Let us work through an example to illustrate the network technique in the AOA format:

Activity	Description of Activity / Task	Expected time	Immediate predecessor activities
a		20	-
b		20	-
c		10	-
d		15	a
e		10	b,c
f		14	b,c

g		4	b,c
h		11	C
i		18	g,h
j		8	d,e

Take note that we should start the network by identifying those activities with no predecessors. In this case activities a, b and c qualify and they can be drawn from the starting node. Next, we need to consider those activities that have certain successors. Activities d to j qualify.

The trick is to now present them on the network in a way that makes sense. Once this is done, the estimated times can also be filled in, where after the critical path and time can be determined. The completed network should look as follows:



Activity-on-arrow

Event 1 represents the start of the project and event 7 the finish. In order to establish the critical path (the longest path through the network that will determine the shortest time to complete the project – the critical time), we need to calculate the total times of all the paths leading from start to finish:

a-d-j = 20 + 15 + 8 = 43 days

b-e-j = 20 + 10 + 8 = 38 days

b-f = 20 + 14 = 34 days

b-g-i = 20 + 4 + 18 = 42 days

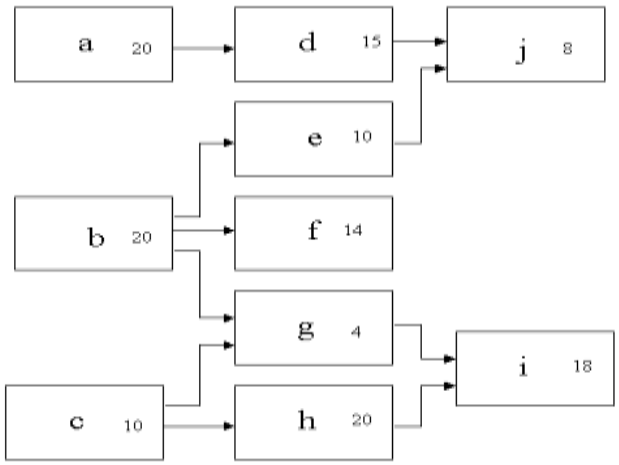
c-h-i = 10 + 11 + 18 = 39 days

c-dummy-e-j = 10 + 0 + 10 + 8 = 28 days

c-dummy-f = 10 + 0 + 14 = 24 days

c-dummy-g-i = 10 + 0 + 4 + 18 = 32 days

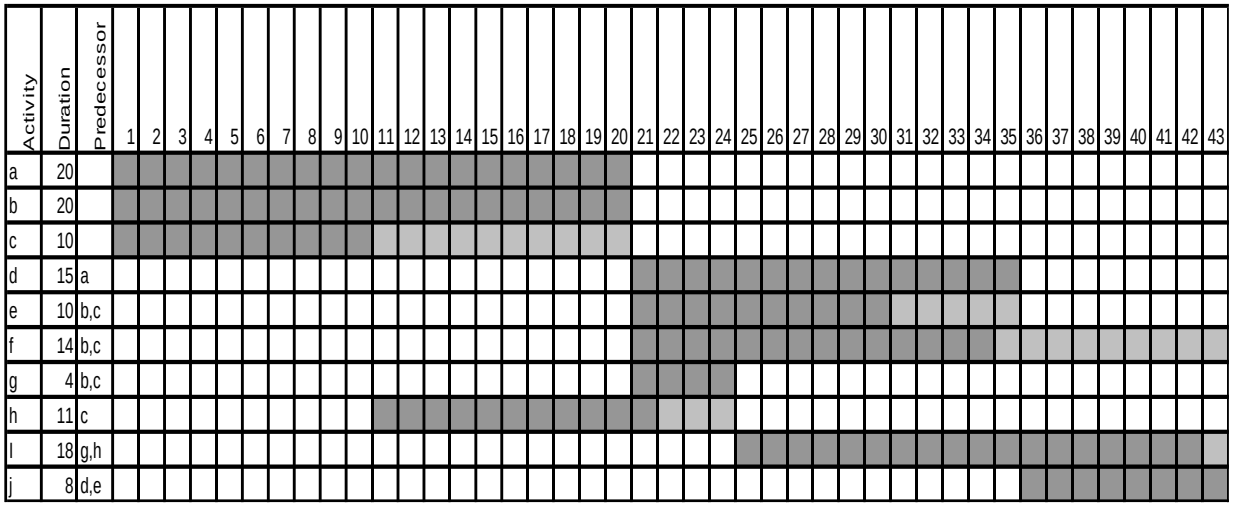
The longest path is a-d-j taking 43 days, meaning that 43 days is the shortest time within which the entire project can be completed. 43 days is hence the critical time and a-d-j the critical path, which is usually indicated on the network as a heavy line. Can you identify the critical activities, i.e. those activities that, if delayed, will delay the completion of the project? Which activities are non-critical?



Activity-on-node

The Gantt Chart

Once a network diagram has been developed, the information can be depicted on a Gantt chart – utilising the same WBS as a template for the Gantt chart. This is a very useful tool that was developed by Henry Gantt during World War 1. It is a scheduled graph that displays the various activities, their duration and other information in a visual format. Our previous example will look as follows on a Gantt chart (note the use of the same elements of the WBS as a template):



The light grey areas on the chart depict float or slack time, or additional time that may be used on the activity without threatening the schedule. Take note that the critical activities (a, d and j) do not have any float time, because if these activities are delayed, it will result in late completion of the project. If a calendar bar is included across the top of the chart, it allows the inclusion of non-working days such as weekends and holidays. If the critical time is longer than a deadline that might have been set for project completion, the use of the Gantt chart assists in expediting, sequencing and reallocating resources among activities. The chart is also helpful in keeping track of the progress of the project.

The Gantt chart can also show some other valuable information such as:

- Milestones: special checkpoints usually indicated by a triangle or a diamond symbol
- Project meetings: indicated by a filled circle or dot
- Project reviews (e.g. audit): indicated by a filled square
- Key decision points: often called "gates".

And using legend descriptions for various chart references.

Determine The Resource Requirements:

Resources include the time, people, money, equipment and facilities used to complete the project. The allocation of time (scheduling) has been discussed in the previous paragraphs. The allocation of physical resources needs to be considered as well.

Physical resources such as labour-hours and machine-hours are often fixed and if the required resources for a project are higher or lower than the resource capacity, optimization becomes a problem (underutilization/insufficient supply). If the project schedule can be adjusted to smooth the use of the resource, project delays may be avoided, and the project will not be saddled with the high cost of excess resources allocated "just to make sure".

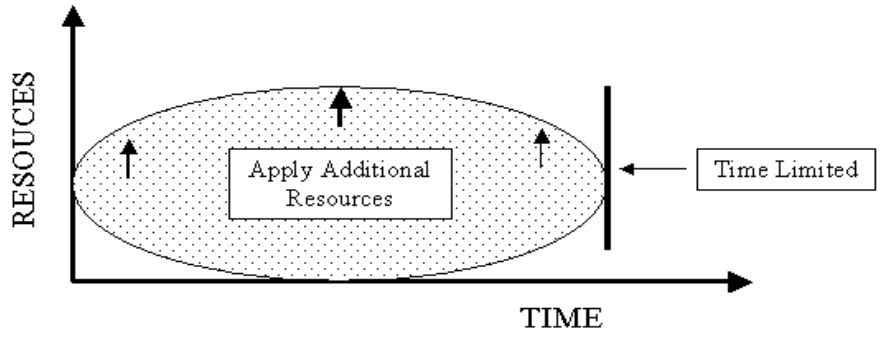
EXAMPLE:

The scope of work determines that 12 tons of steel needs to be erected and past experience dictates that the work can be done in 150 man-hours per ton and the men work 10 hour shifts, thus:

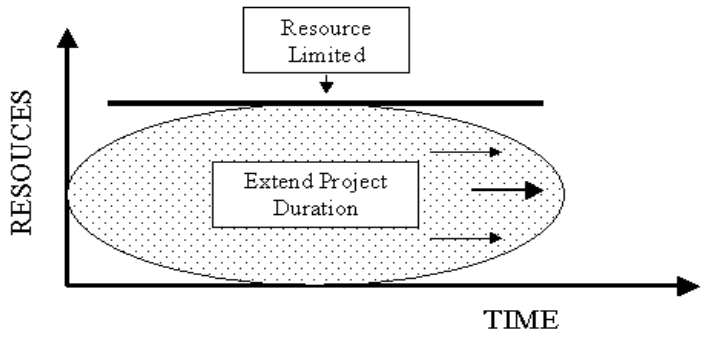
$$\frac{\text{12 tonnes x 150 man-hours per tonne}}{\text{10 hours per day}} = \text{180 man-days}$$

It is important to remember when resources are planned for the project, that different scenarios need to be considered:

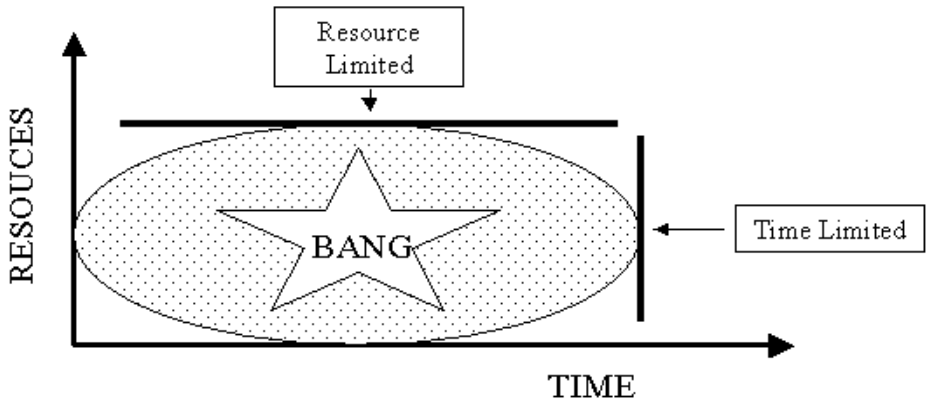
Time-Limited Resource Scheduling:



Resource-Limited Resource Scheduling:



Time & Resource-Limited Resource Scheduling:



The challenge for the project manager is to find the best trade-offs among resources (including time) throughout the duration of the project. The project team has to determine the total loading and availability from project activities on each resource for each time period of the project's duration (resource loading) and then even out the demand for various resources required by shifting activities within their slack allowances (resource levelling).

If it is necessary to speed up a project, two techniques may be considered: crashing the project, which means that you attempt to expedite an activity by the application of additional resources, e.g. overtime, special equipment or additional staff and material. This will obviously result in higher costs; therefore, a time/cost trade-off must be made.

The second technique is known as fast-tracking, mostly used in the construction industry, where the design and construction of a building are overlapped, resulting in shorter project duration.

It is important to compare with the resources available, so that resource smoothing can be done where necessary. The best way of doing so is to create a resource histogram as in the above example. The resource forecast is normally derived from the Bar Chart based on Early Start and the assumption that resources are unlimited (as a first step plan).

RESOURCE TABLE: utilising the WBS template previously formed

Activity or Task Number	Resource Type	Quantity per day	Resource Duration	Lead Time
A	Welder	2	2	0
B	Welder	4	4	2
C	Welder	3	2	6

Determine the project cost and budget:

In order to develop a project budget, the project team has to forecast what resources will be required, the quantity of each, when they will be required and how much they will cost – including the effects of potential price inflation. Uncertainty plays a major role in the budgeting process and must be catered for. Costs that need to be calculated include:

- Capital equipment costs
- Resource direct costs
- Revenue costs for the project team
- Indirect costs, e.g. overheads.

There are a number of budgeting methods. Let us consider two common ones:

Top-down budgeting: Available historic data concerning similar activities and the estimates of top and middle managers are collected to calculate the overall project cost as well as the costs of Level 1 activities in the WBS. The cost estimates are then passed on to lower level managers, who continue the breakdown into estimates for the specific tasks and sub-tasks all the way to the lowest level.

Bottom-up budgeting: The WBS is once again consulted and the individual budgets and schedules of elemental tasks are constructed from the lowest level up to the highest level. The task budgets are then aggregated to determine the total cost of the project. Once a project reserve and a profit figure has been added, the final project budget can be arrived at.