

## Critical Path Analysis & PERT Charts

### Planning and scheduling more complex projects

The benefit of using CPA over Gantt Charts is that Critical Path Analysis formally identifies tasks which must be completed on time for the whole project to be completed on time, and also identifies which tasks can be delayed for a while if resource needs to be reallocated to catch up on missed tasks. The disadvantage of CPA is that the relation of tasks to time is not as immediately obvious as with Gantt Charts. This can make them more difficult to understand for someone who is not familiar with the technique.

A further benefit of Critical Path Analysis is that it helps you to identify the minimum length of time needed to complete a project. Where you need to run an accelerated project, it helps you to identify which project steps you should accelerate to complete the project within the available time. This helps you to minimize cost while still achieving your objective.

As with Gantt Charts, the essential concept behind Critical Path Analysis is that you cannot start some activities until others are finished. These activities need to be completed in a sequence, with each stage being more-or-less completed before the next stage can begin. These are 'sequential' activities.

Other activities are not dependent on completion of any other tasks. You can do these at any time before or after a particular stage is reached. These are non-dependent or 'parallel' tasks.

Use the following steps to draw a CPA Chart:

#### 1. List all activities in the plan

For each activity, show the earliest start date, estimated length of time it will take, and whether it is parallel or sequential. If tasks are sequential, show which stage they depend on.

For the project example used here, you will end up with the same task list as explained in the article on Gantt Charts (we will use the same example as with Gantt Charts to compare the two techniques). The chart is repeated in figure 1 below:

#### **Figure 1. Task List: Planning a custom-written computer project**

*NB: The start week shows when resources become available. Whether a task is parallel or sequential depends largely on context.*

Task	Possible start	Length	Type	Dependent on...
1. High level analysis	week 1	5 days	sequential	
2. Selection of hardware platform	week 1	1 day	sequential	1
3. Installation and commissioning of hardware	week 3	2 weeks	parallel	2
4. Detailed analysis of core modules	week 1	2 weeks	sequential	1
5. Detailed analysis of supporting utilities	week 1	2 weeks	sequential	4
6. Programming of core modules	week 4	3 weeks	sequential	4

7. Programming of supporting modules	week 4	3 weeks	sequential	5
8. Quality assurance of core modules	week 5	1 week	sequential	6
9. Quality assurance of supporting modules	week 5	1 week	sequential	7
10. Core module training	week 7	1 day	parallel	6
11. Development of accounting reporting	week 6	1 week	parallel	5
12. Development of management reporting	week 6	1 week	parallel	5
13. Development of management analysis	week 6	2 weeks	sequential	5
14. Detailed training	week 7	1 week	sequential	1-13
15. Documentation	week 4	2 weeks	parallel	13

## 2. Plot the activities as a circle and arrow diagram

Critical Path Analyses are presented using circle and arrow diagrams.

In these, circles show events within the project, such as the start and finish of tasks. Circles are normally numbered to allow you to identify them.

An arrow running between two event circles shows the activity needed to complete that task. A description of the task is written underneath the arrow. The length of the task is shown above it. By convention, all arrows run left to right.

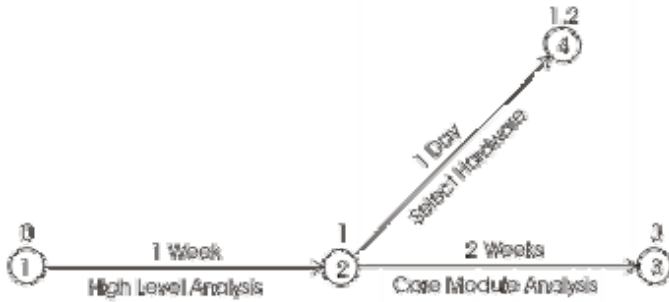
An example of a very simple diagram is shown below:

Figure 2: Simple Circle and Arrow Diagram



This shows the start event (circle 1), and the completion of the 'High Level Analysis' task (circle 2). The arrow between them shows the activity of carrying out the High Level Analysis. This activity should take 1 week.

Where one activity cannot start until another has been completed, we start the arrow for the dependent activity at the completion event circle of the previous activity. An example of this is shown below:



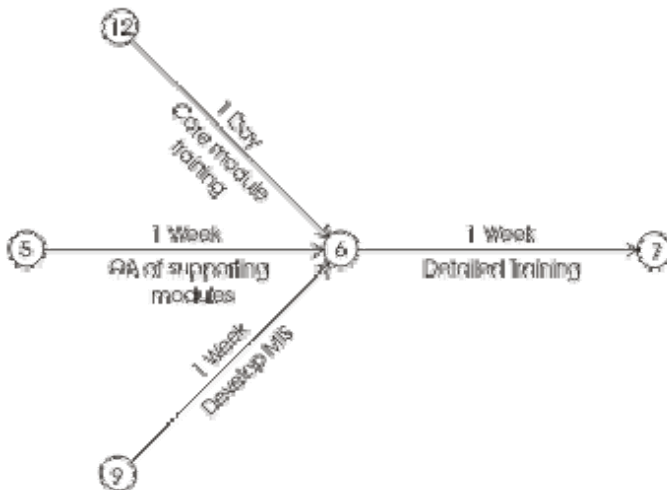
**Figure 3: Circle and Arrow Diagram showing two activities that cannot be started until the first activity has been completed.**

Here the activities of 'Selecting Hardware' and 'Core Module Analysis' cannot be started until 'High Level Analysis' has been completed. This diagram also brings out a number of other important points:

- Within Critical Path Analysis, we refer to activities by the numbers in the circles at each end. For example, the task 'Core Module Analysis' would be called 'activity 2 to 3'. 'Select Hardware' would be 'activity 2 to 4'.
- Activities are not drawn to scale. In the diagram above, activities are 1 week long, 2 weeks long, and 1 day long. Arrows in this case are all the same length.
- In the example above, you can see numbers above the circles. These show the earliest possible time that this stage in the project will be reached. Here units are whole weeks.

A different case is shown below:

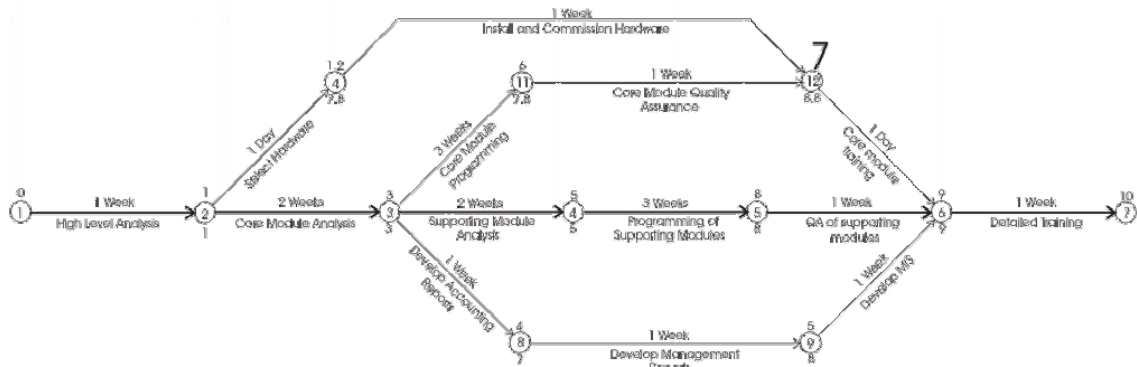
**Figure 4: Circle and Arrow Diagram showing an activity (6 to 7) that cannot start until other activities (12 to 6, 5 to 6, and 9 to 6) have been completed.**



Here activity 6 to 7 cannot start until the other three activities (12 to 6, 5 to 6 and 9 to 6) have been completed.

See below for the full circle and arrow diagram for the computer project we are using as an example.

Figure 4: Critical Path Analysis for Example Computer Project



This shows all the activities that will take place as part of the project. Notice that each event circle has a figure below it as well as a figure above. This shows the latest time that it can be reached with the project still being completed in the minimum time possible. You can calculate this by starting at the last event (in this case number 7), and working backwards.

You can see that event 4 can be completed any time between 1.2 weeks in and 7.8 weeks in. The timing of this event is not critical. Events 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6 and 6 to 7 must be started and completed on time if the project is to be completed in 10 weeks. This is the 'critical path' - these activities must be very closely managed to ensure that activities are completed on time. If jobs on the critical path slip, immediate action should be taken to get the project back on schedule. Otherwise completion of the whole project will slip.

### 'Crash Action'

You may find that you need to complete a project earlier than your Critical Path Analysis says is possible. In this case you need to take action to reduce the length of time spent on project stages.

You could pile resources into every project activity to bring down time spent on each. This would probably consume huge additional resources.

A more efficient way of doing this would be to look only at activities on the critical path.

As an example, it may be necessary to complete the computer project in figure 5 in 8 weeks rather than 10 weeks. In this case you could look at using two analysts in steps '2 to 3' and '3 to 4', and two programmers instead of one in step '4 to 5'. This would shorten the project by two weeks, but would raise the project cost - doubling resources at any stage often only improves productivity by, say, 50%. This occurs as time spent on coordinating the project consumes time gained by increasing resource.

Note that in this example, shortening the project by two weeks brings activities '3 to 11', '11 to 12' and '12 to 6' onto the critical path as well.

### PERT (Program Evaluation and Review Technique)

PERT is a variation on Critical Path Analysis that takes a slightly more skeptical view of time estimates made for each project stage. To use it, estimate the shortest possible time each activity will take, the most likely length of time, and the longest time that might be taken if the activity takes longer than expected.

Use the formula below to calculate the time to use for each project stage:

$$\frac{\text{shortest time} + 4 \times \text{likely time} + \text{longest time}}{6}$$

This helps to bias time estimates away from the unrealistically short time-scales normally assumed.

**Key points:**

Critical Path Analysis is an effective and powerful method of assessing:

- What tasks must be carried out
- Where parallel activity can be performed
- The shortest time in which you can complete a project
- Resources needed to execute a project
- The sequence of activities, scheduling and timings involved
- Task priorities
- The most efficient way of shortening time on urgent projects.

An effective Critical Path Analysis can make the difference between success and failure on complex projects. It can be very useful for assessing the importance of problems faced during the implementation of the plan.

PERT is a variant of Critical Path Analysis that takes a more skeptical view of the time needed to complete each project stage.