



M253 Resource Sheet

Project planning and scheduling

1 Overview

The first step in planning a project is *finding out what to do*. Once the tasks that make up a project have been identified, it becomes important to *determine what order the tasks must be done in and how long they might take*. Once that is known, the project planner can develop a schedule, working either from a starting date, or from a date by which the project must be completed. This resource sheet described techniques for planning a simple project.

2 Introduction

Determining what to do involves decomposing the goal of the project into smaller units that can be used to plan. A technique known as the work breakdown structure or WBS helps the planner to identify the tasks that make up the project.

The next stage of planning is the key to determining deadlines for the delivery of the completed project. It is also sometimes the case that a project is constrained by time from the outset (such as a student project that must be submitted by a certain date), in which case a key to success is determining how to apportion the time available for work in order to complete the project on time.

Usually, people vastly *underestimate* the time required for tasks. The reasons for this vary.

- The people carrying out the work may not be familiar with the task and thus have little basis on which to judge accurately how long something might take.
- Even experienced people can forget to take into account unexpected events, the fact that things can go wrong and may need to be re-done, or that other work may take priority over the task in hand.
- People often fail to take account of the complexity of project work, particularly where several people are trying to work together.

Some tasks can be done at the same time as others, but some must start, or be completed, before others can begin. Perhaps the easiest way to see this is to develop a graphical representation of tasks that indicates which tasks depend upon the start or completion of others. Such a graphical representation is usually made in the form of a network. This document describes a simple network technique (a simple network method) that is likely to be sufficient for simple projects; however, it also forms the basis for two more advanced techniques listed below.

2.1 Critical path analysis (CPA)

This is a technique that involves analysing the identified tasks, each of whose earliest and latest times are estimated, determining all the relationships between tasks in terms of their precedence to produce a graphical representation of the project as a network, then identifying within that network a *critical path* on which lie those tasks whose completion is critical for the timely completion of the project. Other activities with more flexibility as to their timing can then be slotted in.

2.2 Project evaluation and review technique (PERT)

This is a variation of critical path analysis that takes a more pessimistic view of a project. It differs from CPA in that the project planner produces a series of estimates for the duration of each task: the shortest possible time a task will take, the most likely time a task will take, and the longest time it might take. The technique then involves applying a formula to estimate the duration for planning purposes. This ensures that a project's plans are not unduly biased by overly optimistic estimates of time required for each task.

See the *Further resources* section below for further information on CPA and PERT.

3 Identifying tasks

3.1 Preparing a work breakdown structure

A work breakdown structure is a way of specifying in detail the work to be done by decomposing big tasks into their component smaller tasks, until a list of tasks emerges. When the planner reaches an appropriate level of detail (see below), it is time to stop decomposing tasks and to list them.

The planner needs to be guided by some simple guidelines:

- the splitting of major work into tasks should be logical;
- it should be possible to test objectively when the work is complete;
- at the lowest level the work elements should be well-defined tasks for one individual to perform within a reasonable period – say, from a day to a week.

Example 1 Refurbishing a hospital ward

Figure 1 below shows the beginning of a work breakdown structure: the planner has tried to decompose the project objective – refurbishment of a ward – into major ‘packages’ of work in a logical way.

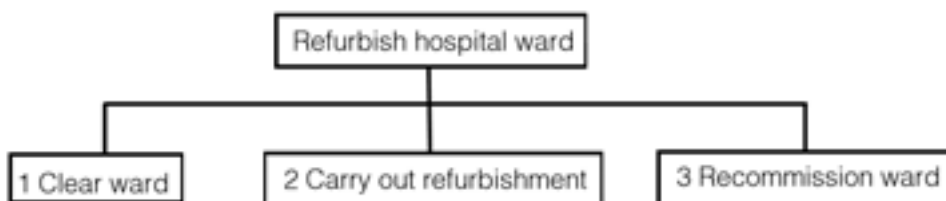


Figure 1 Beginning the work breakdown structure: top-level divisions

The next step is to decompose each work “package” into some components tasks. Figure 2 below shows this further level of decomposition.

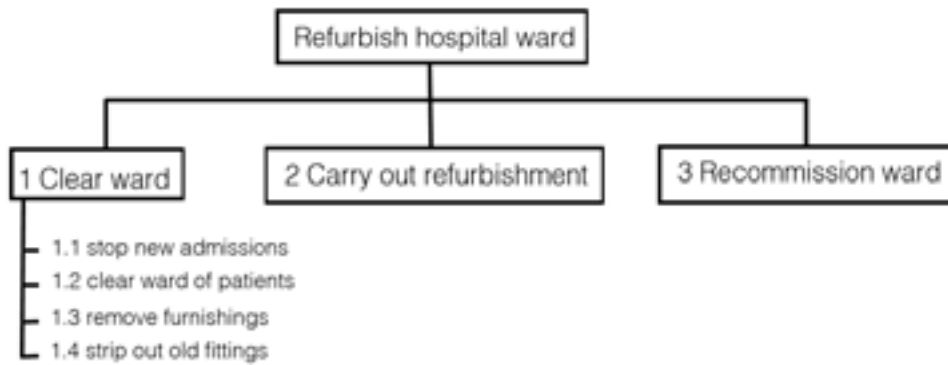


Figure 2 The next level of decomposition. Note that the planner will probably take item 1.4 (strip out old fittings) and subdivide this further, as electrical fittings should be done by an electrician, but other work can be done by a general construction worker

Finally, the tasks identified in this way should be listed. The left two columns of Figure 3 below form such a task list.

<i>Task identifier</i>	<i>Task</i>	<i>Estimated duration (days)</i>
A	Stop new admissions to ward	0
B	Clear ward of patients	3
C	Remove furnishings	1
D	Strip out old electrical fittings and trunking	2
E	Remove floor coverings	2
F	Install new electrical fittings and trunking	4
G	Lay new flooring	2
H	Paint walls and ceiling	4
J	Replace furnishings	1
K	Hang new partition curtains and window curtains	2
L	Begin new admissions to ward	0

Figure 3 Estimating duration of tasks for refurbishment and redecorating a hospital ward

4 Estimating duration

The simplest way to estimate how long a project might take is to make a list of the tasks that make up a project as you saw in the previous section. Number the tasks (this enables you to identify them – it does not imply any order in which they must be done, so using letters of the alphabet may be less confusing than using numerals) and list them down the left-hand side of a piece of paper. Create a new column, in which you enter the time you estimate a task will take. Figure 3 above shows an example for minor refurbishment and the redecorating of a hospital ward. Estimates in this example are based on those of an experienced quantity surveyor. (Note that the letter I has not been used as an identifier: this is because it, and the letter O, are easily confused with numerals.)

5 Determining order: which tasks to do before others

If you examine Figure 3 carefully, you will see that some tasks *must* be done before others can start. For example, it is not possible to remove the furnishings (beds, bedside lockers, visitors' chairs, etc.) until there are no patients using them. (Whilst it might seem possible to remove each set of bed, chair and bedside locker as each patient is discharged from the ward, this would have an adverse effect on patients remaining there and it doesn't provide any substantial gains in time to do so.)

The next step then is to expand the table shown in Figure 3 to include a new column that lists, for each task, any predecessor tasks it may have. The revised table will appear as in Figure 4.

<i>Task identifier</i>	<i>Task</i>	<i>Predecessors</i>	<i>Estimated duration (days)</i>
A	Stop new admissions to ward	—	0
B	Clear ward of patients	—	3
C	Remove furnishings	B	1
D	Strip out old electrical fittings and trunking	C	2
E	Remove floor coverings	C	2
F	Install new electrical fittings and trunking	D, E	4
G	Lay new flooring	E, F	2
H	Paint walls and ceiling	F, G	4
J	Replace furnishings	H	1
K	Hang new partition curtains and window curtains	H	2
L	Begin new admissions to ward	J, K	0

Figure 4 Table extended to show predecessor tasks

From this example, you can see that some tasks (usually early ones) do not have predecessors, whilst others have one and some two. A list of this kind for a very simple project may be sufficient, but it is often wise to proceed to turn this into a graphical form. Some project management software applications will do this automatically based on a list such as Figure 4, but it can easily be done by hand for simple projects. This information sheet describes how to represent this graphically by hand.

Place a sheet of paper in front of you in the landscape orientation (that is, with the longer side of the paper parallel to the edge of your desk or table). The horizontal edges of the paper roughly represent the passage of time. (Some people prefer to work vertically – there are no set rules for this.)

It is not necessary to draw the network to any scale, but it can be helpful to have a rough scale (such as approximately 3 cm to a day or week) in mind. Few simple projects require such a high quality of documentation that a scaled diagram is necessary, and in complex projects, the drawing of a scaled diagram takes place *after* plans are largely finalised.

The notation used in drawing up networks uses circles or boxes connected by arrows or lines. The circle or box (it does not really matter which) identifies the task using the task identifier assigned in the earlier stage of estimating duration, and the connecting arrow or line indicates the duration of the task. (Additional sheets of paper can be attached together if the ‘time line’ becomes long.)

There are some simple rules-of-thumb that can aid the planner in setting out the network.

- Any task that has no predecessor tasks is a candidate for the first task in the network. If there is no clear candidate for this because there are several such tasks, create a ‘dummy’ task, such as ‘start project’ with a duration of zero time, to form a neat chart with a single beginning point.
- Any task that has no successor tasks is a candidate for the last task in the network. If there is more than one candidate task, create a ‘dummy’ task, such as ‘end project’ with a duration of zero time, to form a single ending point.

Select the task with no predecessors (or the dummy beginning task) as being the earliest.

Begin with the earliest task on the left, drawing a circle labelled with the task identifier, as shown in Figure 5.

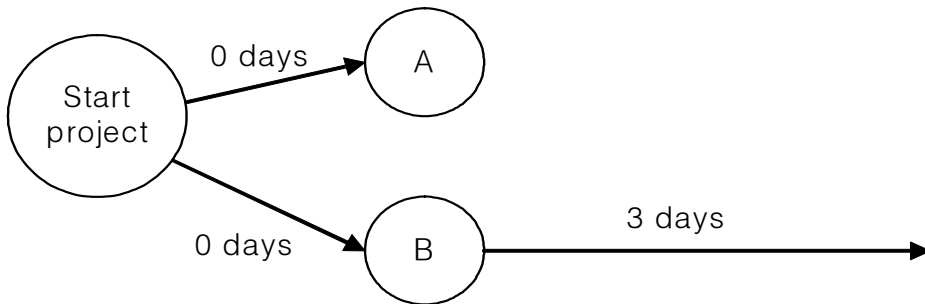


Figure 5 Basic nodes and arrows, showing two tasks, one of which is of zero duration, beginning at the same time

Now for each additional task, draw another node, taking into account predecessors identified as part of the earlier step shown in Figure 4 above. The result will look like Figure 6 below.

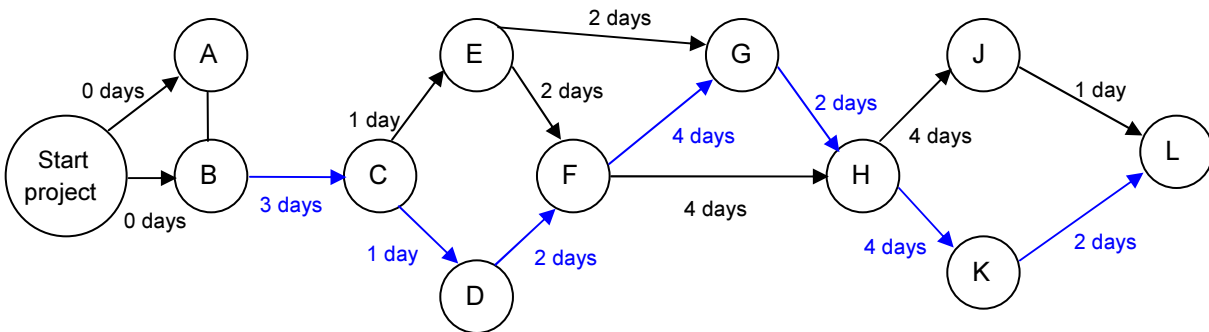


Figure 6 Completed first-pass network diagram for refurbishing and redecorating a hospital ward

You will see from Figure 6 that tasks that *can* be done in parallel (given sufficient resources to do so) are clearly identified using this technique, as are the dependencies between tasks. Note that some of the arrows will not correspond directly to the duration of a task. For example, in Figures 2 and 4, task G depends on the completion of tasks E and F. Task E requires 2 days and task F requires 4 days, and F cannot commence until E is complete. So the duration between the start of E and the start of G is not 2 days (E to G) and not 4 days (F to G) but 6 days (E to F to G). Tasks with zero duration still need an arrow to connect them to subsequent tasks, but it is not possible to draw a (visible) arrow with no length!

By ordering, then adding together, all the task durations taking into account dependencies, it becomes possible to calculate the total duration of the project.

Exercise 1

Calculate the total duration in days for the project of refurbishing and redecorating the hospital ward based on Figures 2 and 4 above.

Discussion

Doing this requires you to have identified that sequences of tasks such as E to F to G must be done one after the other, that H to J and H to K can be done in parallel, and that J to L and K to L can be done in parallel, but will take as long as the longer of the two tasks. Note that tasks that can be done in parallel are often of different durations: the shorter task can either begin at the same time as the longer task, or can begin later without affecting the overall timing of the project. This leeway in starting or finishing a task is referred to as float. The network can now be viewed as identifying those tasks with potential *float* and those without.

The sequence of tasks dictating the overall time required for this project is B to C to D to F to G to H to K to L. This path through the network is highlighted in Figure 6. In cases where there are alternative paths, the longest is chosen; if durations of alternative paths are the same, one can be chosen arbitrarily. Doing this enables the planner to identify the *critical path*: a sequential path through the network that has the least float – altering the starting times or durations of tasks on this path will affect the duration of the entire project.

Adding up the durations for those arrows yields:

$$3 + 1 + 2 + 4 + 2 + 4 + 2 = 18 \text{ days.}$$

Note that this duration is the duration in working days, not calendar days! (Longer projects might be estimated using weeks instead of days, in which case the estimate would be for a duration in working weeks.)

6 Setting a schedule

There are two ways to set a schedule, depending upon whether the project planner has the ability to determine the completion date based on his or her plans, or whether the project already has a deadline that has to be achieved. This section examines both possibilities using the example of refurbishing and redecorating a hospital ward as shown in Figures 2 and 4.

6.1 Finding a completion date

Assume that the hospital trust has approached the estates manager to ask how long it would take to refurbish and redecorate a ward. Given that the planning and organization of the project will take some time, the question that is likely to follow is: when can this project be completed by?

The project planner has already developed the network as shown in Figure 6. Making certain assumptions about the time required to complete the planning and organize the project in terms of getting resources booked or held in reserve (electricians, flooring people, decorators, porters for moving the furnishings, and floor covering, paint, curtains, and so on), let us assume that the project planner believes that the project can start on Monday the 1st of September. The project is assumed to take 18 *working days* to complete. Figure 7 shows a calendar for use in making this scheduling estimate.

September						
Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					
October						
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Figure 7 Planning calendar

The planner now sets this against real dates. Tasks A and B can both begin on the 1st. This means that task C can begin on Thursday the 4th of September, and takes only the day of the 4th to complete. Tasks D and E, which can be done in parallel (if there are sufficient resources!) can begin on Friday the 5th, with a weekend intervening between the first and second days of work. So both D and E should complete by the end of Monday the 8th, and F can begin on Tuesday the 9th. Task F takes 4 days, so completes on Friday the 12th. Task G, which depends on the completion of both tasks E and F, cannot begin until F is complete, and that is going to involve waiting through another weekend. So task G cannot begin until Monday the 15th. Task H begins on the 17th and takes 4 days, which means that yet another weekend intervenes in the work schedule, bringing the completion date of task H to Monday the 22nd. Tasks J and K can begin on the 23rd, and as K takes 2 days, L can begin at the earliest (and assuming nothing has happened that will require over-running this schedule) on the 25th of September.

Exercise 2

Calculate the total elapsed time between the start of the project and the date when new patients can start to be admitted to the ward.

Discussion

This example conveniently begins on the 1st of the month, and we have now found that the final task – admitting new patients – begins on the 25th of the same month. So the total *elapsed (or calendar) time* is 25 days. (Note that this will differ if a different starting day of the week is used or a public holiday intervenes.)

The project planner can now give the hospital trust a date by which the project should be complete (but note the warning in Section 7 below).

6.2 Planning from a pre-determined completion date

Suppose instead that the hospital trust comes to their estates manager and asks that the project to refurbish and redecorate the ward takes place during what they feel sure will be a relatively slack period when hospital admissions are likely to be low. The trust also wants to ensure that plenty of beds are available when the 'flu season commences and admissions are likely to rise steeply. They estimate that this is likely to occur with the onset of cold weather, which they believe will be about the middle of

October. Thus they place a constraint on the project: it must be completed by the 15th of October at the latest.

When a pre-determined completion date forms a constraint on a project, then planning dates by which tasks must start is very similar to finding the completion date except that the planner *works backwards* from the completion date.

Exercise 3

Use the example of the project in Figures 2 and 4 and the calendar in which the 1st of September falls on a Monday (shown in Figure 7) to calculate the start date of the project and its component tasks.

Discussion

Working backwards and remembering the *critical path* identified in Figure 6, task L should begin on the 15th, which is a Wednesday. Task K takes 2 days, so should begin on the Monday, which is the 13th of October (and task J can begin at the same time). A weekend intervenes here, so task H can begin no later than Tuesday the 7th of October. Another weekend will intervene between the start and finish of task G, so task G must begin on Friday the 3rd of October. Task F thus begins on Monday the 29th of September. Task E begins (because of an intervening weekend) on the 25th of September, as can task D. Task C can begin on the 24th of September, which is a Wednesday. Task B, which takes 3 days, could actually begin 3 days earlier despite the intervention of the weekend (because hospitals normally function seven days a week), so no new patients should be admitted after Sunday the 21st, though depending upon the dynamics of patient admissions and how the ward is used it may make most sense to begin the process of not admitting new patients to the ward beginning from Friday the 19th.

Thus, the latest date by which work has to begin would be Friday the 19th (or Sunday the 21st, depending on admissions policies and the type of ward).

7 Of course ...

Of course, things, including projects, rarely go exactly according to plan. The longer the duration, the more people involved, or the more complex the project in terms of the numbers and interdependencies of its constituent tasks, the greater the chance that more advanced techniques such as PERT will be required, and the greater the probability that the project will be completed late or that the quality of the final product will be compromised.

Accurate estimates of time, and thus accurate schedules, are only achievable once the planner has a detailed list of all the tasks that must be completed. Then it is necessary to determine how long each task will take, possibly by using one's best guess (though experienced project planners will have a wealth of experience to draw on, which is why documenting progress and time used is a valuable tool for future plans).

It is vital for the success of a project to allow time for:

- project management tasks;
- project planning tasks;
- liaison with others, including customers, suppliers, co-workers and other *stakeholders*;
- meetings;
- delays in communications;
- quality assurance tasks;
- writing any documentation necessary and making notes.

Good plans, even for simple projects, also allow time for:

- urgent tasks (whether part of this project or something else) to be carried out which have priority over this one;
- accidents and emergencies;
- holidays;
- sickness in essential staff;
- breakdowns in equipment;
- missed deliveries by suppliers;
- interruptions;
- rejection of work because of quality problems;
- etc.

These can more than double the length of time needed to complete a project.

Some of these items can be *timetabled* into the plans. For example, the dates of public holidays are known in advance, and usually individual project team members' holiday plans can either be known in advance or adjusted to fit the schedule through negotiation.

As a rule of thumb, individuals effectively work about 60% of the time, they allocate to a task or project, so for an eight hour day one can normally plan on just under five hours of productive work. (If this sounds low, the rest of the time is consumed in often necessary interruptions, the time taken to stop thinking about one task and switch to working on another, and so on.) So if a task requires 16 hours, one needs to assume that the elapsed time it will take will need to be lengthened by about 40% to take into account the times when work is not effective.

The Resource Sheet on *Risk and contingency planning* has more to say about problems such as illness in key individuals and how to plan for it and cope with it.

8 Summary

Project planning for simple projects involves three main steps.

- 1) identify the tasks (for which the technique called work breakdown structure is best);
- 2) determine the duration of each task and then determine their order, which can most easily be done using a graphical networking technique;
- 3) identify the critical path and then use its total duration to plan either beginning at a starting time or at the completion date.

More than one 'pass' may be necessary before all project constraints are met.

9 Further resources

For short articles on a wide variety of tools for planning and carrying out work, including how to use techniques like CPA, visit:

<http://www.mindtools.com/>

Field, M. and Keller, L. S. (1998) *Project Management*. International Thomson Business Press, London. pp. 190– 97.