# Module 2

## Scope and Time Management

### Introduction

This module examines two core areas of the project management functions – **scope** and **time management**. Project Scope Management includes the processes involved in defining and controlling what is or is not included in a project. It ensures making sure that all project stakeholders have the same understanding of what the deliverables are and how and when they will be delivered. Project time management involves the processes required to ensure timely completion of a project. These include, activity definition, activity sequencing, activity duration estimating, schedule development and schedule control.

At the end of this module, you will be given an assignment, which is a multiple choice test. This test provides a confirmation of understanding of the general concepts of project management including the integration, scope and time management bodies of knowledge as defined in the module notes and based on the international standards and guidelines defined in the PMBOK™ (Project Management Body of Knowledge).

Upon completion of this module you will be able to:

Outcomes

- *demonstrate* an understanding of the triple constraints of a project.
- *conduct* project planning base on the project cycle.
- *apply* the analytical approach in assessing the financial viability of projects using analytical tools such as Net Present Value and Return of Investment.
- *plan* the scope of a project using project tools like the Work Breakdown Structure.
- *discuss* project time management.
- *construct* Network Diagrams and apply PERT technique to estimate project time-line.

Terminology

| | |
|---|---|
| Activity on arrow (AOA) or arrow diagramming method (ADM): | A project diagram in which activities are represented by arrows and are connected at points called nodes to illustrate activity sequencing. |
| Backward pass: | The technique that determines late start and late finish dates for each activity. |
| Baseline dates: | The initial planned dates. |
| Crashing: | A technique for making cost and schedule trade-offs to obtain the greatest amount of schedule compression for the least incremental cost. This involves adding more resources on a critical path item. The trade-off is shortened project duration for higher overall project cost. |
| Controlling processes: | Ensuring that project objectives are met as defined by monitoring, measuring progress against plan, identifying variance from plan and taking corrective action. |
| Closing processes: | Formalising the completion and acceptance of a phase and or the project and closing all associated activities. |
| Critical path method (CPM): | A project network analysis technique used to predict longest total project duration. |
| Change control system: | A formal, documented process that describes when and how official project documents (especially the project plan) may be changed. It describes those authorised to make changes, the procedures to be followed and the tracking system that will be used. |
| Dependency arrows: | Arrows connecting the individual task duration bars show relationships, dependencies and precedents between tasks. |
| Early start: | The earliest possible time an activity can start. |
| Early finish: | The earliest possible time an activity can finish, represented as (early start date + duration). |
| Executing processes: | Managing the resources required to carry out the project as defined in the plan. |
| Fast tracking: | Performing activities in parallel that you would normally do sequentially or in slightly overlapping time frames (e.g., starting to program or code before all of the analysis is complete). |

| | |
|---|---|
| Forward pass: | The technique to determine the early start and early finish dates for each activity |
| Free slack: | The amount of time an activity can be delayed without delaying the early start of any immediately following activity |
| Gantt chart: | A standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in calendar format |
| Initiating processes: | Formal authorisation of the project or phase |
| Late start: | The latest possible time an activity can start without delaying the project completion date |
| Late finish: | The latest possible date an activity can be completed without delaying the overall project completion date. |
| PERT: | A network analysis technique used to estimate project duration when there is a high degree of uncertainty about the individual duration estimates. |
| Project life cycle: | The life cycle starts with initiation phase, planning, implementation, and close out |
| Slipped milestone: | A milestone activity that was completed later than originally planned. |
| Summary tasks: | This summarises the duration for all sub-tasks beneath it – represented by a thick black bar with downward pointing arrows at the beginning and end |
| Task duration bars: | These are smaller lighter-coloured horizontal bars representing the duration of an individual task. |
| Total slack: | The amount of time an activity can be delayed from its early start without delaying the planned project completion date |
| Work breakdown structure (WBS): | The work breakdown structure is a tool that displays in detail, the project statement of work to aid in understanding and communication of the project scope. The WBS is created from the earliest stages of project definition. |
| Work authorisation systems: | This is a formalised process used on large projects to authorise work to begin on a particular activity or work package. |

## Required Reading

Reading

In Praise of Scope Creep:

http://www.users.globalnet.co.uk/~rxv/projmgt/scopecreep.htm

## Project planning

We are going to take a quick look at the elements of project planning, starting with the project life cycle and then examine the importance of detailed planning to the overall success of the project.

Without a clear definition of the project, it's impossible to discern what should be delivered as a result. If requirements are not clear, your project will be impossible to control, and it will become unmanageable. We will review the fundamentals of planning and then move on to the importance of developing a comprehensive work breakdown structure.

Today’s organisations are running at a fast pace. More so than ever, organisations are faced with increasing global competition and as such, want products and services delivered yesterday! Organisations are struggling with multiple projects, tight deadlines and fewer skilled resources available to manage these projects. Project managers struggle with the concepts of best practices and the reality of life in a corporation. Often insufficient time is provided for planning the project appropriately and as a result projects consistently fail to produce the expected results, have cost or time overruns, or just plain fail. In such cases, the project manager can usually look back on his or her experiences and see what went wrong, vowing never to make the same mistake again. Sometimes, however, the cycle continues.

Whether you manage a small, medium or large project, effective planning is the single most critical step to success. Too many project managers either neglect or spend too little time and effort planning. The tendency is to rush to implementation before a clear picture is developed. The project definition must be clear and understood by the stakeholders and the team. Often the directive from the project sponsor is “Just do it” or “We need this in place by next week”, “we don’t have the luxury to spend time planning, we need to do the project”, not allowing the time up front to conduct proper planning activities. Failure to plan, however, usually results in failure to survive.

Without a clearly defined scope, the project has no sustainable basis for success. Building a detailed project plan forces the team and the stakeholders to realistically assess the proposed project. What will the outcome be when the project is finished? What will you have? – Product or service? What will the product/service look like? What are the must-have, nice-to-have features of the product/service? What is the current situation? What is the desired outcome? What are the obstacles keeping you from closing the gap? Who are the primary and secondary stakeholders? What is the problem/change? What are the assumptions/constraints and objectives of the project?

The planning stage of the project includes setting broad-based goals and designing strategies and action plans to reach these goals.

Project planning is a dynamic, "cyclical" process that continues throughout the project life cycle. Planning must take place to deal with problems, change or risks as they occur in the project. Planning begins with the identified and agreed to requirements in mind. It is critical to the success of the project to understand your destination when you start. You will know where you are going and you will have developed plans to arrive at the goal and complete the project successfully. Project managers must learn how to develop a project strategy and plan regarding how to implement that plan. Your organisation, team and stakeholders depend on it.

Project planning is a cycle that is repeated on an on-going basis. For the duration of the project, it is never a finished process. Why? Because resources change or move, factors in the organisation may change causing project objectives to change, unknown risks can occur, or technology may change, requiring project managers to continually monitor and manage this process throughout the life of the project.

The following diagram illustrates the "Project Life Cycle" and the cyclical nature of planning activities.

**The Project Cycle**

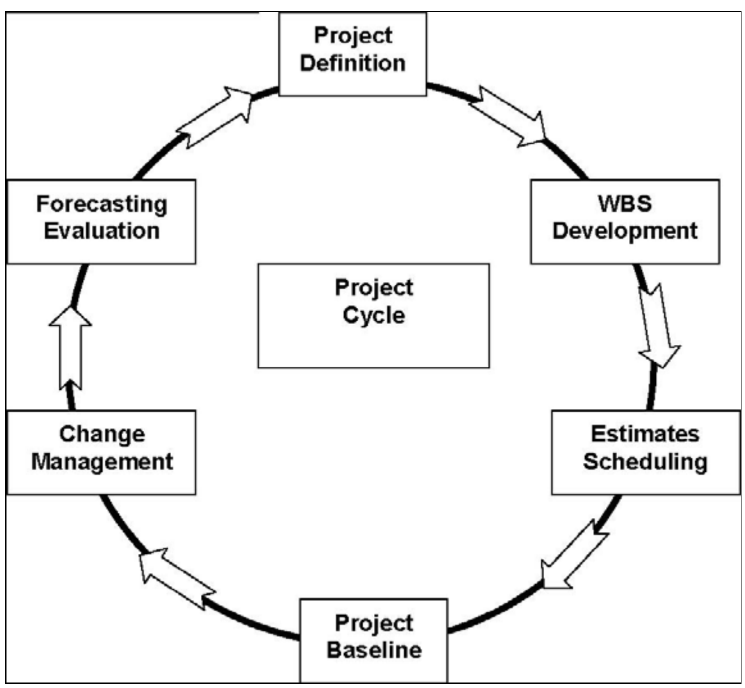



Diagram used with permission Enterprise Project Management Ltd.

## Project definition

Determining clear and agreed to requirements is a fundamental concept in project management. Requirements must be explicit and detailed in a fashion allowing scope to be determined and stakeholders to have a clear understanding about what the project will accomplish. This is the key input into scope definition. Stakeholder issues can affect the potential success or failure of a project. As such it is important that as part of the project definition a stakeholder identification and analysis is conducted and the right stakeholders are brought into the project as early as possible. By doing this you are establishing support for the project early on in the process and will be able to leverage that support going forward to achieve success.

Key inputs to Project Definition:

- Clearly defined requirements
- Defined mission and objectives of the project
- Defined and agreed to statement of work.

The statement of work or scope statement must clearly state the project objectives and should follow the SMART concept:

- **S**pecific
- **M**easurable
- **A**greed to by the team and stakeholders
- **R**ealistic within the specific environment
- **T**ime-constrained.

Acceptance criteria and project success must be agreed to up front with the stakeholders and sponsor, and all deliverables must be specific and objective.

Outputs of Project Definition:

- Project charter
- Stakeholder identification and assessment
- Risk identification, assessment and response
- Quality plan
- Communications plan
- Work breakdown structure.

## Triple constraints

The concept of triple constraints is critical in project management overall and to defining individual projects. Managing a project using the triple constraints allows the project manager to direct the progress of the plan for those components affecting:

1. schedule
2. cost, and
3. quality

within the defined scope of the project. Increased cost will affect time, increased or changed scope affects cost and time, and increased time will affect scope and cost. The bottom line is – if you don't meet the triple constraints, the project will not complete within the defined scope.

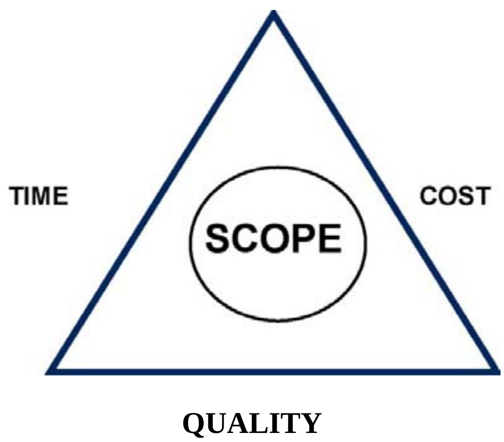



Diagram used with permission from Enterprise Project Management Ltd.

The triple constraints are the indicators used to measure the success of the project. In most organisations, it is often difficult, if not impossible, to create clear metrics for the success or failure of projects. Often, success or failure is determined by the public relations capabilities of the project manager. When defining the project, it is imperative to establish the scope of the project in terms of time, cost and quality, within the context of the agreed to deliverables. In order to define the full scope of the project a work breakdown structure is required. Whatever is "not" defined in the work breakdown structure at the end of planning is "out of scope" for the project. Therefore, as a project manager you need to work with the right team members and stakeholders to develop a thorough structure.

## Scope management

Project scope management can be defined as "the processes involved in defining and controlling what is or is not included in a project". It entails making sure that all project stakeholders have the same understanding of what the deliverables are and how and when they will be delivered.

The five key processes involved in scope management include:

1. **Initiation** – beginning a project or continuing to the next phase. Usually involves the creation of a project charter.
2. **Scope planning** – involves establishing decision-making criteria (a. How do we know when we're done? b. How do we know when we've won? c. Who gets to decide a & b?) Deliverables include scope statement and scope management plan.
3. **Scope definition** – creating a work breakdown structure (WBS) – to break major deliverables down into smaller, more manageable components).
4. **Scope verification** – formal acceptance of scope definition by key stakeholders.
5. **Scope change control** – controlling 'scope creep'.

## Project selection

Projects should support the strategic direction of the organisation and be managed to ensure tangible benefits to the organisation. The organisation's strategic plan should guide the project selection process. We will discuss this in some detail in the final module of this course.

## The analytical approach

There are a number of rational analytical models that can be used in project selection.

1. *Need, funding and will (NFW) model*
   a. Do people agree that the project needs to be done?
   b. Is the organisation prepared to allocate sufficient funds for the project?
   c. Is there a strong will to make the project succeed (especially CEO and senior management support)?
2. *Categorisation approach*
   a. Problems, opportunities and directives (POD)
   b. Windows of opportunity – categorisation based on estimated project time or completion dates
   c. Overall priority – high, medium or low?
3. *Financial models*
   a. Net Present Value (NPV)
   b. Return on Investment (ROI)
   c. Payback Period
   d. Internal Rate of Return (IRR)
   e. Weighted scoring model

   Each of these financial models will be discussed in more detail below.

## Financial models

**Net Present Value (NPV) –** provides a way of comparing projects of different duration, cost and expected benefit.

All projected future costs and returns are 'discounted' or brought back to a present value. (This is based on the time value of money that says a dollar earned or spent today is worth more than a dollar five years from now.)  The present values will depend on the time period and discount or interest rate applied. For example, the net present of $50 earned five years from now is $31 using a 10 per cent discount rate. Another way to think of this is if I gave you $31 today and you put it in a savings account that paid 10 per cent compound annual interest, in five years from now the value of that account would be $50.

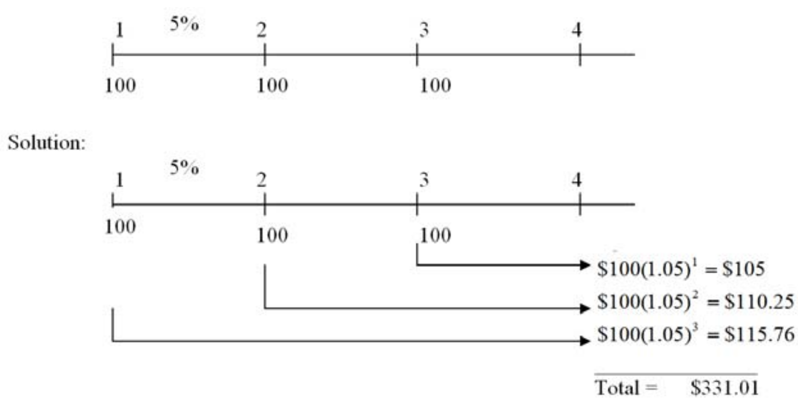
The NPV approach involves the following steps:

1. Estimate and itemise each cash inflow and outflow for the project and when it is expected to occur.
2. Determine the appropriate discount rate.
3. Discount each cash inflow and outflow to the present time period.
4. Add together all the discounted inflows and outflows. (MS Excel has a built in NPV function).

For two or more projects, the project with the highest NPV has the highest present financial value. We will examine this through few examples.

**Example 2.1**

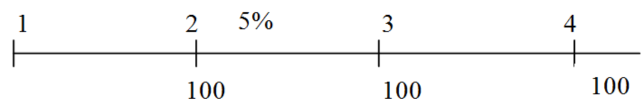
$100 is deposited @ 5 per cent interest at the beginning of each year, what will be total future value at the end of three years.



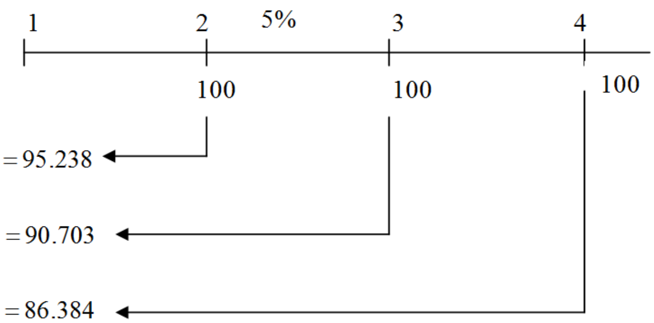

That means $331.01 will be realised at the end of three years if $300 is deposited at the beginning of each of the last three years.

**Example 2.2**

What will be the present value of annuity if $100 will be deposited at the end of each year for next three years? The rate of discount is 5 per cent or the cost of capital is 5 per cent which can be used to adjust the time value of money.




Solution:




$$\frac{100}{(1.05)^1} = 95.238$$

$$\frac{100}{(1.05)^2} = 90.703$$

$$\frac{100}{(1.05)^3} = 86.384$$

Total = $272.325

**Example 2.1** and **2.2** above are just opposite calculations to each other. One calculates the future worth of the present investment and the other one calculates the present worth of the future investment. Important point to remember is that all monetary investment or return must be calculated back to net present value and compared before any decision is taken.

The calculation above that includes the interest rate (5 per cent) and the years can be expressed and generalised in a factor known as annuity or annuity factor. An annuity is a series of equal payments made at a fixed interval for a specified number of periods. The annuity factor is readily available at the end of any financial management text. Equation for present value annuity (PVA) can be expressed as below.

$$PVA = PMT\left(\frac{1}{1+i}\right)^1 + PMT\left(\frac{1}{1+i}\right)^2 + ....... + PMT\left(\frac{1}{1+i}\right)^n$$

$$= PMT\left(\sum_{t=1}^{n}\left(\frac{1}{1+i}\right)^t\right)$$

Where: PMT represents payment at the end of the period

i = interest rate

t = period for which the annuity is calculated

Let's calculate the present value annuity factor (PVAF) @ 10 per cent interest rate using the above formula? The calculation is shown for year 1, 2 and 3 respectively.

$$\left(\frac{1}{1+i}\right)^1 = \left(\frac{1}{1+0.10}\right)^1 = 0.909$$

$$\left(\frac{1}{1+i}\right)^2 = \left(\frac{1}{1+0.10}\right)^2 = 0.826$$

$$\left(\frac{1}{1+i}\right)^3 = \left(\frac{1}{1+0.10}\right)^3 = 0.751$$

and so on.

In the **Example 2.2**, the annuity factor can be calculated for 5 per cent interest rate and used directly.

**Return on Investment (ROI)**

- ROI also uses discounting
- ROI = Income/Investment
- ROI = NPV/Discounted Cost or
- ROI = (Total discounted benefits – total discounted costs)/ total discounted costs

Many organisations have a Required Rate of Return or a minimal acceptable ROI.

More examples on ROI (also known as Average rate of return, ARR) are discussed below.

**Example 2.3**

Calculate average rate of return (ARR) or return on investment (ROI).

| | Machine A | Machine B |
|---|---|---|
| 1. Yearly income | | |
| 1st year | $4500 | $12,000 |
| 2nd year | $6000 | $10,500 |
| 3rd year | $8500 | $8,000 |
| 4th year | $11,000 | $5,500 |
| 2. Estimated life | 6 years | 6 years |
| 3. Initial cost | $50,000 | $55,000 |

**Solution:**

Average income per year:

Machine A = ($4500+$6000+$8500+$11000)/4 = $30,000/4 = $7,500

Machine B = ($12000+ $10500+$8000+$5500)/4 = $9000

Average rate of return (or ROI) for Machine A = $\frac{7500}{50000} x100 = 15\%$

Average rate of return (or ROI) for Machine B = $\frac{9000}{55000} x100 = 16.36\%$

So ROI for Machine B is higher at 16.36 per cent, hence investment is suggested.

**Payback Period –** the amount of time it takes before discounted benefits exceed discounted costs.

- When does NPV become positive?
- How soon does the investment start paying off?
- How long will it take to recoup the dollars invested in a project?

Payback period =

$$= \frac{\text{initial Investment}}{\text{Constant Annual cash Flow}} \text{ or } \frac{\text{Original cost of Acquisition}}{\text{Cash flow after tax}}$$

More examples on payback period are discussed below.

**Example 2.4**

Initial investment for machine A and B are $45,000.

| Yearly income | Cash flow **Machine A** | Cash flow **Machine B** |
|---|---|---|
| 1st year | $10,000 | $20,000 |
| 2nd year | $12,000 | $15,000 |
| 3rd year | $15,000 | $14,000 |
| 4th year | $18,000 | $16,000 |

Calculate the payback period for machine A and B.

**Solution:**

Payback period calculation for Machine A

For the three years total revenue is $10,000+$12,000+$15,000 = $37,000

Remaining $8,000 (=$45,000- $37,000) will be earned in $8000/$45,000= 0.18 year

So the initial investment of $45,000 for Machine A will be paid back in **3.18 years**.

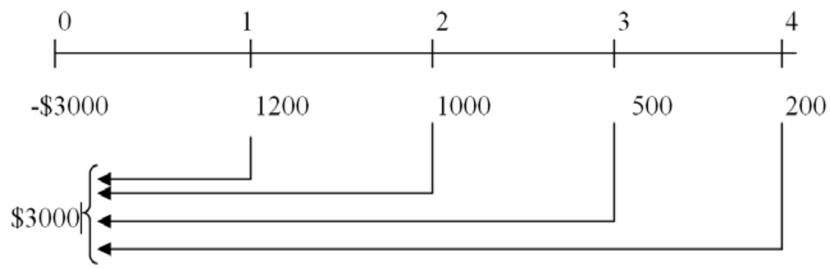
Similarly for Machine B,

$$\text{Payback period} = 2 + \frac{\$45{,}000 - \$35{,}000}{\$14{,}000} = 2.71\ \mathit{years}$$

So payback period for Machine B is **2.71 years,** less than Machine A. Hence investment in Machine B is suggested.

**Internal Rate of Return (IRR)**

Internal rate of return, or IRR, is the discounting rate that equates the present value of future cash flow. That means it is a firm's rate of return at which the present value of all future cash flows is equal to the initial cash outflow. It is also known as time-adjusted rate of return method or yield on investment method. This can be explained through a time line. Assume that the initial cash outflow is $3000.




NPV = -$3000+$3000 = 0

Or mathematically what should be the discounting rate (i.e. IRR) so that all the future earnings will be equal to initial cash outflow of $3000 (expressed as –ve value).

$$-3000 + \frac{1200}{(1+IRR)^1} + \frac{1000}{(1+IRR)^2} + \frac{500}{(1+IRR)^3} + \frac{300}{(1+IRR)^4} = 0$$

Generalising the formula we can write that

$$CF_0 + \frac{CF_1}{(1+IRR)^1} + \frac{CF_2}{(1+IRR)^2} + .... + \frac{CF_n}{(1+IRR)^n} = 0$$

$$OR \quad \sum_{t=1}^{n} \frac{CF}{(1+IRR)^t} = 0$$

Where $CF_0$,1,2--n = cash outflow

IRR = Internal rate of return that needs to be calculated

t = time period of cash flow

**Weighted scoring model**

- Identify selection criteria (time, priority, estimated payback, etc)
- Assign a weight to each criterion
- Assign scores to each criterion for each project
- Calculate weighted score for each project by multiplying weight by score and summing for each project
- Project with highest weighted score wins.

| Criteria (A) | Weight (B) | Project 1 Score (C) | Project 1 Weighted Score (B) X (C) | Project 2 Score (E) | Project 2 Weighted Score (B X E) |
|---|---|---|---|---|---|
| Boss likes it | 40% | 40 | 16 | 60 | 24 |
| Will make a lot of money | 30% | 50 | 15 | 30 | 9 |
| We can do it fast | 20% | 25 | 5 | 25 | 5 |
| Uses lots of nifty new technology | 10% | 20 | 2 | 15 | 1.5 |
| **Total** | | | **38** | | **39.5** |

According to the above system, Project 2 wins because it has the highest weighted score, even though it is expected to make less money. This example also illustrates another point. Project selection is not always made on the basis of rational analysis. Organisational politics can have a strong influence on project selection. This is especially true within a government bureaucracy where both small and large 'P' politics can have a large influence on the decision-making process.

## Project charters

The key document that often defines project initiation is the project charter. A project charter is a document that formally recognises the existence of a project and provides direction on the project's objectives and management. Once the project charter is signed by the project sponsor, it provides authorisation for the project manager to start planning.

The charter is often used to let key members of the organisation know about the existence of the project, and to authorise its implementation. Key project stakeholders should sign the charter.

At a minimum a project charter should contain:

- Title and date of authorisation
- Name of project manager and contact info
- Statement of project Scope
- Summary of approach:
  - roles and responsibilities matrix
  - sign-off page for key stakeholders.

**Sample Project Charter Table of Contents**

1. Project Name

2. Project Objectives
3. Project Purpose
4. Scope (In and Out of Scope)
5. Key Deliverables
6. High Level Schedule (Plan)
7. Key Stakeholders (internal and external)
8. Cross Organisation Team Members
9. Risk Management
10. Links to Other Projects
11. Constraints and Assumptions
12. Completion Criteria
13. Approval.

## Scope planning

Scope planning involves developing documents to clarify project scope and the basis for project decisions including criteria for phase sign-off. (How do we know when we're done?) The key output is a scope statement.

The scope statement, or statement of work, is the key document used to enunciate and confirm the scope of the project. It should include the following:

- **Project justification** (What is the business need? Why are we doing this project?)
- **Project products** (Key products and services – e.g., minimum hardware and software requirements)
- **Summary of project deliverables**
- **Scope management plan** (cost, time and quality measures of success and clearly articulates both what the project will deliver and what it will not deliver) Sometimes called a Statement of Work
- **Scope definition** – The Work Breakdown Structure.

The next step in scope management is scope definition – or breaking the work down into manageable pieces. Good scope definition:

- helps improve the accuracy of time, cost and resource estimates
- defines a baseline for performance measurement and project control
- assists in communicating work responsibilities.

A **work breakdown structure** (WBS) is defined as: "a deliverables-oriented depiction of the work involved in a project that defines the total scope of the project".

In simple terms, it's a detailed listing of what is required to deliver the product/service of the project.

It is the "heart" or foundation of project management that provides the basis for planning and development for the project.

## The Work Breakdown Structure (WBS)

A key strategy of effective planning is to "break" the project down into manageable components of work that can be individually planned, estimated and managed. The process of "breaking" the work down is called the "Work Breakdown Structure". The work breakdown structure is a tool that displays in detail, the project statement of work to aid in understanding and communication of the project scope. The WBS is created from the earliest stages of project definition.

Without the WBS, there is no schedule or cost control in modern project management. The work breakdown structure is a powerful tool for expressing the scope or extent of a project in simple terms. It represents the project in terms of the hierarchy of deliverables it will produce. The WBS starts with a single box at the top, which represents the entire project. The project is then broken down into lower levels such as a phase, and then is further detailed into activity, task and step. The WBS supports the principle of management by objectives/deliverables by providing a map of what is to be produced in the project. (See Sample WBS diagram)

The WBS is the input into activity definition. Once it is determined what to build the next level of detail takes us to specifying how it can be built by developing the activities, tasks and steps to the bottom level of the WBS. Again, this is an important aspect to the development of the WBS. We want to take the project down to a level where the project manager can effectively manage the project.

The WBS must not only cover the "product" of the project, but also the elements related to initiating, planning, implementing, and completing activities of the project. The content should be as explicit as possible.

The WBS should answer the following questions:

1. Does the detail in the WBS reflect the entire project?
2. Are the work packages SMART?
3. Have the tasks been defined clearly?

**WBS Rules**

1. Begin with the scope statement
2. Task descriptions developed using a verb and a noun

3. Develop WBS to lowest level of control required to effectively manage a project (Work Package – guideline 80 hours of effort)
4. Each work package is developed to accomplish a discrete and separate element of work
5. Allow assignment to a single organisational unit for exclusive responsibility
6. Organise the WBS by Task:
    a. phase
    b. activity
    c. task
    d. step.

OR

7. Organise the WBS by Deliverables:
    a. hardware
    b. software
    c. network.

Many project managers today use a combination of deliverables orientation and task orientation, which involve starting the WBS with specific deliverables (what) at the high level and then breaking the tasks out (how) to create the deliverable to the detailed level.

The following diagram describes a typical task oriented and phased, high-level WBS structure. The box at the top represents the entire project and is referred to as WBS level 1. The lower levels which describe the components of the project increasing in detail represent level 2, level 3 and so on. The WBS level is important as it allows reporting of cost estimates at various levels that are often required in the organisation. Project managers typically need to understand and manage all levels of the project. To better facilitate this responsibility for a phase could be allocated to a sub-project leader at a level 2 and team leaders at the level 3.

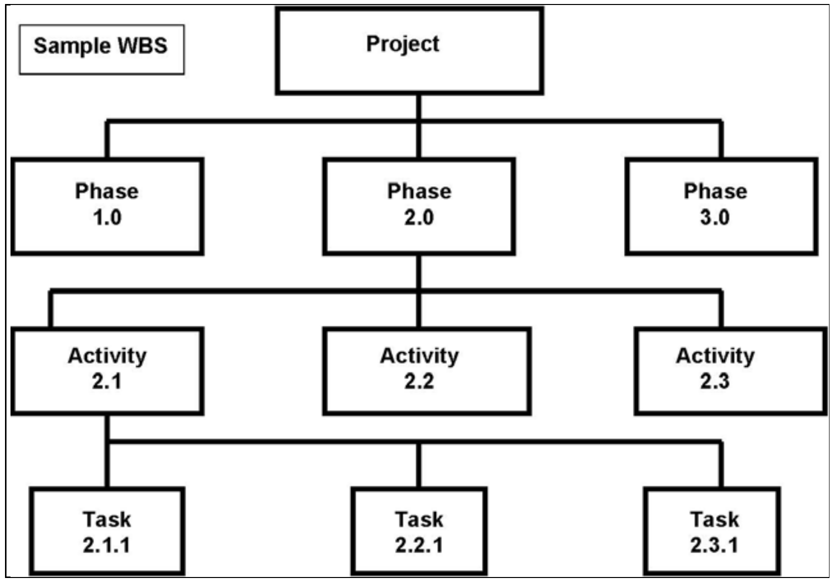



Diagram used with permission Enterprise Project Management Ltd.

The WBS partitions project deliverables into smaller components and provides a mechanism for collecting and organising costs and provides for performance measurement and control.

It provides a simple outline of what is to be produced by the project. The WBS does not deal with time! It is the input into schedule development.

There are four basic approaches to creating work breakdown structures:

1. **Using guidelines** – Many organisations, especially government organisations, will provide strict guidelines for developing a WBS. This enables them to compare costs estimates for various phases or levels of a contract between competing bidders or against their own estimates.
2. **The analogy approach** – This is basically using a WBS developed for another project as a template. Some organisations, particularly those that have a project office, often have a library of documentation from other projects including work breakdown structures.
3. **The top-down approach** – This conventional method of creating a WBS from scratch involves starting with the largest project items and then breaking them down in sub-tasks. This works well for a project manager who already has a good grasp of the technical details of a project, or who has managed a similar project before.
4. **The bottom-up approach** – As the name suggests, this method involves listing all the detailed tasks first and then grouping or arranging them into higher level categories. This approach is often used on entirely new systems or approaches to jobs. While

it is quite time-consuming it also helps in developing project teams and fostering stakeholder buy-in.

Work breakdown structures can be presented in many ways. A common form and the one used in project management software, such as MS Project, is a tabular form like this:

| | ℹ | Task Name | Duration |
|---|---|---|---|
| 1 | | 1 Start Project | 0 days |
| 2 | | ⊟ **2 Initiating tasks** | **11 days** |
| 3 | | 2.1 Initial meeting with project sponsor | 1 day |
| 4 | | 2.2 Research similar projects | 5 days |
| 5 | | 2.3 Draft project requirements | 3 days |
| 6 | | 2.4 Review with sponsor and other stakehold | 1 day |
| 7 | | 2.5 Develop project charter | 1 day |
| 8 | | 2.6 Charter signed | 0 days |
| 9 | | ⊟ **3 Planning tasks** | **11 days** |
| 10 | | 3.1 Develop WBS | 5 days |
| 11 | | 3.2 Estimate durations | 5 days |
| 12 | | 3.3 Assign resources | 4 days |
| 13 | | 3.4 Determine task relationships | 2 days |
| 14 | | 3.5 Enter cost information | 3 days |
| 15 | | 3.6 Review Gantt and PERT chart information | 1 day |
| 16 | | 3.7 Review plan with stakeholders | 1 day |
| 17 | | ⊟ **4 Executing tasks** | **69 days** |
| 18 | | 4.1 Analysis tasks | 20 days |
| 19 | | 4.2 Design tasks | 34 days |
| 20 | | 4.3 Implementation tasks | 20 days |

A **work package** is a deliverable or product at the lowest level of the WBS. In the above illustration, *3.5 Enter cost information* would be an example of a work package for this particular WBS.

To create a work breakdown structure you need to understand the project and its scope as well as the needs and knowledge of the stakeholders. The entire project team should be involved in creating and reviewing the WBS. The principle is “the people who do the work should help plan the work.”

### Scope change control

At the beginning of this module we introduced the term scope creep. This is a phenomenon that often occurs in projects as a result of the best of intentions. It is the tendency for project scope to get larger and larger. As project manager you want to ensure client satisfaction and benefit realisation. It starts with the client coming back to you after the project scope has been agreed to and saying, “I know this wasn’t part of the original project, but if we just did this one more thing, it would be that much better.” That one more thing, of itself, may not add that much to the overall project time or cost. But that process repeated often enough can result in significant cost and time over-runs.

Two methods of controlling scope creep are **scope verification** and **scope change control**. **Scope verification** involves documenting the project's processes and products and getting the key stakeholders to sign off on them. In a project, this is usually accomplished through what are known as a Business Requirements Document and a Technical Specifications Document. **Scope Change Control** usually entails a formalised process for changing project scope wherein the implications in terms of time and cost are clearly stated. Again, key stakeholders are required to sign-off on accepted changes to the scope of the project. The best preventative measure for project scope change is doing a thorough job of requirements and specifications in the first place.

According to the Standish Group[2], the top three reasons for project problems are

1. Lack of stakeholder input
2. Incomplete requirements and specifications
3. Changing requirements and specifications.

**Suggestions for enhancing user involvement**

The following are suggestions for improving user input.

1. Ensure all projects have a client project sponsor
2. Make all documentation readily available
3. Include stakeholders on the project team
4. Hold regular meetings with stakeholders
5. Get stakeholders to sign-off on key deliverables
6. Deliver something to stakeholders and sponsors on a regular basis
7. Co-locate stakeholders with project team if possible.

**Suggestions for reducing incomplete and changing requirements**

1. Develop and follow a requirements management process
2. Use techniques such as prototyping, JAD (Joint Application Design) sessions to gain a thorough understanding of user requirements. JAD was developed by IBM Canada as a short and iterative process to work with stakeholders to define and agree upon requirements in a structure process
3. Put all requirements in writing. Keep them current and readily available

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[2]Johnson, Jim, "CHAOS: The Dollar Drain of Information Technology Project Failures," *Application Development Trends* (January 1995) www.standishgroup.com/chaos.html

4. Provide adequate testing throughout the project life cycle
5. Create a formalised change control system, and require stakeholder sign-off
6. Stick to the completion date (Remember the triple constraint triangle – if the time can't change, very little can change in terms of cost and quality.)

## Project time management

Overall, schedule issues are one of the primary sources of conflict over the life of a project. Scope and cost can be estimated and debated. The schedule, once set, tends to be the least flexible and the most easily measured and evaluated of the three project constraints.

**Definition**: Project Time Management involves the processes required to ensure timely completion of a project. These include:

1. **Activity definition** – identifying the activity or task that must be performed to produce the project deliverables (A task is an element of work that has an expected duration, cost and resource requirements.)
2. **Activity sequencing** – identifying and documenting the relationships between project activities (particularly the order of execution).
3. **Activity duration estimating** – approximating the amount of time or number of work periods needed to complete each activity or task.
4. **Schedule development** – analysing activity sequences, duration estimates and resource requirements to create a workable schedule.
5. **Schedule control** – controlling and managing changes to the project schedule.

**Activity definition** usually entails developing a more detailed work breakdown structure. The project team should review this revised WBS before moving to the next step – activity sequencing. Part of activity definition includes documenting detailed product descriptions, assumptions and constraints.

**Activity sequencing** looks at dependencies and relationships – does one activity need to precede another or can they be done in parallel? Three main types of dependencies:

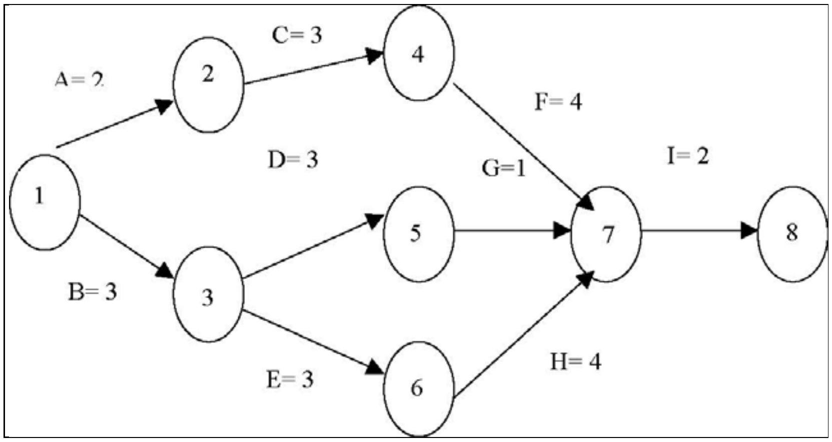
1. **Mandatory** – 'hard logic' – one task cannot start until a previous task is complete (e.g., can't test until you build)
2. **Discretionary** – 'soft logic' – defined by project team (e.g., no detailed design until analysis is signed off)
3. **External** – dependent on non-project activity (e.g., software install project can't start until hardware is delivered).

# Schedule development tools

The key project management tools used to develop accurate and effective schedules include Network Diagrams, Gantt charts and Critical Path analysis.

## Network diagrams

A project network diagram is a *schematic display of the logical relationships among project activities or the sequencing of project activities*. It is the preferred technique for showing activity sequencing.



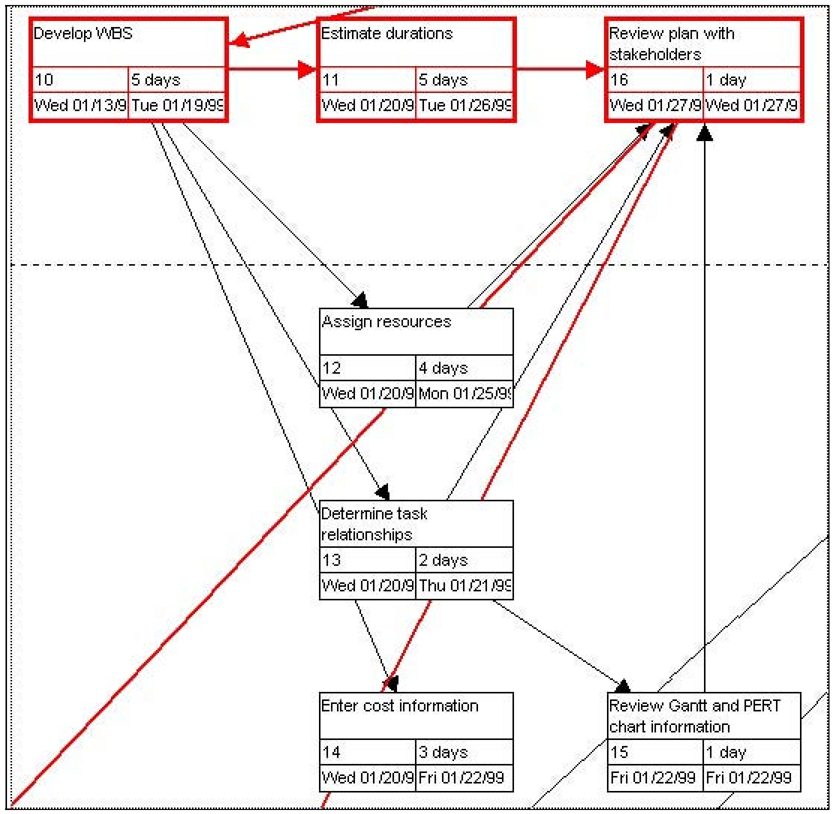

In the above network diagram the letters represent activities or tasks. The arrows show the sequencing, and the values associated with the letters (e.g. D= 3) represent the units of time (days, weeks, etc.) associated with that task or activity. The example diagram uses the **Activity on Arrow (AOA)** or **Arrow Diagramming Method (ADM)**, in which activities are represented by arrows and are connected at points called nodes to illustrate activity sequencing. The total estimated duration of this sample project is the sum of all the numbers associated with arrows **-** or 25 days.

Another way of drawing a network diagram is by the precedence diagramming method (PDM) a network diagramming technique in which boxes represent activities. The diagram below is an extract of a much larger project network diagram. Activities are placed inside the boxes, which represent the nodes in this diagram. Arrows are used to show relationships (There are a lot of arrows in this example that don't seem to go anywhere because it's part of a larger project). One of the key advantages of network diagrams over Activity on Arrow diagrams is the elimination of **dummy activities** – activities with no duration and resources sometimes needed in AOA diagrams to show relationships between activities.

## Activity duration estimating

**Duration** = actual amount of time worked on an activity plus elapsed time. (This may need to take into consideration people working only half time, waiting for some critical resource, or preceding activity). Best estimates will likely come from the people who have to do the work, although there will be a tendency to pad their time estimates as a risk mitigation strategy.

**A Network Diagram that illustrates the Precedence Diagramming Method (PDM)**




The key outputs of duration estimating are:

1. Duration estimates for each activity
2. Document describing basis for estimates and assumptions made
3. Updated work breakdown structure.

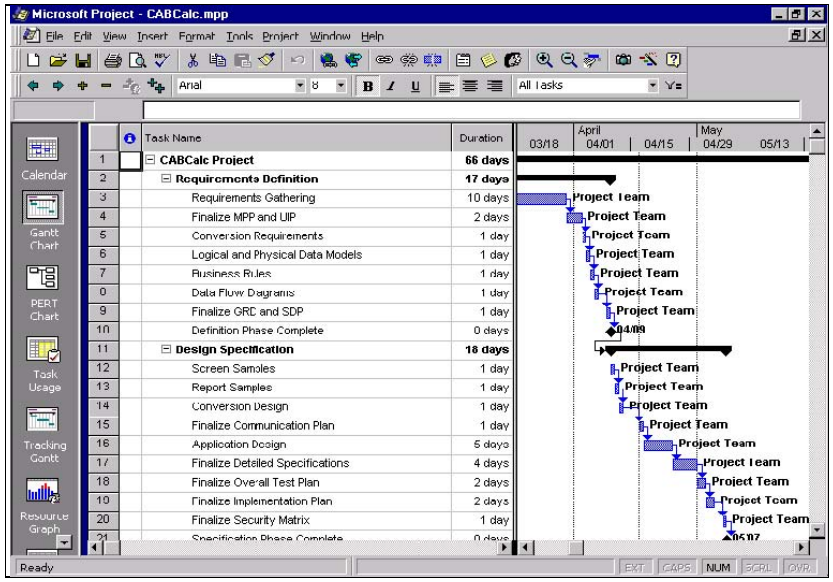
## Schedule development

The goal of schedule development is to create a realistic project schedule that forms the basis for monitoring project progress. The key tools used in developing project schedules are Gantt charts, Network Diagram charts and critical path analysis.

## Gantt charts

A Gantt chart is a standard format for displaying project schedule information by listing project activities and their corresponding start and finish dates in calendar format. Gantt charts were developed by Henry Gantt during World War I for scheduling work in factories. Today they are usually produced by project management software. (See example.)

**Sample Gantt chart**




Activities on the Gantt chart should coincide with the activities on the WBS.

Notice the following features on the above Gantt chart:

1. **Milestones** – a significant event on a project with zero duration represented by a black diamond
2. **Summary tasks** – summarises the duration for all sub-tasks beneath it – represented by a thick black bar with downward pointing arrows at the beginning and end
3. **Task duration bars** – smaller lighter-coloured horizontal bars representing the duration of an individual task
4. **Dependency arrows** – arrows connecting the individual task duration bars show relationships, dependencies and precedents between tasks.

A **tracking Gantt chart** is a variation of a Gantt chart that compares planned and actual project schedule information (also called total float). The planned dates are called baseline dates. A white diamond on a tracking Gantt indicates a **slipped milestone** – or a milestone activity that was completed later than originally planned. Gantt charts are easy to create and provide a standard format for displaying planned and actual activities. However, they do not show relationships and dependencies between tasks as well as network diagrams or PERT charts do.

## Critical path analysis

Critical path analysis or the Critical Path method (CPM) is a project network analysis technique used to predict total project duration. Within any project there will be some tasks, which have some slack or float time associated with them. That is, if they don’t get done exactly on schedule, they won't impact other activities or the overall completion date. However, there are some activities, which if not completed on time will impact the timing of other activities and can throw the whole project off schedule. Thus the **critical path** for a project is *those series of activities that together determine the earliest time by which the project can be completed*.

To find the critical path:

1. Create a work breakdown structure
2. Convert this into a network diagram
3. Estimate the durations for each activity
4. Add together the durations for all activities for each path through the network diagram.

The *path with the longest total duration is the critical path*. There can be more than one critical path for a project if two or more have the same longest total duration. The critical path can change over the life of the project as some activities slip and/or other activities are completed in less time than was initially anticipated. Project management software can automatically calculate and illustrate the critical path at any given time.

**Critical path analysis and schedule trade-offs**

One of the uses of critical path analysis is to allow project managers to determine what trade-offs can be made during the life of the project. For example, if a task on the critical path is behind schedule, it may be possible to add more resources to a subsequent task on the critical path to get the project back on schedule. If money is a bigger constraint than time, it might be possible to negotiate a delayed finish time to stay within budget, rather than paying overtime. One way of analysing these trade-offs is by looking at slack times and early start and finish dates versus late start and finish dates for each activity.

Important definitions:

1. **Free slack** – the amount of time an activity can be delayed without delaying the early start of any immediately following activity
2. **Early start** (ES) – the earliest possible time an activity can start
3. **Total slack**– the amount of time an activity can be delayed from its early start without delaying the planned project completion date
4. **Forward pass** – determine the early start and early finish dates for each activity
5. **Early finish**(EF) – the earliest possible time an activity can finish = early start + duration
6. **Backward pass** – determines late start and late finish dates for each activity

7. **Late start** (LS) – latest possible time an activity can start without delaying the project completion date
8. **Late finish** (LF) – latest possible date an activity can be completed without delaying the overall project completion date.

The easiest way to calculate these is through the use of project management software, however, it can be done manually.

## Techniques for shortening a project schedule

**Crashing** is a technique for making cost and schedule trade-offs to obtain the greatest amount of schedule compression for the least incremental cost. This involves adding more resources on a critical path item. The trade-off is shortened project duration for higher overall project cost.

**Fast tracking** calls for performing activities in parallel that you would normally do sequentially or in slightly overlapping time frames (e.g., starting to program or code before all of the analysis is complete). The trade-off is shortening the project duration at the risk of having to do work over and resulting in longer overall duration.

It is important to update the critical path as activities are completed. Remember, the critical path can and will change over the duration of a project.

**Example of CPM**

Draw a network diagram for computer assembly activities.

| Activity | Designation | Immediate predecessor | Time (weeks) |
|---|---|---|---|
| Design | A | - | 21 |
| Build prototype | B | A | 4 |
| Evaluate equipment | C | A | 7 |
| Test prototype | D | B | 2 |
| Write equipment report | E | C, D | 5 |
| Write methods report | F | C, D | 8 |
| Write final report | G | E, F | 2 |

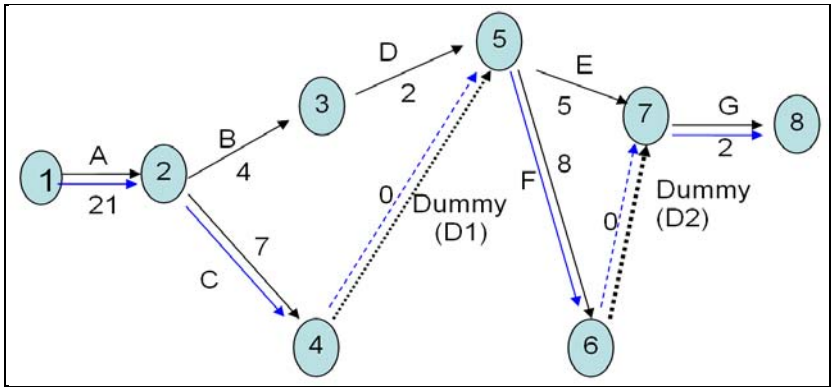
a. Draw a network diagram
b. Find out critical path and project completion time.
c. Show early start (ES), early finish (EF), late start (LS) and late finish (LF), and slack.

**Solution:**

a. Drawing of a network diagram

The network diagram is drawn using the activity of arrow (AOA). The network starts with a node number 1 and ends with a node number 8. Every arrow is denoted by the activity number and its duration. Two dummies are introduced that consume no time but act as conditional to the preceding activities.

The same network diagram can be drawn using activity of node (AON).




b. The critical path calculation

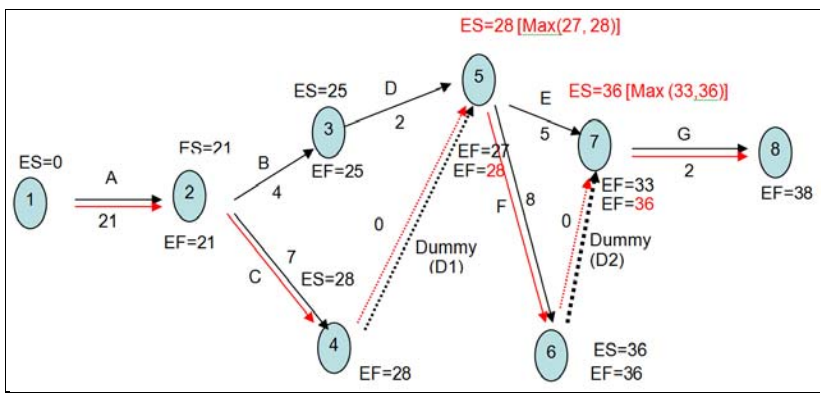
| | | |
|---|---|---|
| A-B-D-E-G | = 21+4+2+5+2 | = 34 weeks |
| A-B-D-F-D2-G | = 21+4+2+8+0+2 | = 37 weeks |
| A-C-D1-E-G | = 21+7+0+5+2 | = 35 weeks |
| A-C-D1-F-D2-G | = 21+7+0+8+0+2 | = 38 weeks |

So the critical path which is the largest duration is **38 weeks**. The critical path is A-C-D1-F-D2-G, denoted by double line.

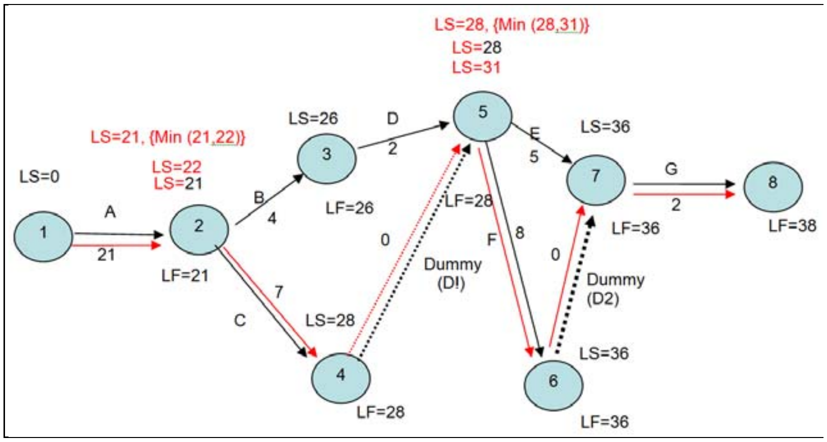
c. Calculation of ES, EF, LS and LF. Also shows the slack calculation which is the difference between LF-EF or LS-ES.

| Task | ES | EF | LS | LF | Slack (LF-EF or LS-ES) |
|---|---|---|---|---|---|
| A | 0 | [0+21] = 21 | 0 | 21 | 0 |
| B | 21 | [21+4] =25 | 22 | 26 | 1 |
| C | 21 | [21+7] =28 | 21 | 28 | 0 |
| D | 25 | [25+2] = 27 | 26 | 28 | 1 |
| Dummy D1 | 28 | [28+0] = 28 | 28 | 28 | 0 |
| E | 28 | [28+3] = 33 | 31 | 36 | 3 |
| F | 28 | [28+8] = 36 | 28 | 36 | 0 |
| Dummy D2 | 36 | [36+0]= 36 | 36 | 36 | 0 |
| G | 36 | [36+2] = 38 | 36 | 38 | 0 |

The calculations are shown in the network diagram. The next two diagrams show a critical path with forward pass method and backward pass method.




Critical path with forward pass method considers the maximum of all the values at the nodal junction. For example, max of 33 and 36 is 36 at node number 7.




Critical path with backward pass method considers the minimum of all the values at the nodal junction. For example, min of 28 and 31 is 28 at node number 2.

1. Tasks having zero slacks are called critical tasks.
2. Critical path contains a set of critical tasks. All tasks in a critical path are having zero slacks.
3. Slack is the amount of time a task can be delayed without affecting the overall completion time of a project.
4. Every project will have at least one critical path.
5. The completion time of a project can be reduced by reducing the task time. Additional resources are required for reducing the task time. The reduction of task with additional resources is called crashing of project.

## PERT – Programme evaluation and review technique

**PERT** – a network analysis technique used to estimate project duration when there is a high degree of uncertainty about the individual duration estimates.

PERT uses **probabilistic time estimates** – estimates of activity duration using optimistic, most likely and pessimistic estimates of activity duration. Thus PERT attempts to address the risk associated with duration estimates. PERT involves more work and is rarely used because there are better methods for assessing **risk**, which we shall discuss in a later module. The basic PERT formula is as follows:

PERT weighted average

$$= \frac{\text{optimistic time} + (4X \text{ most likely time}) + \text{pessimistic time}}{6}$$

**Example of PERT**

The tasks and immediate predecessors with three time estimates (days) are presented in tabular form.

| Task | Immediate predecessors | Optimistic | Most likely | Pessimistic |
|---|---|---|---|---|
| A | None | 3 | 6 | 15 |
| B | None | 2 | 4 | 14 |
| C | A | 6 | 12 | 30 |
| D | A | 2 | 5 | 8 |
| E | C | 5 | 11 | 17 |
| F | D | 3 | 6 | 15 |
| G | B | 3 | 9 | 27 |
| H | E,F | 1 | 4 | 7 |
| I | G,H | 4 | 19 | 28 |

a. Draw the network diagram, find out the critical path and project duration.

b. Calculate ES, EF, LS and LF and slack time for each task.

c. What is the probability that the project will be completed in 53 days and 56 days?

**Solution:**

a. Calculation of Expected time

The expected time (ET) can be calculated using the above formula.

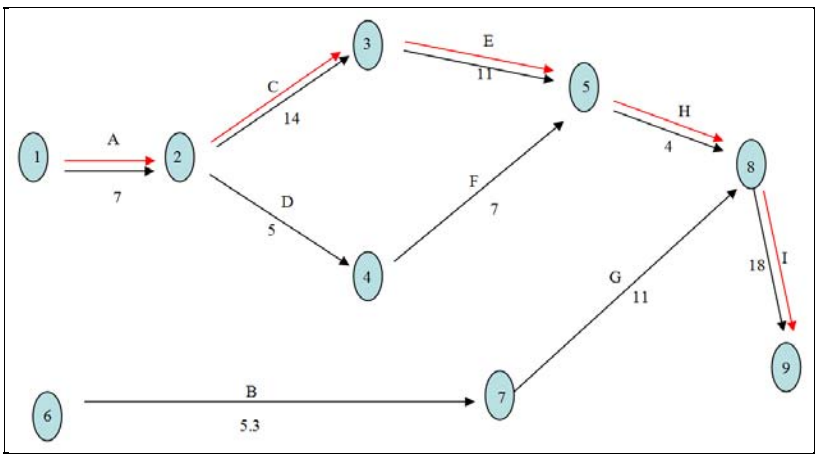
$$\text{ET(A)} = \frac{3 + 4(6) + 15}{6} = 7 \text{ days}$$

$$\text{ET(B)} = \frac{2 + 4(4) + 14}{6} = 5.3 \text{ days}$$

All expected time calculations are presented in tabular form.

| Task | Immediate predecessors | Expected time |
|---|---|---|
| A | None | 7 |
| B | None | 5.333 |
| C | A | 14 |
| D | A | 5 |
| E | C | 11 |
| F | D | 7 |
| G | B | 11 |
| H | E,F | 4 |
| I | G,H | 18 |

Once we calculated the expected time, the network diagram is quite easy to draw similar to CPM network. PERT Network diagram is drawn using activity of arrow (AOA). The network starts with two nodes 1 and 6 and ends with node 9. Activity A and B can have independent start or can start from one origin.




**Critical path calculation:**

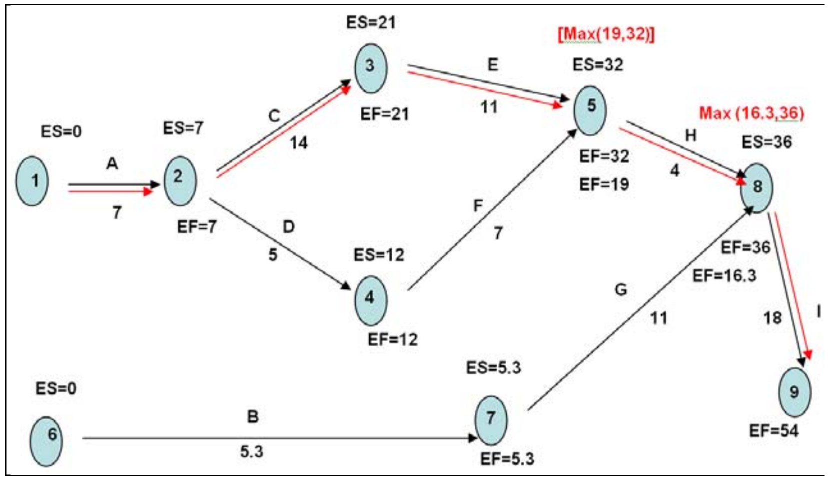
A-C-E-H-I =7+14+11+4+18 = 54 days

A-D-F-H-I =7+5+7+4+18 = 41 days

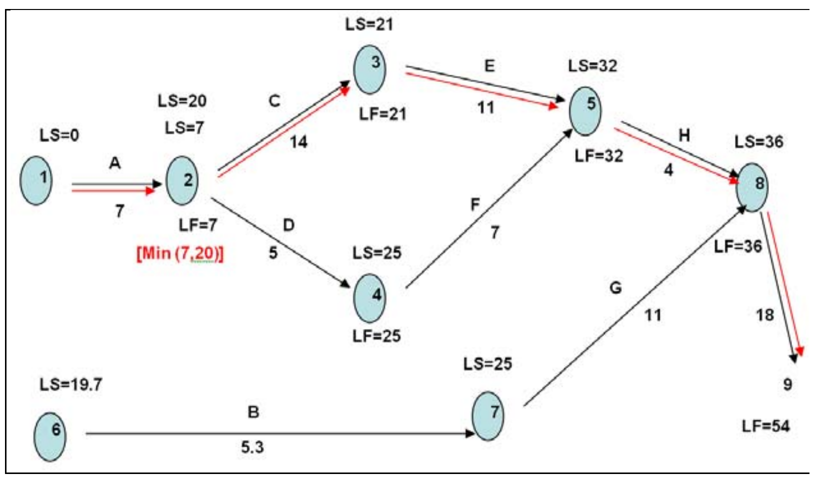
B-G-I = 5.3+11+18 = 34.5 days

So the critical path is A-C-E-H-I = 54 days. The critical path is shown in double line.

Next two network diagrams show the forward and backward pass calculation followed by float or slack calculation in a tabular form.




Forward pass calculation starts from node 1 to node 9. At node 5 and 8, EF time is the maximum of the two values as indicated in bracket in the diagram.




Backward pass calculation starts from node 9 to node 1. At node 2, LS time is the minimum of the two values as indicated in bracket in the diagram.

b. Calculation of ES, EF, LS and LF and slack time for each task.

| Task | ES | EF | LS | LF | Slack (LF-EF or LS-ES) |
|---|---|---|---|---|---|
| A | 0 | [0+7] = 7 | 0 | 7 | 0 |
| B | 0 | [0+5.3] =5.3 | 19.7 | 25 | 19.7 |
| C | 7 | [7+14] =21 | 7 | 21 | 0 |
| D | 7 | [7+5] = 12 | 20 | 25 | 13 |
| E | 21 | [21+11] = 32 | 21 | 32 | 0 |
| F | 12 | [12+7] = 19 | 25 | 32 | 13 |
| G | 5.3 | [5.3+11]=16.3 | 25 | 36 | 19.7 |
| H | 32 | [32+4 ] = 36 | 32 | 36 | 0 |
| I | 36 | [36+18]=54 | 36 | 54 | 0 |

All the tasks in the critical path (A-C-E-H-I) are having zero slack.

c. What is the probability that the project will be completed in 53 days and 56 days?

We need to calculate variance (square of the standard deviation) of all the critical tasks for probability of completion of a project. The variance can be calculated using the formula

$$\sigma^2 = \left( \frac{pessim - Optim}{6} \right)^2$$

Table below uses this formula to calculate the variance of tasks A, C, E, H and I. That gives total variance = 41

| Task | Optimistic | Most likely | Pessimistic | Variance |
|---|---|---|---|---|
| A | 3 | 6 | 15 | 4 |
| B | 2 | 4 | 14 | |
| C | 6 | 12 | 30 | 16 |
| D | 2 | 5 | 8 | |
| E | 5 | 11 | 17 | 4 |
| F | 3 | 6 | 15 | |
| G | 3 | 9 | 27 | |
| H | 1 | 4 | 7 | 1 |
| I | 4 | 19 | 28 | 16 |

Before calculating probability we need to calculate standard normal variate Z which is expressed as

$$Z = \frac{D - T_E}{\sqrt{\sum \sigma^2}}$$

For the project to be completed in 53 days, the value of

$$Z = \frac{53 - 54}{\sqrt{41}} = -.156$$

The probability, P(Z< -.156) = 0.438 or 43.8%

Refer standard normal curve at the end of any statistical text.

So there is a probability 43.8 percent that the project will be completed in 53 days.

Similarly we can calculate the probability that the project will be completed in 56 days. The value of $Z = \frac{56 - 54}{\sqrt{41}} = 0.312$

The probability that P(Z < 0.312) = 0.622 or 62.2%

So there is a probability 62.2 per cent that the project will be completed in 56 days.

## Controlling changes to the project schedule

Project management is more about managing people than about using technology or drawing Gantt charts. The first step in having a workable schedule is making sure that it is realistic in the first place and then allowing for contingencies. A realistic schedule can only be developed with the full participation of all project team members. A second critical step is having regular progress meetings with honest reporting of project successes and bottlenecks. A problem ignored is a problem that is not being managed.

Key leadership skills that have been identified as being helpful for project managers in controlling schedule changes include:

1. **Empowerment** – This allows the project team to take responsibility for their own activities by involving them in creating the detailed schedule and providing timely status reports.
2. **Incentives** – Financial or other incentives encourage people to meet schedule expectations. Programmers have been known to work longer hours to make up for project slippage provided there is a financial incentive and an adequate supply of pizza and refreshments.
3. **Discipline** – Many project managers have found that setting firm dates for key project milestones helps minimise schedule changes.
4. **Negotiation** – It is important to be able to negotiate effectively. As a project manager you do not normally have formal authority to borrow resources directly from functional work groups. You will need to develop effective negotiation skills to negotiate for resources, money and time.

## Software to assist in project time management

Project management software can automate many of the project time management functions from creating Gantt charts and network diagrams to doing critical path analysis and determining slack time. The software contains numerous reports, filters and views that can assist you with scheduling and time management. However, it is just a tool. Being an expert in MS Project will not make you an excellent project manager. Developing strong leadership and people management skills and using the tools to support you, will.

# Module summary

Summary

In this module you learnt the concept of project planning in relation to project cycle. In addition, cost, quality and time are the three important elements in influencing the project constraints. Before embarking on any project, the scope management must be clear. Scope management identifies things to be included and excluded in the project. The next step is selecting project. Project selection can be done using analytical approaches such as NPV. After a project is identified, project charter needs to be developed. This project charter is a document that describes and names the project. After the project charter is identified, the next is scope planning. Scope planning involves developing documents to clarify project scope and the bases for project decisions including criteria for phase sign-off. One way to undertake scope planning is through WBS. Sometimes the scope needs to be changed due to customer request although that has been agreed earlier. Two techniques can be used when scope change occur, scope verification and scope change control. As the project starts to take off, time management is very important. Project time management is important to ensure project completed on time and under the budget. To assist the project manager in managing project time, schedule development tools such as PERT, CPM and others can be used to manage the project time.

# Assignment

Assignment

1. Construct a Project Activity Network Diagram for a simple project of your choice, for example, building a kennel for your dog.
2. From the above diagram, identify the following:-
    a. the Critical Path
    b. opportunities for crashing
    c. opportunities for fast tracking.

# Assessment

Assessment

1. What are the differences between scope management and scope planning?
2. What are the differences between scope verification and scope change control?
3. What is the difference between critical path and probabilistic time estimates?

# Assessment answers

1. Scope management is ***"the processes involved in defining and controlling what is or what is not included in a project".*** The five key processes involved in the scope management. Scope planning is one of the processes in scope management. Scope planning is Scope planning involves developing documents to clarify project scope and the bases for project decisions including criteria for phase sign-off. (How do we know when we are done?). The key output is a scope statement. The scope management, or statement of work, is the key document used to enunciate and confirm the scope of the project.
2. **Scope verification** involves documenting the project's processes and products and getting the key stakeholders to sign off on them. In a project, this is usually accomplished through what are known as a Business Requirements Document and a Technical Specifications Document. **Scope Change Control** usually entails a formalised process for changing project scope wherein the implications in terms of time and cost are clearly stated. Again, key stakeholders are required to sign-off on accepted changes to the scope of the project. The best preventative measure for project scope change is doing a thorough job of requirements and specifications in the first place.
3. The **critical path** for a project is those series of activities that together determine the earliest time by which the project can be completed. To find the critical path, we need to:
    - Create a work breakdown structure;
    - Convert this into a network diagram;
    - Estimate the durations for each activity; and
    - Add together the durations for all activities for each path through the network diagram.

    The path with the longest total duration is the critical path. There can be more than one critical path for a project if two or more have the same longest total duration. Probabilistic time is estimates of activity duration using optimistic, most likely, and pessimistic estimates of activity duration.