2009-01

Project management study guide

Politis, John D.

In-house Publication

PROJECT MANAGEMENT STUDY GUIDE

Higher Colleges of Technology
Dubai Men's College, EMGT 450
and the
Ministry of Public Works
Dubai, UAE

In-house Publication, January 2009

COMPILED AND EDITED BY

Dr John Politis, Ph.D.

C.Eng. (Aircraft), B.Eng. (Mech), MSc (Mech Eng), Grad.Cert.Ent.Mgmt, Ph.D. (Mgmt)

FIEAust, FIPENZ, CPEng, AFAIM, MAMA, MASME, FEANI EUR ING, TEE

The majority of this material is based on previous work of Messrs. Beale, P., and Hartley, S., and we gratefully acknowledge their contribution

Higher Colleges of Technology
Dubai Men's College

Topic 1

The Role of Project Management

Managing Projects -
Critical Skills & Techniques

1 Overview

Topics

1. **The role of projects**
2. Planning and scheduling a project
3. Bar charts and resource allocation
4. Building on the basic techniques
5. Organisation structures for projects
6. Project costs
7. Using computers for project management

Sections

- A brief history
- Organisational objectives
- Relationship between venture and project
- Project life-cycles
- Project features
- Examples of projects
- Managing a project
- Summary

1 The role of projects

Learning outcome

By successfully achieving the stated 'enabling objectives' for this topic, you should be able to:

- Apply the techniques used for managing projects within an organisation.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Identify the role of projects in the running of organisations
- Define the difference between a venture and a project
- Define and describe the four phases of a project
- Describe the techniques used for managing projects

What you will need

Suggested study time	Study Guide	3 hours
	Activities and exercises	1 hour
	Text Book & readings	2
	Total	6 hours

Other resources	Nil

Introduction

Undertaking projects and the management of projects has been happening for as long as we are aware from our historical understanding. Just think about some of the great building projects around the world; for example, the pyramids, ancient cities, the Great Wall of China, skyscrapers, bridges, dams, and the Euro tunnel. What about the building, testing and use of airplanes, submarines, the space shuttle and landing on the moon? These are but a few of the many 'projects' which have been undertaken and completed through human endeavour. For much of our history though, many of these 'projects' were considered as work to be done; a job to complete; or a new endeavour. It is only in relatively recent times that 'project management' has become recognized as a central management discipline. Project management is now considered as a powerful way to integrate organisational functions with tools and techniques which enable groups of people to achieve higher levels of performance and productivity.

A brief history

The first recorded account of project management as a separate dedicated activity has been attributed to the United States defence forces. During the 1950s the development and production of the Polaris ballistic missile by the United States Air Force was done using specific techniques of 'project management'. However, there is evidence that some of the principles of project management have been incorporated into the management of defence force activity as early as the 1930s. This does not mean that they were the first to undertake the management of projects. However, it seems they were the first to identify and classify techniques for managing projects as a dedicated management activity.

Organisational objectives

All organisations are established to achieve a mission. To achieve the mission they normally prepare business plans to cover varying periods into the future. The business plan will nominate objectives to be attained during these periods; for example. A business plan for a transport company will include the following objective:

> *to increase revenue earned from the volume of freight and passengers carried*

The activities carried out in these regular, continuing operations can be called cycled or cyclic activities, the cycle being determined by the period specified in the business plan.

Organisations often also find it necessary to develop a new product or service, modify a procedure, build a new facility, and so on. These are called 'projects' and are non-cycled activities, in the sense that they do not normally recur. Examples of missions, objectives, cyclic and non-cyclic (projects) for two different organisations are shown in Figure 1 – 1.

	A State Rail Authority	**A Packaging Company**
Mission	To provide an effective rail system for the transport of passengers and freight	To provide high quality packaging components to industry:
Typical objectives (yearly)	1. Increasing freight and passenger volume to be carried 2. Profit to be made on operations 3. Enhancement of installations 4. Image building and maintenance 5. Development of human resources	1. Increasing volume of business and market share 2. Profit and return on investment (shareholders dividend) 3. Development of new products 4. Image building and maintenance 5. Development of human resources
Typical cycled activities	1. Carriage of passengers 2. Carriage of freight 3. Regular maintenance of rolling stock 4. Training apprentices 5. Accounting routines	1. Production of existing products 2. Selling of existing products 3. Maintenance of machinery and equipment 4. Training apprentices 5. Accounting routines
Typical projects (non-cycled activities)	1. Track strengthening 2. Design of travel packages 3. Physical image enhancement 4. Improvement of systems	1. Development of new products 2. Improvement of installations 3. Improvement of systems

Figure 1-1: Examples of mission, objectives, and cycled and non-cycled activities

For your organisation, identify and write down examples of the mission, objectives, cycled and non-cycled activities:

1. Mission

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Mission Statement

Dubai Men's College is committed to providing a high quality, career-oriented education for the UAE Nationals in a dynamic and positive atmosphere that encourages creative and constructive thought.

2. Yearly (or another typical period) objectives

   (a) ………………………………………………………………………………………

   (b) ………………………………………………………………………………………

   (c) ………………………………………………………………………………………

3. Typical cycled activities

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

4. Typical non-cycled activities

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Relationship between venture and project

In the discussion that follows the words ‘venture’ and ‘project’ are defined. It is not suggested that these definitions are universally used or accepted, but it is vital to differentiate between the two sets of activities involved.

Venture

A **venture** is defined as the development of an asset (building, system, piece of plant, new product, etc.) and the use of that asset to help in the achievement of an organisation’s objectives and mission. A venture is considered to continue until the use of the asset ceases, at which time it may be replaced by a modification or a different asset. This would then be considered as a new and separate venture.

A venture is normally cash generating in some form, and it feasibility can be judged in the initial stages of analysis by discounted cash flow or similar techniques.

Project

A project is here defined as the sub-set of activities needed to create the asset ready to hand over to the user. The relationship between venture and project as here defined is shown in Figure 1-2.

<------ **Venture** ------>					
Conceptual	Development	Asset in use		Divestment	
Investment Analysis	Asset construction or acquisition	Growth	Maturity	Decline	Death

<------ Project ------>			
Feasibility phase	Formation phase	Execution phase	Handover phase

Figure 1-2: Relationship between a venture and a project

It is vital that the difference in responsibility for a venture and a project is understood. The person responsible for authorising a venture must ensure (as far as possible) that the factors in the future likely to affect the profitability of the venture have been taken into account. This person is responsible for the profitability of the venture over its full term.

The project manager, on the other hand is responsible for delivering the specified asset to the user, meeting the broad project objectives of **scope, quality, time and cost.** The Project Management Institute (Australia) defines these project objectives as follows:

Scope

The work content of a project or component of a project. Scope is fully described by naming all activities performed, the end products which will result, and the resources consumed.

Quality

The standard of the end products whenever possible in quantitative terms, Standards could cover tolerances, performance finish, reliability, maintainability, and so on.

Time

The date when the assets are to be delivered to the Principal, Owner, User, etc. This date may sometimes be varied under specific conditions or contingencies.

Cost

The budgeted costs of the project: these can also be varied under specific conditions or contingencies. Costs can also be expressed in dollars of the day or dollars of the future, which can be particularly important in a long project.

Definitions

These for objectives can be grouped to provide the following definitions:

Project

a project: A project is 'a one-off job that has defined starting and ending dates, a set of clearly specified objectives (or scope of work to be performed to nominated quality standards), a pre-defined budget, and sometimes a temporary organisation that is dismantled once the project is complete'.

Project management

project management: Project management is 'the planning, scheduling, staffing and controlling of project activities to achieve project objectives'.

Project life-cycles

A typical formal starting point for a project is when management (or the owner) authorises the use of resources to investigate an idea that may result in an outcome that will enhance the organisation's ability to achieve its mission (new product, system, building, facility, etc).

The typical finish point is when the project outcome has been produced and has been handed over to (and accepted by) the owner or user.

Phases of a project

In between the start and finish there are typically the following four phases:

- Feasibility
- Formation
- Execution
- Hand over

These phases are represented in Figure 1 – 3.

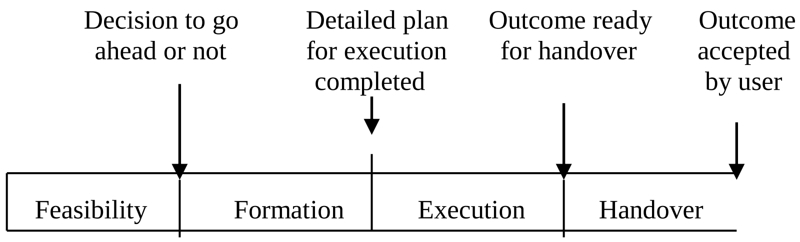


Figure 1-3: Phases of a project

The four phases – ***feasibility, formation, execution, hand over*** are given various titles in the literature. There is, however, general agreement as to what each of those phases covers.

Phase 1 – Feasibility (conceptualisation of the idea)

A conceptual idea or potential investment is explored to see if it can be done and whether it will pay. Its financial contribution will be measured normally by the methods of investment analysis, using for example the discounted cash flow (DCF) method. At the end of this phase (refer Figure 2 – 4) the investment analysis team will report to management or the owner who will then decide whether to proceed or abort.

Phase 2 – Formation (design, planning, and structure)

This phase converts the concept into a clearly defined specification and budget, together with a plan and schedule showing how those objectives will be achieved. At the end of this phase the major investment decision is taken, once again whether to proceed or abort. At this point the objectives should be precisely set so that they can be used as the criteria against which performance in the next phase is measured.

Phase 3 – Execution (production, process, and operation)

In this phase the outcome or product that was approved at the end of Phase 2 is constructed; this is generally the phase when by far the largest cash outflow is incurred. In the case of a building project, for example, equipment is procured, civil and structural works are undertaken, and equipment and facilities are installed. This phase differs totally in character from the previous two phases in that its aim is not to develop new technical options, but to construct as efficiently as possible the building defined in the specifications and by the formative phase.

The mode of control in this phase is one of tight monitoring to keep actual quality, duration and cost within the target limits.

Phase 4 – Hand over (termination, conclusion)

This phase may overlap Phase 3, and involves planning all the activities needed for acceptance and operation of the project: for example, training, debugging, etc. This phase is alternatively called the warranty phase, defects period, or guarantee period; it may include an audit of the effectiveness of Phase 3. It is often undertaken by a special group of people, not in any way connected with the project team. The results of Phase 3 may thus be handed over not only to the sponsor but also to the maintenance or audit team.

It is important to note that in any one project:

- not all of the phases necessarily take place
- the phases and the boundaries between them are not always clearly defined.

Project features

As discussed previously, organisations carry out cycled and non-cycled activities, each contributing in their won way to organisational success. The two types of activity are considerably different, and because we are concerned with the success of projects, we need to identify the features that distinguish a non-cycled activity) will have the following features:

- a clearly defined end result or scope
- defined objectives of time for completion, budgeted cost, and quality in the end result
- a clear start point and a clear finish point, and is thus self-contained
- some elements of uniqueness: even if a project is repeated, for example, overhaul of a power station, there will still be differences from project to project
- a requirement for a number of different resources and disciplines to be used in its execution
- it is often undertaken as a group of activities superimposed on the regular or cycled activities of the organisation.

Start point and finish points

The typical start point for many projects is the decision to commit resources. Typical end points for the execution phase of projects are shown in Figure 1-4.

Project type	End point	Results handed over to
Development of a new product e.g. a new pet food	Product available at all retail outlets, back up stock available, advertising ready to run, sales force trained.	Sales manager and sales staff
Construction of a mining plant	Plant completed, commissioned and run up to ensure it meets specified operating characteristics	Mining company management or (if an in-company project) mining superintendent
Construction of a multi-story office block	Building complete and ready for occupation or leasing	Owner of property company who commissioned building
Overhaul of major plant or equipment	Equipment restored to specified performance: specified modifications carried out and tested	Operator of plant or equipment e.g. power station Superintendent or Operations Director

Figure 1-4: Typical end points for execution phase

Examples of projects

Organisations undertake projects, or non-cycled activities, in many areas. This section describes some areas of application. We should note that investment decisions and the projects resulting from them take place over the full range of human endeavour.

The items listed below result from investment decisions and are all non-cycled activities which would almost always be brought to a successful conclusion by the use of the methods of project management.

Research – fundamental or applied research in all scientific, technical, industrial, education, social fields.

Preliminary Projects – feasibility studies, preparation of tenders.

Construction – industrial plant, mining plant, utilities, commercial and industrial buildings, high-rise residential buildings, hotel.

Civil Engineering – railways, freeways, bridges, harbors, waterways, road programs, airports, and dams.

Town Planning – control of tendering and design procedures and subsequent building and installation of services.

Design – design of all types of plan and equipment, e.g. cars, machine tools, military equipment, electrical and electronic equipment and systems, computers.

Commissioning and Installation – chemical, electrical and mechanical plant and equipment; electronic equipment, including computers.

Marketing – market research, market development programs, development and launch of new products and services, product modification and re-launch.

Administrative Systems – investigation, modification, design, development and installation of all administrative, office, clerical and computerised procedures.

Modification Programs – the modification of existing plant or equipment; the re-layout of a plant, factory, office, etc.

Overhaul – equipment, vehicles, and buildings, both on a routine and an emergency basis.

Managing a project

The main steps to be taken in the management of a project are:

1. Define the project objectives and the start and finish points of the project.
2. Determine the way in which the results are to be achieved.
3. Plan and schedule the activities to be undertaken.
4. Assign resources to the scheduled activities.
5. Optimise the balance between duration and cost.
6. Set up an organisation structure for the management of those resources.
7. Execute the project by issuing progressive instructions to all those taking part in the project.
8. Monitor the progress and cost of the project until it reaches its objectives.

Defining the project objectives

The three basic project objectives are:

1. Achievement of a previously defined end result, generally meeting the requirements of a specification (scope and quality).
2. Achievement of the result within a nominated period of time.
3. Achievement of the result within a budgeted cost.

These objectives interact with each other. For example, if a defined end result is to be met by a certain time, it may be necessary to apply additional resources to those originally planned. The use of those additional resources will almost certainly mean that the budget cost is exceeded.

Determine the method to achieve the end result

In most projects there are a number of ways in which the end-result could be achieved. While the anticipated method for achieving the end result may have been nominated in a preliminary project (tender, feasibility study, etc.), it is vital that the method to be actually used in the project be clearly laid down. This definition of method is an essential first step in the execution phase of the project, unless it was done in precise terms at the end of the formative phase.

A formalised procedure for defining the method is the Work Breakdown Structure (WBS), which is used for many large projects. Discussions on this approach are contained in several of the books listed in the Unit Profile.

The remaining six steps in managing a project are dealt with in detail in subsequent sections of this Study Guide, as follows:

Step 3. Plan and schedule: Topic 2

Step 4. Resource allocation: Topic 3

Step 5. Optimise balance between duration and cost: Topic 6

Step 6. Organisation structure: Topic 5

Step 7. Execute project: Topic 5

Step 8. Monitor project: Topic 7

Complete the following questions:

1. Describe the following broad project objectives:

   Scope..

   ....

   Quality ....

   ....

   Time ....

   ....

   Cost ....

   ....

2. In your own words define:

   A project ....

   ....

   Project management ....

   ....

3. Describe the four phases of a project:

Feasibility ……………………………………………………………

……………………………………………………………………………

Formation ………………………………………………………………

……………………………………………………………………………

Execution ………………………………………………………………

……………………………………………………………………………

Hand-over ………………………………………………………………

……………………………………………………………………………

Summary

This topic provided an introduction to projects. In particular it focussed on the historical foundations and the place of projects within the organisational context.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic establishes the context for the rest of the module?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Introduction to projects

- ☐ Definitions
- ☐ Historical foundations

The role of projects

- ☐ Mission, objectives and projects
- ☐ Relationship between venture and projects
- ☐ Project life-cycles
- ☐ Phases of a project
- ☐ Project features
- ☐ Start and finish points
- ☐ Examples of projects
- ☐ Managing a project

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

EMGT 450

Topic 2

Planning and Scheduling a Project

B

A

S

Bachelor of Engineering Management

1

Contents

Overview

Topics

1. The role of projects
2. **Planning and scheduling a project**
3. Bar charts and resource allocation
4. Building on the basic techniques
5. Organisation structures for projects
6. Project costs
7. Project control
8. Using computers for project management

Sections

- Introduction
- Scoping the project
- Critical path analysis
- CPA glossary of terms
- Using CPA to plan a project
- Milestones
- Dummy activities
- Summary

Planning and scheduling a project

Learning outcome

By successfully achieving the stated ‘enabling objectives’ for this topic, you should be able to:

- Plan and schedule a project.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Appreciate the importance of scoping a project
- Define the objectives of a project, including ‘start’ and ‘finish
- List the activities needed to achieve project objectives
- Identify dependencies between the activities
- Draw a project plan as an arrow diagram (network)
- Estimate activity durations, making appropriate contingency allowances
- Analyse the network (event and activity)
- Identify the critical path for a network

What you will need

Suggested study time	Study Guide	15 hours
	Activities and exercises	5 hours
	Textbook and readings	10 hours
	Total	30 hours

Other resources	Nil

Introduction

Topic 1 provided an introduction to project management, and many of the concepts associated with this discipline. Simply defining a group of activities as a ‘project’ is not enough to ensure that all desired outcomes are achieved.

By following a systematic approach using proven tools and techniques for planning of the project and scheduling the activities, the project manager and project team can meet the project goals in terms of the:

- project cost
- timelines
- project objectives

This topic will introduce students to the principles of project planning and scheduling.

Scoping the project

Projects do not fail at the end, the fail at the beginning.

Scoping a project is the process required to ensure that the project includes all the work required, and only the work required, to complete the project successfully. It is the documented basis for making future project successfully. It is the documented basis for making future project decisions, and for confirming or developing a common understanding of project scope among all stakeholders. It seeks to clarify and document information on the four main variables found in every project – time, cost, performance and people. These can be represented graphically as shown in Figure 2-1.

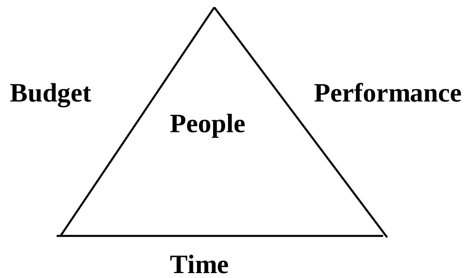


Figure 2.1: **Project scope variables**

By sub-dividing the major project deliverables into smaller more manageable components, scoping allows for:

- improved accuracy of time, cost and quality
- defined baselines for performance measurement and control
- better facilitated responsibility assignments
- minimised final project costs
- pre-empts inevitable changes
- precludes any changes that might disrupt the project rhythm
- minimised requirement of re-work
- minimised increases in time frame
- minimised possibility of lower productivity
- prevents falling morale due to creeping scope.

Project scope defines and controls what is and what is not in the project.
It clearly:

- describes the project in its 'as built' condition
- states the customer's requirements established and understood
- ensures the customer is clear on what they will get for their money
- describes the work to be accomplished

- defines and documents the project in all essential respects before estimates are made
- shows the size of the project
- records how much is to be achieved
- states the length of the project window
- quantifies the obligation on resources.

Once the scope document is completed, it is also used in the process of identifying that a scope change has occurred. It then helps in managing that actual change, and ensuring the changes are beneficial. Change requests (error, omission or value added changes) may be oral, written, direct, indirect, internal, external, legally mandated or optional changes. This requires that the scope document describes how the project scope will be managed and how scope changes will be integrated into the project. It includes an assessment of the expected scope stability, and descriptions of how scope changes will be identified and classified. Further, it defines the procedures for how project scope may be changed (paperwork, tracking and approvals).

Remember that the underlying rationale behind the project scope document is that adequate work is done, unnecessary work is not done and that the project's purpose is achieved.

Scope creep

Creeping scope (sometimes referred to as scope elegance) is the result of misinterpreting the project scope and/or, of poorly defining the project scope initially. Common causes for this creep can be:

- imprecise language (nearly, optimum)
- no pattern, structure or chronological order
- failing to get third party review
- wide variation in task size
- lack of detail in describing the work
- omitting special instructions
- ignoring approvals and specifications.

Critical path analysis

A technique commonly used for the planning, scheduling, and control of projects is **Critical Path Analysis** (CPA). This technique was developed in the late 1950s in the USA during the development of the Polaris missile, and independently by Dupont for the construction and overhaul of chemical plant. Similar techniques were developed during the same period in Russia, France and the UK. In the UK, CPA was used for the overhaul of power stations, where it was credited with reducing overhaul time to 42% of the previous average time.

As previously stated in Topic 1, the main objectives of a project are:

1. To achieve a specific end-results at a predetermined level of quality.
2 To meet time targets.
3. To meet cost targets.

CPA, sometimes referred to as “Critical Path Method’ (CPM) is one of the many tools that can help management achieve these three objectives. In the planning state it will show whether the objectives are realistic and whether modifications should be made to objectives, plans and resources. In the operational stage it will show where things are going wrong and where action can be taken so that project objectives are maintained.

CPA glossary of terms

Although there is not a universal/international terminology associated with CPA, the following terms have received general acceptance.

Activity	An operation or process essential to the completion of a project that consumes time and generally other resources: an activity is represented in a network by an arrow.
Backward Pass	The procedure whereby the latest event times for a network are calculated.
Critical Path	That sequence of activities which determines the minimum total duration for the task or project.
Dependency Rules	1. An event is not reached until all activities leading into it are complete. 2. An activity cannot start until its tail event has been reached.
Dummy	1. Identify Dummy: a link inserted in the network to ensure that all activities are uniquely numbered. 2. Logic Dummy: a logical link, a constraint which represents no specific operation. Note: dummies consume neither resources nor time, and are represented in a network by broken arrows.
Duration	The estimated time required to complete an activity.
Earliest Event Time (TE)	The earliest time at which an event can be reached.
Earliest Finish Time of an Activity (EF)	The earliest possible time at which an activity can finish without affecting the total project time or the logic of the network.
Earliest Start Time of an Activity (ES)	The earliest possible time at which an activity can start without affecting the total project time or the logic of the network.
Event	An event is a point in time defining the beginning and end of an activity or a group of activities. An event is represented in a network by a circle or square.
Float	The time available for an activity in addition to its duration (float may be negative).
Forward Pass	The procedure whereby the earliest event times for a network are determined.
Head Event	The finish event of an activity.
Latest Event Time (TL)	The latest time by which an event can be reached without affecting either the total project duration of the logic of the network.
Latest Finish Time of an Activity (LF)	The latest possible time by which an activity can finish without affecting either the total project time or the logic of the network.

Latest Start Time of an Activity (LS)	The latest possible time that an activity can start without delaying the completion of the project.
Network	A diagram representing the activities and events of a project, their sequence and interrelationships.
Precedence Diagram (Pert Chart)	A graphical representation of a project in which the activities are shown as boxes and the dependencies between the activities are shown as arrows. In many computer packages the precedence diagram is called a Pert Chart.
Resource Limited Scheduling	The scheduling of activities such that pre-determined resource levels are never exceeded, and the project duration minimised.
Slack	Latest event time minus earliest event time: slack refers only to events: it may be negative.
Tail Event	The start event of an activity.
Time Limited Scheduling	The scheduling of activities such that the specified project duration is not exceeded.

Using CPA to plan a project

To apply CPA to the management of a project, the following steps should be applied in sequence. After the initial steps there are a number of options the project manager can exercise if they are needed. The steps are listed, then described in detail:

1. Define the project and its start and finish
2. List the activities
3. Estimate activity durations
4. Draw the network
5. Event analysis
6. Activity analysis
7. Construct bar chart (covered in Topic 3)
8. Resource allocation (covered in Topic 3)
9. Optimisation of duration and cost (covered in Topic 6)

Step 1 – Define the project and its start and finish

What is the project intended to achieve and to what performance or quality specifications? Initial conceptualisation of the project will always involve some degree of evaluation. Possible projects or elements of these projects need to be evaluated before selection of the most appropriate set of activities (new project) which will achieve the desired organisational objectives. In order to select the best project, we need to analyse the clients requirements, define the problem, collect the information, define the project restrictions and define the project objectives. It is also important during this step to define:

- how best to capture what the project is all about by giving it a definitive but concise title
- the point at which the project manager assumes responsibility
- the point at which the project manager hands over specified results of the project to the user, owner or sponsor.

The start and finish of a project are often much harder to define than it might seem. Typical start and finish points are:

Start: decision made to commit resources to the project.

Finish: acceptance by the user (of the results of the project) that the project has been satisfactorily completed.

Step 2 – List the activities

An activity is a task that:

- is **essential** for the completion of a project
- consumes time and/or resources.

Listing the activities should be carried out as a group task, so that all necessary activities will be included in the plan. This step is sometimes accomplished by the application of a process called "Work Breakdown Structure' (WBS).

Work Breakdown Structure

The use of Work Breakdown Structure (WBS) is essentially an estimating process that tries to answer some fundamental project questions:

- What must be done? (identifies the discrete tasks)
- How long will it take? (determining the task durations)
- How much will it cost? (what budget is required)
- Who can do the work? (what resources will we assign to the tasks)

The approach taken by the WBS is quite simple and it looks a lot like an organisational chart. It begins by identifying the total project as one complicated task or 'chunk' and then it breaks down, level by level, each task into several, smaller more manageable tasks. The process is continued until the task can no longer be broken down any further. At this lowest level of task breakdown, an estimate of the task (or sub-task) duration, cost and resource requirements can be made. Figure 2-2 shows the basic arrangement of a Work Breakdown Structure.

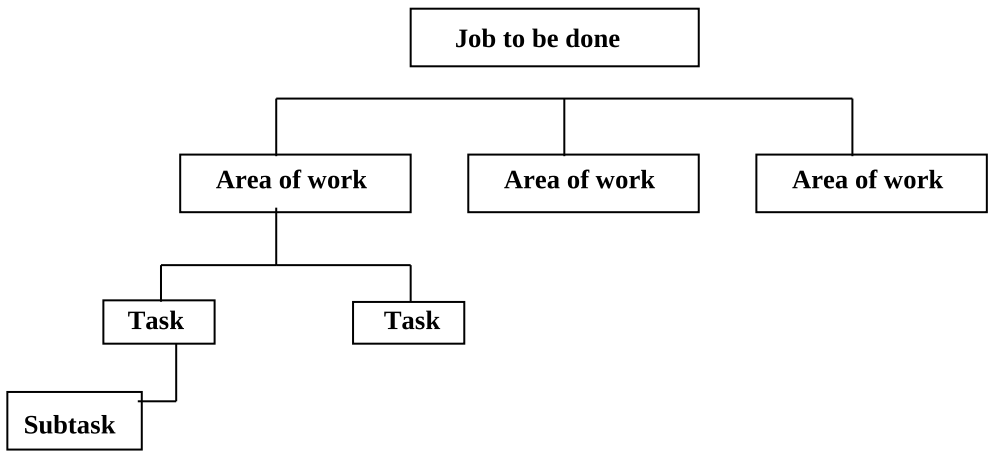


Figure 2-2: Basic layout of a Work Breakdown Structure

Consider the following example. For the job of 'cleaning a home', a Work Breakdown Structure could be drawn as shown in Figure 2-3.

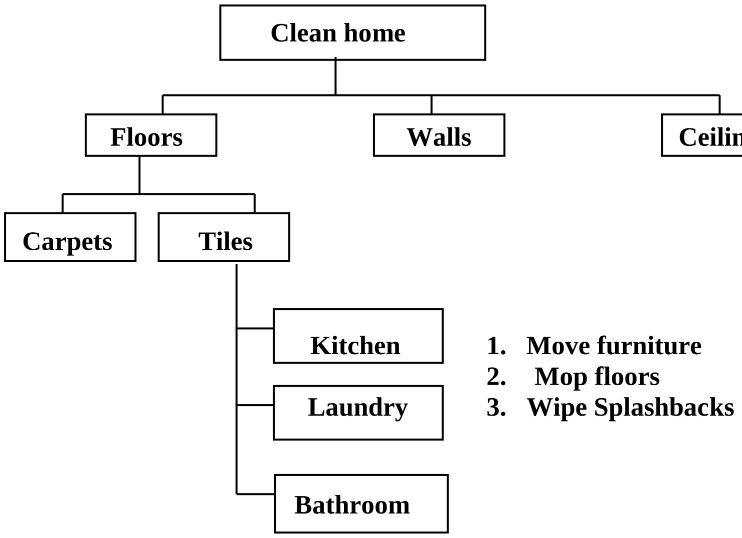


Figure 2-3: Example Work Breakdown Structure

In Figure 2-3, three discrete sub-tasks under the 'Tile' grouping have been identified:

1. move furniture
2. mop floors
3. wipe splashbacks

At this lowest level of task breakdown, an estimate of the task's duration, cost and resource requirements can be made.

Some simple rules (protocols) for drawing and using work breakdown structures are listed below:

- the diagram is a graphic portrayal of the total project scope
- work not in the WBS is outside the scope of the project
- confirms a common understanding of project scope
- it shows the deliverable-oriented grouping of project elements
- it shows dependencies (relationships) between all project tasks
- the logic is not time based
- all tasks are grouped under key stages
- the diagram is a hierarchical structure
- all sub units of work are identified
- the different levels of detail (decomposition) are shown
- the levels shown are sufficient to achieve estimating accuracy
- each descending level shows an increasingly detailed description of the tasks

- all tasks are captured
- ties project together
- is drawn top down
- makes a complex (large) project manageable
- does not need to be symmetrical
- can often be 're-used' as some projects resemble other projects

The Institute of Project Management (A guide to the project management body of knowledge, 1996) states that the intent behind completing a work breakdown structure is to ensure that each major project deliverable is sub-divided into smaller more manageable components, until the deliverables are defined in sufficient detail to support future project activities (planning, executing and closing).

Remember, a work breakdown structure must be manageable, independent, integrateable and measurable. It is similar to a job analysis in that it breaks down every project into a number of distinct sub-units or work components. Because all elements of the project are identified, there is less chance of neglecting or overlooking an essential step. The goal of this technique is to identify works units that are discrete and that will advance the project towards its completion.

Now, back to Step 2 (listing the activities)

Anything that only consumes time but not resources must also be included as an activity (e.g. curing concrete, waiting for responses to questionnaires, waiting for approvals, etc.). However, non-essential activities should not be included.

It is important to clarify the level at which the work breakdown occurs. Most activities can be broken down into smaller, discrete sub-tasks, however, if broken down too much, the planning and management of all the discrete sub-tasks can become laborious and over-complicate the entire process. It is very useful at this stage for each person responsible for a task to nominate the immediate pre-requisite activities for that task. Figure 2-4 is an example of a form which may be used to document this step (a full size blank version is included at Appendix 1). Additional information can also be recorded on the form, such as:

- cost of the activity, which could be split up into various components of cost
- duration (explained further in Step 3)
- department or individual responsibilities
- resources needed

Immediate prerequisites	Code	Description	Duration	Resources	Cost	Person responsible

Figure 2-4: **Example activity list form**

Step 3 – Estimate activity durations and dependencies

The duration of each activity must be estimated. The estimator (who should be the person who will be responsible for carrying out the activity) should base the estimate on the resources normally or realistically available for the activity.

Some people are optimistic estimators whilst others are pessimistic: the project leader should try to assess any variations due to individual personalities and make adjustments.

If an element of a project is carried out with some regularity (e.g. plant overhaul) historical records, timesheets, logs, etc. will provide a factual basis for the estimates.

Guidelines for making duration estimates

Rule number one when making estimates of durations – never use ballpark figures! Why? Because ballpark figures become client targets.

Estimating task duration involves determining the number of work periods likely to be needed to complete the identified activity to the specification required. It is a quantitative assessment and should always include some indication of the range of possible results ± (e.g. 3 days).
While estimation remains both a science and an art form, a number of commonly used estimation techniques (excluding crystal ball gazing) are listed below:

- learn from experience
- make an educated guess
- the client tells you

- use information from project files
- use the project team knowledge
- rely on historical data
- use random task allocation (that is, estimate in random fashion, not consecutively)
- ask the experts
- apply analogous estimation (actual duration of previous similar task used as basis for the estimate)
- use trial simulations (Monte Carlo Analysis)
- build a prototype or model

Irrespective of which technique you adopt (and try them all), you will improve your estimation techniques by:

- always documenting any underlying assumptions
- showing any factors that might affect the estimate validity
- telling how the estimate was derived and any assumptions you have made.

Another technique used in estimation is the use of a PERT Weight Average formula that quantifies three estimates. Again, the final result is skewed left or right depending on the strength of the weight used, and on which variable was weighted. The PERT Weighted Average Estimate formula is shown below, where:

T_e = expected time
T_o = optimistic time
T_m = probable time
T_p = pessimistic time

$$\mathbf{Te} = \frac{T_o + 4T_m + T_p}{6}$$

Applying Monte Carlo to project management

In project management, the technique can be used to model the project cost, or it can be applied to certain project risks that you've identified. The more common use is in the creation of the project schedule and the determination of the project end date.

When you put together your project schedule, you typically create a series of tasks and an estimated duration for each task. When you're finished, you look at the resulting timeline to see the estimated end date. As we all know, the chances of hitting that exact end date aren't 100 percent; you're never 100 percent sure of the duration of the underlying activities. Since uncertainty is associated with each step, a Monte Carlo analysis can be performed.

A simple example
To use the Monte Carlo analysis, instead of just one estimate of duration for an activity, we create three. First, we estimate the most likely duration, and then we estimate the worst case and the best case. With each estimate, we assign what we think is a likely probability that it

will occur. (An even more sophisticated approach is to use a distribution model that represents the probability of every possible outcome for the task, but that is more than we'll get into in this discussion.)

Let's look at a small project with three tasks that must be worked on sequentially. Task A is likely to take three days (70 percent probability), but it is possible that it could take two days (10 percent) or four days (20 percent).

Task B will likely take six days (60 percent), but could take as few as five days (20 percent) or as many as eight days (20 percent). Task C will probably take four days (80 percent), three days (5 percent), or five days (15 percent).

How long will this project take to complete?

The guts of Monte Carlo

The Monte Carlo analysis involves a series of random simulations on our three-step project. Each time, the analysis software plugs in random task durations for A, B, and C based on the probabilities that we provided. It's possible that the first time through, it would calculate 12 days (2 + 6 + 4). The next time, it might calculate 11 days (3 + 5 + 3). Then it could calculate 12 days again (3 + 5 + 4).

Now, imagine that this simulation were run 1,000 times. By the time the simulation was completed, you would expect around 700 simulations in which task A took three days (70 percent). Likewise, there should be around 150 simulations where task C took five days (15 percent). Each time a simulation is run, an end date is determined.

The results

When the Monte Carlo analysis is complete, you don't have a single end date. You have a probability curve showing expected outcomes and the probability of achieving each one.

For the purposes of scheduling, we would look at a cumulative curve showing the probability of completing the project between the best case, 10 days (2 + 5 + 3), and the worst case, 17 days (4 + 8 + 5).

When you tell your stakeholders when the project will be completed, you typically pick the duration that gives you a 90 percent chance of success. In other words, you would say that, based on the Monte Carlo simulation, you have a 90 percent chance of completion within X days.

Summary

Our example contained three tasks. Think about the projects that you have with hundreds, or thousands, of tasks. The Monte Carlo analysis allows you to show the uncertainty associated with the duration of these tasks.

Many, but not all, project management scheduling packages allow you to perform these simulations. The software can run thousands of simulations on your workplan and then show the dates on which you have a 50 percent chance of completion, 80 percent chance of completion, 90 percent chance of completion, etc.

Tori, you also asked whether Monte Carlo analysis was something that unsophisticated project managers should use. I think the answer is no. Certain projects contain enough risk and uncertainty that it would make sense to use this technique, but much more diligence is required for the detailed estimates.

An example is a project that you are estimating in an outsourcing relationship. Many of the activities may be vague, but you still need to be able to commit to a timeline and end date that you have a high likelihood of achieving. In general, the technique can also be used to provide safe end-date estimates for any large project. After running the simulations, you would not want to pick the end date that has a 50-50 chance of success. The Monte Carlo analysis will tell you the date that you have an 80 percent chance to achieve, or a 90 percent chance, depending on how safe you need to be.

If you provide estimates and probabilities for detailed activities that aren't well thought out, the resulting simulations will be invalid as well, and you may end up with schedule completion dates that aren't realistic. Stick to the best-guess estimate for each task at this point, and then utilize Monte Carlo analysis on projects that contain a lot of scheduling risk and where it makes sense to perform the additional diligence around estimating the work in terms of multiple durations and probabilities.

Project management veteran Tom Mochal is director of internal development at a software company in Atlanta. Most recently, he worked for the Coca-Cola Company, where he was responsible for deploying, training, and coaching the IS division on project management and life-cycle skills. He's also worked for Eastman Kodak and Cap Gemini America and has developed a project management methodology called TenStep.

Source: http://techrepublic.com.com/5100-6330_11-1027705.htm

Task relationships

One of the questions that must be answered in all types of projects is whether there is any relationship or link between the project tasks. That is, are the start and finish dates of tasks determined by the start and or finish dates of another tasks in the project, or can tasks start and finish independently of other tasks.

While many projects will contain a number of independent tasks you have no relationship with any other task in the project (that is, they can start and or finish without any impact on any other task), most projects contain tasks that are largely constrained by other tasks.

Activities must be sequenced accurately if a realistic and achievable schedule is to be developed.

Four relationship types have been classified in project management as follows (refer Figure 2-5):

- Finish – Start: Relationships where a task (task B) cannot start until its predecessor (task A) has finished. This is the most common relationship [FS].

- Finish – Finish: Relationships where task (B) cannot finish until task (A) finished [FF].
- Start – Start: Relationships where task (B) cannot start until task (A) starts [SS].
- Start – Finish: Relationships where task (B) cannot finish until task (A) starts [SF]

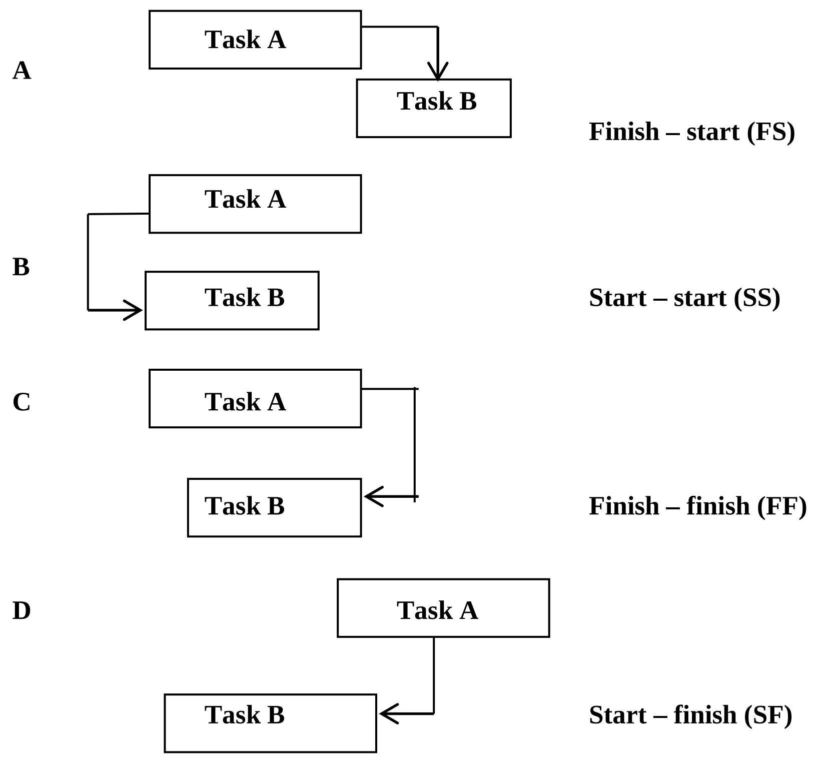
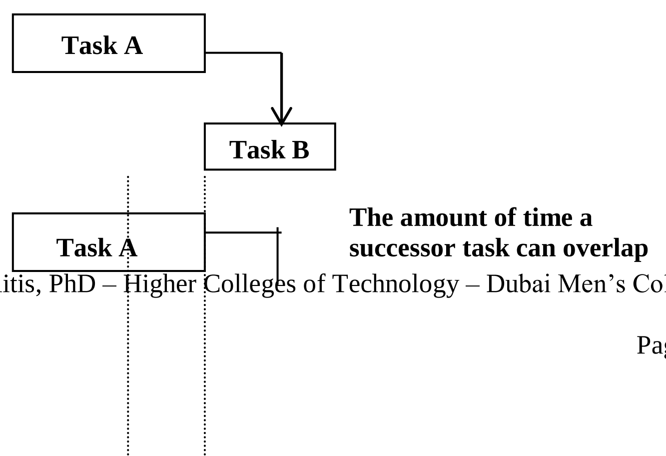


Figure 2-5: Relationship types

Lead and lag times

Relationships can become even more complex when the concept of lead and lag time is introduced.

Lead time is when the successor task may start prior to the full completion of its predecessor task. Note, the Finish-Start [FS] relationship does not change (refer Figure 2-6).



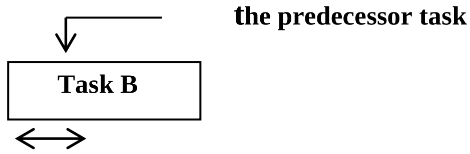


Figure 2-6: Lead time

Lag time is the amount of time a task can be delayed, again in relation to its predecessor. Note, the Finish-Start [FS] relationship does not change (refer Figure 2-7).

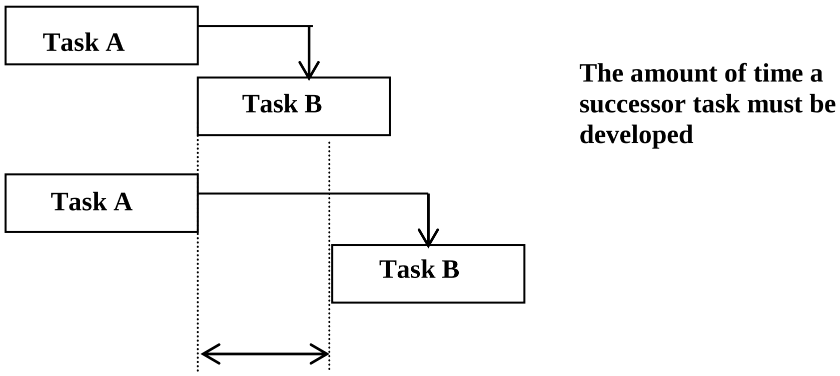


Figure 2-7: Lag time

Dependencies

Dependencies must be determined for all activities recorded on the activity list. Code each activity with an alpha code (A, B, C, D, etc.) in the 'Code' column, then determine which activity or activities must be completed before each activity can start. Record these in the 'pre-requisites' column. Pre-requisites can also be called 'predecessors'. It is possible for an activity to have:

- No pre-requisites (if the activity starts at the beginning of the project)
- No pre-requisite
- Multiple pre-requisites.

Exercise 2-1 Complete the following:

1. What does CPA stand for?

………………………………………………………………………

2. Why is CPA used in project management?

…………………………………………………………………………

…………………………………………………………………………

3. What are the three main objectives of a project?

- ……………………………………………………………………
- ……………………………………………………………………
- ……………………………………………………………………

4. Identify the start and finish points for a 'general' project, such as
- Making preparations for a wedding, or
- Arranging an overseas flight, or
- Building a brick barbecue

Start point …………………………………………………………

………………………………………………………………………..

Finish point ………………………………………………………..

………………………………………………………………………...

5. List in sequence all the activities involved in this project and estimate the activity durations.

Code	Description	Duration

Workbook activity 2-1 (a)

Complete Activity 2-1 Building a fence (Part A).

Step 4 – Draw the network (schedule)

One of the primary features that distinguishes project management from traditional management is the special attention project managers give to scheduling.

The network diagram (sometimes referred to as a schedule) is a graphical representation of the project showing the dependencies between the different project activities. It shows, in particular, which activities must be done in sequence and which activities can be done at the same time.

When you develop a schedule, you determine the start and finish dates for all the project tasks. That is, you impose a deadline on the project timeline that you want met. If these dates are not realistic and achievable, it is unlikely that the task or even project will be finished on time as scheduled. The development of the schedule is an iterative one that requires input from:

- activity list of all project tasks

- identification of task relationships
- estimates of task duration
- resource requirements
- task constraints
- milestones
- float
- lead and lag time
- resource calendars
- assumptions

When you develop (draw) a schedule diagram, either of two main tools can be used: the PERT (Program Evaluation Review Technique) chart or the Gantt chart. Some project managers actually prefer to use both: the PERT chart for initial planning and the Gantt chart for scheduling. This is the process we will follow, so that you can develop skills in the use of both techniques. The development and use of Gantt charts, will be covered in detail in Topic 3.

The PERT chart consists of a series of nodes (events) and connecting arrows (tasks or activities) indicating the relationship between the tasks. In its simplest form it will show all tasks to be performed and the relationship between them (refer Figure 2-8).

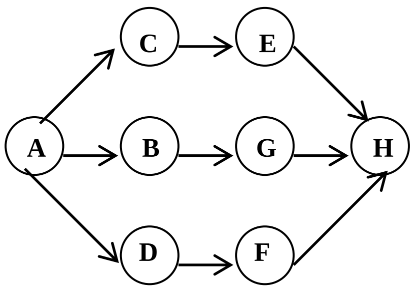


Figure 2-8: Simple PERT chart

For project management, a slightly more sophisticated type of PERT chart is used which can display both the activities and the events which come before and after activities. It is also very useful to show on the chart information about the parameters which affect each activity and event.

There are two basic symbols used in PERT network diagrams used in project management: the activity (arrow) and the event (normally a rectangle). You will notice that in many network diagrams the event symbol (rectangle) has been subdivided into smaller elements – this will be explained in the following sections.

Figure 2-9 shows an example of the simple pattern of a PERT network.

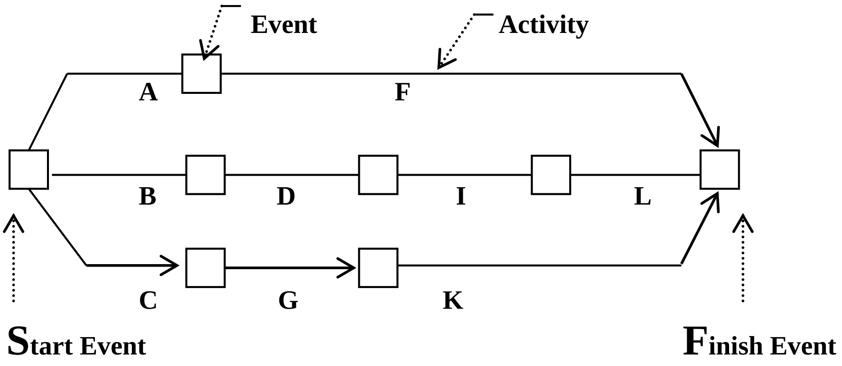


Figure 2-8: Simple pattern of a network

All members of the project team should take a part in drawing the network, so that all dependencies are correctly stated. Some practical suggestions for drawing networks are listed below.

- The network must start from one event and must end on one event.
- Networks are normally wider than they are deep, so if drawing on paper, use the paper in landscape orientation.
- Use a pencil (and an eraser), or consider using a chalkboard or a white board. when the network has been drawn on a chalkboard or white board, a useful and time-saving technique is to photograph it for subsequent reproduction by a draughtsperson. Electronic white boards with copying facilities make the drawing and saving of network diagrams (and any other project information) much easier.
- The events of the network are numbered when the network has been finished and agreed upon. The numbers are used for identifying activities. Two suggestions for numbering events are:

- number events so that an **activity tail event** number is always lower than its **head event** number
- leave gaps in the numbers so that additional or forgotten activities can easily be inserted without either violating the previous suggestion or having to re-number a section of the network.

Figure 2-10 shows an example network with all activities identified and events numbered.

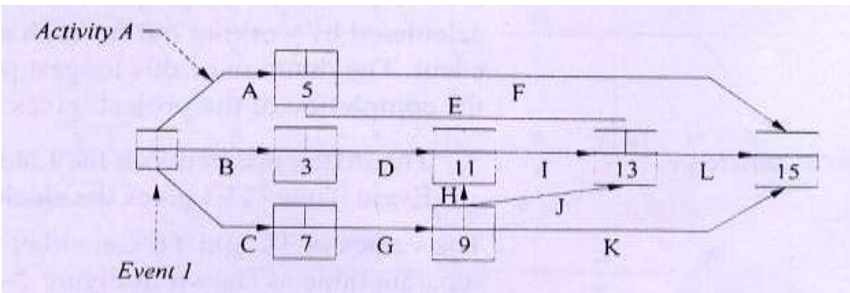


Figure 2-10: Network diagram – with activities identified and event numbered

As you can see in Figure 2-10, the activities are coded from A through to L and the events are numbered 1, 3, 5, 6, 9, 11, 13 and 15. When the network has been drawn and agreed upon by all team members, the activity durations are shown against each activity, as shown in Figure 2-11.

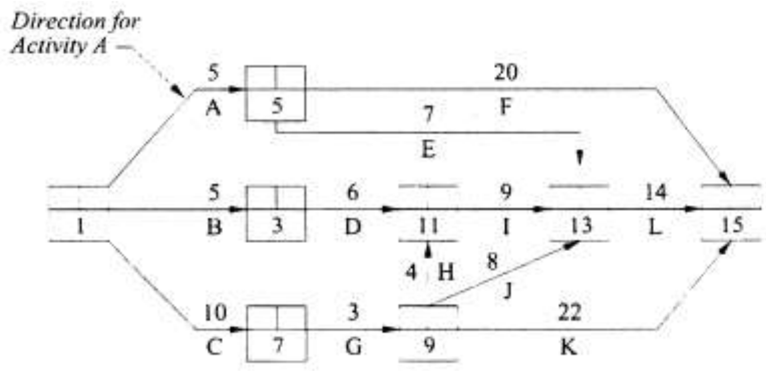


Figure 2-11: Network diagram – with activity durations inserted

Step 5 – Event analysis

Event analysis is the next step performed, which consists of the following:

forward pass

1. Make a forward pass through the network to calculate the **earliest event time** (TE) for each event.

The earliest event time is the earliest time at which an event can be reached, taking into account all paths leading to that event. An event is not reached until all activities leading to it are complete. The earliest event time for the final event of the network will be the minimum duration of the project. When calculating earliest event times it is normal to assume that the project starts at time zero.

backward pass

2. Make a backward pass through the network to calculate the **latest event time** (TL) for each event.

The latest event time is the latest time at which an even can be reached if the completion of the project is not to be delayed. The latest event time is calculated by working out for each event the longest path back to that event. The duration of this longest path, subtracted from the latest date for the completion of the project, gives the latest event time for each event.

calculate difference

3. The difference between the Latest Event Time (TL) and Earliest Event Time (TE) gives the **slack** of each event.

The values of TL and TE can either be shown on the network or on a separate table as shown in Figure 2-12 and Figure 2-13 (blank form at Appendix 2).

Event Number	Earliest Event Time (TE)	Latest Event Time (TL)	Event Slack (TL-TE)
1	0	0	0
3	5	11	16
5	5	19	14
7	10	10	0
9	13	13	0
11	17	17	0
13	26	26	0
15	40	40	0

Figure 2-12: Event analysis table

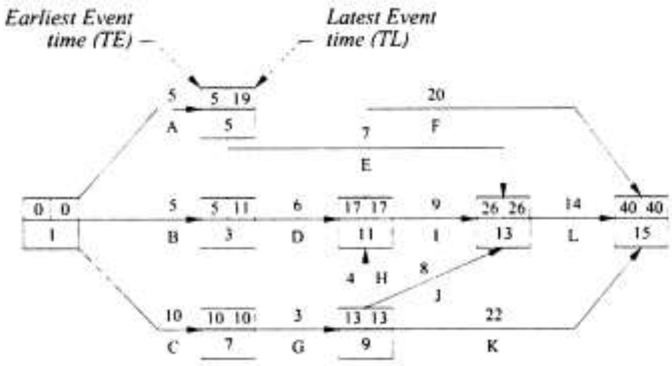


Figure 2-13: Network showing earliest (TE) and latest (TL) event times

Identify critical path

4. The critical path (the longest sequence of activities through the path network is identified as passing through those events having minimum slack in the network. When events are in parallel, the critical path will go through the event with the minimum slack of those events in parallel. It is important to note that the numerical value of the slack can be positive, zero or negative. Figure 2-14 shows the critical path through a network (shown by dotted line).

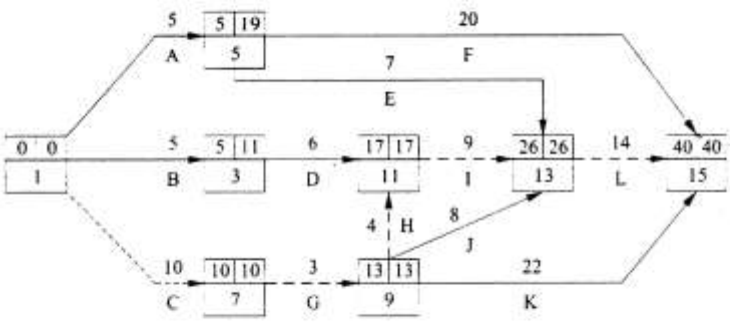


Figure 2-14: Critical path through a network

Workbook activity 2-1 (b)

Complete Activity 2-2 Building a fence (Part B).

Step 6 – Activity analysis

After the event analysis is complete, the activity analysis can be carried out. This analysis determines:

- The earliest time an activity can start.
- The earliest time an activity can finish.
- The latest time an activity can start if the project is not to be delayed
- The latest time an activity can finish if the project is not to be delayed
- The reserve time available for re-scheduling any activity assuming that the project is not to be delayed: this reserve time is knows as float.

The concept of float

Another useful scheduling concept is that of float. By definition, float is the amount of time a task may be delayed from its early start date/time without delaying the project finish date/time. It is a mathematical calculation that can change as the project progresses. It is also referred to as slack, total float, free float and or path float.

While some projects deliberately schedule float into their schedule as a common contingency measure, it is wise to also remember that when using float, the work often expands to fill the time available.

- **Total float:** the amount of time a task can be delayed or extended with affecting the total project time.
- **Free float:** the amount of time a task can be delayed or extended without affecting the start of any succeeding tasks.
- **Independent float:** the amount of time a task can consume without affecting any other preceding or succeeding task.

Collectively, float is calculated as the amount of time between the scheduled start of a task and the late start of each task. It can be recorded as zero, positive or negative, as shown in Figure 2-15.

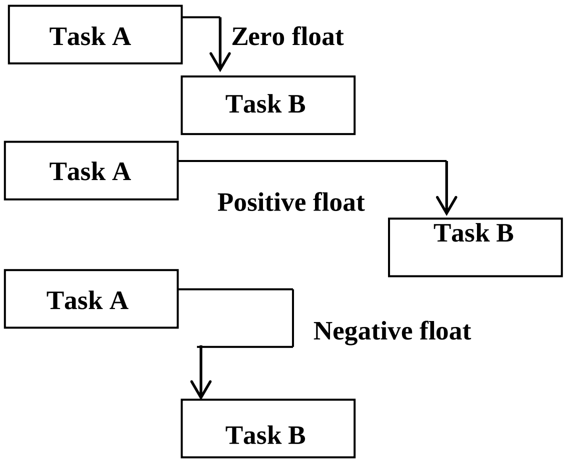


Figure 2-15: Types of float

An activity analysis is performed by following a systematic procedure to compile an activity analysis table as shown at Figure 2-15 (also provided at Appendix 3).

ACTIVITY			START		FINISH		FLOAT
No.	**Description**	**Duration (D)**	**Early (ES)**	**Late (LS)**	**Early (EF)**	**Late (LF)**	**Float (FLT)**

Figure 2-16: Example activity analysis table

Observe the following sequence, which describes each step and shows the derivation process when completing the activity analysis table.

Sequence	Description	Derivation/Calculation
1	Activity number	Network after numbering events
2	Activity description	Activity list
3	Duration (D)	Activity List
4	Early Start (ES)	Event Analysis (network): TE for Tail Event
5	Late Finish (LF)	Event Analysis (network): TL for Head Event
6	Early Finish (EF)	Calculation: EF = ES + D
7	Late Start (LS)	Calculation: LS = LF - D
8	Float (FLT)	Calculation: FLT = (LF – ES) - D

It is useful to consider the preparation of the Activity Analysis Table in three stages. These stages correspond with the sequence previously described and as shown in Figure 2-17.

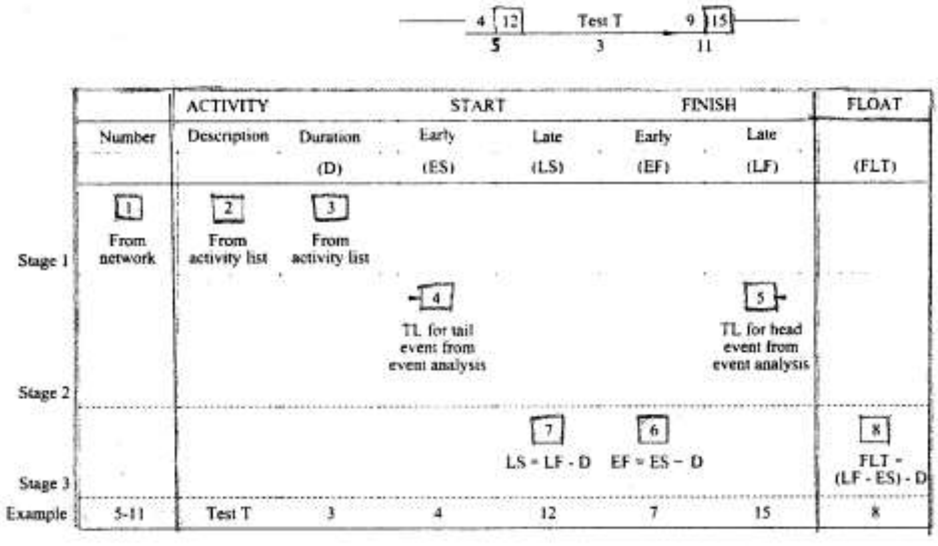


Figure 2–17: Stages in preparing an activity analysis table

In this way a complete analysis can occur of all activities. Figure 2-18 shows the results of the event analysis performed on the previously discussed network shown at Figure 2-13.

ACTIVITY			START		FINISH		FLOAT
No.	**Description**	**Duration (D)**	**Early (ES)**	**Late (LS)**	**Early (EF)**	**Late (LF)**	**Float (FLT)**
1-3	B	5 days	0	6	5	11	6
1-5	A	5	0	14	5	19	14
1-7	C	10	0	0	10	10	0
3-11	D	6	5	11	11	17	6
5-13	E	7	5	19	12	26	14
5-15	F	20	5	20	25	40	15
7-9	G	3	10	10	13	13	0
9-11	H	4	13	13	17	17	0
9-13	J	8	13	18	21	26	5
9-15	K	22	13	18	35	40	5
11-13	I	9	17	17	26	26	0
13-15	L	14	26	26	40	40	0

Figure 2-18: Completed activity analysis table

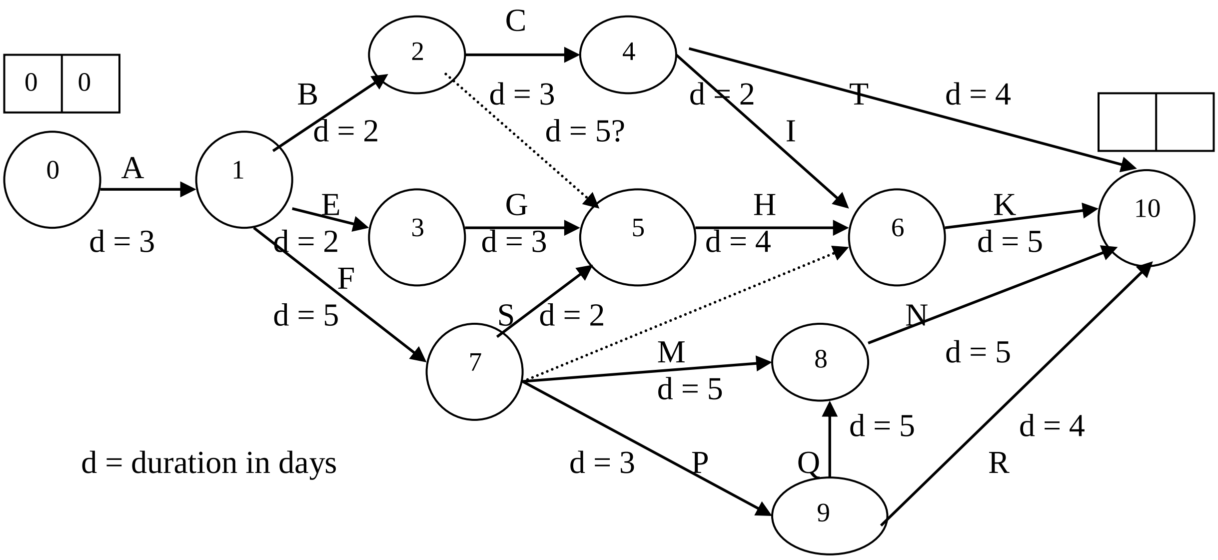
Workbook activity 2-1 (c)

Complete Activity 2-3 Building a fence (Part C).

Network Class Practice

In the network diagram below compute the Earliest Start Date (ES) and the Latest Finish Date (LF) of each activity. Also identify the Critical Path(s).

What would happen if the duration of activity B changes to 12 days? (Note: consider the dummy activity.)



Also completed activity analysis table

ACTIVITY			START		FINISH		FLOAT
No.	**Description**	**Duration (D)**	**Early (ES)**	**Late (LS)**	**Early (EF)**	**Late (LF)**	**Float (FLT)**
0-1	A	3 days	0	0	3	3	0
1-2	B	2	3	9	5	11	6
1-3	E	2	3	7	5	99	4
1-7	F	5	3	3	8	8	0
2-4	C	3	5	11	8	14	6
3-5	G	3	5	9	8	12	4
4-6	I	2	8	14	10	16	6
4-10	T	4	8	17	12	21	9
5-6	H	4	10	12	14	16	2
6-10	K	5	14	16	19	21	2
7-5	S	2	8	10	10	12	2
7-8	M	5	8	11	13	16	3
7-9	P	3	8	8	11	11	0
8-10	N	5	16	16	21	21	0
9-8	Q	5	11	11	16	16	0
9-10	R	4	11	17	15	21	6

Step 7 – Construct Bar chart

Up to this point we have spent a lot of time in the analysis and planning of our project. The CPA and PERT techniques allowed us to diagrammatically show the extent of the project and the relationships between the various activities and events.

The logical next step is to convert all of the analysis and planning data into a schedule for the project. The ideal schedule will provide an effective means for planning, organising and controlling a project.

One of the earliest and still most popular scheduling tools is the Gantt chart. Developed by Henry Gantt in the early 1900s, the Gantt chart is an effective way to convey the scheduling of a project. The simplicity and graphical representation of a Gantt chart make is easily understood. Figure 2-19 provides a simple example of a Gantt bar chart.

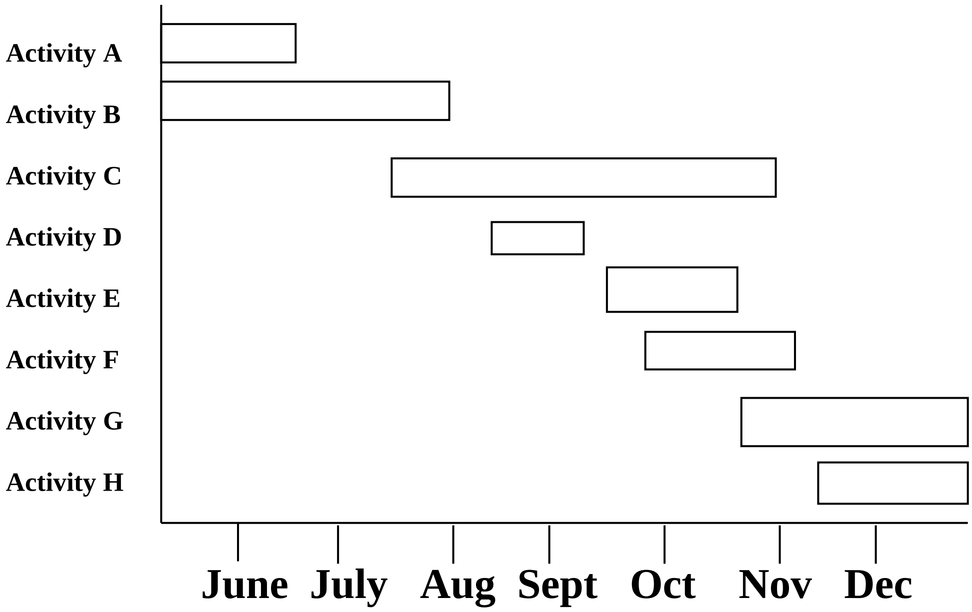


Figure 2-19: Simple Gantt bar chart

The use and development of bar charts for project management will be covered in greater detail in Topic 3.

Step 8 – Resource allocation

A project manager uses resources of various types to carry out a project. There is always some limit to the availability of each resource: therefore resources must be allocated so that the project objectives of time, cost, and adherence to specification are attained to the greatest degree possible. The considerations for resource allocation will be covered in detail in Topic 3.

Step 9 – Optimisation of duration and cost

There are different types of costs associated with projects. Some costs are directly incurred through the carrying out of the activities of a project, whereas other costs are directly related to the 'time' (duration) of each part of the project. Several methods can be used to optimise both the duration and cost of the project. These will be covered in details in Topic 6.

Milestones

In scheduling the project, consideration should be given to including appropriate milestones.

A milestone is defined as a significant event in the project, usually the commencement or completion of a major deliverable, that is a measurable, tangible, verifiable outcome, result or item produced as part of the project. Another way of thinking about milestones is that of a fixed point at any given time during the progress of a project where actual progress can be compared against estimated progress.

They are a significant landmark, development or turning point in the project life-cycle. They are commonly used to mark the completion of a major segment of the project. They do not represent the actual doing of the work (effort expended, resources assigned, costs accrued), they instead signal either the commencement or completion of the work. Milestones represent a point in time when something happens, whereas tasks stretch over time and represent a continuing activity.

Milestones are commonly scheduled with zero duration, zero resources and hence zero costs. They are often used to mark (flag):

- Completion of a task
- Completion of deliverables
- Completion of third party events
- Completion of key stages
- Decision points
- Audit points
- Conclusion of a project phase, stage.

Diagrammatically, milestones are represented as diamonds in the Gantt schedule diagram. Some texts refer to these milestones point as ‘phrase exists’. ‘stage gates’ or even ‘kill points’.

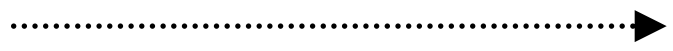
In fact, a milestone chart will provide an effective and concise summary of the projects progress.

Dummy activities

In the arrow diagram method of representing a project it is necessary to use dummy activities so that:

- Every activity is uniquely numbered (Identity Dummy)
- Correct logic is maintained where there is a common predecessor activity (Logic Dummy). Both of these two needs are explained in more detail below.

A dummy activity is essentially a link, and has a duration of zero. It is represented in a network by an arrow with a broken rather than a solid line, thus:



Identity dummy

Two activities in a network could start from the same event and end on the same event, as shown in Figure 2-20.

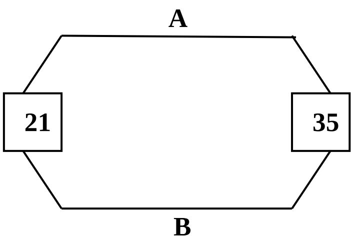


Figure 2-20: Basic network

Both activities (A and B) have the same identification. 21-35. This ambiguity can be resolved by using a identity dummy which clarifies on the network diagram which activity is A and which is B, as shown in Figure 2-21.

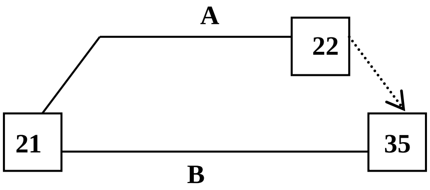


Figure 2-21: Identity dummy

Logic dummies

When two successor activities have predecessor activities, one of which is common to both and others of which are not, a dummy activity must be used to represent the logic correctly. Consider this set of activities which was needed in the development of an electromechanical product:

A. Produce prototype
B. Make electrical test gear
C. Make mechanical test gear
D. Carry out electrical tests
E. Carry out mechanical tests

We can see that D depends on A and B, while E depends on A and C: A is common, B and C are not. If we were then to draw a network which reflects the relationship between these activities, we could derive something similar to that shown in Figure 2-22.

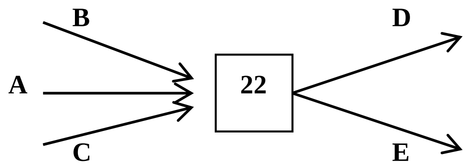


Figure 2-22: Network relationship

However, we have incorrectly represented that E cannot start until B is finished, and D cannot start until C is finished. Depending on the relative activity durations, this could make a significant difference to the project duration. The correct representation of the relationship between A, B, C, D and E, is shown in Figure 2-23

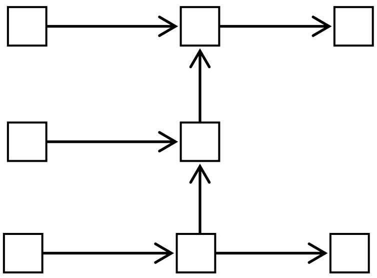


Figure 2-23: Correct relationship

Workbook activity 2-2

Complete Activity 2-4 Logic dummies

Exercise 2-2

Define in your own words the following terms:

1. Project scoping

2. PERT network

3. Gantt chart

4. The 'Critical Path' of a network

5. Float

6. Milestones

7. Lead Time

8. Lag Time

Summary

This topic provided an introduction to project planning and scheduling. In particular it focused on the techniques used to ensure that projects are achievable and manageable.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic relates to the rest of the module?
- Do your feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, email or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Concepts and definitions

θ Project scoping
θ Main variables of a project
θ Scope creep
θ Work breakdown structure (WBS)
θ Gantt charts
θ PERT charts
θ Task relationships
θ Lead time
θ Lag time
θ Float
θ Milestones
θ Critical Path / Analysis (CPA)

The CPA process

- θ define the project
- θ list the activities
- θ estimate activity durations
- θ draw the network
- θ event analysis
- θ construct bar chart (overview)
- θ resource allocation (overview)
- θ optimisation of duration and cost (overview)

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.

EMGT 450

Topic 3

Bar Charts and Resource Allocation

B

A

S

Bachelor of Engineering Management

3

Contents

Overview

Topics	Sections
1. The role of projects	Introduction
2. Planning and scheduling a project	Bar charts
3. Bar charts and resource allocation	Resource allocation
4. Building on the basic techniques	Summary
5. Organisation structures for projects	
6. Project costs	
7. Project control	
8. Using computers for project management	

3

Bar charts and resource allocation

Learning outcome

By successfully achieving the stated 'enabling objectives, for this topic, you should he able to:

- convert a critical path network to a time-scaled bar chart, and carry out allocation of limited resources.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- explain the use of Gantt and linked bar charts
- identify tile advantages and disadvantages of Gantt and linked bar charts
- construct a Gantt chart from a network
- construct a linked bar chart from a network
- define and identify the resources needed to achieve project objectives
- carry out a time-limited resource allocation (one project, one resource)
- carry out a resource-limited resource allocation (one project, one resource)
- define resource allocation requirements for a typical organization

What you will need

Suggested study time	Study Guide	8 hours
	Activities and exercises	7 hours
	Textbook & readings	5 hours
	Total	20 hours
Other resource	Nil	

Introduction

In the previous Topic we covered the planning and scheduling of a project. In doing this we outlined nine steps for Critical Path Analysis. This topic will cover in greater detail two of these steps; namely **constructing bar charts** and **resource allocation**.

The use of bar charts will enable the project manager to see all activities in a project plotted against a time scale. Charts provide a useful diagrammatic representation of the entire project.

Similar to many of the other project management tools and techniques, charting and resource allocation are important aspects of the project planning and scheduling phase.

Bar charts

A bar chart is a representation of activities on a time scale. Each activity is shown as a line or bar whose length is proportional to the duration of the activity.

The duration (time) scale of the chart can be in hours, days, weeks, or months depending on the overall duration of the project and the nature of the activities. Taking as an example a bar chart with a scale in days, each day call be identified as a calendar date (project management software Can be used to plot a project, ensuring that weekends are not counted as days in the project 'work' time). The bar chart is useful for three main reasons:

1 . It is easy for members of a project to see when activities should be done.
2. Progress of activities can be shown on the chart and it is immediately clear when activities are starting to slip.
3. Resource requirements can be shown for each activity and in total day by day; it can then be seen where resources are overloaded (too heavily utilized) or underloaded (insufficiently utilized).

A bar chart call be drawn in either of two forms with each being explained further in the following sections of these notes:

- Gantt chart
- Linked bar chart

Gantt charts

One of the earliest and still most popular scheduling tools is the Gantt Chart. Developed by Henry Gantt in the early 1900s, the Gantt chart is prepared by listing tile work activities as discrete tasks oil tile vertical axis and plotting each one against a time line on the horizontal axis. In this way, the chart quickly conveys the overall plan and the individual status of the total project and the completed work to-date. Tile horizontal bars are drawn for each project activity along, the time line and depict output, both planned and actual, over a period of time (refer to figure 3-1).

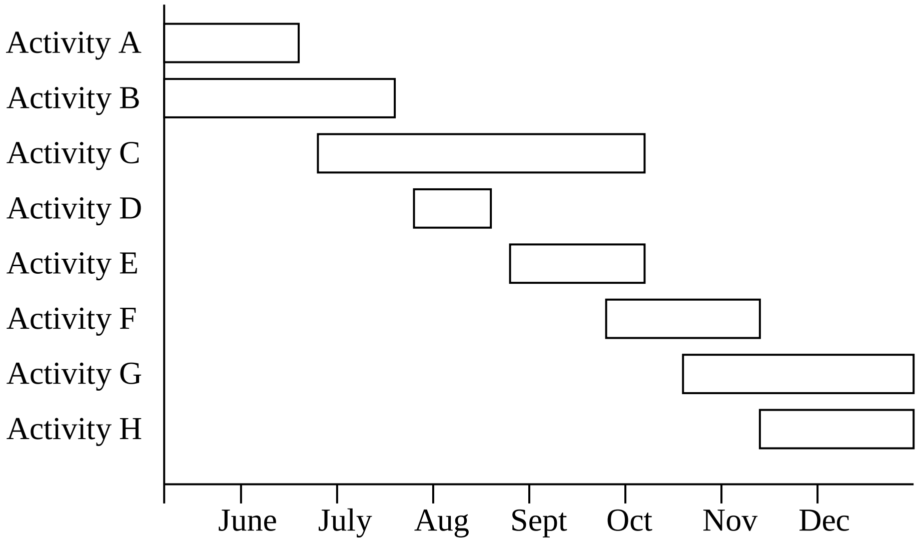


Figure 3-1: Example of Gantt chart

The Gantt chart shows each activity on a separate line. This method allows information about a particular activity to be recorded on that line, but makes relationships between activities (e.g. dependencies) difficult to identify. Many project management software packages use the basic Gantt chart for the plotting of a project.

Linked bar charts

A linked bar chart (sometimes referred to as a sequenced Gantt) is similar to the Gantt chart previously described. However, the major difference is seen in the way that sequences or chains of activities are collected or joined into relationships clearer continuous bars. This makes relationships between activities much clearer than in the normal Gantt chart (refer to Figure 3-2).

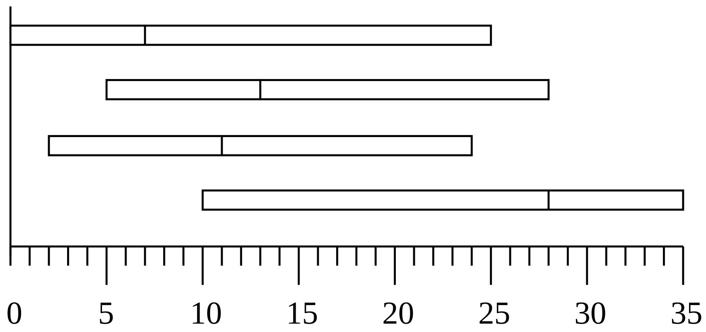


Figure 3-2: Example of linked bar-chart

Both types of charts can be used for project planning and management. Some project managers use both, the Gantt chart for initial planning and the linked bar chart to display all the relationships. If only using one of the types, the linked bar chart would be preferable because the dependencies are explicit, the incidence of the float is clear, and the representation is compact.

Constructing a bar chart

The construction of a basic Gantt chart from a network is simply, a matter of identifying the time scale for the horizontal axis and plotting each activity in the sequence they occur during the project, ensuring that their start and finish times align with the appropriate point on the chart timescale.

Constructing, a linked bar chart is a little more complex, however not difficult. The steps in preparing, linked bar charts from an arrow diagram are:

1. Work out a suitable timescale for the bar chart.
2. Identify the number of *chains* of activities in the arrow diagram.
3. Number those chains.
4. Set out an outline of the bar chart oil squared paper. Being sure to place the chains or bars in the same relative positions as the chains of arrows in the arrow diagram (topological congruence).
5. Draw the bars for all activities each bar at its early start. This can be done in any sequence. But the two recommended sequences are:
   - from the top down
   - starting with the critical path and expanding outwards from that.
6. Show all dependencies by vertical lines.
7. Indicate where float is available.

Figure 3-3 shows a linked bar chart with all features identified.

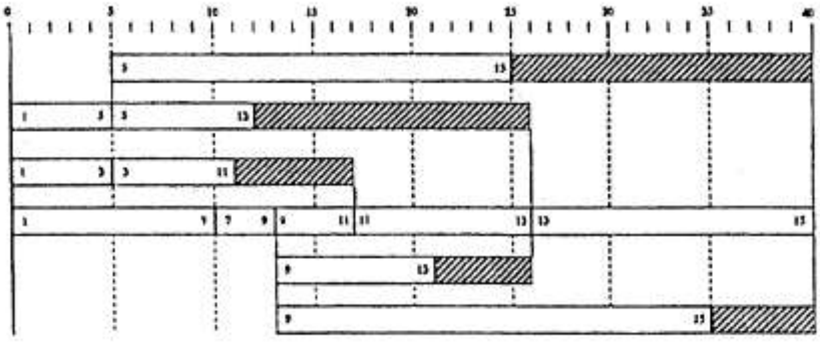


Figure 3-3: Linked bar chart

Workbook activity 3-1

Complete Activity 3-1 Production of a manual

Resource allocation

A project manager uses resources of various sorts to carry out a project. There is always some limit to the availability of each resource, therefore resources must be allocated so that the project objectives of time, cost, and adherence to specification are attained to the greatest degree possible.

The two main types of resource allocation used are:

1. **Time-limited.** resource allocation, where a project must be completed by a certain time. Tills implies that a deficiency in resources shown by comparing the resources needed with the resources immediately available must be rectified by transfer, hiring, or sub-contracting of the extra resources.
2. **Resource-limited.** resource allocation, where there is all absolute limit to the resource/s being allocated over the planning period. This may be caused by insufficient funds to obtain the resources or simply a lack of' availability of the resource/s themselves. The effect of this absolute limit may be that the project cannot be completed until later than tile date originally planned (careful planning of the project will identify these types of problems, hereby ensuring that tile project timelines are reasonable and realistic).

Types of resources

All resources must be considered in tile allocation process, especially those resources that are in limited supply generally, or have limited availability over the planning period. The availability of most resources can be provided given enough time, however most projects take place over a specified and usually limited period.

There are many different types of resources that can be used in a project. which can be categorized as either:

- human
- plant and machinery
- money
- space

Human
The human resources can be divided into several main categories (i.e. professional, sub- professional. technical. trades, process). They can be further divided into sub-categories within each main category. For example, the trades category could be divided into:

- Fitters
- Electricians
- Boilermakers
- Riggers

- Carpenters
- Bricklayers, etc.

This type of categorization can occur for all of the human resources required in a project.

Plant and machinery

Static and mobile plant and equipment have resource limits over a planning period. With such items often being of great importance to the planning of a project. These items of plant and machinery usually are not sitting idle for lengthy periods. Many are utilized regularly by the owning organization, therefore careful planning (and negotiation) will have to occur to ensure that the use of the resource for your project will not deprive others of a valuable resource.

Money

Money is normally available in limited quantities per time period in accordance with an organization cash flow. In the case of small projects money may not be significant, but in large projects it may have very important effect oil planning.

Space

Where space is limited e.g. oil a high platform or in an underground tunnel, it becomes a resource within which activities must be planned. When planning a project, the network diagram and Gantt chart may allow several activities to be performed at the same time (in parallel). This may also be preferable to ensure the project is completed in tile minimum time. However, if the space (where the activities must be carried out) does not allow them to be performed at the same time, then the project will have to be planned accordingly. An example of a space constraint is the limiting of 'hot work' to only one operation at one time on an oilrig.

Ensuring safety should also be a key factor when determining tile level of FT resource allocation allowed at any particular time.

‘Sink’ resources

Some resources are often not allocated because they are considered to be available whenever required. The purchasing department of a company is frequently considered to be ready to carry out their job (e.g. a purchasing transaction) at any time as required. This may not be true, and may result in unrealistic planning- and subsequent achievement of project goals.

Exercise 3-1

For your organization, or a project you are familiar with, identify and write down examples of special or unusual resources:

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

1. What implications will these types of resources have on project planning?

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

Pre-requisites to resource allocation

Before performing a resource analysis. the following information is required by the project planner:

- knowledge of how much of each resource is required for each activity
- the project network, converted to a bar chart
- the limits of availability of each resource over the planning period.

Also consider the following aspects of resource allocation:

- resource allocation is a process where computers can be very useful, especially for multiple resources and multiple projects
- once resource allocation has been done. almost all activities will be critical if resource levels are to be maintained
- some activities may be able to be split, which might provide other options for resource scheduling
- the movement of resources between different activities may present problems (or advantages).

Resource allocation of a single resource

Occasionally in project management, there are a number of activities in a project all requiring the use of the same resource: which is the only one of these resources available. Although this situation does not occur very often, it does provide a good example of the considerations and manipulations that are needed to make the best use of the resources.

In carrying out resource allocation we must first construct a bar chart for the project (you will do this as part of the normal project planning process as discussed in Topic 2). The steps that follow the construction of the bar chart are:

1. Indicate on the bar chart how much of the resource (e.g. how many people) are needed for carrying out each activity.

2. With all activities starting as early as they can, total up the resources needed in each time period (taking into account all the activities scheduled to occur in accordance with the bar chart) and construct a loading histogram. Check that the number of person days on the histogram is the same as the number of person days calculated from the activity list.

3. If a resource limit exists, show it on the histogram. If there is no significant resource constraint, calculate the total person days needed for the project, divide that figure by the days needed for the project and thus arrive at a target for the number of people to take part in the project.

4. If the project is time constrained (i.e. it must finish by a certain date) smooth the load in such a way that tile load is as even as possible over the complete project duration. Because of the time constraint, the average crew required may exceed that available. In such a case additional crew must be hired to deal with overloading. Where the project completion date is absolutely fixed, as for example. in setting up a stand for all exhibitions, then the overloads must be coped with in some way.

5. If the project is resource constrained. i.e. there is no way in which more of the resource can be made available, then loading must be done so that the resource limit is never exceeded. This can of course mean that the project may not be completed by the originally anticipated date. The resource allocation should then be done so that the duration over-run is kept to a minimum.

The problem with resource allocation

One of the shortcomings of scheduling procedures is that often they do not adequately address the problems of resource availability and utilization, as they focus on time and not physical resources. Schedules need to be evaluated not just in terms of meeting project milestones, but also in terms of timing and the use of scarce resources.

Remember, that project management is all about balancing and managing tile constant trade-off between time, cost and performance (resources).

If all three of these variables (time, cost and performance) are fixed. The project is said to be ‘over-determined'. This means that the project manager has probably lost all flexibility to perform the necessary trade off between these variables to ensure the successful completion of the project.

Certainly fixed levels can still allow some room for maneuvering, although this is difficult to obtain as often budgets, schedules and specifications are assigned (and monitored) by senior management with little regard for the uncertainties of reality.

Resource loading

This is the process of assigning, a specific number of resources for a set time period that is required to complete a scheduled task. Resource loading will give the organization a general understanding of the resource demands for the project and as such is an excellent way to produce a rough, early guide for resource planning. By loading the project schedule, the project manager is ensuring that the required resources in the required amount are available when and where they are required over the life of the project.

Resource Leveling

Resource leveling (also called resource smoothing) aims to minimize the period-by-period variations in resource loading by shifting- tasks within their respective float (slack) allowances to create a smoother distribution of resource usage.

The basic procedure for resource leveling is straightforward. In the project shown in Figure 3-1:

- task 'a" takes two days and needs two resources
- task 'b' takes three days and two resources
- task 'c' takes five days and four resources to complete

All tasks are scheduled to start together and must all be competed for the project to finish. Task (c) is the critical task as it takes the longest (it drives the project finish date).

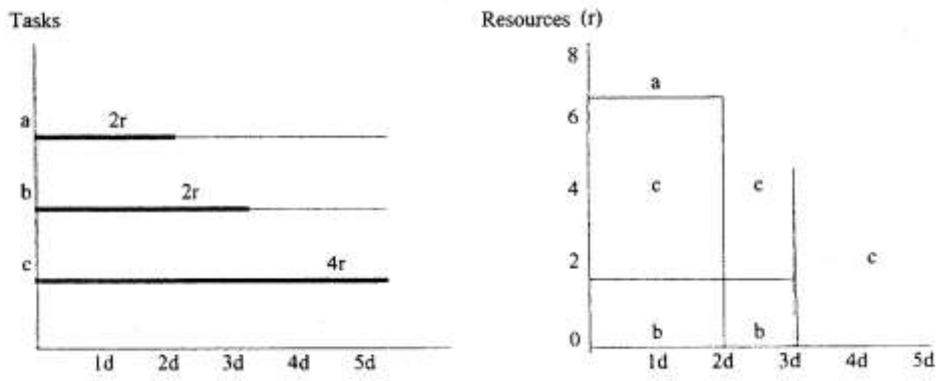


Figure 3-4: Before leveling,

If all these tasks start at their earliest start dates, the resource leveling diagram shows decreasing labour varying from eight resources to four resources over the project timeline (refer to Figure 3-4). However, if the schedule could be negotiated whereby task (b) was delayed for two days (which is its available float/slack time), the resource leveling diagram is smoothed as shown in. Note the same result would have occurred if task (a) was delayed until day three and task (b) started as scheduled.

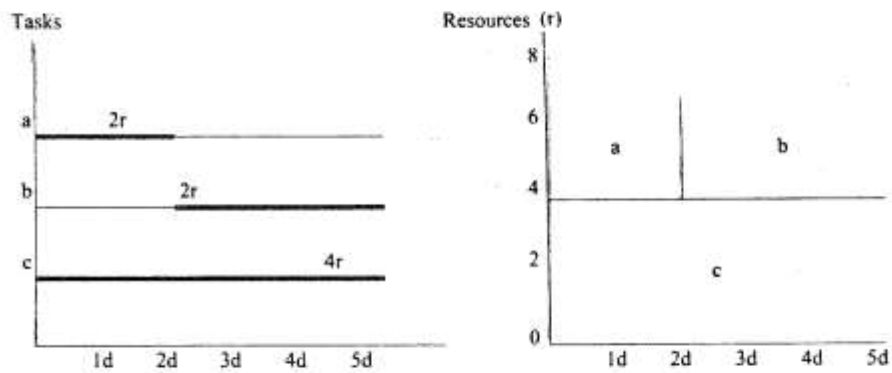


Figure 3-5: After leveling

Exercise 3-2

In your own words, define the following:

1. Gantt chart

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

2. Linked bar chart

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

3. Time-limited resource allocation

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

4. Resource-limited resource allocation

……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………
……………………………………………………………………………………

Workbook activity 3-2 — Complete Activity 3-2 Resource allocation (time limited).

Workbook activity 3-3 — Complete Activity 3-3 Resource allocation (resource limited).

Summary

This topic provided discussion of charting and resource allocation of projects. In particular it focused on the techniques which can be used when performing these activities.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic relates to the rest of the module?
- Do you feel you can achieve each of the stated enabling objectives?

If you can proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

You should now be able to complete Assignment which is due at the end of Week 12.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Charting

θ Gantt charts
θ Linked bar charts
θ Construction of' charts
θ Linked bar charts

Resource allocation

θ Time-limited allocation
θ Resource- limited allocation
θ Types of resources
θ Resource allocation process
θ Resource loading
θ Resource leveling (smoothing)

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues, which you may want to recall when discussing this topic with the lecturer or another student.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

EMGT 450

Topic 4

Building on the Basic Techniques

B

A

S

Bachelor of Engineering Management

4

Contents

Overview

Topics

1. The role of projects
2. Planning and scheduling a project
3. Bar charts and resource allocation
4. **Building on the basic techniques**
5. Organisation structures for projects
6. Project costs
7. Project control
8. Using computers for project management

Sections

- Introduction
- Managing large projects
- Managing risk
- Summary

4 Building on the basic techniques

Learning outcome

By successfully achieving the stated 'enabling objectives' for this topic, you should be able to:

- apply the basic techniques of project management to large projects, incremental projects and evolutionary projects.

Enabling objectives

You may be assessed oil the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- define the following types of projects
  - large
  - incremental
  - prototyping or evolutionary

- describe the concepts of
  - network and chart hierarchies
  - fast tracking
  - risk
  - 'what-ifs'

- apply techniques for fast tracking of a project
- use hierarchies of networks and bar charts to manage large projects
- apply methods for the evaluation and containment of risks in projects
- develop a monolithic project into an incremental or prototyping project
- apply the 'what-if' method to a project

What you will need

Suggested study time	Study Guide	6 hours
	Activities and exercises	10 hours
	Textbook & readings	10 hours
	Total	26 hours
Other resources	Nil	

Introduction

In the previous topics we have covered the basic principles and techniques for conceptualising, planning and scheduling, projects. Although these techniques are applicable to all types of projects, many projects are more complex in nature. This Topic III extend on the basic techniques, covering other tools useful for large and varied types of projects.

The application of these 'additional' techniques will allow more accurate planning, and scheduling of projects and greater control over all phases of' project implementation.

Managing large projects

Hierarchies of networks

Networks call be drawn to incorporate varying degrees of detail.   A particular person in all organisation at a particular level draws a network for planning and control. In general, the higher the level, the greater the scope of the network. In order to provide this greater scope and to remain useable, the activities in a higher level network must themselves be much broader in scope.

Take, for example, a company planning to introduce a range of products over a five year period. Product X is one of these products. From the viewpoint of the company's board, there may be only activities to be controlled: 'develop product X'. and 'launch product X'.   There is of' course some interaction between these two activities, and a more detailed network for each of these two activities will probably indicate more than one interface.

The project manager in charge of development will have a network which he/she will use for planning and/or control. One of the activities in the network could well be 'carry out field trials'. This could in turn be expressed as a subsidiary network, and have its own project manager.

The various levels in the hierarchy of network must of course be integrated with each other, and the higher levels in the hierarchy are sometimes called Summary level networks. The rationale of having the hierarchy is that information is provided to different levels of' management to allow each level to apply control appropriate to that control at each level. The control at each level relationship between the levels is shown in Figure 4-1.

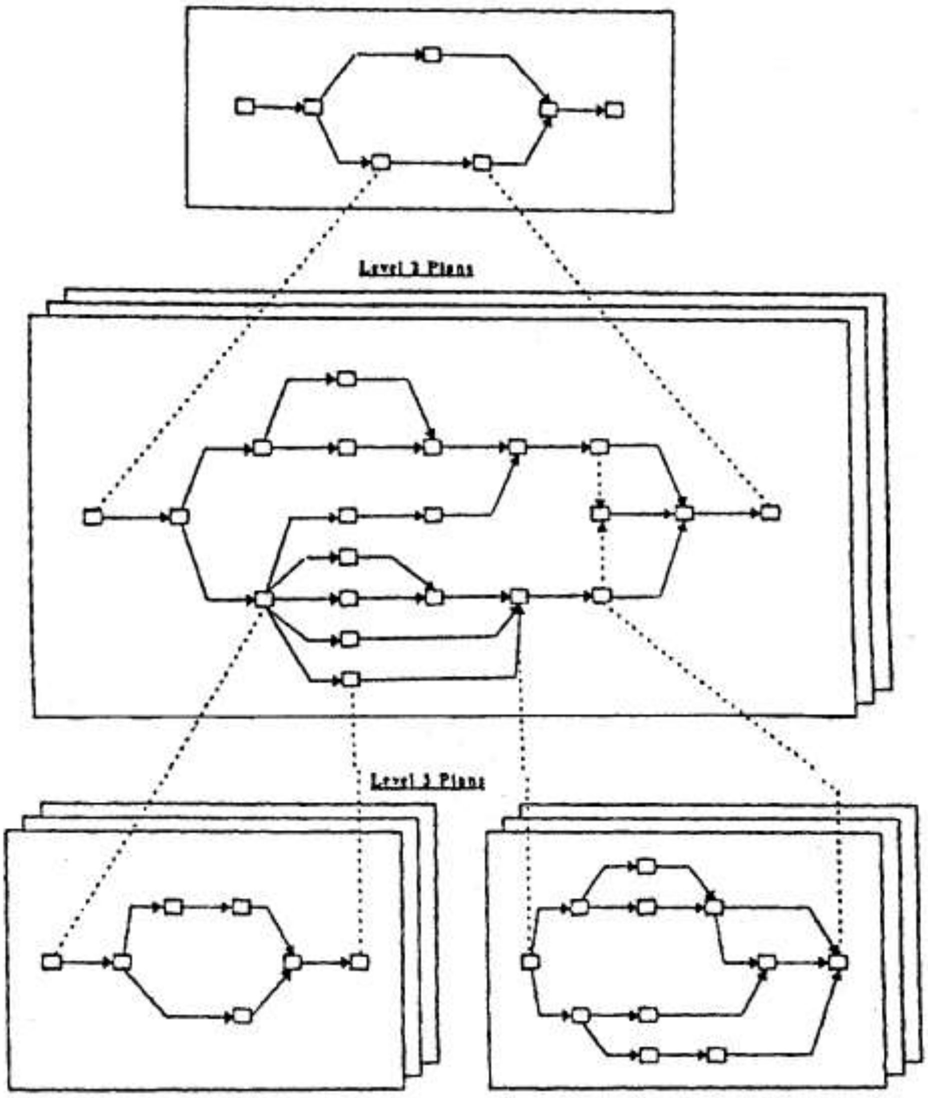


Figure 4-1: Hierarchy of network plans

Work breakdown structures

As described previously in Topic 2, in some large projects the main activities as shown in the Level I network of Figure 4-1 are called **'Packages of Work' or 'Work Breakdown Structures'**. The important point in this dissection of work is that each package can, if necessary, be given to a sub-contractor who will be responsible for achieving the clearly defined output of that package. The owners or the project manager's organisation can of course carry out such packages of work.

These packages in turn need to be managed using the techniques of project management, and may themselves require sub-packages to be carried out by sub-package managers (similar to levels 2 and 3 in Figure 4-1).

Workbook activity 4-1

Complete Activity 4-1

Managing risk in projects

Risk is inherent in any human activity. Because projects are generally once-only occurrences they have a greater degree of risk than activities that occur regularly. The project owner and manager must therefore take action to forecast and manage the risk of the project. The main stages in doing this are:

- break project down into major or packages or groupings of activities
- for each package determine the degree of risk
- determine what steps can be taken to either to avoid, reduce, or contain the risks so determined
- incorporate these steps into the project plan.

Determining the degree of risk

There are a number of major factors that must be considered when assessing the risk attached to each package of work. The list that follows is an outline only, and should be developed and modified in the light of' the specific project and the project team, experience of that sort of project.

Technological

The following_four types of project of increasing complexity (with associated increasing- risk) have been identified by Aaron Shenhar:

Type A: Low-tech projects based on well-established technologies.

Type B: Medium-tech projects which will include some new but existing technologies or a new feature on a limited scale.

Type C: High-tech projects which integrate many new but existing, technologies.

Type D: Super-high-tech project designed to integrate immature technologies that are to be developed during the project's execution time.

(Source: Shenhar. A. Project Management December 1991 March 1992)

Industrial

The risk of delays to industrial disputes may need to be evaluated in the light of the site, trades, and history of disputation.

Political

This normally applies only to offshore projects where there may be a lack of political stability; but in working for any organization there are always risks that project progress and outcomes may be affected by political infighting within the organization.

Environmental

The location of the project may add risk because of harsh climate, difficulty of access and lack of services normally readily available to the project team.

Steps to avoid, reduce, or contain risk avoidance

Risk may be avoided by substituting a well-established technology for a develqping technology. For example, some of the delays associated with the building of the Sydney Opera House could have been avoided (for technological reasons) had it been decided not to clad the roof with white tiles. Whilst all risks cannot be avoided, careful planning up front in the planning stages of a project, will help to minimize risk.

Risk reduction Reduction of risk can be achieved by supplying back-up resources for work packages identified as 'risk', either in the form of plant, human resources, or materials. It is extremely important to monitor project implementation closely. In that way the risk areas of a project can receive additional effort as required.

Risk containment Containment of risk is achieved by incorporating contingency allowances so that if something does overrun, sufficient allowance and flexibility is available to contain time and cost within realistic and acceptable limits.

Incorporating risk assessment results

If it has been decided to avoid or reduce risk it may be necessary to change the project plan to take account of' substitute activities. It should also be noted that avoidance may result in a lesser quality output, whilst a reduction of risk may increase project cost.

To ensure containment of risk, two major items must be agreed by both the owners and the project manager:

1. **The amount of contingency for each package**-this may be broken down into contingencies for each sub-package or activity: it is almost always the case that only a small percentage of constituent activities have a high risk, at whatever level of project.

2. **The way in which use of the contingency can be authorised**-this can require an authorisation in the event that a certain situation arises (e.g. is a certain time contingency automatically applicable if more than a pre-determined amount of rain falls, or does it have to be signed off by the owner?).

Fast tracking

Fast tracking is the process of starting a successor activity before a predecessor activity has been completely finished. In the general case this would seem to be sensible because it will allow a project to be completed sooner, as shown in Figure 4-2. If the three activities are not allowed to Overlap, the project duration is 22.5 weeks, however: by fast tracking and overlapping these activities by 50% the project duration decreases to 12.5 weeks.

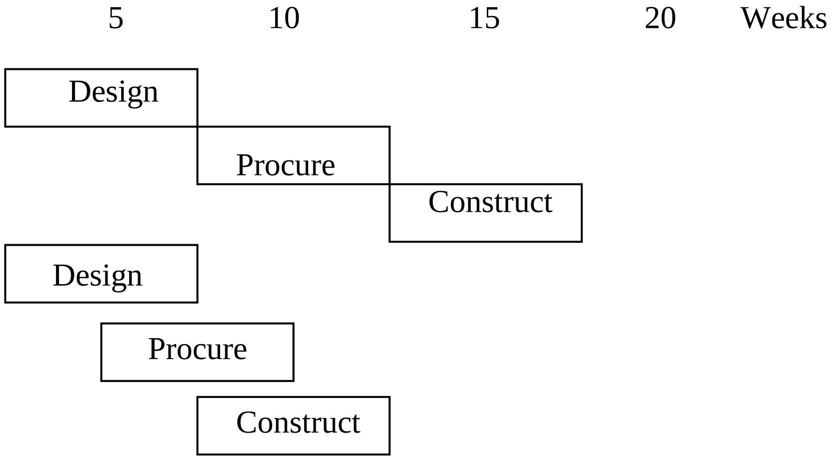


Figure 4-2: Effect of fast tracking

While completion of the project ten weeks early may seem very attractive, the owner and project manager must consider the risks for example:

- The last stages of design may show that changes have to be made to the first stages of procurement. However, a contract may have already been entered into for the supply of material for these stages.

- The design change may mean that an item already constructed has to be modified. This can greatly increase cost, as it may involve the complete pull-apart or strip-down of' something, the manufacture of' a different part or a rebuild.

Closely associated with fast tracking is risk management. The more you attempt to fast track a project, the greater the chance of risk. When considering fast tracking a project (or parts of a project), it is best to identify those activities for fast tracking which will have minimum risk (and therefore impact) for the rest of the project. If attempting to fast track high-risk activities, remember to make appropriate contingency allowances and monitor progress very closely.

Workbook activity 4-2

Complete Activity 4-2

Incremental and prototyping planning methods

Some projects involve construction or development, where it is difficult to forecast at the outset exactly what the format of the end-result will be. In other projects it may be important for 'political' reasons to deliver something the sponsor can use in what seems a reasonable timeframe. If a project does not deliver at least some results within a reasonable timeframe, sponsors can become impatient and project team members will become disheartened.

These two conditions apply to many systems related projects, where the requirements for the system develop as the project progresses (e.g. a computerised system). In such a project we will say for the sake of simplicity that there are four main activities or stages:

- **Analysis:** The sponsors needs in terms of functions, volumes, geographic spread etc. are analysed - this stage will include a large amount of data collection and personal discussion.
- **Design:** A system is designed to meet the sponsors needs, especially of scope and output-the design of the system is agreed with the sponsor.
- **Coding/programming:** The system as designed is coded.
- **Implementation/installation:** The coded system is implemented - this will generally include the input of the relevant information base, the development of operating procedures (if not included in an earlier stage) and the training - of operators and managers.

There are three ways in which such a project can be planned:

1. Traditional
2. Incremental
3. Prototyping (Evolutionary)

Traditional approach

The traditional (or monolithic) approach (refer Figure 4-3) breaks down the project into four main activities of:

- analysis
- design

- coding
- implementing

These activities must be undertaken in sequence, and no activity can start until its predecessor has been completed. The work undertaken in each phase must be thorough, leaving no loose ends. The development process is thought of as an assembly line, allowing each activity to be undertaken by different people. Finally, no productive user capability is installed until very near the end of the project.

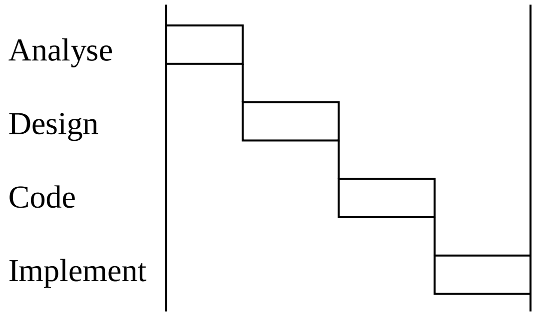


Figure 4-3: Development and implementation of a system-Monolithic approach

Incremental approach

The incremental approach (Figure 4-4) focuses on designing an expandable system that can be installed in stages. At the end of each stage an additional part of the system is provided ready for use to the sponsor. The first stage is likely to spend a greater amount of time on analysis and design to provide basis for the subsequent stages. Figure 4-4 shows that some activities overlap, indicating that those activities have been fast tracked. Note that this diagram illustrates three incremental phases – there may be more depending, oil the complexity of the system.

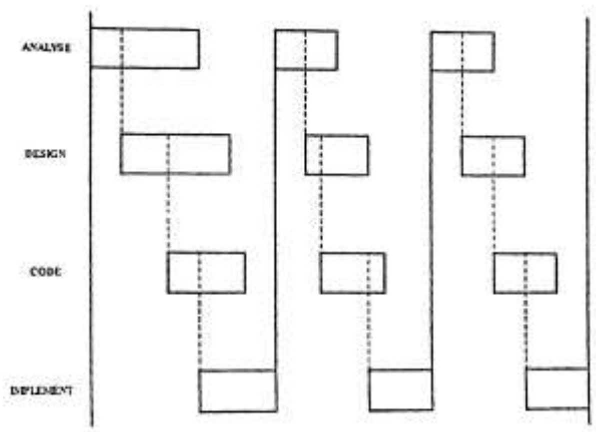


Figure 4-4: Development and implementation of a system-Incremental approach

Prototyping approach (evolutionary)

In the prototyping approach (Figure 4-5) an inexpensive experimental version of a system is developed and installed within a short period of time. This prototype will be run for a limited period and then be evaluated, after which further development will result in a second prototype, and so on until a satisfactory result is reached. It is possible that the first prototype will reveal sufficient information to progress with full-scale implementation. Note that Figure 4-5 illustrates two development phases-there may be more than this, but there should be never less than two.

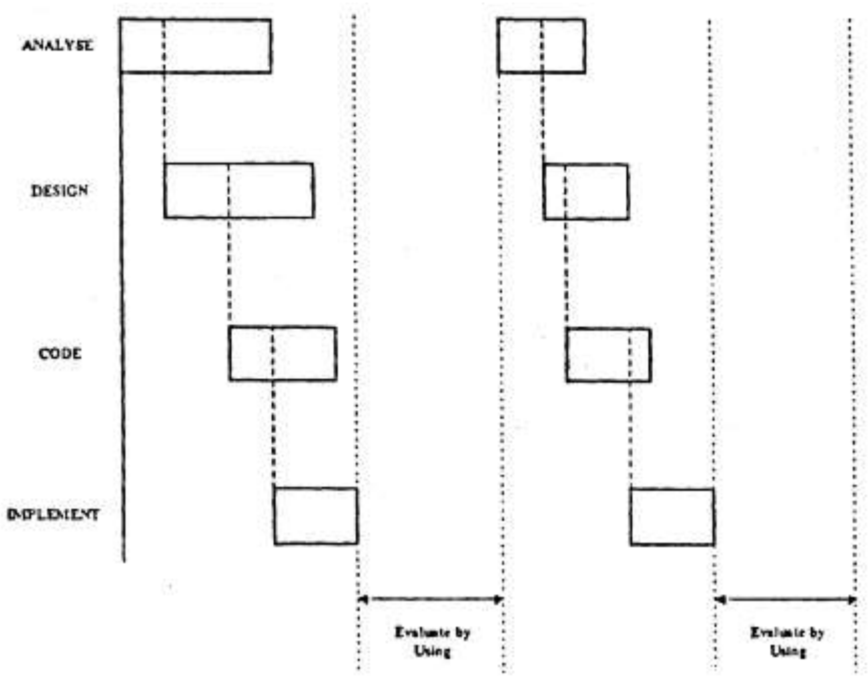


Figure 4-5: Development and implementation of a system – Prototyping approach

Streamlining by 'what-ifs'

Except in the simplest of projects it is unlikely that the first pass at planning and scheduling the project will result in a completely acceptable result. The duration may be too long, the cost too high, or the product of the project not completely satisfying the owners needs. In such cases the project manager and owner can jointly try out alternative courses of action (what-ifs) until they arrive at a realistic and satisfactory result.

Some typical examples and questions that have arisen, and then answered by the ‘what-if' procedure are:

typical questions

- If we combine these two packages, would we get the same overall tender pricing and save on the administration costs?

- The client has not yet decided on the plant maintenance philosophy - we may need a large workshop or a small one but with more spares.
- What cost estimates should be allowed, and when is the latest date we need the clients' decision to make sure time is left to get it designed and built?

- Is the scope of this project defined enough to reduce the estimate contingency to 10%? What time contingency should be added to the overall program for undefined scope items?

- This package is very large. Are there enough contractors around to tender for that competitively? There are too many packages of similar type-e.g. for buildings-all requiring establishment costs, can we speed up the design and have only one package?

- The delivery of piles is critical, the equipment design and ground loadings are six months away. Can we take the risk and separately package an order now, guessing the lengths and sizes required? What are the client's guide-lines on the cost/time balance - would lie risk a
- $0.5 million over-supply of steel plies to cut three months off the program?

- This is an extension to an existing plant. If we assume continuous shifts are to be worked, can we cut back the shutdown period?
- Should we check with several potential tenders on that? What are the likely cost penalties?
- What industrial problems might arise with this packaging? Will contractors be able to work seven day shifts? Must we assume a limit on overtime? Are there particular trades that should be encouraged to be first oil site, and should we package them accordingly?

These types of questions and decisions would be typical of the optimising process balancing the time/cost/quality effects of one alternative against another.

Time is often the dominant parameter, leading to a number of work packages. The design process call is staged over time. Permitting progressive issue of tender documents. Any long-lead items can often be sufficiently specified and separately packaged before final design completion of particular plant areas.

Increasing the number of packages to reduce project time will lead to higher costs of project management (for tender preparation, issue, award, monitoring, and control etc.), and will add to the risks of interface conflict and warranty assignment. Benefits gained from one parameter tend to be offset to varying degrees against the others, hence the need to optimise that balance for each specific project and client requirement.

Many trial programs need to be drawn up and examined, usually with reference back to the client's representative on specific issues where an obvious choice is not clearly apparent. A typical process for streamlining an original project plan using ‘what-ifs', would include the following:

- an initial brain storming session (deriving many possible alternatives)
- critical evaluation of all alternatives
- selection of possible alternatives
- substitution of alternatives into the network
- quantification of the impact on the 'total’ project.

Workbook activity 4-3

Complete Activity 4-3

Summary

This topic built on the basic techniques covered in Topic 2 and Topic 3. In particular it focused on those techniques which can help to refine and streamline projects.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how, this topic relates to the rest of the module?

- Do you feel you can achieve each of the stated enabling objectives'?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, email or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Large projects

- ☐ Network hierarchies
- ☐ Levels of work and responsibility
- ☐ Work breakdown structures

Risk management and fast tracking

- ☐ What is risk?
- ☐ Risk assessment
- ☐ Contingency allowances
- ☐ Degrees of risk
- ☐ Avoiding, reducing and containing risk
- ☐ Incorporating risk assessment results
- ☐ What is fast tracking?
- ☐ Considerations for fast tracking

Incremental and prototyping projects

- Monolithic projects
- Incremental projects
- Prototyping projects
- Resource levelling (smoothing)

Streamlining

- What-ifs?
- Typical questions
- Considerations for streamlining

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.

EMGT 450

Topic 5

Organization Structures for Projects

B

A

S

Bachelor of Engineering Management

CONTENTS

5

Overview

Topics

1. The role of projects
2. Planning and scheduling a project
3. Bar charts and resource allocation
4. Building on the basic techniques
5. **Organization structures for projects**
6. Project cost
7. Project contrrol
9. Using computers for Project management

Sections

- Introduction
- Parties to a project
- Project organization structures
- Procedure for selecting a project manager
- Summary

5 Organization structures for projects

Learning outcome

By successfully achieving the stated 'enabling objectives' for this topic, you should be able to:

- Plan project organization structures to ensure effective and efficient use of human resources.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Define and describe the parties to a project
- Identify the types of links between parties
- Evaluate the effectiveness of different project organization structures
- Apply appropriate procedures to the selection of a project manager

What you will need

Suggested study time	Study Guide	3 hours
	Activities and exercises	7 hours
	Text Book & readings	Nil
	Total	10 hours
Other resources	Nil	

Introduction

In many cases, projects are undertaken to provide organizations with revenue-generating outcomes, or the equivalent for non-profit organizations. The project team responsible for the execution of the project is generally a sub-unit within a parent organization. But often a project team is undertaking a project for an organization other than its parent, and often it will have some temporary and partial control of another organization (a contractor or sub-contractor).

In this Topic we describe the organizational units with which a project team may be associated. We then show some of the possible relationships between those units, and consider procedures used for selection of a project manager.

Parties to a project

Many projects (especially large-scale projects) involve relationships with a range of different people, with each person being involved, interested or responsible for a different part of the project. These are the parties to a project. These people can be either:

- **Project team:** The group of people, led by a project manager, responsible for the achievement of project objectives, as defined to them: they will normally be assigned to the project team by the parent organization.

- **Parent:** The organization to whom the members of the project team belong, who sets their objectives and provides their resources, and to whom they are accountable as a team for achieving project objectives.

- **Client/sponsors:** The organizational unit for whom the project outcome is being created, or the project is being carried out. The client could be:
  - the parent itself
  - a sub unit of the parent
  - a completely distinct organization, not in any way connected with the parent.

- **Contractor/subcontractor:** A legal entity engaged by the client, parent, or project team to carry out a defined section of the work needed to achieve project objectives.

Links between the parties

Typical relationships between the various organizational units involved in carrying out a project are shown in Figure 5-1. These are typical relationships for a medium to large project carried out for a client by a firm with special skills in project management.

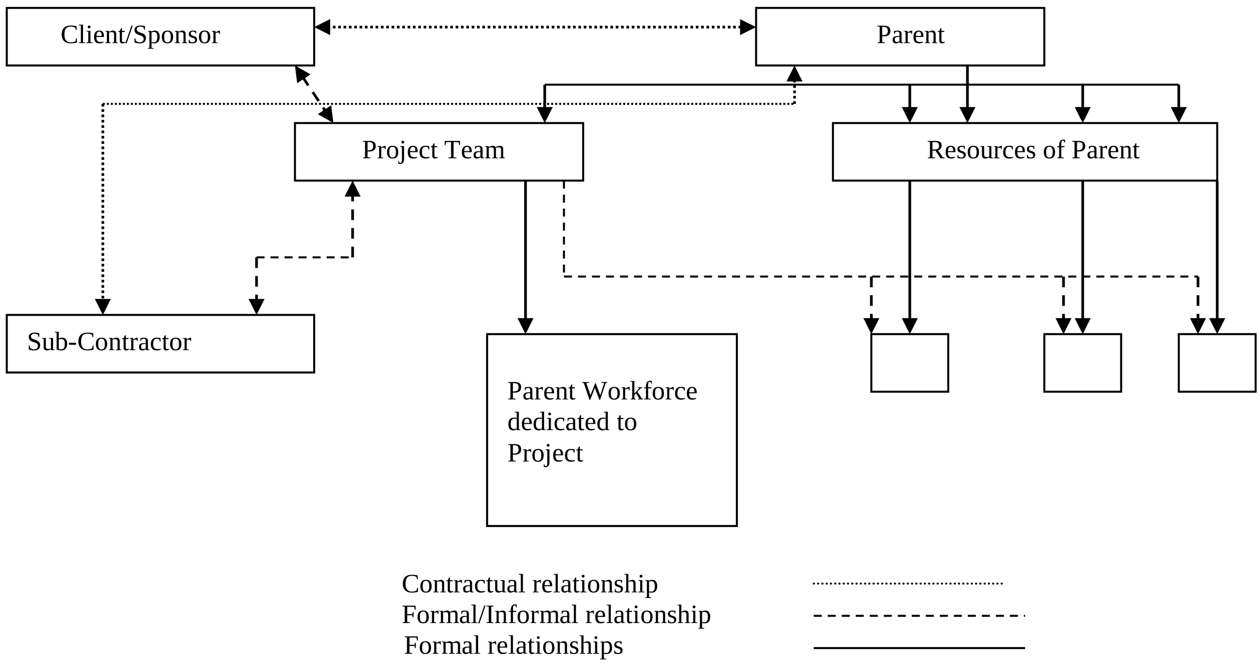


Figure 5-1: Organizational links relevant to a project

Formal contracts should exist between parent and client and between parent and sub-contractor. Because the project team is not normally a separate legal entity it cannot enter into contracts: however, there must be clearly established procedures for control, communication, and reporting between the project team, client and sub-contractors. The links between the project team, the parent, and any workforce dedicated to the project are the formal links defined by the parent organization.

Additional links, which may be formal or informal, exist between the project team and other resources of the parent. Such resources could include:

- Accounting
- Procurement
- Computing
- Drawing office
- Personnel

Under some circumstances resources may be seconded from these and other functional groups to the project team for the duration of the project. However, there will still be some relationship between the people seconded to the project team and the functional groups within the parent.

Teams and teamwork

A team or working group is a logical and fundamental element of an organization which can be a focus for improving the effectiveness of the organization.

The use of teams and teamwork can improve the performance of a group through the involvement and participation among members.

A project team is usually best formed for each project. Each project is different, often requiring quite different resources (including staffing) due to the size and complexity of the project. Common members of a project team are:

- project manager/controller
- project engineer
- contract administrator
- service manager

For the project team to work effectively, several factors must be included in the main objectives of the team including:

- communication
- problem solving
- decision making
- group process management
- resource utilization

Project organization structures

When projects are initiated, a decision must be made as to how to integrate the project and its parent organization. Often there is senior management influence (non-project). The role of project manager is strongly affected by the nominated organizational structure. As a result, the project manager needs to understand and appreciate the advantages and disadvantages of all the different organizational structures.

Process for planning a project organization structure

The steps listed below are those that apply to all forms of organization, however, they need to be modified to meet the particular needs of project organization.

1. Decide the objectives of the project and the method by which it will be carried out.
2. Identify the activities to be undertaken in achieving project results and in managing the project: the second group of activities include such things as: managing, operating the planning and control system, accounting, purchasing, quality control (if not included as a project activity) and all other 'overhead' functions.
3. Divide or group the 'overhead' activities into jobs so that each job represents a reasonable amount of work for one person.
4. Arrange those jobs into an organization structure (or incorporate them into an existing structure) to give the project manager an effective system for coordination and control.

Principles of organization

Consider the following principles of organization:

- There should be one boss – an individual should be accountable to only one superior: however, in the management of projects this is sometimes impossible.
- A manager is responsible for the work of subordinates.
- Responsibility requires commensurate authority.
- An individual's span of control should be limited.
- There should be some similarity between the departments or activities controlled by one person (homogeneity).

There are three different types of project organizational structures, each with their own advantages and disadvantages:

1. functional
2. matrix
3. projectised (pure).

Functional organization

Advantages	**Disadvantages**
• Maximum staff flexibility	• Client not the focus of activity or concern
• Temporary assignments	• Activities oriented to functional unit
• Grouped specialist	• Few staff given full responsibility
• Normal career path advancement	• Lack of coordinated effort
• Staff rotation	• Several layers of management to navigate
• Easy to re-assign back to normal work	• Not a mainstream activity or interest resulting in a lack of direction and motivation

Matrix organization

Advantages	Disadvantages
• Project is the point of emphasis	• Delicate balance of authority and power
• Sole responsibility assigned to one individual	• Political infighting and avoiding blame
• Access to entire staff reservoir	• Highly resistant to shutting down project
• Reduced duplication of functional divisions	• Violates the principle of 'unity of command'
• Preserves consistent practices and policies	• Split loyalties and confusion
• Company-wide balance of resources	• Variety and disorder
• Integrated functional specialists	
• Functional units can lend capacity	

Projectised organization (pure project)

Advantages	Disadvantages
• Full line authority	• Personnel become narrow focused
• Complete dedicated workforce	• Ostracized from functional area
• Workforce responsible exclusively to project manager	• Possibility of duplication of effort in clerical, administration, and other required support functions
• No permission from functional heads required	• Inconsistent policies and procedures
• Shortened lines of communication, faster communication and fewer failures	• Stockpiling of knowledge and equipment longer than needed, 'just in case'
• Strong and separate identity	• Corner cutting justified by needing to respond to client exigency
• High level of commitment	• The disease 'projectitis' develops as the project takes on a life of its own
• Task orientation	• Bitter competition and rivalry between different projects
• Swift decision making due to centralized authority	• Uncertainty about life after the project (being laid off, re-assigned, low prestige work, team broken up, rusty and dated skills)
• Faster reaction time • Unity of command • Structurally simple and flexible • Holistic approach to the project • More or less permanent cadre of experts	

Choosing an organizational structure

Realistically, the choice of an appropriate organizational structure should be determined by the situation at hand – that is, the variables underpinning the project. Sadly, there are no step-by-step procedures, rule books or generic guidelines (other than intuition) that provide detailed instructions as to the best structure for every project.

Consider the evidence, organization culture and the project variables and aim for a 'best fit' structure under the current circumstances.

Types of project organization structure

The organization to carry out a project can be structured in a variety of ways, which can be classified into five groups (refer Figure 5-2). They move from a weak structure (functional) in which there is often no single project manager to a strong structure (projectised) where there is one project manager with effectively total authority over all resources required in the project.

Structure	**Description**
Functional	The project is divided into segments and assigned to relevant functional groups: the head of each functional group is responsible for his segment of the project. Functional and upper levels of management formally coordinate the project.
Weak matrix	A person is formally designated to oversee the project across different functional areas. This person has limited authority over functional people in the project, and serves primarily to plan and co-ordinate the project. The functional managers retain primary responsibility for their specific segments.
Matrix	A person is assigned to oversee the project and interacts on an equal basis with functional managers. This person and the functional managers jointly direct work flow segments and approve technical and operating decisions.
Strong Matrix	A manager is assigned to oversee the project and is responsible for the completion of the project. Functional managers' influence is limited to assigning personnel and providing expert advice.
Projectised	A manager is put in charge of a project team composed of a core group of personnel from several functional areas, assigned on a full-time basis. The functional managers have no formal involvement.

Figure 5-2: Project organization structures

Procedure for selecting a project manager

In selecting the best person for project manager, it is worthwhile considering the following main features of the project:

- What is the importance and priority of the project?
- What management, technical functions and disciplines are involved?
- What is the duration and cost of the project?
- What time and attendance will be needed to manage the project effectively?

The answer to these questions will assist in the selection process.

Characteristics of a good project manager

Although every project is different and every project team is different, there are some characteristics, which distinguish a good project manager:

- formal status in the company structure
- leadership/management skills, for example, communication, persuasion, negotiation
- expertise relevant to the project, for example, marketing, engineering, manufacture, finance, purchasing, etc.
- respect in which individual is held
- personality, that is, informal authority
- availability over expected project horizon
- knowledge of company structure and policies
- commitment to project
- experience in project management
- involvement in preliminary project e.g. feasibility study, investment analysis, tender, market research
- involvement in start or finish of project

The project leader/manager should be matched with the project to the greatest degree possible, especially for important projects (and most projects are).

Workbook activity 5-1 **Complete Activity 5-1**

Summary

The topic covered the organization structures and principles for project management.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic relates tot he rest of the module?
- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Organization structures

- ❑ Parties to a project
- ❑ Links between the parties
- ❑ Types of organization structures
- ❑ Principles of organization structures
- ❑ Functional organization
- ❑ Matrix organization
- ❑ Projectised organization
- ❑ Selecting a project manager
- ❑ Characteristics of a good project manager

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.

EMGT 450

Topic 6

Project Cost

B

A

S

Bachelor of Engineering Management

CONTENTS

6

Page

Overview

Topics

1. The role of projects
2. Planning and scheduling a project
3. Bar charts and resource Allocation
4. Building on the basic Techniques
5. Organization structures for projects
6. **Project costs**
7. Project control
8. Using computers for project management

Sections

- Introduction
- Types of costs associated with projects
- Direct project costs
- Duration costs
- Project cost optimising
- Working with budgets
- Summary

6 Project costs

Learning outcome

By successfully achieving the stated ‘enabling objectives’ for this topic, you should be able to:

- Identify the costs associated with managing a project and optimise the balance between direct and duration costs.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- Identify and define the type of cost associated with running a project
- Estimate direct project costs
- Estimate the opportunity costs associated with a project
- What you will need optimise the balance between the direct costs and the opportunity costs of a project

What you will need

Suggested study time	Study Guide	3 hours
	Activities and exercises	10 hours
	Text Book & readings	Nil
	Total	13 hours
Other resources	Nil	

Introduction

Probably the most important consideration of any project is the cost. It does not matter whether the organisation is profit-making or non-profit, the costs associated with any project need to be planned, controlled and monitored.

There are many different costs associated with most projects. The costs are either directly related to each activity performed in the project or a cost associated with elapsed time.

This topic will cover the types of costs commonly incurred in the running of projects.

Types of costs associated with projects

The costs associated with managing a project are either:

- direct costs
- duration costs

Direct costs are incurred in carrying out the activities, work packages etc. that will achieve the required results of the project.

Duration costs are incurred for each period of time from when the project starts until the required results are handed over to, and are usable by, the project's sponsor – these duration costs can be categorised into two sub-categories:

- **administrative** costs
- **opportunity** costs

The two types of cost (direct, and duration) are discussed in more detail in the following paragraphs.

Direct project costs

As discussed in previous topics, a project can be divided into work packages, which are generally sub-projects of the main project or discrete activities. The packages or activities can be carried out by the project manager’s own labour, or can be subcontracted. In either case the more detailed breakdown will lead to:

- more accurate estimates of cost
- the opportunity to control costs more tightly

Direct project costs are defined as the costs incurred by carrying out the activities needed to achieve the project outcome. The major types of direct costs that can be incurred are listed below, with methods of estimating the costs also shown.

Labour

For each activity it is necessary to estimate:

(a) The number of people of a particular category needed to carry out that activity.
(b) How long (given nominated conditions) it will take for those people to complete the activity
(c) The charge-out rate for this unit of labour per unit of time (hours, days, weeks, etc.)

Materials

For each item of material an estimate must be made for:

(a) The quantity required in the end product or outcome
(b) An allowance for wastage, where appropriate
(c) Cost per unit of measurement (e.g. meter, kilogram), including where appropriate, freight, handling charges, etc.

Use of plant and equipment owned by the organisation

It is important that an appropriate charge is made for equipment owned by the organisation. To do this an hourly charge-out rate needs to be calculated, taking into account all the costs associated with owning and operating equipment.

Sub-contracted work or equipment

For sub-contracted items the costs are normally known because the price is fixed before the work starts. It is important however, to identify exactly what the quoted price covers. It may be necessary to add extra amounts for items that may not have been shown in the original contract price (e.g. insurance, allowances, transport and accommodation, etc).

Figure 6-1 shows how the direct costs of a project can be estimated.

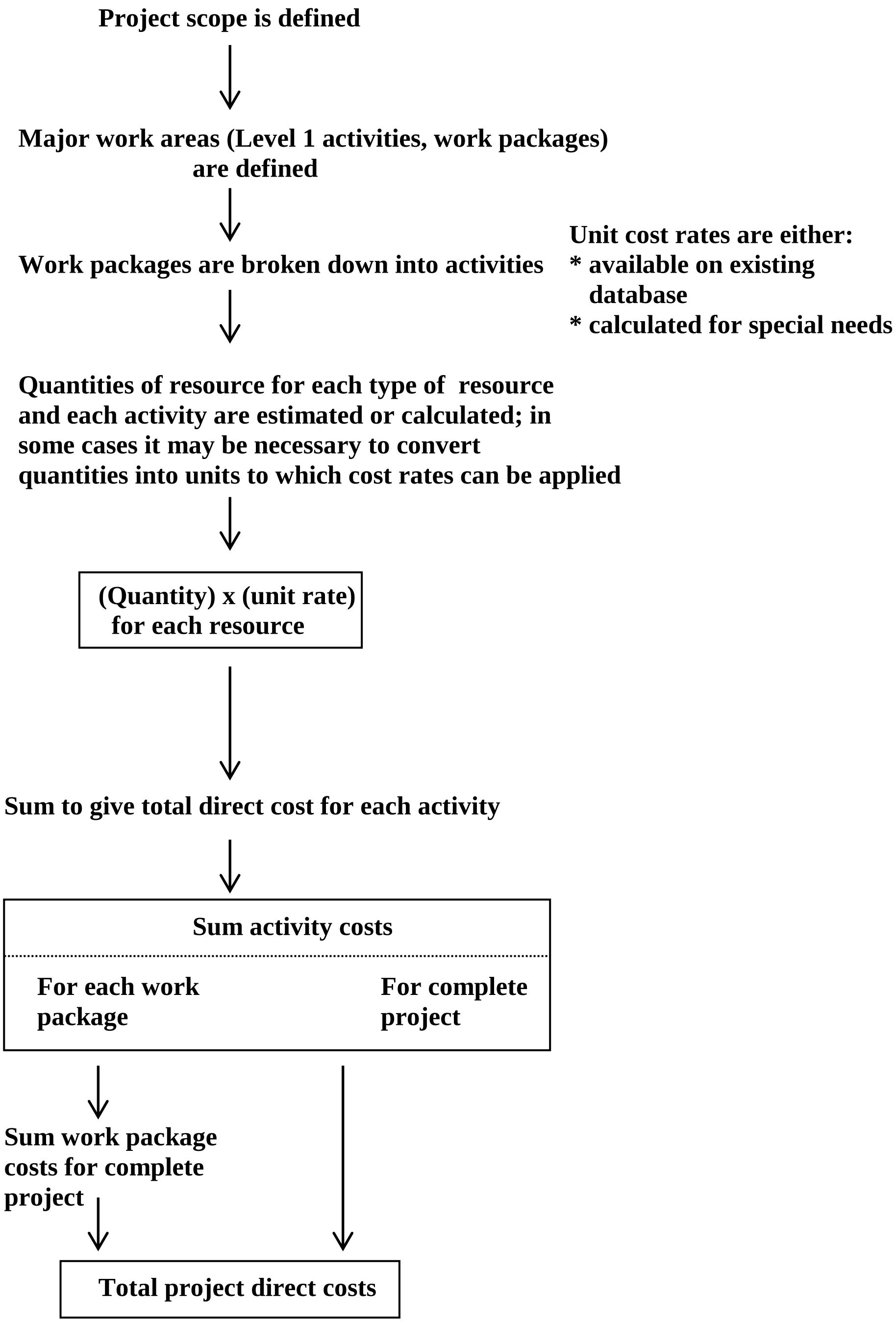


Figure 6-1: Steps in estimating direct costs of a project

Duration costs

As mentioned previously, duration costs can be categorised into two sub-categories:

- administrative costs
- opportunity costs

Administrative costs

While a large project is running, it needs a permanent administrative body. This can include such costs as:

- Project manager
- Project administrator
- Other project management staff
- Offices and office facilities
- Communication facilities
- Project management transport

Some of these costs will not be incurred in smaller projects. The essential characteristic of these costs is that they are likely to occur whether any direct work is taking place on the project or not.

Opportunity costs

While a project is running, income may be lost – or more correctly, not gained. For example, when a chemical plant is off-stream, the output from that plant is not available for sale. This may represent a loss of thousands of dollars per day. Similarly, when a product is under development and not available to the market, potential daily income from that product is lost either by diversion to other goods or to competitors.

Workbook activity 5-1

Complete Activity 6-1

Project cost optimising

In certain types of projects the costs can be substantial, and it is often very beneficial to see if employing more resources on the project to reduce its duration can reduce some of these costs. This process is called project cost optimising.

The cost-slope concept

It may sometimes be possible to decrease the duration of an activity or a project by assigning additional resources. These additional resources are often more expensive than the normal resources: for example, overtime or weekend working, hiring of subcontractors, use of more powerful plant – all of these are likely to be more expensive per unit of work done.

Bye way of example, let us assume that assigning more resources can reduce an activity's duration, but that the reduced duration is going to cost more. There are four quantities to be considered:

- normal duration
- crash (or accelerated) duration
- normal cost
- crash cost

The cost slope is given by using the following calculation:

$$\textit{Cost slope} = \frac{\textit{Crash cost} - \textit{Normal cost}}{\textit{Normal duration} - \textit{Crash duration}}$$

This derives a figure (in dollars) for each specified unit of time.

Figure 6-2 overleaf, shows an example of cost slope calculation. The dangers of the cost slope concept are:

- It is often extremely difficult to obtain reliable figures for the changes in cost resulting from changes in duration time.
- The relationship between time and cost tends to be a stepped function rather than a linear or curvilinear one.

Optimising project cost

Examination of the project network and using the cost-slope concept makes it possible to calculate the cost of reducing the project by one day, two days, and so on. There is of course a limit below which the project duration cannot be reduced.

If the administrative and opportunity costs are known with reasonable accuracy, and the costs per day of reducing the project time are known, then a minimum total cost will occur when the marginal cost of reducing the project by one day is equal to the duration cost. This will also give the optimum project duration if costs are to be minimised.

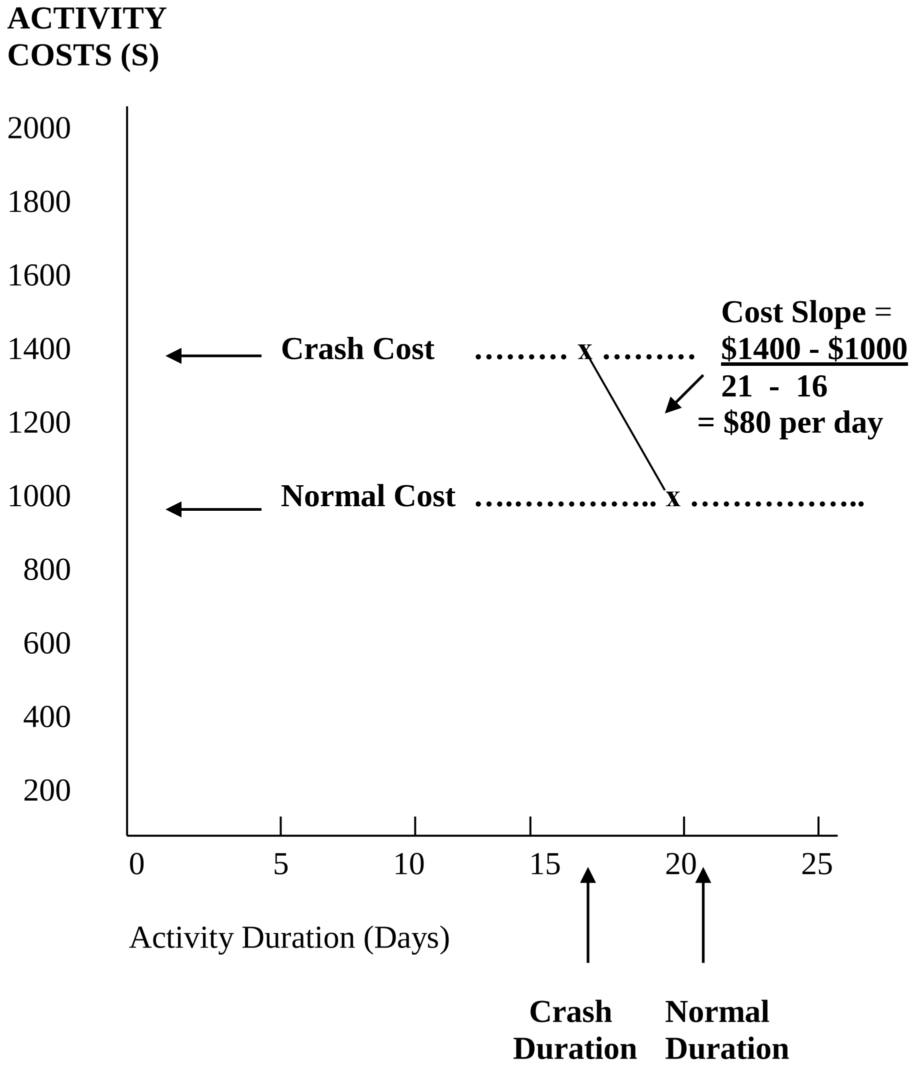


Figure 6-2: Calculation of cost slope

Working with budgets

The planning of future activities for your business in financial terms is what budgeting is all about. In a personal sense, it is a comparison between your available money and the likely spending or desired spending pattern. From a business perspective, it estimates how much money you need for your business and how to control what is spent. In addition, it also provides a benchmark to work towards by helping coordinate and control staff and their activities. And let's not forget the management credibility it also projects with outside interests (banks, investor's shareholders and other parties).

Specific advantages for using budgets include:

- increased ability to make better decisions
- cost control
- more reliable profits
- assess operational financial requirements
- identify areas needing evaluating and control
- diagnose problems in advance
- valuable communication tool
- improved credibility of management
- encourages constructive input from staff
- short term strategies to achieve long term objectives

There are also a number of disadvantages involved in budgeting as follows:

- they can be costly to prepare
- high degree of uncertainty
- erroneous and unreliable estimates and assumptions
- assumes constant rate of change
- unrealistic targets set
- failure to adjust for cyclical influences (seasonal, economic)
- planning often delays action
- restrict initiative and innovation
- blind business to new opportunities
- appear to be inflexible
- requires co-operative top to bottom support.

Approaches to budgets

Budgets can be developed by a variety of techniques, including:

- **Traditional** – previous year's level of performance is used as the basis to build the next years figures, assuming those activities continue. The present level of activity and spending is accepted as the starting point.
- **Zero based** – each activity and outlay must be justified rather than simply continuing from a previous period. The approach starts with zero spending for each activity.
- **Program** – activities are grouped together to allow for projecting costs and sales generated by each program, or major activity. It strives to identify and eliminate programs that are closely or that duplicate other programs.
- **Periodic** – prepared for specific lengths of time, say 12 months.
- Rolling – as the first period is completed, it is deleted and a new future period is added. The advantage is that it forces you to maintain ongoing planning which is preferable to waiting until the end of the current period.
- **Computerised** – high speed calculations with complete accuracy. Excellent for 'what if' scenarios and sensitivity analysis.
- **Top down** – a strategy based on collecting the judgements and experiences of top and middle managers together with available past data concerning similar activities. Overall project costs are estimated and then given to lower-level managers who continue the breakdown into budget estimates for specific sub-project work packages (tasks).
- **Bottom up** – individual task budgets are estimated in detail by the people charged with doing or managing those tasks. Resulting figures are discussed, agreed on and aggregated to give the total project cost.

Comparison of budgets with actual results

Planned operations (budget figures) must be compared with the results achieved. If actuals correspond with the expected figures, then performance can be considered to be satisfactory. If there is a material difference between the two, the difference must be investigated and action taken to correct the cause where possible. Reasons behind the different figures could include:

- incorrect budget figures
- unexpected rises in costs
- errors in arithmetic
- schedule not conducted as planned
- changes in client objective
- budget cutbacks
- market changes and incorrect forecasts

Remember, when preparing budgets, always:
- give underlying assumptions
- show tolerance level
- state factors that affect validity
- indicate how budget derived

A possible format for budgeting could be the following simple model:

January 1999

Budget	Actual	Variance	Variance %	Tolerance±	Responsibility	Estimate	Action

Fixed and variable costs

Fixed expenses

Most projects incur fixed expenses which remain constant over a given period of time (current accounting period). This occurs irrespective of the output, stage or completion status of the project (refer Figure 6-3). Examples include:
- leases
- loan repayments
- depreciation
- rates
- insurance
- taxes

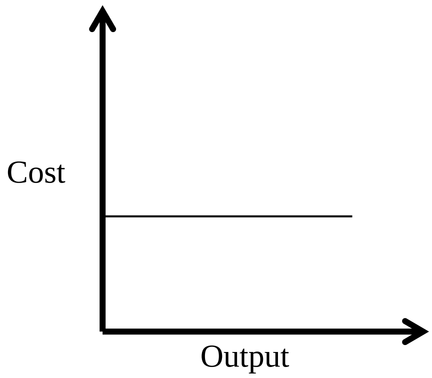


Figure 6-3: Fixed expenses during the project

Variable expenses

These are project expenses which vary in direct proportion to the level of task activity. As levels increase, so do variable costs and as activity levels decrease variable costs will also fall. Variable costs are hard to calculate in advance as they are closely linked to the number of items produced or used, and economics of scale that may result from usage increases (refer Figure 6-4). Example of variable costs are:

- raw materials
- electricity
- labour

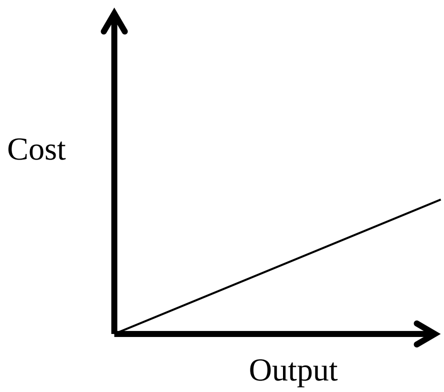


Figure 6-4: Variable expenses during the project

Exercise 2-1 Complete the following:

6. Define ‘direct costs’

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

7. Define ‘duration costs’

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

8. Describe the principle of cost optimisation.

…………………………………………………………………………

…………………………………………………………………………

…………………………………………………………………………

Workbook activity 6-2 **Complete Activity 6-2**

Summary

This topic covered the costs associated with project management.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic relates tot he rest of the module?
- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away.

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Project costs

- ❑ Direct costs
- ❑ Estimating direct costs
- ❑ Duration costs
- ❑ Administrative costs
- ❑ Opportunity costs
- ❑ Cost optimising
- ❑ Cost slope
- ❑ Budgets
- ❑ Fixed and variable costs

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.

EMGT 450

Topic 7

Project Control

B

A

S

Bachelor of Engineering Management

CONTENTS

7

Overview

Topics

1. The role of projects
2. Planning and scheduling a project
3. Bar charts and resource allocation
4. Building on the basic techniques
5. Organization structures for projects
6. Project costs

7. Project control

8. Using computers for project management

6. Using computers for project management

Sections

- Introduction
- Project control
- Characteristics of a project control system
- Methods of project progress control
- Methods of project progress cost control
- Measuring actual progress to date
- Summary

7 Project control

Learning outcome

By successfully achieving the stated 'enabling objectives' for this topic, you should be able to:

- establish systems for control of project progress and costs.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- define the elements of a control system
- explain the principles of a control system as applied to the management of projects
- describe the process for developing a project control system
- describe methods for reporting project control information
- convert data for progress and performance into usable information for project management decision making
- set up a system for project cost control

What you will need

Suggested study time	Study Guide	3 hours
	Activities and exercises	5 hours
	Text Book & readings	Nil
	Total	8 hours
Other resources	Nil	

Introduction

Project control is an essential aspect of project management. Just as 'planning and scheduling' is critical in defining the project objectives and the processes for implementation, project control is critical to the success of the project.

Project control allows the project manager to measure performance against desired or 'target' goals for the project. In this way, refinements and/or corrective action can be taken at the appropriate point to ensure the project stays 'on track'.

This topic will introduce project control as an essential element of project management.

Project control

The term control when used in relation to the process of management means **the steps taken to ensure that a plan is adhered to as far as possible.** The steps are:

1. Set targets (establish plan)
2. Measure performance
3. Compare performance with target
4. Take corrective action if necessary

The principles in applying these steps to the management of projects are described below:

1. **Sufficient targets**. For effective control the project must be divided into activities of appropriate duration. For example, in a project lasting ten working days, it would be inappropriate to have one activity lasting seven days. In such a project, one activity should not be longer than two days: should an activity have duration greater than that, it should be divided in some suitable way.

2. **Measurements should be pertinent**. Typical measurements which are pertinent in the control of a project are:

    - progress in terms of time
    - cost of labour
    - cost of material
    - cost of any other items such as sub-contract work, plant hire, penalties, and administrative costs
    - total cost

3. **Measurements should be precise**. In most projects there is a strong emphasis on time. It is therefore important that the time measurements should be realistic. This applies in particular to supervisors and managers responsible for reporting how much of an activity has been achieved or how much is left to do. (It is worth making the point that after a time the project manager and other members of a project team will get to know who are the optimists and who are the pessimists, and for what reasons.)

4. **Measurements should be in the same units**. Generally, this is quite obvious, but in some projects it may be necessary to make the distinction clearly between those activities expressed in different units: for example:

    - elapsed working days
    - person days
    - 8-hour shifts

- 12-hour shifts
- 5-day weeks
- 7-day weeks

5. **Frequency**. The frequency of measurement will depend on:
   - the duration of the project
   - the total cost of the project
   - the urgency or importance of the project
   - the opportunity to take corrective action
   - the activity being measured
   - the cost of making the measurement

6. **Recency**. The processing of measurements into information from which action can be taken should be as rapid as possible consistent with the factors listed in the previous point.

Characteristic of project control system

Lewis (1997) believes that every project operating under an effective control system should have the following characteristics:

- A focus on what is important – that is, that the project mission and objectives are achieved

- A system for taking corrective action – that is, the control system must use deviation data is initiate corrective action otherwise it is simply a monitoring, system. Remember, responding to deviations does not mean 'panic mode' every time.

- An emphasis on timely responses – that is, information on project status must be available on a real-time basis because if action is taken too late, it will be ineffective.

(Source: Lewis, J., 1997. Team-based project management. American Management Association, New York.)

Additional suggestions for what makes an effective project control system could include:

- comprehensive reporting procedures with a reliable and verifiable audit trail
- agreed performance (quality) standards in place with the ability to measure these standards
- open channels of communication (top-down, bottom-up, and diagonal)
- identification of all relevant issued and potential problems impacting on the project
- frequent and periodic comparison of actual progress and expenditure to schedules and budgets (earned value analysis)
- changing the tracking emphasis from money actually spent to the work actually performed by relating cost with schedule performance (earned value analysis)
- periodic re-estimation of time and cost to complete remaining work (earned value analysis)
- ability to measure status and accomplishments
- thorough planning of all the work required to complete the project
- good skills in estimating time, labor and costs
- a disciplined approach to budgeting and spending
- exception reporting procedures
- regular (productive) meetings and feedback with project stakeholders
- on-going project reviews, revisions and approvals where required
- factoring in contingency planning in the original schedule.

Methods of project progress control

Use of critical path analysis (CPA)

CPA is very useful in helping a project manager to control project progress. Because the project is broken up into activities, it is easy to see when an activity is complete, and thus a certain percentage of the project has been achieved. One requirement is that no activity should be long (or short) relative to the other activities. A long activity should if possible be sub-divided into sub-activities so that its progress can be more accurately and closely monitored.

Collection of data and conversion to management information

Progress data should be collected at an appropriate frequency. The fundamental need is for the project manager to have information while there is still time to start to act on it to meet project time objectives. In general it is better to err on the side of more frequent collection rather than less.

Project team members should be asked to say (in respect of current activities) either what % of the activity is complete or how many more days they will take to complete the activity. The 'days remaining' method is probably the better of the two.

After collection of the data, which should be by direct observation or questioning, it should be transmitted to the project information system to update the network, activity analysis, and bar chart. Rapid conversion is important, so that the project manager constantly knows the real situation and can thus make more timely decisions.

Methods of project cost control

In designing a system for controlling project costs the Project Manager must address the following points:

- Is it necessary to measure cost performance against each work package or activity, or will control be sufficient if the cost performance for the whole project is measured regularly?
- Will it be necessary to set up a cost control system for the project separate from the accounting system of the organisation: if so, how will the relevant costs in the two systems be reconciled?
- At what point is it considered that costs are incurred, for example, commitment, placing of order, delivery (in the case of materials), use, receipt of invoice, payment, or allocation to the appropriate account?

In operating the Project cost control system, one of the major problems is to ensure that actual costs incurred are matched with the budgeted cost for the same item of work, activity, or package. In one terminology the work done is said to have a specified earned value, which is another way of describing the activities or packages (or part thereof) completed. Comparison of the earned value with the actual cost of earning that value will show the Project Manager the incidence of variances.

Another major problem in operating a project cost control system is that in many cases the costs are presented as fait accompli, and there is nothing the Project Manager can do retrospectively. Two actions a Project Manager can take in terms of controlling costs are:

1. To have costs measured before commitment and compared with budget, and to do everything possible to reduce committed costs to the budgeted figure.
2. To develop ways for carrying out activities or packages later in the project at reduced cost, while not impairing the functionality of the activity or package outcome.

Measuring actual progress to date

One of the major difficulties in controlling projects (as distinct from reporting projects) is the issue of progress to date.

For any given task, it should be possible to estimate, predict or calculate the actual amount of effort, costs, person hours or duration completed. Factors that make this process difficult include the project life-cycle phase, the length of the project, the type of estimate and the accuracy of the estimates.

While there is no accepted standard rule of thumb to follow, a number of approached are listed below:

- **0/100** – no value is recorded until the task is fully completed.
- **Milestone** – value is earned when the milestone (control point) is reached. Budgets are assignment to the milestone rather than the individual task.
- **Standard dollar expenses** – a percentage of the costs are to be assigned to an equal percentage of time interval passed.
- **50/50 rule** – half the budget is recorded for each task at the time the work is scheduled to begin, and the other half at the time the work is scheduled to be completed.
- **Level of effort** – based on the passage of time over the total scheduled time. It measures the resources consumed over a given period of time.
- **Equivalent units** – progress is measured by the number of completed units, rather than labour considerations.

Workbook activity 7-1

Complete Activity 7-1

Summary

This topic covered the costs of project control.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic relates tot he rest of the module?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember, that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away).

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Project control

- ☐ Principles
- ☐ Characteristics of a project control system
- ☐ Methods of progress control
- ☐ Methods of cost control
- ☐ Measuring actual progress to date

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.

EMGT 450

Topic 8

Using Computers for Project Management

B

A

S

Bachelor of Engineering Management

CONTENTS

8

Overview

Topics

1. The role of projects
2. Planning and scheduling a project
3. Bar charts and resource allocation computers
4. Building on the basic techniques
5. Organization structures for projects
6. Project costs
7. Project control
8. **Using computers for project management**

Sections

- Introduction
- Benefits of using for project management
- Selecting a computer package
- Requirements of a computer-based project management package
- Summary

8 Using computers for project management

Learning outcome

By successfully achieving the stated ‘enabling objectives’ for this topic, you should be able to:

- select a project management computer package to assist in successful achievement of project objectives.

Enabling objectives

You may be assessed on the following objectives. These objectives should enable you to achieve the learning outcome stated above.

- identify the benefits of using computer based project management packages
- identify the requirements for a project management computer package
- describe the steps in selecting a computer based project management package
- use a computer based project management package

What you will need

Suggested study time	Study Guide	2 hours
	Activities and exercises	Nil
	Text Book & readings	Nil
	Total	2 hours

Other resources	Nil

Introduction

The previous topics in this unit have provided an introduction to many of the aspects of project management. As you will have already seen, there are many tasks to be performed before, during and after a project.

The use of information technology (specifically computers) allows many of the project management functions to be performed faster and better than could be achieved by other means. Tasks such as planning, organising, networking, charting, tracking and recording are much simpler to achieve through the use of computers and appropriate project management software

This topic will provide an introduction to the use of computers in project management.

Benefits of using computers for project management

As you will have seen from the previous topics you have studied, project management involves many complex tasks, with many interrelationships existing between the activities. Project management includes (amongst other things):

- planning
- scheduling
- organising
- evaluating
- analysing
- charting
- networking
- tracking
- managing
- controlling
- budgeting
- recording

Many of these types of tasks are readily and often more easily done by computers. The current availability of software can make many of these tasks much simpler, and certainly less laborious. Some of the specific tasks can also be automated by the use of computers (e.g. scheduling and tracking).

Selecting a computer package

The following steps can be followed to identify and select an appropriate computer-based package for project management:

1. Decide what you want from the package. What are your criteria for performance (refer list below)?
2. Identify computer packages available: possible initial sources are:
   - Computer world Green Book
   - DP Index and Software Register
3. Evaluate (using a coarse or preliminary screen) the packages against the major criteria (the musts) as determined in 1 above.
4. For those packages remaining identify existing users of each package and get reports on the effectiveness of each package (refer list below).
5. Select the most appropriate package.
6. Obtain hardware (assuming that possession of hardware has not acted as a constraint on selection) and software.
7. Set up the package (hardware and software).
8. Train staff in use of the package.

Requirements for a computer-based project management package

A computer package for project management must, above all else, be able to perform the specific project management tasks required from it. As a starting point in deriving a specification of requirements for a computer package, the following list identifies many of the main features commonly found in project management software. The list does not claim to cover all features of all available packages.

Project scheduler

- Critical path techniques
- Multiple projects
- Notation
  - arrow
  - precedence
- Number of activities/projects
- Sub-networks/projects
- Total of current activities (over all projects)
- Ability to explode/implode (hierarchies)
- Activity number range
- Activity description length
- Maximum number of predecessors
- Indication of priorities: *Projects/Activities*
- Milestones
- Options (*what-ifs*?)/ability
- Activity updating
  - % complete
  - remaining duration
- Schedule maintenance: *Plan Vs actual*
- Built-in security
- On-line help

Resources

- Time-limited / Resource-limited allocation
- Maximum resources / project
- Maximum resources / activity
- User-defined resource limits
- Multiple project resource pool
- Resource-levelling capability
- Allocation:
  - constant / unit time
  - variable / unit time

Costing

- Costs assignable to activities
  - materials
  - labour
  - plant
  - overhead
  - other

- Activity costing:
  - constant / unit time
  - variable / unit time

- Cost monitoring:
  - per activity
  - per project

- 'Duration' costs

- Cost optimisation

Reports

- High resolution graphics capability
- Flexible user-defined report generator
- Time-scaling options

Project scheduler / calendar

- Number of calendars / project
- Calendar divisions – *Hours*
  - days
  - weeks
  - shifts, etc.
- Optional non-working days
- Flexible date formatting

Software interfaces

- CAD Systems *(e.g. AutoCAD)*
- Spreadsheets
  - *Excel*
  - *Lotus 1-2-3*
- Industry standard DBMS
- Printer / plotter drivers

Conditions of use

- Purchase / lease
- Portable / Bureau Dependent

Hardware

- Mainframe / Mini /PC
- Proprietor *OS / UNIX*
- Configuration dependencies

Costs

- Hardware and software
- Annual maintenance / licence fees training
- Port-sales support

Other

- Qualified user references

Summary

This topic covered the use of computer based packages for project management.

Before progressing, return to the beginning of this topic and revisit the stated enabling objectives.

- Can you see how this topic relates tot he rest of the module?

- Do you feel you can achieve each of the stated enabling objectives?

If you can, proceed to the competency checklist and complete as a double check to confirm your ability. If you cannot achieve each of the enabling objectives, re-read the appropriate text and re-do the activities and exercises until you can. Remember that if you need assistance in your study, the lecturer is there to provide assistance. They are only a phone call away.

Check your progress

You should now refer back to the enabling objectives stated at the beginning of this topic and make sure you have achieved them. If you are unsure, we encourage you to re-read the appropriate text and try the activities and exercises again.

If you need assistance in your study, the lecturer and other staff (e.g. engineering librarian) are there to provide assistance. We are only a fax, e-mail or telephone call away).

Checklist

Use the following checklist to identify whether you achieved the essential elements of each enabling objective in this topic.

Performance criteria 4

Use of computers for project management

- ☐ Benefits
- ☐ Selecting a computer-based package
- ☐ Check list of requirements

Make some notes

Insert your own thoughts about this topic here. Make a few notes about your progress or any issues which you may want to recall when discussing this topic with the lecturer or another student.