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# Project management: the start of the project journey

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# Contents

# Introduction

This free course introduces projects: what they are and how they come about as a result of ideas, responses to problems and planning. Key players in the project game are introduced. The course then looks at how feasibility studies are carried out. Technical, social, political, environmental and financial feasibility are explored and assessed. Decision making tools are discussed. Once a proposal for action has been accepted by management, a project results. This course looks at various ways of organising the life cycles of projects and what the project manager's job consists of.

This OpenLearn course provides a sample of postgraduate study in Management.

# Learning Outcomes

After studying this course, you should be able to:

- define what a project is
- understand the importance of risk
- define the questions a decision maker needs to ask
- list the main activities and tasks of a project manager
- consider phased development, prototype approaches or agile methods.

# 1 Conception: 'The journey begins'

To write about projects, we have to define what they are and describe how they arise. This course will concentrate on describing what a project is, and how it can arise as a part of a planning process, as a response to a changing environment, as a business opportunity, as a problem or as a newly identified requirement.

Projects often appear to be mysterious: it can be difficult to define exactly what a project is, and to the man or woman in the average organisation they seem to appear rather in the same way that mushrooms sprout – overnight. They are very diverse, and may range from one or two people making an effort over a few days or weeks to dozens or even hundreds of people working over a period of years.

## Learning outcomes

At the end of Section 1, you should be able to:

- define what a project is
- use a variety of knowledge-gathering and idea-generating techniques to develop objectives for action
- use Pareto analysis and cause and effect diagrams to explore problem areas
- generate simple matrix diagrams to relate objectives to strategies
- name and describe the chief roles various people can assume relating to proposals and projects
- relate all these roles to the process of organisational planning
- explain different views of quality and show that a structured approach to planning improves quality.

## 1.1 What is a project?

Projects and project work are often contrasted with *operations*, which describe the normal day-to-day activities of an organisation, whereas the word *project* is often used to describe something outside normal day-to-day work. Of course, in some fields, such as construction, research and software design, the normal day-to-day work is carrying out projects. What then *is* a project?

Projects vary so much that they are difficult to define concisely, but the general view is that projects are concerned with bringing about change in an organised manner. From an academic perspective, a *project* is:

> a temporary organisation to which resources are assigned to do work to bring about beneficial change.

(Turner, 2006, p. 1)

Project management is also an established profession in many countries around the world and its practitioners have developed bodies of knowledge. For example, the Association for Project Management (APM) in the United Kingdom defines a *project* as:

> a unique, transient endeavour undertaken to achieve a desired outcome.

> (APM, 2006, p. 150)

The net outcome or result allows a broad interpretation of the possible outputs or products for a project. Now that projects take place in just about every organisation in the UK, there is also a British Standard for project management (BS 6079). The current version was prepared by representatives from a cross-section of industrial bodies, such as the Institution of Civil Engineers, government bodies, such as the Ministry of Defence, as well as the APM. A *project* is defined as:

> a unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources.

> (BS 6079-2, 2000, p. 10)

In order to bring about a desired change, a project has the following characteristics:

- a project is a unique undertaking: each one will differ from every other in some respect
- projects have specific objectives (or goals) to achieve
- projects require resources
- projects have budgets
- projects have schedules
- projects require the effort of people
- measures of quality will apply.

The uniqueness of projects means that they take place in an atmosphere of uncertainty (for which there may be some risk associated). For our purposes, we will define a **project** as organised work towards a pre-defined goal or **objective** that requires resources and effort, a unique (and therefore possibly risky) venture having a budget and schedule. Individual projects can be anywhere in the 'spectrum of uniqueness': from an endeavour in which just about everything you do is unique to something that is merely fairly novel. An academic research project, for example, is somewhat different from one that improves the routine operation of existing machinery.

In practice, the primary goal or objective will be broken down into a number of objectives in order to achieve the desired outcome. Once a project has met its objectives, it ceases to exist; therefore project work is also characterised by impermanence.

Quality in the context of projects will be discussed throughout this course. Defining quality is not trivial and there are a number of different perspectives from which quality can be viewed. Our view of **quality** is based on the following definition:

> The degree to which a set of inherent characteristics fulfils *requirements.*

> (ISO 9000, 2005)

Note that ISO 9000 defines a requirement as:

a need or expectation that is stated, generally implied or obligatory.

In ISO 9000 each inherent characteristic of a product, process or system is related to a requirement.

When it comes to the act of initiating a particular project, someone will have to justify the request for the resources needed to realise the intended **benefits**. Some effort is required to prepare enough evidence to gain approval for the project to go ahead. A **business case** is the term used for a document that sets out the justification for a project and its strategic rationale (APM, 2006, p. 68). In order to make a decision to invest in those resources, estimates of costs, timescales and benefits are needed even though detailed information may not be available at this early stage. In effect, the business case is the initial project plan with sufficient information in it to answer all the questions that the decision maker might ask – for example:

- What do you want to achieve?
- Why do you want to do it?
- How are you going to do it?
- When are you going to do it?
- Who is going to be affected?
- What resources do you need?

An analogy that is commonly used to describe the concept of a project is that of a journey. The daily trip to and from work by car might be part of your routine, so it's not really a project. But a special trip to somewhere new could be a real challenge. There will be a reason for that journey, which would require a plan about how to reach the destination and what needs to be done on the way. Additional effort is needed to keep track of your progress and make sure you keep to the intended route. Hence, **project management** is about the application of knowledge, skills, tools and techniques so that the project can be defined, planned, monitored, controlled and delivered in order to achieve its agreed benefits (APM, 2006, p. 151).

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### Activity 1

Think about how you might identify whether or not a project is successful. List those items that you would look at to determine a project's success.

#### Discussion

One way to identify whether a project is successful is to ask the following questions:

- Did the project achieve its time, cost and quality objectives?
- Does the project meet the customer's perceived requirements?
- Does the project's outcome make the client want to come back to do further business?
- Has the project been completed leaving the project organisation fit and able to continue further work?

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The analogy that a project is a special journey for a particular reason identifies the need to differentiate between project success and product success. For example, a project can meet all of its cost, time and quality objectives, but may fail its business goals and vice

versa. We will return to the subject of success in Section 5. But it should be noted that any assessment of success involves both objective and subjective criteria.

# Examples of projects

An aircraft manufacturer finds that the nose wheel on the prototype of a new aircraft collapses too easily and institutes a project to strengthen the nose wheel design. (Where designs are the result of a 'committee' or 'concurrent engineering' approach, as is often the case in the aircraft and automotive industries, what one group does with their part of a design may force another group to redesign. For example, when the wing strut in one aircraft design was strengthened, maintenance to part of the aircraft became impossible – the fitter could not reach existing wiring because the maintenance access shrank to make room for the stronger wing strut! A project had to be initiated to redesign the maintenance access.)

A construction firm may be contracted to construct access roads and a group of small factory units on derelict land in order to generate business and jobs in a depressed area of the country. This may involve surveying, demolishing walls, clearing any rubble, removing trees and shrubs, levelling the site, laying out the access roads and constructing them, constructing foundations and erecting the buildings required by the plans.

A research and development department in a chemical firm may be asked to devote time to exploring the possibilities of developing products using a new polymer. At the same time, some analysis of the potential market and the manufacturing process would be made.

A software development firm may be asked to make modifications to an existing database system in order to allow users to prepare reports directly using the data retrieved rather than having to transcribe it to a word-processing system. This may involve developing an understanding of the database and the word-processing systems, interviewing or observing users, developing specifications, writing and testing code, installing the new version of the software and providing training and documentation.

The marketing group of a company may be asked to prepare the launch of a new product. This may involve market research, planning and executing an advertising campaign, organising promotional events and press releases, and liaising with wholesalers and retail outlets.

A charity working in the developing world may determine in consultation with local people that a well needs to be dug. This may involve consulting people to determine a good site, consulting an expert hydrologist, organising local labour and materials and carrying out the work. It may involve earlier effort to determine the best local materials available and the best ways of using them for this project. It may also involve training local people to maintain the well and working with local groups to ensure that the new resource is shared fairly.

A government body may have to respond to legislative changes. For example, the change in the UK from the old basis of local taxation, the rates (based on 'rateable value', which was in turn related to property value), to the community charge (the poll tax, which was a charge on individuals) obliged local government bodies to make major changes to computer systems and undertake a major effort to identify whom to tax. Subsequently, the change from the poll tax to the council tax (which combines a highly modified element of the poll tax with an element of the tax based on property value) required further major system changes and another major effort to assess properties to assign them to tax

bands. These formed, in a relatively short period, two separate major projects to institute the changes: one for the poll tax and then one for the council tax.

Sometimes the work needed to achieve a major organisational goal or objective will be far greater than can easily be organised and carried out in a single project. This may mean that the organisation will undertake a **programme** that consists of a number of interrelated projects. The Association for Project Management defines a programme as:

> a group of related projects, which may include related business-as-usual activities, that together achieve a beneficial change of a strategic nature for an organisation.

<div align="right">(APM, 2006, p. 149)</div>

It is also conceivable that more than one programme will be needed in order to achieve a strategic objective. The term **portfolio** is defined as:

> a grouping of an organisation's projects, programmes and related business-as-usual activities taking into account resource constraints.

<div align="right">(APM, 2006, p. 147)</div>

The Olympic Games is an example of a portfolio that is owned by the country that acts as the host of such a special event. Consequently, a programme is associated with each of the different sports involved as well as one to deal with the changes in infrastructure needed for the Olympic Games to go ahead. It is also possible that a portfolio can refer to a group of projects and/or programmes that have no inter-dependencies other than sharing or competing for the same resources. Our next step is to consider who might be involved in the conception of a project.

## SAQ 1

Based on the characteristics that we have associated with projects and your own experience, draw up a table to compare project management with managing operations.

Answer

The answer is shown in Table S.1.

### Table S.1 Project management versus operations management

| Projects | Operations |
|---|---|
| Significant change | Any changes small and evolutionary |
| Limited in time and scope | Never-ending |
| Unique | Repetitive |
| Resources transient | Resources stable |
| Goal-oriented management | Role-oriented management |
| Transient | Stable |
| Attempt to balance performance, time and budget | Performance, time and budget usually fixed and balanced |
| Need to balance objectives | Management generally in state of equilibrium |
| More exciting (perhaps!) | Steady as she goes' feel |

> You may have listed other aspects.

## 1.2 Organisations and 'players in the game'

Projects take place within organisations whose structures, philosophies and cultures affect how work is planned and carried out. A detailed study of organisational behaviour is beyond the scope of this course, but you need to be aware that projects take place within a social environment consisting of people who are affected by, and have an influence on, the outcome of projects (see, for example, Boddy, 2002).

## Organisational structures

Business and other organisations in the west or based on western models are normally structured as hierarchies using vertical lines of reporting. A person, usually called the managing director or chief executive officer, occupies the pinnacle of this hierarchy, takes advice from a board of directors on the strategic goals or objectives of the business and seeks the agreement of the board for strategic, controversial or difficult decisions. Below the managing director, the organisation may be divided into functional areas: marketing, product design and engineering, manufacturing, sales, finance and human resources (also known as personnel). Some large organisations may divide themselves at this level by general groups of products. A large firm engaged in oil exploration might be divided along the lines of exploration, instrumentation, information systems and so on.

Small groups of people can operate with very little formal structure to get their work done. Indeed, members of project teams are expected to be able to take up more than one role; the project manager may also be the chief engineer, for example. As part of their day-to-day job (non-project work), it is commonplace to establish functional areas which often reflect specialist groups:

- marketing
- product design and engineering
- manufacturing
- sales
- purchasing
- information systems
- finance
- human resources

Many large organisations, such as those that manufacture electrical goods, may also divide into groups to reflect the different classes of product. For example, the division responsible for washing machines and the one responsible for televisions will have their own, separate functional areas. A project to develop a new product may, for example, involve the marketing, information systems, product design and engineering and manufacturing areas of a company. The loyalties of people working in hierarchical organisations tend to follow lines of vertical reporting and conflicts might arise as a result of horizontal links within the project, as the different areas may have different objectives and cultures. Forming a team to work on a project is seen as beneficial. Such a grouping brings diverse knowledge, assumptions, ideas and skills to bear upon the project's goal.

But the tension across the various linkages within the team can have a detrimental effect on the outcome of a project unless care is taken to ensure otherwise.

# 'Players in the game'

All the various 'players' in the project 'game', who may only be involved peripherally, are important. It is important to be aware of who they are and what role they play in the project environment, especially their different attitudes towards the project. A **stakeholder** is any person or group of people who has an interest in a project, is affected by it or who can influence its outcome. Stakeholders include:

- all the people whose work is changed in any way by the project
- those who are affected by it
- those who grant resources to the project
- those who can obstruct, block or stall the work in any way.

It should be noted that stakeholders' influence on an outcome may vary at different points in the life of a project. Learning who these people are and understanding their motives is an important aspect of organisational behaviour (McShane and Von Glinow, 2004). Identifying these people during project conception provides the foundation for achieving a successful outcome. Some of the key stakeholders who are most likely to be identified as a project is initiated are described in Table 1.

## Table 1 Key stakeholders

| Stakeholder | Description |
| --- | --- |
| **Sponsor** | The sponsor is the person or body of individuals for whom the project is undertaken. The sponsor is also seen as the primary risk taker owing to the responsibility to ensure that the project is successful in the eyes of the stakeholders. The sponsoring organisation provides the resources (such as money and people). |
| **Champion** | A champion is someone who acts as an advocate for a proposal or project; someone who has the ear of the people in power and who promotes the cause of the proposal or project. It's not always the person who has the bright idea about some new product or service; it tends to be someone who has some genuine influence in the organisation when it comes to bringing about change. So, the champion will provide support in times of difficulty (see Boddy and Buchanan 1992, p. 26), but it is a different role from that of the sponsor (Morris, 1994). |
| **Client** | The client is a person (or organisation) in the position of requesting or commissioning the services of some other organisation or person – some form of payment is involved. There may be a formal contract so that a sense of ownership takes on a legal meaning. Within the same organisation, there are informal contracts between departments or functional groups (forming client–supplier relationships). |
| **Customer** | The common understanding of a customer is the one who buys, which is a similar term to client. For example, an organisation's marketing department might be the client who instigates the development of a new product for which we (the public) are its customers. |
| **Owner** | The term can be taken to mean something similar to client or customer, though in a legal sense it is much more narrowly defined, Boddy and Buchanan (1992) use the term *owner* more in the sense of one with an attitude of strong attachment to the aims of a project. |

| Blockers or objectors | People or bodies that will resist the project. |
|---|---|

In practice, *client* and *customer* are terms that give rise to some confusion. They can be used synonymously or be kept apart depending upon the context. The distinction, for example, is commonly made in the following contexts:

● a lawyer has clients for his services

● shops have customers for the products on the shelves.

This is a particular problem for English speakers, although less so for Dutch or French speakers as they have only one word: 'klant' or 'client', respectively. We should note that the resolution of confusing terms and ambiguities is an important factor in project definition. It's a consequence of the relationship between language and the context in which it is used. The confusion can be compounded in organisations where, for example, you are considered a client up to the point at which some money changes hands and referred to as a customer thereafter.

Subsequently, other equally important types of stakeholder will emerge. In the field of software development, for example, there are two vital 'players in the game'.

## Table 2 Additional stakeholders in a software development project

| Stakeholder | Description |
|---|---|
| End users | The people who will ultimately operate (or make use of) the product. If the product does not help the users do their work, it will not be successful. |
| Developer | A person who is part of the team that builds the product. |

A surprisingly large number of people can be involved in one way or another with projects. They are all important to some degree, which is why they are stakeholders. It may not be possible to meet every stakeholder during a project's lifetime, but it is important to be aware of their existence and potential influence. The statutory and regulatory bodies are to be found on most lists of project stakeholders, since they can affect both the product and the manner of its development. In the pharmaceutical industry, for example, the development of new drugs is constrained by regulatory requirements related to the licences needed to sell the new product. In the construction industry, a particular project can be affected by changes in the health and safety regulations during its lifetime.

Some people can take on a variety of stakeholder roles and change between them as the project unfolds. The politics of organisations are such that you will find people swapping roles not only because of their team membership but also because of their wish to affect the outcome – either favourably or adversely.

## Example 1

At a distance learning institution, such as The Open University, the geographical dispersion of both students and their tutors has to be addressed in order for the tutors to be able to assess their students' progress on a given course of study. The UK postal service became the key component of the solution that enabled The Open University to deal with large numbers of assignments. At regular intervals during the presentation of a course, students are required to submit their assignments to their tutor through the postal service. After marking a set of assignments, each tutor sends them to The Open University's Milton Keynes campus, where the marks for each student assignment are recorded before the assignments are returned to the students – again by post. There is a

dedicated Assignment Handling Office as well as a separate Student Records Office on the University campus.

The early prototype for a computer-based service for submitting, marking and handling assignments originated from a group of academics in the Faculty of Mathematics and Computing. The eventual development of the electronic tutor-marked assignment (eTMA) system, which is in use at the time of writing this course, was performed by members of The Open University's Management Services Division.

From the information in Example 1, some of the stakeholders in the project for the electronic assignment system can be readily identified, but others are less easily found. For example, you might think that someone in a position of authority inside the Management Services Division would be the project sponsor. However, in organisations where people are grouped according to certain special skills like 'software developer' and 'computing academic', the role of sponsor may be hard to identify. In fact, the sponsor was the Head of the Assignment Handling Office, although the term sponsor was not used. While there was a group of academics who developed a specific method of electronic assignment handling, they would not have been seen as project champions unless they were able to exert some influence on the decision to go ahead with the project. The Assignment Handling Office seems to be the client for the new system.

One of the reasons for introducing the eTMA system was to provide students with a more efficient service, although it was seen originally as giving students a choice of submission systems. Had the intention been to completely replace the postal system with the new electronic system, there might have been some hostile stakeholders inside the Assignment Handling Office anxious about their future role at the University.

# 1.3 The project environment: strategic planning

Projects have to be planned. Indeed, an organisation must plan to have projects. By **planning** we mean the process of formulating an organised method of achieving something which is to be done (such as a project) or of proceeding. Projects do not take place in isolation: they have an environment which gives birth to them and with which they interact for the rest of their lives.

# The environment of the organisation

An early step in planning is the gathering of information about the environment in which an organisation operates – the market, the economy, the technology and the legislative and regulatory climate. Knowing the market implies understanding the *present* market an organisation and its products have, and *forecasting* markets for new or revised products and services.

# The mission

A common starting point for strategic planning is for a group of people to prepare a **mission statement** for itself. The mission statement should be a brief description of what the group (which could be the entire organisation or some part of it) believes it has been organised to do. Ideally, a single sentence should encapsulate what the group believes it exists to do. Certainly it should be no more than a short paragraph. Longer statements

tend to become confused and confusing, too long to read and too long to remember. It should be succinct enough to be recalled readily, and compatible with the activities the group is actually doing or is contemplating doing. You may be familiar with the following mission statement:

> The Open University is open to people, places, methods and ideas. It promotes educational opportunity and social justice by providing high-quality university education to all who wish to realise their ambitions and fulfil their potential.
>
> Through academic research, pedagogic innovation and collaborative partnership, it seeks to be a world leader in the design, content and delivery of supported open and distance learning.

There is some feeling that mission statements are influenced by fashion and of little value. This may be because many published mission statements in the past have sounded too much like public relations exercises with no substance behind them or were long and complicated. However, if they are properly written in the right spirit, they have genuine value, focusing attention on what an organisation thinks it is or ought to be doing. The good mission statement creates boundaries within which objectives can be set. For example, if it were suggested that The Open University might undertake the manufacture of computers for students and others in order to increase its income, it should be immediately obvious that this activity would fall well outside the boundaries set by its mission statement. This should signal that the proposed objective is beyond the organisation's likely available expertise, experience and infrastructure. To attempt to meet such an objective would require major organisational change.

A mission statement is effective when it encapsulates the core values of an organisation concisely and clearly, allowing immediate comparison with any suggestions for activities. But more than a mission statement is required in order to identify what the objectives of the organisation are.

# Change from above

**Strategic planning** sets the direction and route for an organisation at a macro level. Within business organisations it is the normal function of a board of directors to formulate the strategic plans. They will do this at least to maintain the organisation's place in the market and to meet the requirements of their customers, and will also consider strategic plans in the search for new growth and new business. In other types of organisation, such as campaigning groups or charitable organisations or government, a comparable responsible body will exist: in the case of charities and campaigning groups, there are normally boards of trustees. These bodies formulate strategic plans for their organisation in response to changes in their environments or changes in legislation. The result of this activity is, in the end, projects because projects are one of the major ways in which an organisation can effect change. The role of a project is to move from a starting place to an end point which corresponds to a particular goal that has been taken from the strategic plans of the organisation.

# Change from below and from outside

Change can also be prompted from within the organisation. A bright idea from a member of staff that appears to offer the organisation something valuable (more diversity, new

income, improved ability to survive, a need among customers or users hitherto unperceived, improved quality of product or service) can develop into a project to realise that idea.

### Example 2

A worker at a catering firm noticed that there was no place to obtain lunch on the large industrial estate where the firm was located. He realised that many workers on the estate were having either to bring packed lunches or to travel some distance to eat. He suggested to his management that the catering firm could open a small restaurant with a takeaway food bar in a little used area of their premises and thereby increase their business. The resulting restaurant drew on existing space, expertise and staff, and brought in new income, which was particularly useful because all the trade was in **cash** and this improved **cash flow**, which in turn helped improve the firm's ability to survive.

Planning activities for some types of organisation will involve a simultaneous flow of ideas from the top down and from the bottom up to generate ideas which can become organisational objectives for change.

Change often comes from outside the organisation: responses to changes in legislation might be required, work may be needed to meet a new standard, or a potential customer may approach a firm with an idea that will require change.

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### SAQ 2

In the example above the worker was employed by a *catering* firm. What is the significance of this in the context of the preceding discussion?

#### Answer

It is more likely that such a suggestion will fit with the *mission* of a catering firm but not with the mission of other types of organisation.

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# Strategic planning

The ways in which strategic planning takes place in an organisation are as varied as the organisations themselves. Planning may be conducted autocratically, through orders from the board of directors; it may be conducted consensually by wide consultation and discussion throughout an organisation; it may be proactive or reactive; it may be a mixture of these things – real life, including that encompassed by planning in organisations, is less well defined, less clear-cut and much messier than descriptions of it would lead one to believe.

In what follows we suggest some ways of planning and some tools for doing so. Our descriptions are not exhaustive. They suggest ways of proceeding which are not the only ways and which will not fit easily into all organisational cultures. We hope that what we suggest provides an orderly way to progress from an organisation's present situation towards a future that is more the result of planning than of whim or chance. What we suggest is also a process that can be carried out in top-down fashion, starting with the highest levels of an organisation and moving downwards through divisions, groups and even to the team level.

The decision making involved in strategic planning is not trivial: there are a number of tools available to help the organisation to come to an informed decision about change. Once the questions shown in Figure 1 have been explored and their outcomes drawn up at the level of the whole organisation, they are passed downwards: a strategic plan at organisational level becomes an objective at the divisional level. The division then asks the questions in the figure again, develops the outcomes and passes the results downwards. This way of planning can also work where there is no 'downwards' – for example in a cooperative where groups within the organisation may use these tools and then negotiate with other peer groups.
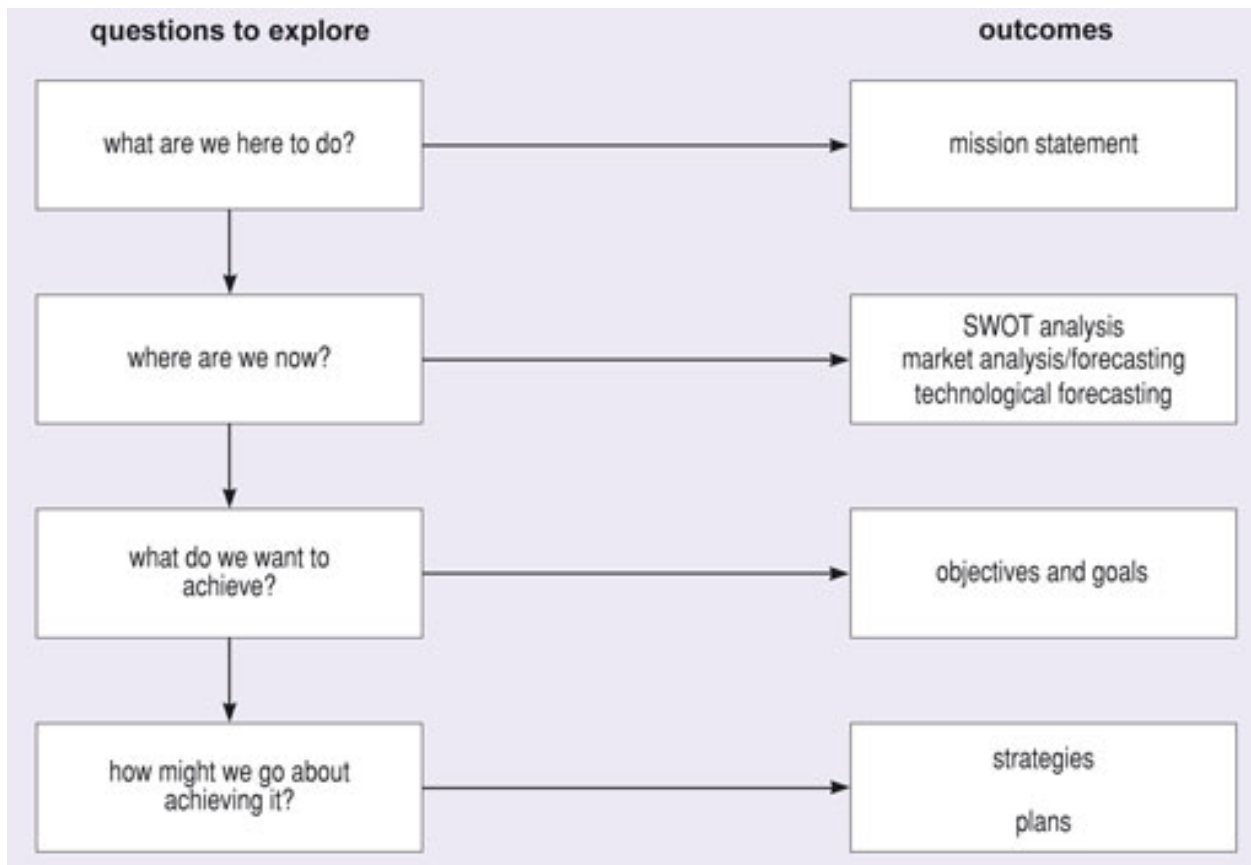


Figure 1 Strategic planning questions and their outcomes

## Strengths, weaknesses, opportunities, threats

One of the commonest analytical tools is **SWOT** analysis (SWOT is an acronym for strengths, weaknesses, opportunities, threats). This form of analysis provides a structure for studying both the internal and the external environments of an organisation. The organisation's strengths, weaknesses, opportunities and threats will be documented, investigated and discussed. The strengths and weaknesses generally arise in an organisation's internal environment (present products or projects, customers, staff, morale, information flows) and the opportunities and threats arise in the organisation's external environment (competition, economic climate, potential market, legislation). There are commonly used acronyms to help categorise these external factors. PESTLE stands for political, economic, social, technological, legal and environmental. STEEP is a rearranged form, which includes legal factors under political, and a shortened form is

known as PEST (or STEP), which stands for political, environmental, social and technological. PESTLE is probably the most useful (see, for example, Harpham, 2000).

Example 3 shows the results of SWOT analysis that might be done by a company that makes computing equipment for industrial use.

## Example 3

Strengths

1    Our company has an established customer base and a growing reputation.

2    Our business is currently economically viable and profitable.

3    We now have an established group of salespeople, committed to our products and experienced with the products and with selling them.

4    Our new wireless data collector, soon to be released on the market, is in an exciting area.

Weaknesses

1    Income is still too low to enable research and development into new areas related to our business.

2    The products to date have been marketed solely for industrial needs and we have not explored other potential markets.

3    Some products have low sales.

4    The process of developing new products or improving existing products is lengthy, and we do not respond to customer requests quickly enough at present.

5    Some products are now dated.

6    Our unrelated product lines hinder sales.

7    It is difficult to recruit industrial design personnel with appropriate skills and knowledge of our specialised needs.

Opportunities

1    Significant numbers of our products have a commercial market as well as an industrial market.

2    There are new areas related to our present product lines, ripe for exploration and development.

3    There is customer interest in products related to our present lines but which we do not currently produce.

Threats

1    Competitors might copy and modify our designs to produce an improved or cheaper product.

2    We may face legal action due to the operational safety of some of our products.

3    Our products are sold all over the world. So, we may be exposed to the politics in different countries.

Such an analysis can be made, not only for a whole organisation, but for any part of an organisation. A group concerned with a single product can, for example, carry out a SWOT analysis on that product and the way it is produced and marketed. One of the

problems of a SWOT analysis is that it can be very subjective. For example, two people in the same company are not likely to produce the same internal and external factors (unless, of course, they get together and negotiate). So, you do have to be realistic about any analysis, which is, after all, just the first step in making a plan for action. A SWOT analysis is best carried out by a team of people who will tend to provide a more balanced view than an individual.

Having studied such analyses a board of directors or trustees may use them to decide how to emphasise or build on an organisation's strengths, address its weaknesses, take advantage of its opportunities and avoid or reduce its threats. A project or projects (in the form of a programme or a portfolio) may then arise as a result. Although the need for the organisation to undertake a project will normally be formulated by senior management or a customer, the project itself is, as yet, unborn. There may just be an uneasy thought by someone in senior management that all is not well or that something is needed.

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### Activity 2

Carry out a brief SWOT analysis for the group or department where you work, or for a group, such as a club or affinity group, to which you belong. Try to list at least three factors in each category.

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## 1.4 Two investigative tools

Some objectives will necessarily be concerned with improving an existing situation, procedure, process or product in order to address a weakness; in other words, they will be concerned with reducing or eliminating problems. In order to do so effectively, the problem has to be investigated thoroughly to determine whether or not the problem is serious and whether it is worth tackling. There are two commonly used tools for this purpose, **Pareto analysis** and **cause and effect** diagrams.

## Pareto analysis

An Italian economist, Vilfredo Pareto, is credited with the development of this technique, which relies on an almost universal truism concerning the relationship between *value* and *quantity*. There are countless everyday examples: in a warehouse 20% of items will usually represent 80% of total stock value; 80% of quality problems will be accounted for by 20% of the possible causes of failure. The ratio of 20:80 occurs so often that many people think of this ratio as Pareto's law.

For example, in a computer system there will be frequent but minor failures in disk accesses: these failures are normally overcome simply by retrying the access. Far more rarely, a disk's read head will touch the delicate magnetic surface, and then the disk is effectively destroyed and access is impossible under any circumstances. The former occurs frequently but with little impact, the latter rarely but with great impact. Pareto analysis consists of drawing columns that represent the magnitude of a problem, or of each aspect of a large problem. These columns are then arranged in order of magnitude, starting with the largest. (The column height represents the value of correcting the problem, so columns of the same size may refer to small but frequently occurring difficulties *or* to major difficulties that occur less often.)
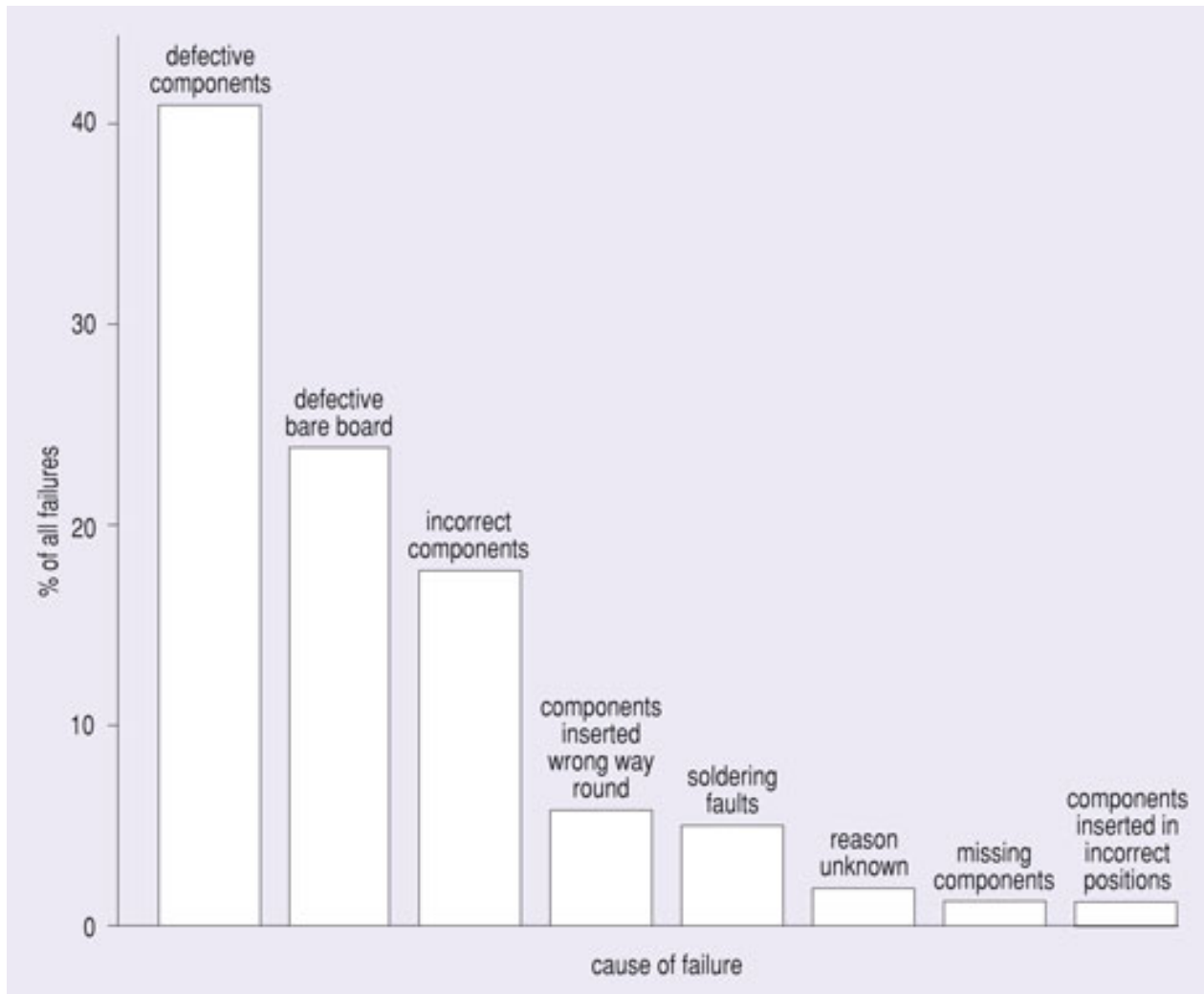
Figure 2 Pareto analysis of printed circuit board failures

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SAQ 3

Assume that following an examination of the production records for widgets you find the following: of a weekly production of 100 000 widgets worth £10 each, quality control staff remove 5 due to unacceptable burring remaining on the metal, 200 because they are unbalanced (out of round) and 50 to be repolished as the polishing is not good enough. Customers in the same week returned a shipment of 500 because they arrived scratched and gouged and so were unusable, and a shipment of 350 because the size despatched was not the size ordered. (Both returned shipments incurred additional shipping charges, but for this question you should focus only on the values of the shipments.) Either draw columns or use the figures given here to undertake a Pareto analysis.

(a) Place these categories of faulty widgets in order from most to least value.

(b) Where does the analysis suggest you could achieve the greatest improvement in quality?

---

Answer

(a) In Figure S.1 we have drawn columns showing the cost of each category of fault and the percentage of total production that this represents, but this problem is simple enough for you to be able to manipulate the figures directly. The order is:

500 scratched and gouged

350 incorrect size despatched

200 out of round

50 substandard polishing

5 burring.

(b) The analysis suggests that the greatest value improvement can be obtained by addressing the scratching and gouging problem, and then by correcting problems in the despatch of orders.

In reality the Pareto analysis may produce different results as other factors are certain to have an effect. Rectifying the problem of the incorrect size of widget will probably entail only the cost of taking the 350 wrong ones back into stock and despatching the right ones. The 200 widgets that were out of round will have to be scrapped and replaced by new ones at twice the cost of the faulty 200.
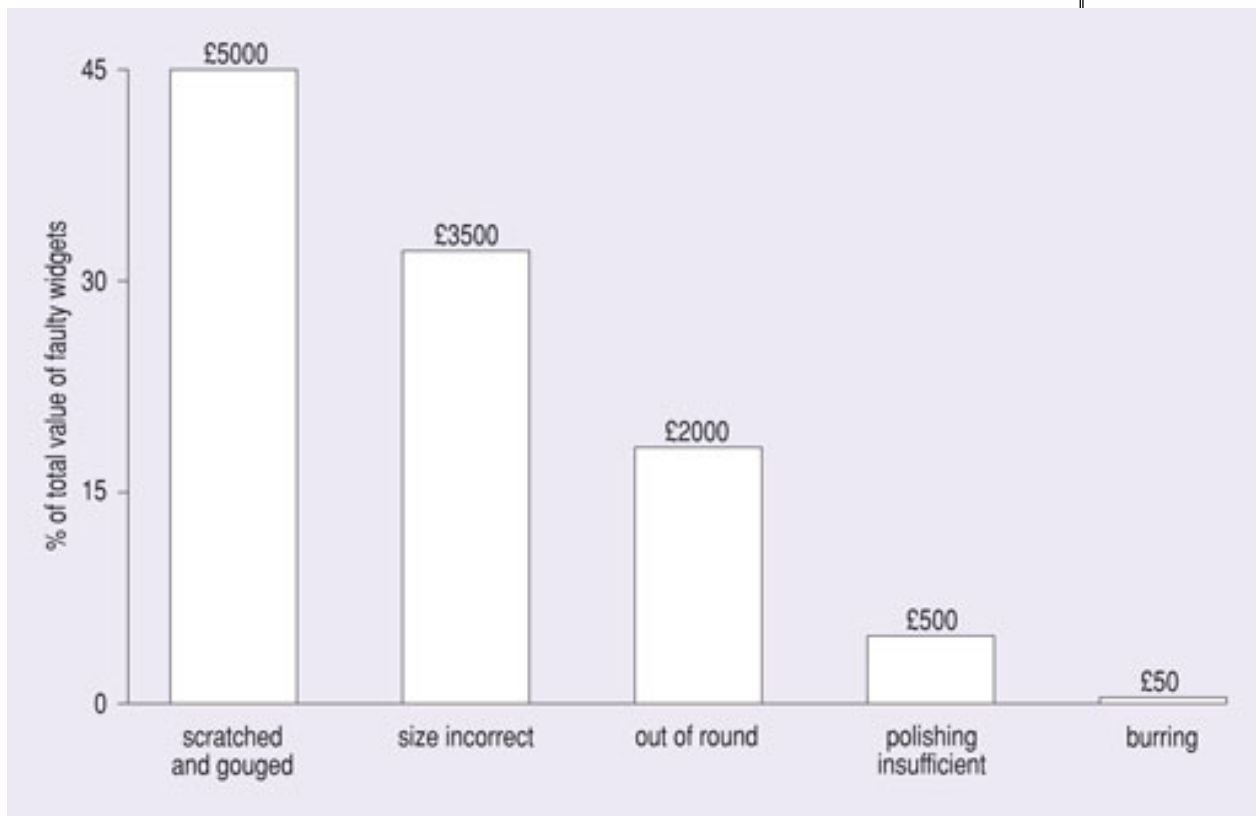


Figure S.1 Pareto analysis of widget problems

Having identified which problems might merit further investigation, the next stage is to study the symptoms of the problems, develop theories of the causes of those symptoms and then carry out further analysis and experimentation to establish true causes. A technique which is likely to be useful here is cause and effect diagramming.

# Cause and effect diagrams

Cause and effect diagrams are often known as **Ishikawa** or **fishbone diagrams**. Their origin lies in the investigation of sources of variation in production processes. The resulting diagram is a way of identifying, sorting and then displaying the possible causes of a specific problem or quality characteristic. So, you will be able to illustrate the relationship between a specific outcome and all the factors that influence it. The diagram can then be used to identify areas where data should be collected for further study.

The first step involves the definition of an occurrence (an effect). The next step is to identify those factors which contribute to it (the causes) and then examine them in order to determine the root causes of the effect, because they are the ones that must be tackled. In practice, this is achieved by establishing the categories under which the causes will be listed. There are four commonly used categories:

- methods, machinery, materials and people, or
- policies, procedures, people and plant.

Sometimes a fifth category, environment, is needed. An example is shown in Figure 3. Note that major causes are connected directly to the main arrow, sub-causes (such as under-inflated tyres in the figure) are connected to these lines, and sub-sub-causes (such as no record of tyre pressure) are connected to these. This establishes a chain of major and minor causes within each of the categories.
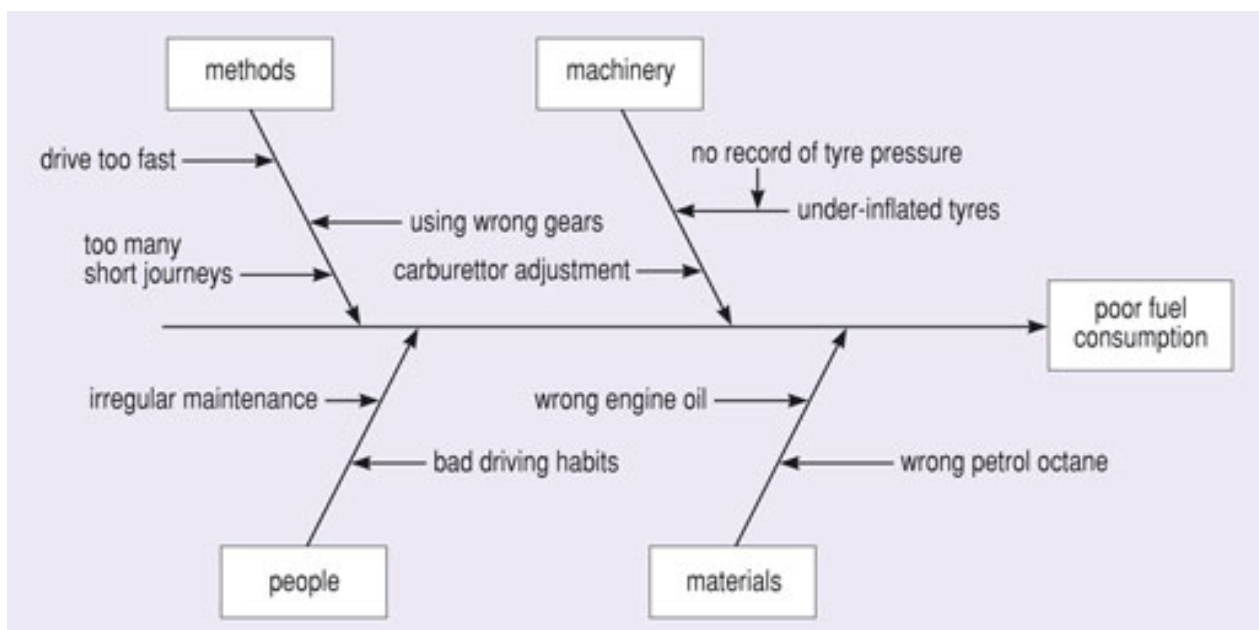


Figure 3 A cause and effect diagram for determining the causes of poor fuel consumption for a petrol-driven car

### Activity 3

While you do not have enough information to draw a complete cause and effect diagram for the fuel consumption problem, you should be able to formulate questions that will reveal more detail so that you can identify a cause that you can take more action on. Give an example related to the contributing causes of irregular maintenance.

Discussion

When we think about cause and effect, it is common to consider the reasons for things. So, we want to explore the reasoning that leads to evaluations at increasing levels of detail. The simplest way to do this is to ask a series of questions such as: why was maintenance so irregular?

One response might be that the driver was not aware of the frequency with which the car had to be serviced. Another driver might know when to have the maintenance done, but not always have the money to pay for the work.

As the analysis proceeds, it should help you identify those causes that warrant further investigation. The overall balance of the diagram can be informative. For example, areas where the diagram is getting busy in terms of the number of items and level of detail may indicate a need for further investigation. Those causes that seem to be repeated in more than one branch may be the root causes that you should be acting upon. Assess each cause for what might be measured so that it is possible to quantify the effects of the changes made within a project.

Having determined the source of a problem and the value that would accrue to the organisation if it could be eliminated or at least greatly reduced, the resulting objective should become clear, and possibly so should some strategies to achieve the objective.

# 1.5 Organisational objectives

Objectives are those things the organisation wants to achieve, the 'whats' of the organisation. A typical top-level objective in a profit-oriented organisation might be to increase profit. In a producer cooperative a top-level objective might *be to improve the standard of living among our members and their families*. In a campaigning organisation with a 'green' outlook a high-level objective might be *to encourage* the public to reduce their dependence on the private motor car.

Activity 4

Think of a group of which you are a member; it could be any group such as a group where you work, your family or a club. Write down three to five high-level objectives you think such a group would have.

Discussion

For a family group, three high-level objectives might be:

- to provide financial security for each family member
- to provide an environment of peace and safety, away from the world at large
- to provide a sound educational and social upbringing for any children.

Notice that all the objectives mentioned so far contain verbs such as *to improve, to encourage* and to *provide*. This is because objectives imply that action is required in order to achieve a **goal**. A goal might be 'a happy family life', but the members will need to take action to provide the financial security, the peaceful, safe environment and the sound upbringing of any children. Goals mark the general outcome of some effort or express the

desired state that you would like to achieve. In contrast, objectives are often required to be SMART:

- *Specific*: be precise about what you want to achieve.
- *Measurable*: quantify your objectives.
- *Achievable*: are you attempting too much?
- *Realistic*: do you have the resources to reach the objective?
- *Timed*: state when you will achieve the objective.

For example, an internet-based mail order company might instigate a project with an objective to reduce delivery costs by 12 per cent by the end of the current financial year.

# Identifying objectives

As we have mentioned earlier, it is usually the function of the board of directors or a similar stakeholder grouping to determine what the high-level objectives should be. There are a number of techniques for achieving this, which we illustrate below. In practice, there is a balance to be struck in order to achieve a set of objectives. For example, how much should be done individually or collectively? There will also be a variety of factors affecting the dynamics of achieving a result such as the tendency to value consensus at the price of the quality of a decision or to make more extreme decisions as a group than as individuals working alone (see, for example, McShane and Von Glinow, 2004, pp. 307–9).

# Brainstorming

*Brainstorming* is one of the most popular techniques for generating a large number of ideas for the solution to a problem. The technique, which originated in the advertising industry in the 1930s, has three phases. In the first phase, participants, ideally a close-knit group of five or six people working in a private area and without interruptions or interference, call out ideas (usually in response to a question that identifies the problem). A facilitator or compère, who encourages participation and discourages criticism at this stage, writes the ideas on a black-or whiteboard, on a flipchart, on notes stuck to a bulletin board, or any combination of these, where every participant can see them all. When the pace of the interaction among the participants begins to falter or when the participants agree to stop presenting ideas, the group can move to the second phase, where they discuss the products of the first phase and can reject (possibly with reference to the mission statement) or keep individual ideas. Those which are kept can then be criticised constructively and roughly ranked in order of importance, interest or feasibility. A suitable form of criticism is to ask whether an idea can be developed in some way to make it more usable. The process may be repeated, which may involve rejecting some of the ideas kept in the first round of this phase. In the final phase the participants seek consensus on a form of ranking and use this to develop a ranked set of objectives.

Part of the preparation for a brainstorming session is to have a clear definition of the problem you want to solve and, if possible, identify any criteria that have to be met. The facilitator can use that definition to keep the group focused, especially when a particular train of thought takes the group away from the problem.

It is possible to brainstorm by yourself. While you can generate lots of ideas, it is not the same as working in a group. Working in a group is useful when individuals reach their limit on an idea. Another member of the group, with a different background and experiences,

will often pick up the idea and take it forward. You need to remember that brainstorming is a lateral thinking activity that encourages you into new ways of looking at the problem. You are trying to open up possibilities and challenge assumptions.

The leader of a brainstorming session should encourage all of the members of the group, especially the quieter ones, to contribute. By relaxing the normal rules of work, the group has freedom to explore those wild and wacky ideas as well as the solid and practical ones. You can have fun, but the creative atmosphere can be stifled when ideas are criticised.

One of the problems of brainstorming with a group of people in a room is not getting all the ideas down on paper. When a group is very lively there is a chance that one voice might not be heard. So, some organisations try electronic forms of brainstorming such as email. The facilitator begins the process by posing a question. Each participant is then able to record their ideas as soon as they occur, which can lead to a greater number of ideas in comparison with brainstorming with a group in a single location. There are also dedicated software applications that let all the participants share ideas anonymously, which is a benefit for those who may be reluctant to contribute in a group environment. In contrast, some participants may feel threatened by some of the statements generated through the anonymity of individual contributions. So, the participants' contributions may need to be moderated to guard against flaming and any other overt attempts to gain undue power and influence over the group.

In a conventional face-to-face session where all the participants are in the same place for a finite period of time, other things can be used to stimulate the discussion. For example, experts from a completely different domain may be brought in to demonstrate their products or ways of working. Because of the dislocation in time and place, electronic brainstorming requires more coordination and needs some planning to introduce extra examples and activities. There are some tricks that work in either environment when the ideas generation gets stuck. For example, you can consider how to prevent something from happening and reverse the ideas – sometimes called *negative brainstorming*, which follows the maxim:

> In every opportunity there is a threat. In every threat there is an opportunity.

## Nominal group technique

Another technique for obtaining objectives is the *nominal group technique*, developed by Delbecq et al. (1986). Once the problem is defined, the members of the group independently and silently write down as many ideas as possible over a set period of time (typically an hour or so). Then the group comes together in order to discuss the ideas. As with brainstorming, criticism and debate are discouraged although members can ask for clarification of ideas. In the next stage, members record their votes on the ideas in order to achieve a rank ordering or rating. Thus it is similar to but not as freewheeling as brainstorming. Its higher degree of structure is thought to maintain a higher task orientation and reduce the potential for conflict in comparison with brainstorming. However, the reduced social interaction in a nominal group can be a problem when the members are expected to produce more creative ideas.

# Affinity diagrams

Both brainstorming and the nominal group technique result in a ranked list of objectives. The group can then classify their organisational objectives using *affinity diagrams* – drawing connecting lines between different objectives that are related in some way. A thick line can be used to indicate a strong affinity, and a thin line a weaker affinity. This helps to group related objectives together. Once these affinities have been identified, objectives can be classified under descriptive headings. An example of headings under which objectives were classified by an organisation devoted to promoting quality assurance and management techniques is:

- to increase the effectiveness of the service provided
- to increase customer satisfaction
- to increase profitability
- to increase job satisfaction
- to build a strong, global organisation.

We are less interested in how these objectives are identified and codified within an organisation than in how these objectives, which describe what the organisation wants to do, are developed into proposals (and ultimately into project plans) which enable the organisation to achieve its objectives. From a quality point of view, we are also concerned with how the organisation and the people working within it can ensure their activities, including project activities, all work towards achieving their objectives.

# Towards project proposals

Objectives are what the organisation wants to achieve. The effort required to do so occurs within some period of planning: this year, over the next five years, over the next decade.

Turning objectives, the *whats* of an organisation, into plans, which are the highest-level *hows*, is the next task. We all have objectives we want to achieve. Say, for example, that we want to eat. We might plan how to achieve this objective by preparing a meal at home or going to a restaurant. Even this simple example shows us something important: *there is almost always more than one way to achieve an objective*. When there is more than one way to achieve an objective and more than one person or group involved, some degree of disagreement or conflict may arise. Someone who likes home-cooked food may well want to prepare a meal at home, but another person who is tired of eating the same sorts of food so frequently may want to visit a restaurant that serves exotic cuisine. Even one person can feel ambivalent about how an objective is to be accomplished: a tired mother may welcome a trip to a restaurant as a break from cooking, but may also dread having to deal with her small children in a public setting. These disagreements, conflicts and ambivalences can adversely affect the outcome of any decision. In organisations, they can cause a programme or project to stray from the spirit of the objectives it was designed to achieve and thereby can seriously compromise the quality of the result.

The use of organised brainstorming and group planning, particularly if widely practised in an organisation at all levels, will generally have two beneficial effects: people will feel that their attempts to contribute are welcomed and treated seriously; a good chance therefore exists that they will feel a measure of support for the outcome. People will be clearer about what the desired outcome is and how individuals and groups should work towards

achieving it. Both these factors are unquantifiable, but contribute to the achievement of quality.

# Matrix diagrams

The brainstorming technique together with an organising principle can be used to achieve the next level of planning within an organisation. This may still be a rather high and strategic level of planning, but the techniques described here can be repeated at lower levels where more detailed work is done to develop programme and, finally, project plans.

Identified objectives form the 'what' column in a matrix diagram, as shown in Figure 4. Scale ratings are given to indicate the importance of each objective based on an analysis of organisational requirements. A group (which may not be the same group that has identified the objectives) then brainstorms as described above, but the goal of this brainstorming session is to identify key strategies ('hows') to meet the already identified objectives. Strategies are then linked to objectives by placing them in the other dimension of the matrix diagram and indicating whether links are non-existent, weak, medium or strong.

| objectives | importance rating | identify and quantify costs | identify customer needs | undertake marketing research | study and improve quality assurance techniques used | identify and eliminate areas of wasted effort | reduce paperwork |
|---|---|---|---|---|---|---|---|
| reduce operating costs | 1 | strong link | | | weak link | medium link | medium link |
| provide better customer service | 2 | | strong link | | weak link | | medium link |
| increase marketability of systems | 3 | medium link | strong link | strong link | medium link | | |
| increase employee satisfaction | 4 | weak link | | | medium link | strong link | strong link |

weak link · medium link · strong link

Figure 4 A simple matrix diagram relating ranked objectives to strategies for achieving them

Reiterating this process can be used to identify lower-level objectives and lower-level strategies and finally tactics. Taking Figure 4 as a brief example, in the next iteration the strategy of identifying and quantifying costs can become an objective, and a group can brainstorm or otherwise identify strategies for doing so: for example, looking at past invoices for certain items, identifying cheaper sources, identifying handling costs for those items and so on. You might ask customers to participate in this process, perhaps through market research or by direct participation in identifying and ranking objectives.

A project manager may have no input at all at the strategic level. However, as the key strategies are identified and increasingly refined through iteration, strategies can turn into programmes of change, and the tactics of realising those strategies can become projects. A project, to give yet another definition, becomes a way of employing a strategy or strategies to achieve an objective or objectives. This process – identifying objectives,

refining and classifying them, rating them according to an agreed scale of importance, brainstorming key strategies and establishing the links between objectives and strategies – can also be used at the project level.

One clear advantage of carrying out planning in this top-down fashion is that it helps to keep people's minds focused on the mission and key objectives of the organisation as they resolve strategies into finer and finer detail. Suggestions for changes from lower down in the organisational hierarchy can be evaluated by a similar method: how well does this suggestion fit with the organisation's mission and objectives? This reduces the chances of creating projects that will not have, or may eventually lose, the support of higher management, or projects that diverge significantly from the main business of the organisation. Having a project mission statement and objectives that are clearly stated and understood by all the participants and management can be a major factor in the success of the project.

### Example 4

A successful project to develop a system to check whether telephone bills had been paid and, if not, to remind customers by telephone is described in Norris et al. (1993). The authors note that having a strongly stated project objective prevented effort on this project from going astray. At one point the project team was tempted to apply a great deal of expensive and difficult technology to the problem. By going back to the project's objective – to maximise the number of outstanding bills that get paid each month – the project team realised that the project was not about developing and implementing exciting new technology but about reminding people to pay bills. As a result, the final design was quite different from the initial thoughts of the project team. They avoided focusing on an isolated technical solution that was itself problematic and concentrated instead on the problem of reminding users who had not yet paid to do so. Norris et al. (p. 29) ask why the project went so well and answer their own question: 'The main thing was kept the main thing. The project team never lost sight of their objective. They could easily have been seduced by ''clever'' solutions – the use of [automatic] message senders, smart software to detect answer phones, and so on. They continually asked the question, ''Will this clear more unpaid accounts?'''.

## From objectives towards actions

We have not yet indicated where in this cycle objectives become actions and organisational plans turn into proposals for action. Drawing such a line is not so straightforward. However, as the process of identifying objectives and then determining the strategy or strategies to achieve those objectives continues, two things occur. One is that the ranking of objectives, combined with a notion of the strength of links between objectives and strategies, will gradually emerge as a set of priorities: objectives and strategies deemed the most effective to realise those objectives. As yet, no attempt has been made to determine the benefits of achieving a particular objective, nor whether a strategy is feasible and what it is likely to cost to effect that strategy. This is a necessary step before a project can be organised and authorised. It is a rare organisation that can afford to try all identified strategies to meet all of its objectives. That is why it is important to be able to rank objectives in importance and to identify those strategies which will be most effective at achieving the most important objectives.

The second thing that happens is that the proposals for action become increasingly detailed, and this enables a more accurate judgement to be made of their desirability, their

likely costs and likely benefits. Different proposals compete against each other for organisational attention, and it becomes clearer as these become more detailed which are likely to be more do-able and of greater benefit.

The process of determining benefit increasingly is one of determining the value a proposal has for the organisation. This also provides a measure by which one proposal can be compared with another when choices must be made. However, *value* in this sense is not simply a matter of cost to build or cost to buy. It is a complex process, called the **value process**, of assessing each aspect of a proposal over its lifetime. At this early stage in planning, before any investment is made, the process is called **value planning**. Later you will meet some methods for assessing the financial costs and benefits of proposals. These form a part of value planning provided such aspects as an assessment of running costs (energy, maintenance, repair and replacement) and, ultimately, decommissioning costs are included.

# Requirements

Generally speaking, a requirement identifies an expression of need, demand or obligation. An essential factor to ensure the quality of any project or any deliverable or product is to get the requirements for it right. If the requirements are not clearly and completely set out, any project or design based on them cannot succeed. Getting the requirements correctly defined during the initial phase of the project will minimise escalation of costs due to rework, client dissatisfaction and excessive changes during project execution and maintenance of the product afterwards.

Getting the requirements right involves the successful identification of:

- who is best placed to define the requirements
- what constitute acceptable and appropriate requirements
- what constitutes an acceptable demonstration that each element of those requirements has been achieved
- the resolution of technical, financial or organisational conflicts of interest that may appear in the requirements
- the agreement on and documentation of the requirements and demonstrations in the proposal.

### Example 5

A large computer system often requires a data communications network. The network consists of a number of separate components. It is exceedingly complex and the suitability of particular components cannot be judged solely on simple criteria such as their cost. Instead, they have to be judged on a number of complex and interlinked criteria: compatibility with all the other components used on several levels ranging from the mechanical and electrical to the use of different protocols; capacity, dependability, ease of installation and size; the financial soundness and reputation of the manufacturer (can the manufacturer deliver the products wanted on time, and will the manufacturer still be in business when it becomes necessary to expand the network and more components are needed?); maintainability (ease and cost); ability to allow interconnection to other networks; running and purchase costs; and so on. All of these will have some bearing on whether component A is more suitable than components B, C or D, which may appear to

do the same function and be cheaper to purchase. *Making the correct choice is an important quality issue*.

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**Requirements** are a statement of the need that a project has to satisfy (APM, 2006). Each one identifies what is expected of a product or project. Drawing up the statement of requirements is one of the earliest steps in planning. A requirement is different from a specification in that the requirement is the starting point of a development and is an expression of those aspects which will define the thing to be done and the product to be developed. Requirements should not be confused with **deliverables**, which are the end products of a project as well as the measurable results of certain intermediate activities. A specification is a statement of the characteristics of a deliverable, such as its size or performance standards. A requirement might be 'to be able to travel independently of the public transport system'. This could be met in a number of ways: by motor car, motor cycle or bicycle or on foot. A deliverable resulting from such a requirement would vary depending upon the stage of definition, but could be stated as: 'a super-mini car' or 'an 1100 cc petrol-powered motor car capable of carrying four passengers' or even one that specified in detail the length, width, height and colour.

It is only after much further work in feasibility studies and design, and often after prototypes have been built and tried, that a firm technical specification can be made.

A requirement must be *appropriate and well defined*. It is important to determine whether the proposed requirement is *appropriate* to real needs and expectations and to the value that the potential client will put on it. Then the client has to agree that the requirement is appropriate and meets his or her needs.

Even when a requirement is appropriate and well defined and everyone agrees on its meaning, if the parties have not agreed on how to demonstrate that a requirement has been met, the way is left open for the agreement concerning its meaning to break down over time. Setting out how it will be possible to demonstrate that a requirement has been met is therefore very important. This process is known as **acceptance testing**. The acceptance test criteria for each project deliverable need to be established at the same time as its specification. Desired characteristics are often set out in simple terms such as 'easy to use', 'safe', 'reliable' – but how will anyone know when 'safe' or 'reliable' have been achieved? It is best to avoid abstract or unquantified terms. One way is to state the required quality, say 'easy to use', and then list what factors contribute to this quality. For example, 'easy to use' can include:

- appropriate documentation written in plain English
- clues on the item itself which indicate how it should be used (for example, an item's shape could mean it will only fit with another item in one obvious way)
- displays on the item directing clearly how it is to be used
- parts ergonomically designed for typical users, remembering that many people are not 'typical' (they may, for example, be colour-blind or left-handed or of above average height or users of a wheelchair).

This is not an exhaustive list of ways in which the quality 'easy to use' can be refined, but you should see how important it is to define a quality in a concrete and measurable way. It will be necessary to look at these specifics at a later stage and turn them into demonstrations. For example, the first item on our list above is 'appropriate documentation'. Later on, we might want to specify that the demonstration of this is 'the existence of a user's manual which is complete, contains several useful and accurate worked examples and accurate and uncluttered illustrations'. Demonstrations must be

testable, so they are expected to include components that are measurable. In the case of a new manual for a road de-icing project, we might include: 'Operators shall be able to generate a de-icing schedule after one day's training'.

This is a testable statement because it is straightforward to see whether or not the operators are indeed able to generate a schedule after just one day's training (Robertson and Robertson, 2006).

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### Activity 5

Assume you are drawing up the requirements for a door. First, list two or three qualities that a door should exhibit, then refine these by listing two contributing factors for each quality.

#### Discussion

Three qualities that we could think of were: easy to use, draught-proof, attractive appearance. (You may have a different list.) The contributing factors we identified are shown in Table 3 (in some cases we have listed more than two).

**Table 3 Qualities and contributing factors**

| Quality | Contributing factors |
|---|---|
| Easy to use | Handle opens easily |
| | Door swings or slides out of the way with minimal effort |
| | Door is wide enough to permit easy passage |
| Draught-proof | Frame overlaps with door edges and fits well |
| | Seals used to improve draught-proofing |
| Attractive appearance | Smooth surface |
| | Pleasing proportions |
| | Attractive hardware used |

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We have not said anything about demonstrations here, but it would be possible at this early stage to set some additional qualities and contributing factors, such as extending the quality 'easy to use' by specifying that 'the door must be usable by wheelchair users, people with Zimmer frames or pushchairs or with their arms full'. This would have a bearing on the door being wide enough, needing only minimal effort to open and close it, and the handle being easy to reach.

Requirements will affect the cost of any item and any project, and yet cost is only one criterion and may not be the most important. Other aspects may be vital to the success of the project.

### Example 6

The design team for an early space satellite did not communicate to the purchasing manager the fact that all electronic parts needed to be 'high reliability' – able to perform after having been subjected to the pressures and vibrations of a launch, under conditions of near vacuum and alternating very low and very high temperatures. The purchasing manager proceeded to acquire electronic parts on the basis of price alone. High-reliability electronics are, of course, far more expensive than their ordinary counterparts. One of the

key electronic components of the satellite failed to survive the launch because it was of the ordinary type.

## Next step: feasibility

Once you have identified and ranked objectives and strategies at the organisational level and analysed major problems and their causes, made decisions about which to pursue further and set out your requirements and specifications, the next step is to identify those potential strategies which should be surveyed to see how feasible (how profitably do-able) they are. This stage is referred to as a **feasibility study** and places an emphasis on both technical and financial aspects. Feasibility studies may be undertaken for one or more potential strategies and the results of these studies may be used to decide which proposals to pursue.

## 1.6 Summary

This section has set the scene for projects by describing organisations and the players – sponsor, champion, client, customer, owner and other stakeholders. It showed how organisations can go about identifying their mission and objectives, how those objectives and the strategies to achieve them can be explored and refined in a structured way, how problems can be analysed and then, broadly, how the feasibility of various possible actions can be determined. It is then up to management to decide which actions to pursue.

Having studied this section, you should be able to:

- define, in your own words, what a project is
- name and define the chief roles various people can assume in respect to proposals and projects
- explain the purpose of a mission statement
- define and carry out a simple SWOT analysis
- explain and carry out a Pareto analysis of a problem
- explain the role of cause and effect diagrams
- generate simple matrix diagrams to relate objectives to strategies
- relate all of these tools to the process of organisational planning
- explain how quality is improved when a structured approach to planning is used, ensuring that mission, objectives and strategies are clearly identified
- set acceptable requirements for proposed projects.

## 2 Feasibility

Undertaking a full assessment of whether a proposal is feasible or not is a substantial piece of work and may even become a project in its own right. In the early days, a project manager may be involved but sometimes is not. However, it is important for any project manager to understand the processes by which proposals are evaluated and assessed.

At this point, let us assume that we have a project proposal, or quite probably several proposals, to consider. We need to decide next whether any of them are worth pursuing further. We need to assess their feasibility.

In what follows, we do not expect you to learn all the details or memorise all the terms, particularly those associated with cost–benefit analyses and accounting. However, you will find it beneficial as a practising project manager to be able to read proposals with a critical eye. Have we reached agreement on the statement of requirements? How complete is the specification? How sound is the method used to calculate profitability? How good is the assessment of the technical and technological factors? Have social, political and environmental factors been considered adequately?

As you study this section, bear in mind that your aim should be to develop your critical faculties for when you assess proposals.

# Learning outcomes

At the end of Section 2, you should be able to:

* describe the elements of a feasibility study
* state the general aims of a functional specification
* describe what a scenario is and generate some simple scenarios in response to a statement of a problem
* assess the maturity of a technology
* use tools for the development or assessment of a proposal
* understand the uses and limitations of payback, rate of return and discounted cash flow methods
* understand the importance of risk.

# 2.1 The feasibility study

A team should be designated to undertake a feasibility study for any proposal that appears to be worth accepting. This study should attempt to generate scenarios which are potentially acceptable solutions. The resulting scenarios – different versions of what might be done – and all objectives that are to be addressed by the study should be used to prepare a functional specification that identifies *what has to be done and what constraints apply to doing it.* It ensures that there is *at least one satisfactory way* of doing it, but it does not specify how the objective is to be achieved. That step occurs as part of the project planning, if the proposal is accepted and authorised by management. A functional specification is related to a business case since it is a refinement of a proposal's scope, objectives and financial and time constraints, and addresses the questions of technical and economic feasibility.

Assessing the feasibility of a proposed scenario requires an understanding of the political, economic, social, technological, legal and environmental (PESTLE) factors involved. Note that the financial and technical aspects – the 'hard', quantifiable aspects – are only part of the problem to be analysed. The other factors are 'soft'. The soft systems methodology (SSM) is an approach that deals with information beyond the 'hard' information of quantities and facts. Checkland (1981) defined the SSM after research into the Concorde project, which led to the development of a supersonic passenger aircraft. The SSM can be

used early in a study to identify the interactions that need to be considered in any assessment. It is particularly useful for identifying those aspects of any problem or proposal that fall outside normal operations research and 'engineering' concerns with function, construction and operation (see, for example, Checkland and Scholes, 1990). A particular technique employed by the SSM that is useful in feasibility studies is rich picture analysis. This is an analyst's holistic (describing the situation as a whole) representation of a situation: it identifies problem areas, structures, processes and political, psychological and social factors. Financial, technical or regulatory constraints can also be captured in the picture. Figure 5 is a rich picture of the project to construct the bridge over the river Humber.
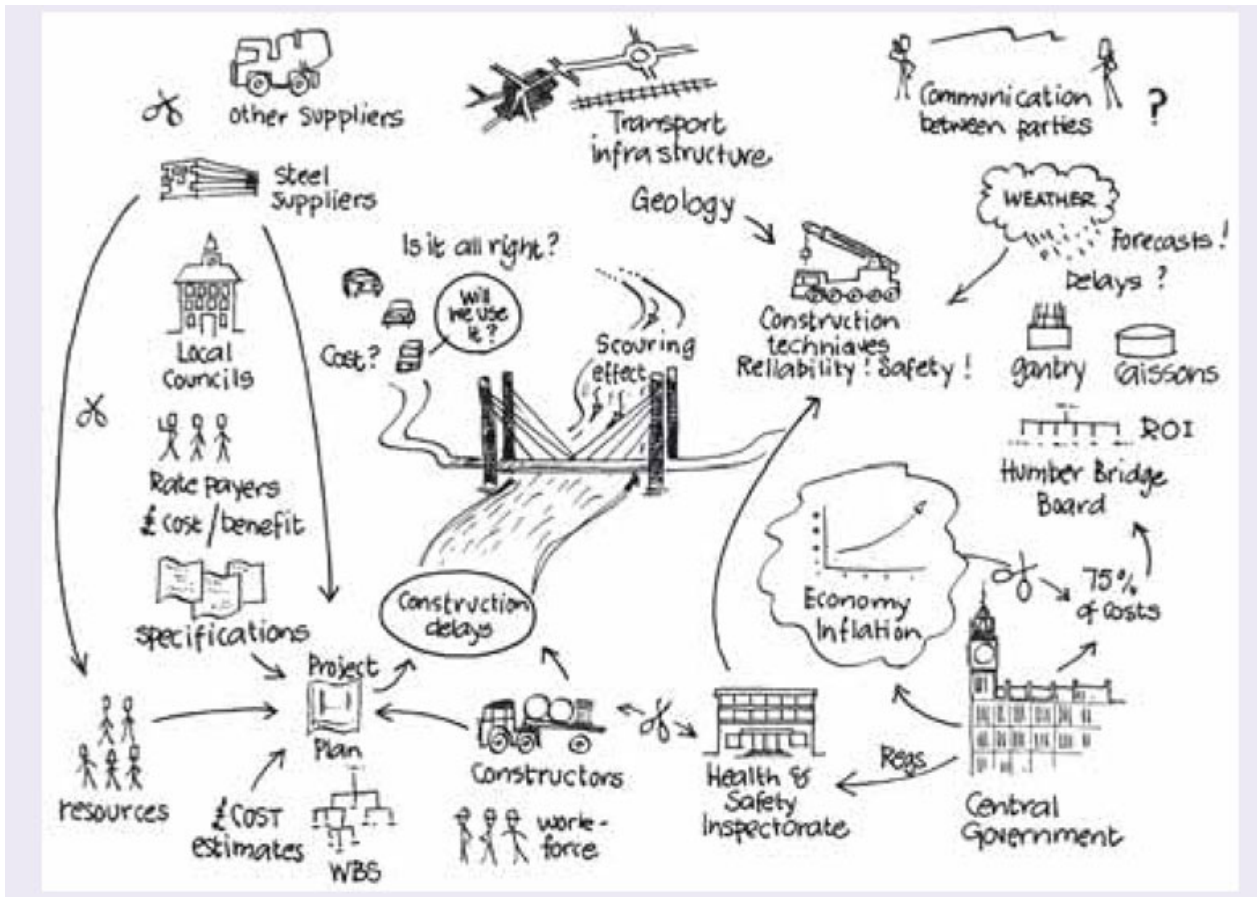


Figure 5 Rich picture of the construction of the Humber Bridge (adapted from Stewart and Fortune, 1994)

### Activity 6

Sketch a quick rich picture of your 'project' to study. Include all the elements you think affect you and your project, or that your project has an effect on.

#### Discussion

Your picture will, of course, be unique to you. But you probably have included your job, your boss(es), partner and other family members if you have them, and your costs of studying, as we have in our picture (Figure 6). Perhaps you have pictured how it affects your living arrangements, and what strains and stresses (or benefits!) it gives to your social life.
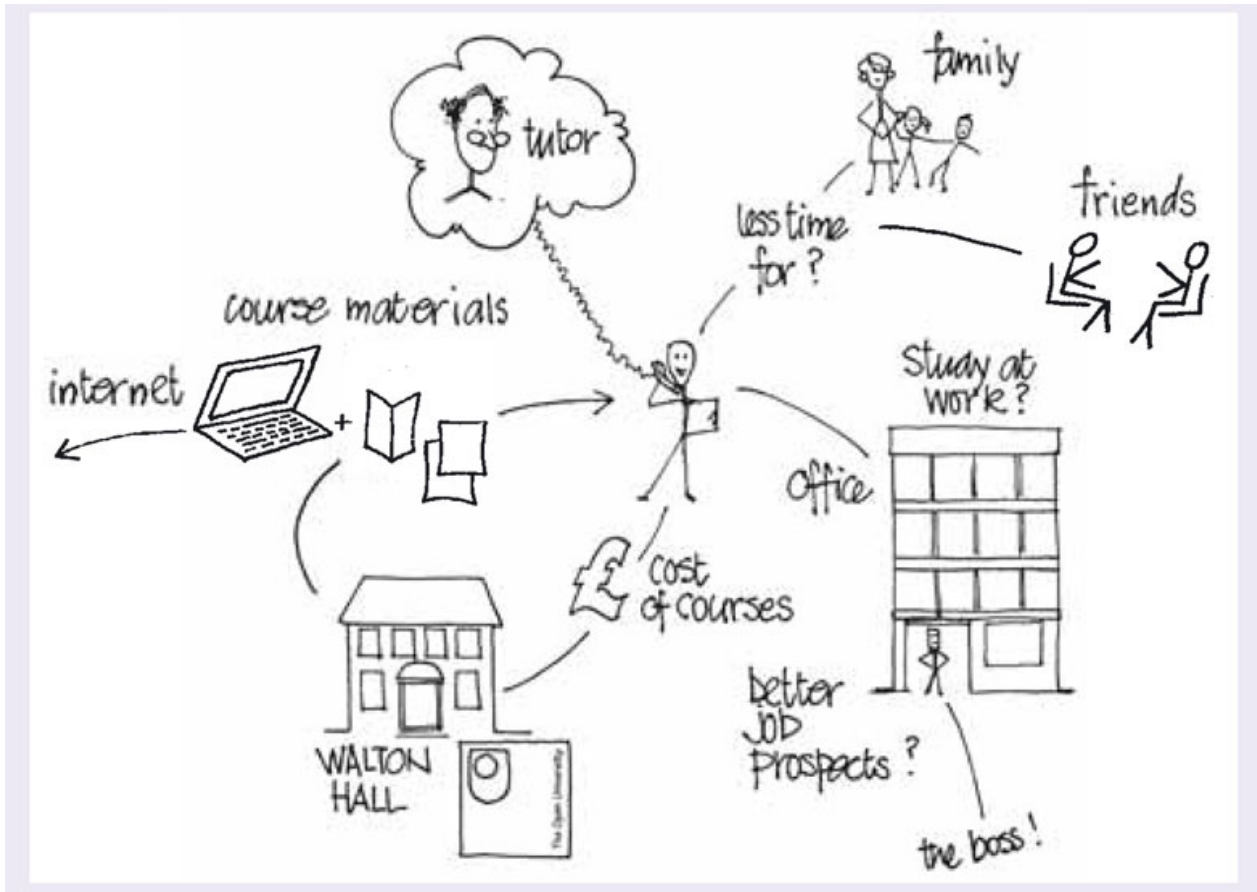
Figure 6 A 'rich picture' of studying M865

# Generating acceptable scenarios

In the context of defining a project, a **scenario** is a brief description of a system, process or set of procedures that should meet the identified objectives. As noted above, for every objective there are a number of possible strategies – the objective of eating can be satisfied by: assembling raw food in a salad; assembling and preparing ingredients for a cooked meal at home; going to a friend's for a meal; going to a café or restaurant; or getting a meal to take away. Each of these would be a possible scenario for satisfying a need to eat. Developing scenarios is an activity in which brainstorming can again play a role. Many ideas can be generated, but then must be looked at critically, and modified, selected or rejected.

## Activity 7

Make a brief list of possible scenarios to meet the need to move people and their baggage around a large site like a major airport. Brainstorm on your own if you like, or ask friends or colleagues to join in.

## Discussion

Some possible scenarios are:

- provide wide pavements, stairs, road crossings, etc., with baggage carts allowing the movement of people on foot, pushing carts containing their baggage

- provide moving belts (travelators), escalators and lifts, and baggage carts for movement on foot, as above
- provide individual electric carts in which one to four people can load their baggage and drive themselves or be driven by a hired driver around the site
- provide petrol-or diesel-driven buses with baggage racks to move groups of people and their baggage around the site
- provide a fixed roadbed or rail system of automatically controlled cars or wagons in which groups of people and their baggage can be moved around the site (e.g. a monorail, a form of small train or tram, or similar).

The scenarios above describe current ways of transporting people and baggage at major airports. At some later point, you may be expected to refine the scenarios. For example, should an airport charge people to use the powered carts? Brainstorming may generate some more far-fetched or off-the-wall ideas:

- provide booths to teleport people and baggage from one place to another by converting them into pure energy which can be beamed at the speed of light
- provide anti-gravity discs of, say, 1.5 metres diameter upon which one to three people and their baggage can stand; the discs then move under automatic control.

You may have thought of other possible scenarios.

We have included far-fetched ideas in our discussion of this activity to show briefly how an idea which may appear so far-fetched as to be silly can be modified to use an existing or emerging technology. Look at the second of our far-fetched ideas. Anti-gravity is, at best, a very long way from achieving reality. However, it is possible to use the technology of superconductors to lift a weight and then to move it using linear electric motors; this is an emerging technology currently being explored for its application to public transport. While it may still seem far-fetched, such a technology may in future be used to lift a disc on which people and their baggage stand and to move the disc and its burden under automatic control around a site such as an airport.

### SAQ 4

What is the role of a scenario and how is a scenario developed?

#### Answer

The purpose of a scenario is to provide a general statement of an idea of what is involved in order to meet an objective. This provides a basis for subsequent assessment. Scenarios are developed from ideas, by any method for generating ideas and selecting those that are possible or reasonable.

## 2.2 Technical feasibility

We have generated some scenarios for moving people and luggage around a site such as a major airport. How do we assess the technical feasibility of these scenarios? We do not intend to answer such a broad question at this point. However, we do need to be sure that the chosen technology is sound, otherwise the probability of things going wrong will be high.

We can determine whether a technology is *mature*. For example, the technologies of laying pavements, building stairways and so on is very mature, though new materials will from time to time appear on the market and influence the technology. An example is the use of extremely hard-wearing rubber tiles in places such as train stations, airports and the like to provide a more pleasant and safer surface to walk on, reduce noise levels and yet be nearly as durable as harder surfaces.

Some technologies are only relatively mature and are still undergoing active development. The use of fixed-rail or fixed-bed cars, trains and trams is an example: there has been continuous change in such technology to increase safety, improve the comfort of the ride, increase speed and reduce running and maintenance costs and side effects such as noise. The Paris Metro originally used iron-wheeled vehicles on fixed iron rails but has moved to rubber-tyred vehicles running on concrete 'tracks'; both Gatwick and Stansted airports have automatic, driverless rail vehicles to move people.

Other technologies, such as superconductors and linear motors, are only just emerging: a few scale-model prototypes have been built to develop an understanding of the characteristics of the technology and to help make it usable at full scale and at an affordable cost. For example, the maglev train connects the new airport in Shanghai to the city's metro system.

Not only do we need to assess whether a technology is mature, sound and applicable – we also need to assess a variety of technical aspects of any proposal. These vary enormously and often require experienced or expert people to evaluate them properly. Even the building of a house by an experienced building contractor requires this sort of assessment. For example, the soil on the building site will affect how the foundations have to be constructed. A house built on clay has different requirements from one built on sandy soil; one built on a hillside with the potential for slippage is different yet again from one built where the earth is stable. (A soil engineer may be called to take samples and prepare a report before building commences.) Marketing projects have to take into account the fact that markets vary due to climatic, cultural and economic differences: you cannot market air-conditioners very successfully in a cold climate, nor to people who cannot afford them. A software developer may need expert advice from the hardware manufacturer before undertaking a project using that manufacturer's platform. A project to dig a well in the developing world will need an assessment from a hydrologist about the depth, suitability and extent of the local aquifers and water table.

You should bear in mind that cost is by no means the only factor determining whether a project is worthwhile, though its ease of measurement may tend to give it prominence. Several techniques exist for dealing with anything where cost is of less importance than other aspects of a project or product.

## Features analysis

**Features** analysis is a method of gathering and organising information about different products which have the same purpose and comparing them in terms other than those of cost. **Features** are those elements of a piece of equipment, a system or some other major constituent of the project which are regarded as important in the context of the project's requirements.

Assume that your company plans to publish a series of 'how to' books on a highly technical subject. You are asked to interview a number of 'typical' buyers and users of this type of book to find out what their needs are. You find that most of your subjects mention

durability, portability, ability to keep the pages clean and ability to prop up the open book and have it stay open at the correct page. What, then, are the features?

If you look at the requirement for durability, then a feature might be the materials used for covers and pages, and the type of binding used. The binding is also a feature that will dictate whether an open book can be easily propped up and will stay open at the right page. Portability will probably be determined more by dimensions and weight. (You may have to find out more about this requirement: do people want to be able to carry the book under an arm, in a briefcase, in a pocket?) Being able to keep the pages clean will depend on the paper used, which will also have a bearing on the weight of the finished product.

Note that a feature, such as the type of paper used, can have a bearing on two or more other features (such as weight and ability to stay clean). One sample of paper may contribute more to one feature (saving weight) and less to the other (ability to stay clean), while another sample may be easier to keep clean but weigh more.

A features analysis of the proposed system components will focus attention on the features of any requirement that are likely to prove important to the achievement of something that works and that satisfies needs. The importance of these features needs to be determined so that competing proposals or products can be judged accordingly. (One inevitable feature is of course cost, but it may not be the most important feature.)

Undertaking a features analysis entails identifying those features in the requirements likely to be vital, or very important, to the final outcome of the proposal. When important features have been identified they can be given a weighting (or weight factor), which assigns a value that indicates the *relative importance* of one feature compared with all the others.

Each identified feature becomes a category with several constituent elements. If we take robustness of a system as an example, we can analyse ways in which a system can be robust: it continues to operate in spite of power failures; the communications channels will not fail; the central computer has to be designed so that a failure in the hardware will not cause the system to cease to operate; and so on. These elements are painstakingly listed, and each will have a point value attached to it so that the total number of points for the elements listed under one feature will be 1.00. Each feature will be assigned a weight factor which indicates its relative importance to other features looked at in the analysis. An example using the factor *passenger/luggagecapacity* in choosing a new motor car is shown in Table 4. The weight factor here (0.25) indicates that passenger/luggage capacity will make up one-quarter of the value given to the overall analysis of the new car.

## Table 4 Part of a features analysis for choosing a new motor car

| Feature/element | Weight factor | Point value |
| --- | --- | --- |
| Passenger/luggage capacity | 0.25 | |
| Front seat headroom | | 0.13 |
| Front seat legroom | | 0.17 |
| Back seat headroom | | 0.10 |
| Back seat legroom | | 0.10 |
| Total seating capacity | | 0.16 |
| Luggage capacity in boot | | 0.14 |
| Luggage capacity on roof-rack | | 0.08 |
| Ability to rearrange seating | | 0.06 |

| | | |
|---|---|---|
| Glove box capacity | | 0.03 |
| Other small item storage | | 0.03 |
| **Total** | | **1.00** |

In this case we have chosen as an important feature of a new motor car the passenger and luggage carrying capacity. We can go further and identify other features for choosing a motor car, as shown in Table 5. Each such feature will then have the elements that constitute that feature also listed and given point values, and the total value of the features for an item will be 1.00.

## Table 5 Features and weight factors for choosing a new motor car

| Feature | Weight factor |
|---|---|
| Driver comfort | 0.25 |
| Passenger/luggage capacity | 0.25 |
| Safety | 0.25 |
| Handling | 0.10 |
| Reliability | 0.10 |
| Passenger comfort | 0.05 |
| Total | 1.00 |

Following the descriptions of features, weight factors and the elements that make up the features and their point values, each candidate product must be rated. Using the feature described in Table 4, motor car A might have sufficient front seat headroom for people 1.8 metres (6 feet) tall while motor car B might easily accommodate people of 1.95 metres (6 feet 4 inches). If a car-hire firm employs several drivers who are over 1.8 metres tall, they will have a preference – because of this element of the passenger and luggage feature – for motor car B, though other elements and features must enter into the final choice. In carrying out the features analysis, you would have to decide whether to give motor car B the full point value for front seat headroom of 0.13 and how much point value (perhaps only 0.09) to give motor car A. When all the elements of a feature have been rated for all the candidate products, they are added up. Let us say that motor car A has a point count of 0.58 for the passenger/luggage capacity feature and motor car B has a point count of 0.71.

All the features identified are assessed and point values added up. Then the point value for each feature is multiplied by the weight factor for that feature. Thus motor car A in our example will have a weight-adjusted rating for passenger/luggage capacity of 0.145, obtained by multiplying motor car A's point count of 0.58 by the weighting assigned to passenger/luggage capacity (0.25); similarly B's point count of 0.71 multiplied by 0.25 gives a weight-adjusted rating of 0.1775.

The weight-adjusted scores for all features being considered are then summed for each candidate product to obtain a figure of merit (FOM), and the candidate with the highest FOM should normally be the product chosen. (A figure of merit assigns a numeric value to a cost or benefit based on an arbitrarily decided and often weighted scale: for example, you might rate a computer according to the desirability of its speed, memory capacity and reliability.)

The problems with features analysis are fairly obvious:

- there may be many constituent elements for each feature
- deciding upon the actual weightings to use
- qualitative ranking systems (e.g. those using categories like poor, average, good and excellent) are more difficult to analyse though they may be easier to use when rating elements
- complete consensus about the weightings of features and rankings will rarely occur.

Thus the result of a features analysis is to some extent arbitrary. Nevertheless, a features analysis can be a highly valuable exercise since it will help an organisation to identify, rate and rank those features of a system which they find important more objectively.

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### Activity 8

Imagine you are planning to buy some luggage to use in your new job, which will involve a great deal of long-distance international travel over the next two or three years. You may need to be away from your home for up to six weeks at a time. You will need to be able to carry sufficient clothes for up to six weeks for a variety of climates, as you may spend a couple of weeks in Moscow in winter, followed by a couple of weeks in equatorial Africa. You should also expect to carry small amounts of paperwork and perhaps some sample

List what you feel will be important features to judge in comparing different makes of luggage. Assign weight factors to them.

#### Discussion

Possible features of importance are: durability, empty weight, capacity, ease of carrying, security of locks, internal compartmentalisation, degree of water-proofness, ease of recognition at the luggage conveyor at the airport, appearance. You may have suggested others, depending on what is important to you. Likewise, any weighting you assign to these features will also vary, though the specification that you will do a great deal of travel for the next two to three years probably means that durability will have a relatively high rating.

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### Activity 9

Take the feature ease of carrying and list some elements that you feel make up this feature.

#### Discussion

Some that occurred to us are: the comfort of the handle, the balance of the case, the presence of a shoulder strap (on smaller cases), the presence of wheels on larger cases, ease of using the wheels (e.g. does the case fall over when pulled along?), a strap or handle for pulling of sufficient length and strength to allow a person to walk upright while pulling the case along.

You may have thought of others.

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### SAQ 5

(a) List the main steps of a features analysis.

(b) What is the value of doing a features analysis?

## Answer

(a) Main steps are:

1  Identify important features.

2  Identify the constituent elements of each feature.

3  List the elements.

4  Attach a point value to each depending upon its relative contribution to the feature. Ensure that the sum of all the points for the elements of a feature adds up to 1.00.

5  Assess the features using the constituent elements and assign the point values for each constituent assessed.

6  Sum the point values.

7  Multiply the sum of point values for each feature by the weight factor for that feature.

8  Sum these for all features to obtain a figure of merit (FOM) for the candidate product.

Products can then be compared using their figures of merit.

(b) The value of doing a features analysis is in taking an objective view of the features identified in the requirements as key or important, then establishing a ranking system and applying it in an attempt to find the product whose features most closely meet the requirements.

# Environmental and social factors

Increasingly, environmental or ecological factors must be considered when assessing the feasibility of any proposal. Such considerations may be prompted by a feeling that an organisation's existing and potential customers would prefer to buy products which are less harmful to the environment than alternatives, or by concern among shareholders or employees, or may be demanded by health and safety legislation. It is beyond the scope of this course to discuss in detail the assessment of environmental factors, but Example 7 gives an idea of the types of things looked at in such an environmental impact assessment (EIA). When assessing the environmental impact of any project it is important to consider it over the broadest possible time span. In a manufacturing project, this means taking into account not only the impact of the product itself and any pollution created in the manufacturing process but also the raw materials and energy used for its manufacture and the method of its eventual disposal.

## Example 7

Hydro-electric power generation is an alternative to the use of coal to generate electricity. The building of dams to locate generators to provide a renewable energy source brings a substantial environmental benefit in comparison with the construction of power stations that use coal. It takes about 400 grams of coal to produce 1 kilowatt-hour of electricity, so a hydro-electric power station that has a capacity of 10 000 megawatts will reduce coal consumption by about 12 million tonnes a year. Hence, there will be a substantial improvement in air quality because of the reduced gaseous emissions (such as sulphur dioxide and carbon monoxide).

It is also increasingly common to assess social factors in determining feasibility; this is particularly true in projects undertaken in the under-developed world. These may range from social factors within a single group or office (for example, where a new technology is likely to be introduced) to broader social concerns about the effects of a project, process or product on employment, the health of workers and the general public, and safety issues. One of the earliest examples of incorporating these concerns into the development of software was the ETHICS (effective technical and human implementation of computer systems) method (Mumford, 1983). ETHICS looks at using participative methods to explore organisational issues such as goals, values and sources of job satisfaction in designing computer systems, and incorporating these issues with technical solutions into a design. Since then, participative methods to explore organisational issues have been the subject of many research projects (see, for example, McShane and Von Glinow, 2004). In addition, the tools and techniques used for EIA often include social factors, such as land use and employment, with physical and biological headings used to analyse environmental conditions (European Commission).

A reservoir behind a dam reduces the chances of flooding downstream from the dam, although reducing the water flow to prevent flooding places a constraint on the amount of electricity that can be generated. At the same time, a large reservoir increases the amount of gases emitted, such as methane, that are the by-products of rotting vegetation. While the control of water flow will affect the amount of downstream erosion of the river bank, the potential build-up of silt on the upstream side could reduce the effectiveness of the dam for electricity generation. The large volumes of water contained in reservoirs will also have an impact on the ecosystem. For example, some animal habitats will be threatened, while others may be helped.

Once the reservoir starts to fill up, the social impact will increase. For instance, people will be forced to move to a different location because the village or town where they live will be submerged, and a number of archaeological sites may be lost.

## Other technical factors

Tram systems are seen as an important way of addressing problems of traffic congestion and public transport needs in large cities. Because trams are powered by electricity, there are environmental benefits (less noise and air pollution) in comparison with diesel-powered buses. The 1990s saw a revival of tram systems in the UK (see British Trams). Manchester Metrolink, which opened in 1992, made use of existing railway track owned by British Rail, which minimised disruption to road traffic during the construction phase. By concentrating on popular commuter routes, Manchester's trams attracted nearly 20% more passengers than expected. In contrast, the tram system in Sheffield, which opened in 1994, made use of existing roads around the city. In order to minimise disruption to traffic, the tram routes were located on streets in areas that were in need of redevelopment, such as the derelict industrial area in the Don Valley. However, blocked access to shops and local traffic delays during construction alienated many local people along the route. This raised questions as to whether the new trams in Sheffield would attract sufficient passengers (at the time of writing, approximately 11 million passenger trips are made each year). The increased capacity of trams over buses contributes to the potential benefit with respect to traffic congestion, with each tram potentially removing 150 cars off the area's roads (British Trams). For example, a new tram system opened in Nottingham with an objective of reducing congestion by taking up to 2 million car journeys

off the road. Unfortunately, the project was affected by a lack of specialist staff (BBC, 2004).

Technical factors other than the maturity of a technology may be:

- the utility of the technology (for example, in the selection of computer systems for collecting fares for the new trams)
- the usability of systems (such as access to the new trams by disabled people)
- the degree of disruption during the construction or installation phase
- use of and improvement to existing infrastructure or the development of new infrastructure
- notions of general social utility (Sheffield's choice of tram routes)
- marketability (Manchester's choice of tram routes).

Assessing whether a particular technology is suitable for a particular situation will depend both on the situation and on the objectives of the organisation. Returning to our activity of developing scenarios about moving people and baggage, an airport authority with an existing large and busy airport will want a technical solution which will not be too disruptive to install and will work immediately, perhaps using a system of buses. An airport authority building a new airport can more safely choose a technical solution which might cause too much disruption if it were attempted in an existing facility, such as a fixed-roadbed system like a monorail. An organisation exploring novel applications for superconductors and linear motors may want to develop the technology of moving discs.

In addition to purely technological factors, technical constraints may apply to any plans. If you plan to start a restaurant business, the opening hours allowed by a local authority will be a constraint to consider, as perhaps will the availability of car parking facilities or public transport.

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### Activity 10

Make a very brief technological, social and environmental assessment in terms of *questions* to be asked of a plan to collect and recycle steel and tin-plate cans in a medium-sized town. (Note that we are not looking for the technical answers here, just the questions that might be asked.)

Spend no more than three to five minutes on this.

#### Discussion

Our list of questions for this assessment follows.

**Technological factors**

- How mature is the process of recycling steel and tin-plate?

**Social factors**

- Could local people be persuaded to recycle their tins?
- Are there reasonable places to put recycling collection points? Would it be better to have collections from homes?
- Is this likely to affect employment in the area?
- Would local people object to siting a recycling plant here (smells, noise, generation of more road traffic)?
- How much disruption would there be in building the plant?

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**Environmental factors**

- How much energy is consumed by the processes, compared to energy consumed in extracting raw materials for making steel and tin-plate? Where does the energy originate? How 'clean' or 'dirty' is the process of energy generation used in the locality?
- What are the waste products (including air, water and soil pollutants) generated by the recycling process, and how can these be minimised and handled safely?
- Can permission for the plant be obtained from the local authority?
- Is the road infrastructure able to support another industrial site in the area?

You may have other questions in your list.

# 2.3 Financial feasibility

Before investment of resources in selecting and carrying out a potential project can proceed, two sets of questions need to be considered:

1    Will the investment of resources in a particular project be worthwhile when compared with the cost associated with those resources? How worthwhile will it be?

2    Where there are several alternative opportunities for investing resources, which one gives the best rewards?

# Cost–benefit analysis

The technique that should almost certainly be used during any feasibility study is **cost–benefit analysis**. This means:

- identifying, specifying and evaluating the costs, including purchase, construction, maintenance, repair, running costs such as energy consumption and decommissioning, of the proposal for its projected lifetime
- identifying, specifying and evaluating the benefits of the proposal over its projected lifetime.

No matter what the size and nature of a proposal, the methods of evaluation are always the same: the specification of costs and benefits is the first stage. The types of cost and types of benefit involved in a particular project obviously depend upon the nature of the proposal and can vary as much as the proposals themselves.

For every item of proposal cost and every item of proposal benefit, you need to specify:

- its value in money terms or its value in terms of desirability (using some numeric scale)
- whether it is capital or revenue in nature (see below)
- its likely timing (when it occurs)
- whether it occurs once or recurs
- whether recurring items will remain constant or vary as time goes by (e.g. because of inflationary factors)

- where recurring items are expected to vary, for what reasons and by how much.

Fortunately, many of the types of costs and benefits are common to many projects. In some cases it is of value to be able to look at each phase of a project in terms of that phase's costs and benefits and to assess them in isolation from the rest of the project – a technique called **value engineering**. In practice, value engineering is concerned with optimising the conceptual, technical and operational aspects of a project's deliverables (APM, 2006). In other words, do the incremental costs of the various features and functions of the deliverables add appropriate value to the end product?

Some costs and benefits cannot be easily translated into financial terms. These are called **intangible** costs and benefits. As you have already seen, some intangible costs and benefits can be rated by developing a figure of merit. Other intangible costs and benefits may not be expressible in any numeric way – an example might be improved employee morale. The term cost–benefit analysis is often applied in a broad way to allow management to judge non-monetary and non-quantifiable costs and benefits as well as financial costs and benefits. A cost–benefit analysis may look not only at the financial feasibility of a potential project but also at intangible costs and benefits.

Another piece of information needed in carrying out a cost–benefit analysis is whether an item of financial cost or benefit is of a capital or of a revenue nature. (You should learn the difference between **capital** and **revenue** and what **financing costs**, **overheads, depreciation** and **inflation** are. You do not need to memorise how to calculate these, but should be able to do so using standard tables and descriptions of the formulas used. You should be able to state which methods are likely to yield sound results.)

The following checklist of costs and saving is provide for you take away use to make sure that nothing is overlooked when testing a projects financial feasibility.

Evaluating Proposals Financially

# Capital costs

**Capital costs** are incurred in the acquisition or enhancement of **assets**. Assets are usually **tangible** things such as land, buildings, plant, machinery, fixtures, fittings, stocks of materials and cash *owned* by the organisation. Capital costs include:

- the basic purchase price of an asset
- any additional costs which are incurred in installing and commissioning an asset and putting it into working order.

Capital expenditure usually occurs at the outset of work but there are exceptions. Any subsequent costs which relate to the acquisition or enhancement of assets should be treated as capital and regarded as part of the total investment.

# Revenue costs

Any cost incurred in a project other than for the acquisition or enhancement of assets is called **revenue cost**. Revenue costs (sometimes referred to as running costs) are those costs incurred on a continuing basis as part of day-to-day operations. These need to include projected maintenance and repair costs, the cost of replacing worn-out components and the like. Examples are given in Table 6, which shows a sample cash flow statement.

One type of revenue cost sometimes attributed to a project, even if that project does not use internal resources, is overhead allocation. The term overheads refers to the day-to-day revenue expenses (the running costs) which appear as charges against income that apply to the organisation generally and are not directly attributable to any specific area within the organisation (which is why they are sometimes called *indirect costs*).
Examples are:

- administrative costs, such as building rent and local taxes, staff salaries, electricity and other services, insurances, stationery and so on
- general management salaries and costs
- depreciation on administrative offices, machinery and furniture.

If you are interested in learning how depreciation costs are calculated, see the paper entitled below.

Depreciation Costs

If a proposal results directly in an increase in any of the overhead costs, the amount of the increase represents a revenue cost directly attributable to the proposal and the increase must be allowed for when calculating a project's financial viability. Examples are additional taxes, additional insurance costs and salaries of additional staff. Depreciation is another revenue cost.


# Financing costs

Every project has to be financed. Money has to be found to pay for the initial investment in the project and perhaps also to finance subsequent revenue costs if the benefits in the initial years are inadequate to cover these. As with other resources, the use of financial resources itself costs money: financing costs. These are usually the interest that has to be paid on the outstanding balance of funds invested in a project until such time as the project benefits have paid off those balances. (This is exactly like paying interest charges on a reducing bank loan.) To determine whether the proposal is economically viable, the percentage rate of a project's financing costs is compared against the calculation of project profitability. It is therefore vital in proposal evaluation to know what your financing costs will be, otherwise there is no way of deciding whether a project will be worthwhile as an investment.

Unfortunately, the determination of the financing cost rate is not altogether straightforward. It depends upon where the funds come from. In business, there are three principal sources of funds for investment in a project:

- finance already available in the business
- finance borrowed from someone else (e.g. a bank)
- additional capital invested by shareholders.

Where the organisation is not a business, other sources of finance may be available and have minimal or no associated costs:

- grants from governments or foundations (these are sometimes available to businesses as well)
- subsidies from governments (sometimes available to businesses)
- donations from other organisations or individuals
- tax income (in the case of government organisations).

Of course, a mixture of these sources may be possible. Grants and subsidies reduce the capital costs in a project, and are best treated as reducing the costs of the project in respect of which they are granted (a process called *netting off* ).

Funds already in a business will not be simply lying around – they will be used to finance assets and generate profits, and so these funds will already be earning money themselves. If, therefore, a proposal calls upon these funds to finance a project, there will be a lost *opportunity cost*. It is usually important that the expected **rate ofreturn** from the proposal is at least equal to, and preferably much higher than, the rate of return currently earned by the funds in their present use. The exception to this is when the anticipated returns from the project are somewhat intangible.

The financing cost of funds borrowed from someone else is quite simply the rate of interest they charge for the loan.

Obtaining additional capital from shareholders is normally only used to finance substantial long-term projects. The financing cost will be the rate of dividend that will have to be offered to subscribers to tempt them into contributing the funds.

To be really prudent and to ensure that a cost–benefit analysis cannot be criticised for underestimating the financing costs, the best course is to use as the financing cost rate the highest of:

1    the rate of interest that would be charged on borrowed funds

2    the rate that could be earned on funds if invested to the best advantage elsewhere

3    the current return on investment (ROI) of the business.

If a proposal's evaluation shows a potential rate of return in excess of the selected financing cost rate, then the project is potentially viable and it becomes management's responsibility to try to find the funds from the cheapest source available. However, it must always be borne in mind that future cash flow forecasts are based on judgements and may turn out to be substantially different.


## Effects of time on values

For reasons that will become clear later, project benefits obtained early in the life of a project are worth more in real terms than the same benefits received in the more distant future. Similarly, costs incurred early in a project have a greater impact than if those costs are deferred to a later time. The **payback period** and average annual rate of return methods of evaluation ignore this fact because they are based on the unrealistic assumption that every pound (euro, dollar or other unit of currency) of cost and benefit is the same no matter when it is received or spent and no matter what rate of interest could be earned or charged on it as time goes by. Only the **discounted cash flow** methods of evaluation take the effects of time and interest rates on money values into account.

This is not the only consideration. Recurring costs and benefits can vary year by year for a number of reasons. If such variations can be predicted with a reasonable degree of certainty they must be accounted for in the proposal evaluation. An obvious example is where the implementation of a proposal results in fewer people being needed in a department. The initial saving in payroll costs is easily evaluated and is a revenue benefit. But the saving will become worth more and more in currency unit terms each year because the payroll cost per capita increases every year irrespective of inflationary factors as a result of progressive wage and salary structures and pay bargaining. (If the reduction in people is part of a larger trend of rising unemployment, however, taxes and

levies may also rise to fund increased levels of unemployment benefit, retraining programmes and other social effects. This is much more difficult to calculate, but should remain a factor to be considered.) Another example is the escalation of fuel costs. An initial saving in fuel consumption becomes worth more each year in money terms (provided, of course, that the lower consumption rate is maintained *and* that the real cost of fuel continues to rise).

Finally, many organisations adopt the policy of allowing for inflation in proposal evaluations. Having established the basic values of recurring costs and benefits, a blanket percentage increase is then applied to all values, year by year, on a compound basis (the increases of one year being included in the calculations of the following year). Inflation may not affect all types of benefits and costs equally (for example, fuel costs may rise faster than the rate of general inflation). It is also difficult to predict with any acceptable degree of certainty the trend in inflation rates more than one year ahead.

## Cash flow statements

Once all the data in respect of every cash outflow and inflow has been assembled, a **cash flow statement** for the project can be prepared. Let us take an example.

## FatPac Haulage

Ten years ago your organisation acquired an ailing warehouse and road transport company (FatPac Haulage) whose assets consisted of some insubstantial buildings used as garages and a storage depot, together with five lorries which at that time were relatively new and in good condition. The business has grown rapidly. The premises are now inadequate, expensive to heat and maintain and expensive to insure as there is only a primitive sprinkler system installed. The five lorries are now uneconomic to run. Diesel and repair bills have become prohibitive; breakdowns and lost operating hours are excessive. With more lorry capacity, better reliability and faster service FatPac could easily obtain more business. A project is under consideration to replace the lorries and to rebuild the depot with better equipment, full insulation, an effective sprinkler system and in-company lorry maintenance.

Table 6 shows a sample cash flow statement that might be prepared to show the expected cash flows arising from the project. By convention, year 0 represents the starting point of the project, while year n represents the net flow for that year.

**Table 6 A sample cash flow for a project for the FatPac Haulage Company**

| Year 4 | | Year 5 | | | | Ye-ar 6 | Year 7 | | |
|---|---|---|---|---|---|---|---|---|---|
| **Capital inflows** | £k | £k | £k | £k | £k | £k | £k | |
| Grants | 50 | | | | | | | |
| Profits on trade-in | 5 | | | | | | | |
| **Revenue inflows** | | | | | | | | |
| Outside repair and maintenance savings heating savings, fuel savings | | 60 | 73 | 86 | 100 | 113 | 113 | 113 |

| Increased profits | | 45 | 55 | 65 | 75 | 85 | 85 | 85 |
|---|---|---|---|---|---|---|---|---|
| Insurance savings | | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| **Total inflows** | 55 | 110 | 133 | 156 | 180 | 203 | 203 | 203 |
| **Capital outflows** | £k | £k | £k | £k | £k | £k | £k | £k |
| New lorries | 170 | | | | | | | |
| Buildings | 150 | | | | | | | |
| Fixtures and fittings | 50 | | | | | | | |
| Site clearance, etc. | 20 | | | | | | | |
| Machinery | 20 | | | | | | | |
| Installation costs | 15 | | | | | | | |
| **Revenue outflows** | £k | £k | £k | £k | £k | £k | £k | £k |
| Materials, garage power | | 7 | 9 | 10 | 12 | 13 | 13 | 13 |
| Payroll costs | | 15 | 16 | 17 | 17 | 18 | 19 | 20 |
| Increased local taxes | | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Total outflows** | 425 | 25 | 28 | 30 | 32 | 34 | 35 | 36 |
| **Net cash flow*** | (370) | 85 | 105 | 126 | 148 | 169 | 168 | 167 |

*( ) = a negative net cash flow, or, if you prefer, a cash outflow. Note that the savings projected as revenue inflows from outside repair and maintenance, heating and fuel are obtained by determining the running costs for the present equipment and buildings, the running costs for the proposed buildings and equipment, and taking the difference.

# Choosing the correct number of years

To decide what is the most appropriate number of years over which a proposal should be evaluated is difficult. Too short a period (say three years in the example of FatPac Haulage) would ignore the very real possibility of longer-term project benefits. Many projects, especially those of a substantial nature, often prove unprofitable in early years but, once consolidated, produce rapidly increasing and very substantial benefits in the medium and longer term which more than justify their early shortfalls in cash flow. In the case of a wind farm or an advanced and speculative research and development project, however, a perfectly suitable period may be quite long: 20 years or more.

Conversely, to try to evaluate a project over too long a period means that one may be trying to justify an investment from benefits that are so far in the future that they may never happen. The longer the timescale, the greater is the possibility of a wrong decision being taken to pursue a proposal because:

- there is an increasing possibility of business problems
- there is a greater likelihood that assets in use will become less reliable and economic to run and could require replacement
- marketing factors could change significantly
- risk and uncertainty upset forecasts.

# Establishing a method for calculating value

Here we look at three methods for evaluating project proposals financially:

●   the payback method
●   the net present value method
●   the internal rate of return method.

Note that we will show our calculations in full so that you can follow what we are doing. This degree of arithmetical accuracy can mislead people into believing that there really will be, say, £21 736.37 profit at the end of the third year, when in fact figures like these are forecasts based on 'best informed guess' estimates, which can often be quite rough. Hence it is more sensible to show projected profits and losses in round figures. In our example, it would be accurate enough to say that we expect a profit of about £22 000 at the end of the third year. In practice, the calculations for each of the three methods are performed using a spreadsheet on a personal computer.

# The payback period method

The payback period method is simple but produces the least meaningful results. Yet it is by far the most commonly used. It simply asks the question: 'How long will it take to repay the capital investment?' In other words, how long will it take before the accumulated cash flow (including capital expenditures) becomes positive?

As a simple example, an organisation invests £100 000 in a proposal for which the estimate contains a positive net cash flow (i.e. the excess of **cash inflows** over outflows) of £25 000 per year. So, the organisation can expect to recover the initial investment in:

$$\frac{£100\ 000}{£25\ 000} = 4 \text{ years}$$

In reality, the cash flow is likely to vary year by year, but it is still a simple calculation. Suppose the expected pattern of net cash flow in the above example was modified as follows:

| Year 1 | £45000 |
|--------|--------|
| Year 2 | £35000 |

| Year 3 | £20000 |
|--------|--------|
| Year 4 | £20000 |
| Year 5 | £15000 |

Now, we can see that it would take only three years to recover the initial investment.

There are three important points to be considered when using the payback method for evaluating a proposal:

1   The cash flows should be calculated after tax. The reason is that this method is based on the recovery of the project investment out of its net income and it is only what is left out of the income after the tax authorities have taken their share that is available for use.

2   Exclude depreciation charges from revenue costs. Depreciation costs (for such things as new machinery and computers) are normally included in the calculation of a proposal's cash outflows. So, they must not be recovered twice when looking for the complete reimbursement of the total project investment.

3   Until the payback point is reached, there is an outstanding (but decreasing) balance of funds being used to finance the investment and therefore incurring financing costs (either real or notional depending where the funds come from). If it is possible to calculate what these financing costs are, they should be included as revenue costs (cash outflows) in the cash flow statement.

The inherent simplicity of the payback method has been the main reason for its popularity in many organisations. However, there are some serious limitations:

●   The method completely ignores positive cash flows received after the payback point.

●   It only looks at cash flow and completely ignores profitability or return on investment.

●   It does not take into account the total lifetime cost of all items in a proposal. For example, a piece of equipment may have a high disposal or decommissioning cost.

●   It assumes that all money is of equal value regardless of when it is spent or received, although this criticism is partly lessened if all financing costs are included in the cash flow statement.

●   If a short payback period is required, the method will reduce the chances of accepting many longer-term proposals.

When considering project proposals, it is common to look for the earliest possible payback point so that an organisation can move into profit sooner rather than later. As a result, many worthwhile (but longer-term) proposals which would give a high rate of return on investment do not get accepted. It is best to use the payback method, if at all, in conjunction with a second method – one of the rate of return methods – to reach a better overall decision when comparing proposals.

---

### SAQ 6

Assume you want to invest £20 000 and there are two proposals you can choose. Proposal A requires an investment of £20 000 and should have a positive net cash flow of £3200 annually for the first seven years. Proposal B also requires an investment of £20 000 and estimates net cash flows of:

| | |
|---|---|
| Year 1 | –£2000 |
| Year 2 | £2675 |
| Year 3 | £3200 |
| Year 4 | £4550 |
| Year 5 | £6550 |
| Year 6 | £7000 |
| Year 7 | £8000 |

How do the projects compare using the payback method?

Answer

The calculation of payback period for proposal A is simple:

Payback period = 20000/3200 = 6.25 years, assuming a linear revenue inflow.

Proposal B is slightly more complex, as shown in Table S.2 below.

## Table S.2 Net cash flows for proposal B

| Year | Flow in year £ | Cumulative cashflow at year end £ |
|---|---|---|
| 0 | –20 000 | –20 000 |
| 1 | –2 000 | –22 000 |
| 2 | 2 675 | –19 325 |
| 3 | 3 200 | –16 125 |
| 4 | 4 550 | –11 575 |
| 5 | 6 550 | –5 025 |
| 6 | 7 000 | 1 975 |
| 7 | 8 000 | 9 975 |

Proposal B will recover the initial project investment some time before the end of Year 6, at which point it would have achieved a surplus of £1975. If we assume that the £7000 net annual cash inflow for Year 6 occurs in 12 equal monthly cash inflows, it will be nearly the ninth month of the year before payback is achieved: approximately 5.75 years.

Therefore it seems that proposal B is likely to pay back its investment sooner than proposal A. However, when reaching this conclusion it is necessary to consider the accuracy of the estimates. In this case a difference of 6 months in payback may be significant.

# Discounted cash flow methods

When the projected time span of a proposal extends over more than one financial period, the 'time value of money' needs to be taken into account. Discounted cash flow is concerned with relating future cash inflows and outflows over the life of a project using a common base value in order to give more validity to comparing project proposals with different durations and rates of cash flow. This is an aspect of the **opportunity** cost of a project; that is, the cost associated with not doing something else with the resources. For example, if The Open University decided to build a new office block on the land it owns, the opportunity cost is some other thing that might be done with the land and construction funds instead.

The cash flows in a proposal are different from the data generally found in a company's balance sheet. Hogg (1994) identified some rules that will help prepare a consistent view of the financial health of a proposal:

- Use cash flows, *not* profit figures.
- Ignore those costs that have already been incurred or committed to (sometimes known as *sunk costs*).
- Only include costs that arise directly from the project (fixed costs, which would be incurred whether or not the project goes ahead, should be included).
- Opportunity costs must be taken into account (developing one area of a business to the detriment of another).

Compounding

If you deposit a certain amount of money in a place where it will accrue interest, such as a savings account, the total amount of money will build up every year (assuming it is left alone). We can calculate the future value (FV) of an investment by compounding its present value (PV) for n years with an interest rate (r) as follows:

$FV = PV(1 + r/100)^n$

For example, £5 deposited for 3 years with an interest rate of 10% will have a future value of:

$£5 \times (1+10/100)^3 = £5 \times (1.10)^3 = £5 \times 1.331 = £6.66$

In a similar way, a company might invest £100 000 in a project involving some new machinery, additional workforce and so on. The income generated through the sale of its goods and services will be used to repay the initial investment. In other words, the cash flows from these sales should be equal to or exceed the interest that would have been generated had the money been put in a savings account. The company would choose *an internal rate of return* in order to evaluate the project over a number of years. If that rate was 10%, the value of the project would increase as follows (rounded to the nearest thousand pounds):

| Year 0 | £100 000 |
|--------|----------|
| Year 1 | £110 000 |
| Year 2 | £121 000 |
| Year 3 | £133 000 |

In practice, the internal rate of return is typically higher than the interest rate used for savings accounts. This is because companies often take out loans to fund the initial investment. If, for example, a finance house provided a loan of £100 000 with an interest rate of 10% for the project, then it would just about be viable. Terminating the project after 1 year would provide exactly the amount needed to repay the finance.

Discounting

Discounting is essentially the reverse of compounding. All future values are discounted back to today's terms, known as the present value (PV), based on the principle that 'a pound today is worth more than a pound tomorrow'. Going back to the savings account example, we could say that if we were to be promised £6.66 in three years' time (the future value), it would be equivalent to being paid £5 now (the present value) at a given rate of interest (10%). This is because £5 invested now at 10% would grow to £6.66 in 3 years. Thus, the present value of £6.66 in 3 years' time is £5, using a discount rate of 10%.

Similarly, if we wanted £5 in a year's time with the same rate of interest, its present value would be:

£5/(1+10/100) = £5/1.1 = £4.55

In effect, we have rearranged the formula used for compounding:

$PV = FV/(1+r)^n$

In this context, the rate of interest, r, is known as the discount rate. We can see that the present value reduces as the future period is increased. For example, in order to get £5 in 2 years' time, the present value would be:

£5/(1.161.1) = £5/1.21 = £4.13

and over 3 years, the present value becomes:

£5/(1.161.161.1) = £5/1.331 = £3.76

The idea of present value can be applied to both inflows and outflows when evaluating a project proposal. Suppose a manufacturing company anticipates an income of £5000 through the sale of finished goods in the third year of a project. If its internal rate of return (IRR) is 10%, that cash flow should be discounted to give a present value of £5000/1.331 = £3757 (rounded up to the nearest pound). Similarly, a fuel bill of £5000 in the third year of the same project leads to a present value of –£5000/1.331 which is –£3757 (note that the minus sign indicates the direction of the flow: an outflow in this case).

---

SAQ 7

Assume that you have just won a competition prize of £1000.

(a) If you invest this money in a savings scheme that guarantees an after-tax annual return of 3% and you leave all interest earned in the account for five years, what will your account contain at the end of that period?

(b) If you do not invest this money but leave it tucked away in a drawer for the full period, and inflation runs at 3% a year, what will your £1000 prize be worth in present terms at the end of that period?

(c) Imagine that you have invested your money in the savings scheme, but you want to determine what your money will be worth at the end of the five-year period in present-day terms (taking inflation into account). How much will your savings scheme yield you in present-day terms at the end of five years?

---

> ### Answer
>
> (a) This is a compounding problem. At the end of the first year you will have £1000 x 1.03 = £1030. That is multiplied by the same factor to obtain the second year's total of £1060.90. Likewise, the third year is £1092.73, the fourth year is £1125.51 and the fifth and final year is £1159.27 (all rounded to the nearest penny).
>
> (b) This is a discounting problem. At the end of the period your money will be worth £862.61 in present-day terms. This was found by dividing £1000 by (1.03)5or 1.159.
>
> (c) This is both a compounding and a discounting problem. Intuition should tell you that if the rate of inflation is the same as the rate of compounded return on your investment, you will break even – your money will be worth £1000 in present-day terms at the end of five years.

## Net present value (NPV) method

In the course of a project, the discounting argument can be applied to all the inflows and outflows encountered by the organisation. That is to say the present value calculation can be applied to both the benefits and the costs in a proposal in order to determine its **net present value** (NPV):

net present value = present value of benefits-present value of costs

In other words:

$$NPV = A_0 + \sum_{t=1}^{n} \frac{NCF_t}{(1+r)^t}$$

where $A_0$ is the initial cash investment (the cost), which will be negative, $r$ is the discounting rate (also known as the required rate of return) and $NCF_t$ is the net cash flow (the benefits accrued) during period $t$.

(Note: for the non-mathematical, $\Sigma$ means 'sum', the $t = 1$ subscript says 'start from the first item' and the $n$ superscript means 'continue until all are calculated and summed'.)

Consequently, the minimum criterion for investment in a project proposal is that the net present value is greater than or equal to zero at a given discounting rate.

Recall the proposal with an initial investment of £100 000 that we used to illustrate the payback method. We will use the net cash flow (NCF) for each year to calculate the net present value using a discount rate of 10%. We will not modify the cash flow in year 0 since it represents the present-day value of that cash flow. For each of the subsequent years, we will apply the discounting principle to calculate the present value.

**Table 7**

| Year | Net cash flow, NCF (£) | Discounting factor | NPV (£)NPV (£) |
|------|------------------------|--------------------|----------------|
| 0 | (100 000) | none | (100 000) |
| 1 | 45 000 | /1.1 | 40 909 |
| 2 | 35 000 | | 28 926 |
| /1.1$^2$ | (= | 1.21) | |
| 3 | 20 000 | | 15 026 |
| /1.1$^3$ | (= | 1.331) | |
| 4 | 20 000 | | 13 660 |
| /1.1$^4$ | (= | 1.4641) | |
| 5 | 15 000 | | 9 314 |
| /1.1$^5$ | (= | 1.61051) | |
| Total net present value of the proposal's NCFs = | | | 7 835 |

This result means that, after allowing for financing costs at 10% per annum compounded over 5 years, this proposal will more than pay for the initial investment. In other words, the project is forecast to generate a return that is in excess of 10%. It is financially viable, according to the net present value method. If the NPV were negative, this would infer a return of under 10%.

When two or more proposals of a similar size are being evaluated, the one with the highest NPV will probably be selected. If, at the end of the calculations, a proposal has a negative NPV, it means that the rate of return generated by that proposal is less than the rate required. Unless there were some overriding non-financial reasons for doing so, that proposal would not be implemented.

The chances of reaching the minimum criterion for NPV are affected by the value given to the discount rate. For instance, companies tend to use a discount rate closer to the interest rate for a bank loan rather than the rate associated with a savings account. Some will choose a higher rate to avoid undesired consequences. Many companies use different discount rates depending on the level of risk. High-technology companies may use discount rates of up to 40%. To overcome the difficulty of selecting an appropriate discount rate, it is recommended that you should determine the rate of return implied by the cash flow estimates in a proposal. The result will help management decide whether or not the rate is adequate for their purposes.

---

SAQ 8

Assume that by investing £20 000 cash in the stock market you could be certain of a 12% rate of return. Now calculate the NPV of proposal B in SAQ 6, using 12% as the discount rate.

Answer

The answer appears in Table S.3.

### Table S.3 NPV of proposal B using 12% discount rate

| Year | Net cash flow £ | Discount factor | NPV £ |
|------|-----------------|-----------------|-------|
| 0 | –20 000 | 1.0000 | –20 000 |

---

| 1 | –2 000 | 0.8929 | –1 785 |
|---|--------|--------|--------|
| 2 | 2 675 | 0.7972 | 2 132 |
| 3 | 3 200 | 0.7118 | 2 277 |
| 4 | 4 550 | 0.6355 | 2 891 |
| 5 | 6 550 | 0.5674 | 3 716 |
| 6 | 7 000 | 0.5066 | 3 546 |
| 7 | 8 000 | 0.4523 | 3 618 |

Total net present value of proposal: –£3605.

# Internal rate of return (IRR) method

large projects. A small project might have only a modest NPV compared with a much bigger project, but require a much smaller initial investment. To make a ranking possible for projects of different sizes the NPV method may be extended to give a figure called the internal rate of return.

The IRR method calculates the rate of return to be obtained from a proposal, assuming that the discounted values of future cash flows will pay exactly for the initial investment. That is to say, you should look for a discount rate that gives an NPV of zero. The answer is typically found by:

● trying out different rates (typically, by using progressively higher rates) until you find the one that gives you an NPV that is closest to zero

● constructing a graph of NPV for different discount rates until you are confident about the point of intersection of the discount rate axis when the NPV = 0.

Using the same NCFs as the proposal (costing £100 000) we used to illustrate the NPV method, we can try out an increasing series of discount rates as shown in Table 8:

**Table 8**

| Rate | | | | | | | Sum | NPV |
|------|------|------|------|------|------|------|------|------|
| % | Year | 1 | 2 | 3 | 4 | 5 | | |
| | NCF (£) | 45 000 | 35 000 | 20 000 | 20 000 | 15 000 | | |
| 10 | | 40 909 | 28 926 | 15 026 | 13 660 | 9 314 | 107 835 | 7 835 |
| 11 | | 40 541 | 28 407 | 14 624 | 13 175 | 8 902 | 105 648 | 5 648 |
| 12 | | 40 179 | 27 902 | 14 236 | 12 710 | 8 511 | 103 538 | 3 538 |
| 13 | | 39 823 | 27 410 | 13 861 | 12 266 | 8 141 | 101 502 | 1 502 |
| 14 | | 39 474 | 26 931 | 13 499 | 11 842 | 7 791 | 99 537 | –463 |

Hence, the suggested IRR to get closest to an NPV of zero is 14%. This means that the proposal is worth implementing if management will accept a rate of return of less than 14% per annum (which they would probably do if it were possible to finance the project with a loan with a positive NPV at 12%, say).

Figure 8 shows a graphical method for finding an IRR for the same proposal using six calculations with different discount rates. It shows an NPV of zero for a discount rate slightly less than 14%. Note that the graph of NPV against discount rate is a curve and not

a straight line. While two points, one for an NPV above 0 and one for an NPV below 0, would be sufficient to find an IRR, the level of accuracy is improved by using more data points. If you are using a spreadsheet to find an IRR, the calculations can be used to generate a simple graph like the one shown in Figure 8.
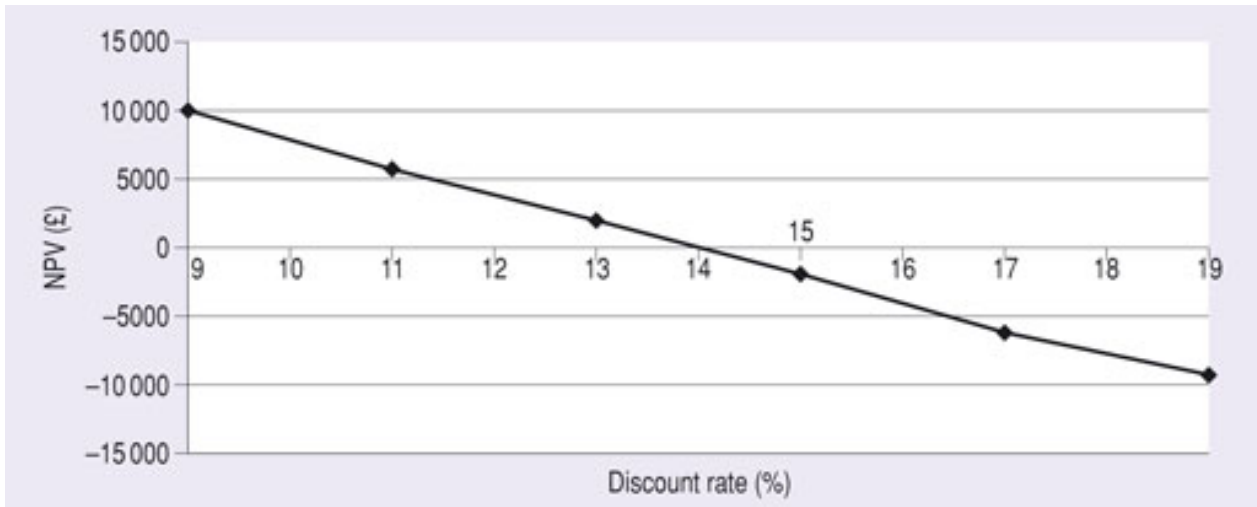


Figure 8 A proposal's NPV graph for different discount rates

The IRR method is not the only method to use, because it is not always possible to judge the relative viability of proposals by ranking their IRRs. It is preferable to rank similar proposals by their NPVs using the same rate of interest, which is possible when management policy determines the discount rate to use. However, this may not be possible for every financial evaluation. For example, management may not take into account the relative stability of banking interest rates and inflation, as well as their potential fluctuation over time.

SAQ 9

What is the IRR of proposal B (from SAQ 6) to the nearest percentage point?

Answer

A trial and error method is required to establish the value of the discount rate that gives a value of NPV equal to zero. We have already tried 12% and found a large negative NPV so next we might try 6%. You would find that this gave a positive NPV. Successive trials between these values show that at 7% the NPV is still positive (£867), and at 8% it is negative (–£137). You should therefore conclude that the internal rate of return of this proposal is just under 8%.

SAQ 10

To see the effect of project size on the value of IRR and NPV, answer the following questions:

(a) What is the value of IRR of a project twice the size of proposal B in every respect (i.e. all cash flows are doubled)?

(b) What is the effect on NPV of doubling the size of a project?

> **Answer**
>
> (a) The value of IRR is independent of project size.
>
> (b) The value of NPV would be doubled.

## 2.4 Risk and uncertainty

**Risk** and **uncertainty** are pervasive. The term risk originates from the Italian verb *riscare*, which means 'to run into danger'. Consequently, our general understanding is that risk represents the *chance* of adverse consequences or loss occurring; an interpretation that the insurance industry thrives upon. Generally, risks can be identified and once identified the probability of the risk occurring needs to be assessed. However, there may also be doubt about the *validity* of qualitative or quantitative data: this is called *uncertainty*. We can also use the term uncertainty to mean a state where too little is known about something, and the very lack of knowledge represents a danger that can only be addressed by gathering more information (see, for example, Chapman and Ward, 2003). Example 8 illustrates the distinction between risk and uncertainty.

### Example 8

Your company is asked to store some substance you know nothing about. What risks are associated with this request? They are difficult to determine until you find out whether, for example, the substance is explosive, flammable, corrosive, poisonous and so on. If you find that the substance is explosive, you now know that there is a risk of explosion in storing the substance. Further investigations of the uncertainty surrounding the substance might reveal to you that it is only explosive if heated above a certain temperature. You now not only know the risk, but can make a probabilistic assessment of whether temperatures in your storage area are likely to be within the safe limits during the time you need to store the substance. (The knowledge also allows you to plan actions that might reduce the risk of explosion further, for example by installing air conditioning or refrigeration.

While there are many interpretations of risk, some authors take a phenomenological view when they write about dealing with risk. In order to manage risk in a project context, Edwards and Bowen (2005) identify four aspects of risk phenomena:

- the probability that an event will occur
- the nature of the event
- the consequences of that event
- the period of exposure to the event (as well as its consequences).

Any person preparing a proposal must take risks and uncertainties into account. To do either requires first that areas of uncertainty and risk are identified. At the stage of making proposals, perceived risks must be brought clearly to the attention of those in authority to make decisions in the matter – the problem is 'escalated' to more senior managers. The problem may then be delegated to someone with the express purpose of investigating further. Crockford (1980) listed the following categories of risks:

- fire and natural disaster
- accident
- political and social risk (war, civil disturbance, theft and vandalism)

- technical risk

- marketing risk

- labour risk (stoppages and strikes, turnover of personnel)

- liability risks (product liability, safety).

Some people would expand this list to include environmental problems (problems short of natural disaster but nevertheless serious), and would include under social risks demonstrations against a project and adverse social effects (for example, having to relocate large numbers of people to make way for the project). Edwards and Bowen (2005) have classified risk within two separate branches: natural and human. The sub-categories of natural risk comprise biological, climate (or weather), geological and extra-terrestrial. The sub-categories of human risk are: cultural, economic, financial, health, legal, managerial, political, social and technical. However, Edwards and Bowen acknowledge that human risks are harder to classify than natural risks because of the overlaps and relationships within humanly devised systems (2005, p. 27).

## High-risk proposals

It is likely that the potential for variation of costs should be considered a risk if novel elements predominate in a project. Proposals involving research, development or immature technologies tend to be of higher risk than projects in more mature areas such as civil engineering. However, Chicken (1994, p. 6) notes that major civil engineering projects which are novel, such as the Sydney Opera House, the Thames Flood Barrier and the Channel Tunnel, suffer from variation in costs, often by factors of from 10 to 200 times original estimates. More recently, the new parliament building in Edinburgh and the replacement Wembley Stadium suffered from variation in costs. Information systems developments are also prone to this problem. In many cases, the sources of such variation can be found in a failure to implement 'best practice' with respect to the management of projects (see, for example, RAE, 2004).

Three dimensions of risk exist:

- size

- technological maturity (the incorporation of novel methods, techniques, materials, etc.)

- structural complexity.

The larger a proposed project is, the greater the risk. Increase in size usually means an increase in complexity, including the complexity of administration, management and communication among the participants. Technological risks lie in the extent to which the technology and the methods proposed to be used are new and untried, innovative or unfamiliar. Structural complexity refers both to the arrangement of the component parts of the proposed project and to the structure of teams, management and relationships between groups.

## 2.5 Summary

A practising project manager – indeed, anyone who works regularly in a project environment – can benefit from being able to apply his or her critical faculties to proposals. People can also find themselves in the position of participating in drawing up a

feasibility study for a proposal. The feasibility study develops a scenario and a functional specification (what the new or revised system should do); it should identify whether the scenario is technically feasible, its likelihood of success in ecological, social and political terms and whether it is financially feasible. Financial feasibility is assessed in a cost–benefit analysis that thoroughly identifies and assesses tangible and intangible costs and benefits. A cash flow statement for the proposal is produced, then analysed by one or more of a number of methods ranging from the simple payback period to the internal rate of return. You have been given some practice in each of these methods in this section. The risks inherent in a proposal also affect its feasibility, so identifying, assessing and managing them is important. At such an early stage as the feasibility study, risks are brought to the attention of more senior managers and may be delegated to someone to explore further. Proposals resulting in projects that are large, or that have many novel elements or that depend upon an immature technology, or that are structurally complex to manage, are identified as very risky ventures.

Having studied this section, you should be able to:

- describe the elements of a feasibility study
- state the general aims of a functional specification
- sketch a rich picture to represent the 'soft' (social, political, ecological) elements of a proposal
- describe what a scenario is and generate some simple scenarios in response to a statement of a problem
- assess the maturity of a technology, given that you know something about the area (for example, people working in civil engineering would not be expected to assess the maturity of software development methods, and people working in software engineering would not be expected to assess the maturity of some area of materials science)
- carry out a features analysis and explain how a figure of merit can be derived
- frame some questions to be investigated in an ecological assessment of a proposal
- identify and distinguish between capital and revenue costs, and tangible and intangible costs and benefits
- understand what is meant by financing costs, internal costs and overheads or indirect costs
- describe the effect of time on values
- draw up a simple cash flow statement and justify your choice of the period used
- make a simple evaluation based on payback period, and know the limitations of this method
- calculate net present value and internal rate of return from given cash flows
- list categories of risk
- list the three dimensions of risk in proposals.

# 3 Making decisions

Given a set of proposals for which the feasibility has been assessed, management must now decide which proposals to pursue. What decision makers are looking for is the *best* option available.

Decisions are too often made on the basis of personal inclination and interest, for 'political' reasons – enhancing the power or prestige of an individual or a group within the organisational hierarchy – or for better reasons but in the absence of full information about the possible risks and outcomes of the decision. We have laid more stress on investigating how and why decisions are made and whether structured and scientifically based methods of decision making are possible, since making a bad decision will be costly. We now describe some factors to be considered and some methods that aid decision making.

## Learning outcomes

At the end of Section 3, you should be able to:

- describe an appropriate model for deciding which proposal to pursue
- explain why it is necessary to calculate profitability in the same way for proposals which are being compared in order to choose from them
- calculate expected monetary value (EMV) for possible outcomes in a decision tree
- explain how proposal-ranking formulas work
- use a checklist or measured checklist
- state the main limitation of these techniques
- list some of the questions a decision maker needs to ask before making a decision.

## 3.1 A model for decision making

The goal of a process for making decisions is to move towards a desired state of affairs through a series of rational choices from one or more alternatives. Problems are related to the gap between 'what is' and 'what ought to be'. Opportunities are also related to a potentially better situation based on current expectations. So, the basic framework for a rational decision making process is based on six steps (McShane and Von Glinow, 2004, p. 236):

1 Identify the problem or opportunity.
2 Choose the best (or most appropriate) decision style.
3 Develop alternative solutions.
4 Choose the best solution.
5 Implement the selected alternative.
6 Evaluate decision outcomes.

When it comes to evaluating and comparing proposals and deciding upon a course of action, the most appropriate decision style is to be objective rather than subjective and quantitative rather than qualitative. Just as an architect designing a building will use a

standard to measure the dimensions – a millimetre, centimetre or metre – structured aids to making decisions can be applied to evaluating and comparing proposals and deciding upon a course of action. Bazerman recommends the use of weighted criteria to arrive at the optimal decision as follows (2006, p. 4):

- *Identify the criteria* that are needed for the objectives to be accomplished by the decision making process.
- *Weight the criteria* by taking into account their varying importance.
- *Rate each alternative course of action on each criterion.* This is often the most difficult step as the decision maker has to answer the question, 'How well will each of the alternative solutions achieve each of the defined criteria?'
- *Compute the optimal decision* by multiplying the ratings by the weight of each criterion, add up the results across the criteria for each alternative and then choose the solution with the highest sum of the weighted ratings.

A decision maker also needs to ask whether a proposal for a project has coherence, which is the degree of relationship of the different parts of a proposal to each other and to the objectives and needs of the organisation. The principle of coherence is an aid to 'comparing like with like'. If two competing proposals use different methods of calculating profitability, it will be very difficult to make an informed decision about which is better.

## 3.2 Aids to decision making

## Decision trees

One particular decision making technique is to use a **decision tree**. A decision tree is a way of representing graphically the decision processes and their various possible outcomes. They are particularly useful when you have to make a decision about a choice of route when there are uncertainties about the results of adopting that route.

Let us take a simple example. Suppose that you are developing a software product and you want to decide whether to buy in a package to form a part of that product or whether to develop a package yourself. You believe that the chances of good sales will be improved if you develop your own package although developing your own package will cost more. This situation can be represented in the decision tree of Figure 9.
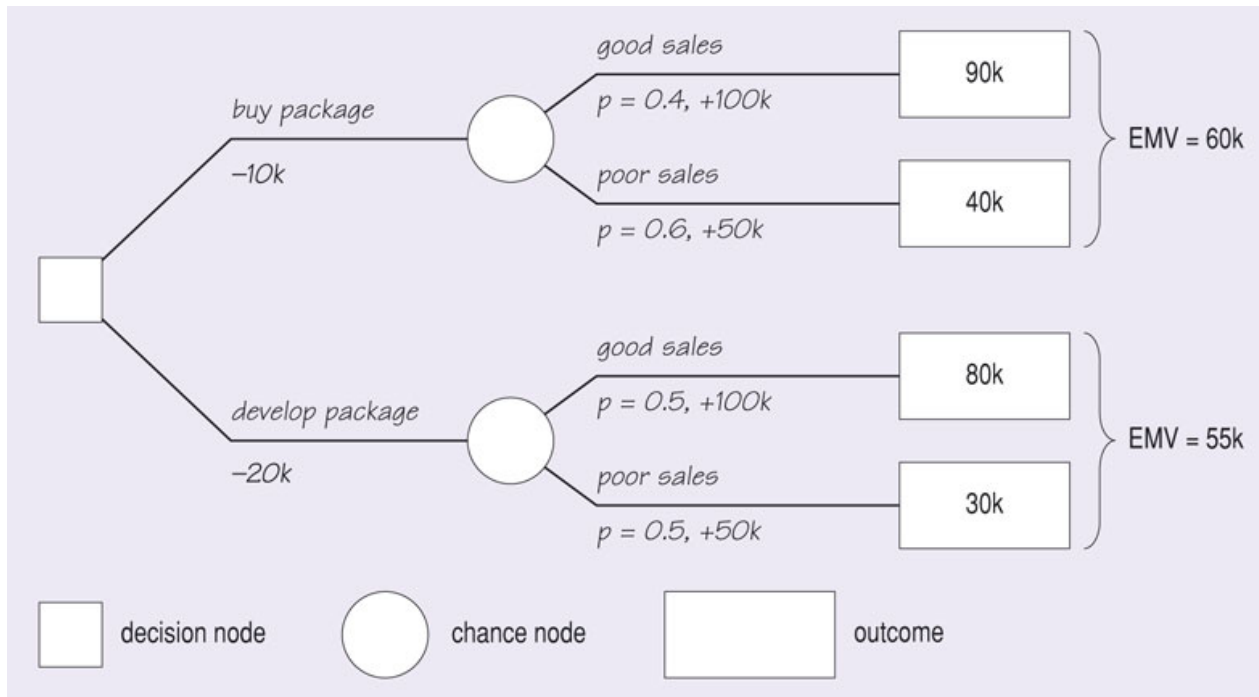
Figure 9 A simple decision tree (monetary values are expressed in thousands of pounds)

In this decision tree, options or *decision nodes* are represented by squares, and chance nodes by circles. The main decision is at the left, whether to buy or develop a package. The costs of the options at that point (£10 000 to buy, £20 000 to develop) are shown against the branches. Each of these branches has a chance node shown, with the probabilities of reaching particular outcomes given (e.g. 40% probability of achieving good sales of £100 000). The final rectangle (the leaf at the end of each branch) gives the total value of reaching that particular outcome, including any costs and benefits attached to branches en route. For example, the top leaf on the right of the tree is worth £90 000, as a result of profits of £100 000 minus the cost of buying the package initially, £10000.

It is now possible to see how the expected monetary value (EMV) for each of the two options shown in Figure 9 is calculated using the formula:

$$EMV = \sum_{i=1}^{n} P_i V_i$$

where

$V_i$ is the value of outcome i,

$P_i$ is the probability that outcome i will occur, and each probability is expressed as a decimal between 0 and 1,

n is the number of possible outcomes, and the sum of the probabilities for n is equal to 1.

Applying the formula to the option to 'buy the package' gives:

EMV= [0.46(100k − 10k)] + [0.66(50k − 10k)]=(0.4690k) + (0.6640k)=60k

Applying the formula to the option to 'develop the package' gives:

EMV=[0.56(100k − 20k)] + [0.56(50k − 20k)]=(0.5 680k) + (0.5630k)=55k

The probabilities assigned at the chance nodes are subjective probabilities, perhaps arrived at by using one or more forecasting techniques, and the values of outcomes may be estimated using one or other of the financial appraisal techniques referred to earlier.

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### SAQ 11

(a) Construct a decision tree to choose from three possible products that might be developed. The costs of developing each product are shown in the first column of Table 9. Estimates have been made of the probability of getting high or low growth for each of the products. The value of the product is in each case higher if high growth can be obtained. The values of the products in each case are as estimated in column 5.

(b) Calculate the EMV of each option.

**Table 9 The probabilities and values of the different options**

| Product | Cost £k | Growth | Probability | Value £k |
|---|---|---|---|---|
| A | 18 | High | 0.6 | 33 |
| | | Low | 0.4 | 19 |
| B | 20 | High | 0.5 | 30 |
| | | Low | 0.5 | 18 |
| C | 15 | High | 0.7 | 25 |
| | | Low | 0.3 | 15 |

Answer

(a) The decision tree is as shown in Figure S.2. The values of the outcomes at each leaf are the net benefits of the whole path from decision to the end of the path. Note that the value of an outcome can be negative.

(b) The values of the EMV for each decision are also shown on the figure: £9400, £4000 and £7000.
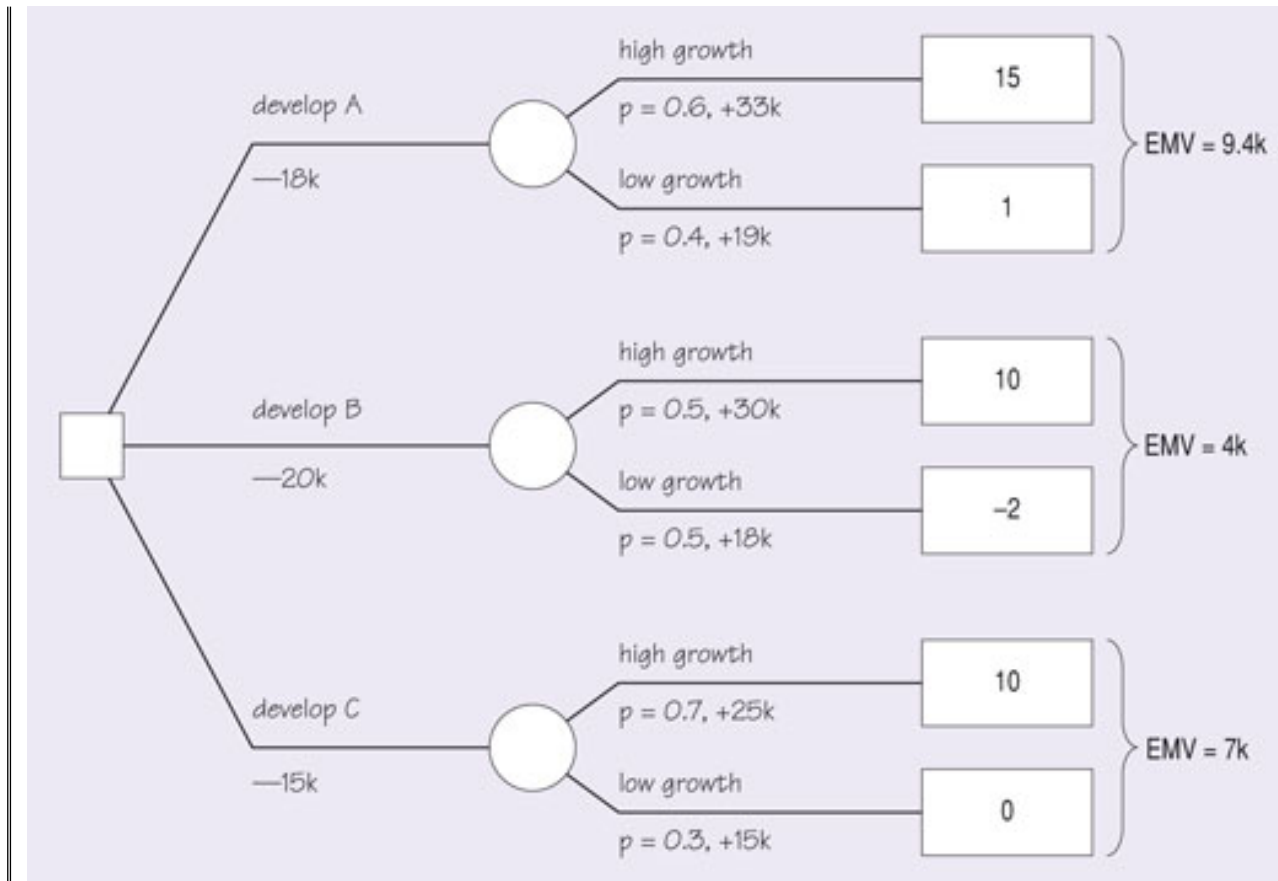
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Figure S.2 Decision tree for three products

The users of the decision trees shown so far have had only one decision to make. This has been the decision shown at the left-hand side of the tree. However, a decision tree can be more elaborate and include further decision nodes, representing further decisions that you will have to make along the route to the outcome. Such a tree is shown in Figure 10, where the primary decision is to choose between the development of two products, A and B. We have already seen product A in Figure 9

If you choose product A you still have to decide whether or not to buy a package as discussed earlier.
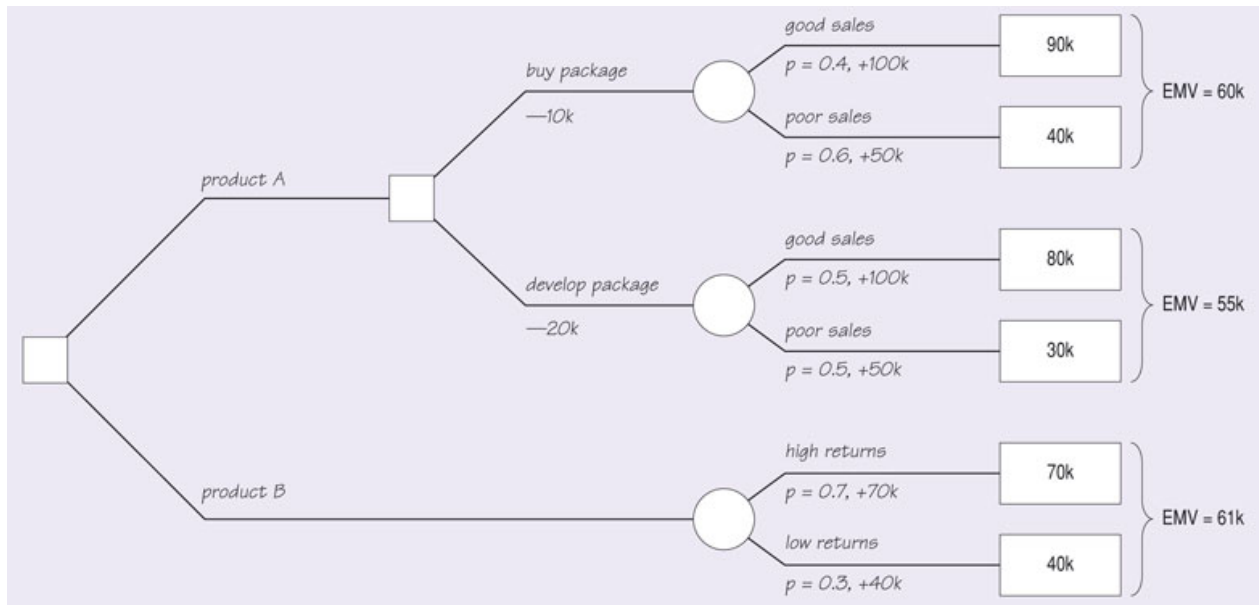
Figure 10 A tree with more than one decision node

The way to tackle such trees is to look at the subsidiary decision first. In fact we have already done this for product A, and found that the EMV of buying a package was higher than the EMV of developing one, so we conclude that at that decision point we will take the higher-value branch. The tree can then be simplified by cutting out the irrelevant branch and removing that decision node. Since the EMV of product A, as found in Figure 9, is at best £60 000, the decision tree of Figure 10 now indicates product B as the higher-valued choice. (As with all such decisions you must remember the likely accuracy of the estimates, and there may be other, non-monetary, reasons for choosing product A.)

In a tree that has a number of subsidiary decisions you would need to eliminate each node in turn until the tree is reduced to the principal decision, all the other decisions having been taken on the way that gave the optimal value.

# Proposal ranking formulas

The technique of *proposal ranking formulas* is unsophisticated and suitable only when fairly low expenditure is being considered. The viability of different proposals is compared by ranking them in order according to payback time or rate of return.

# Proposal selection index

Proposals can be ranked according to a proposal selection index of the form:

$I = P_T 6 P_C 6 NPV$

where $P_T$ is a measure of each proposal's anticipated technical success, $P_C$ is a similar measure of anticipated commercial success and NPV is the anticipated net present value of each proposal.

# Checklists

Checklists of the type shown in figure can be used to assess various aspects of a number of proposals – in this case R & D proposals – and then used to make comparisons between the different options.

KEY

1 = Unacceptable

2 = Unfavourable

3 = Adequate

4 = Favourable

5 = Most favourable

| Economic merits | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Estimated sales revenue | | | | | |
| Production costs | | | | | |
| R & D costs | | | | | |
| Capital investment | | | | | |
| Return on capital | | | | | |
| Risk level | | | | | |

| R & D implications | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Probability of success | | | | | |
| Degree of novelty | | | | | |
| Company's existing know-how | | | | | |
| Time to develop product | | | | | |
| Manpower requirements | | | | | |
| Patent status | | | | | |

| Production implications | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Process familiarity | | | | | |
| Process flexibility | | | | | |
| Compatibility with existing operations | | | | | |
| Equipment availability | | | | | |
| Raw materials availability | | | | | |
| Production hazards | | | | | |
| Freight or transport problems | | | | | |

| Marketing implications | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Market size | | | | | |
| Market variability | | | | | |
| Number of customers | | | | | |
| Number of competitors | | | | | |
| Growth rate | | | | | |
| Compatibility with existing products | | | | | |
| Promotional requirements | | | | | |
| Product adaptability | | | | | |
| Competitors' ability to imitate | | | | | |

Figure 11 A project comparison checklist (after de la Mare, 1982)

# Measured checklists

This method is almost identical to the previous one but instead of various aspects being rated on a scale that stretches from 'unacceptable' to 'most favourable' they are scored

numerically. An example of a measured checklist, again for an R & D project, is shown in Figure 12.

| | | | | | | | | | | Score |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Peak sales revenue | Value (millions) | 0.5 | 1 | 2 | 5 | 10 | | | |
| | | Score | 10 | 40 | 80 | 130 | 190 | | → | ............ |
| 2 | Production costs (as % of 1 above) | % | 20 | 30 | 40 | 50 | 60 | | | |
| | | Score | 60 | 40 | 20 | 10 | 0 | | → | ............ |
| 3 | Capital investment (as % of 1 above) | % | 0 | 50 | 75 | 100 | 150 | | | |
| | | Score | 50 | 40 | 30 | 20 | 10 | | → | ............ |
| 4 | R & D costs | Value (units) | 10 000 | 50 000 | 100 000 | 300 000 | 500 000 | | | |
| | | Score | 150 | 100 | 60 | 30 | 0 | | → | ............ |
| 5 | Extent of competition | Degree | none | slight | moderate | appreciable | extensive | | | |
| | | Score | 100 | 70 | 50 | 20 | 0 | | → | ............ |
| 6 | Synergy with existing products | Degree | negative | none | little | appreciable | extensive | | | |
| | | Score | −20 | 0 | 5 | 10 | 50 | | → | ............ |
| 7 | Production know-how | Degree | most inadequate | needs training | adequate | more than adequate | most appropriate | | | |
| | | Score | −10 | 0 | 5 | 10 | 20 | | → | ............ |
| 8 | Probability of technical success | % | 20 | 40 | 60 | 80 | 100 | | | |
| | | Score | 0 | 30 | 40 | 50 | 60 | | → | ............ |
| 9 | Market acceptance of product | Degree | much resistance | some resistance | neutral | willing acceptance | ready acceptance | | | |
| | | Score | −50 | 0 | 10 | 20 | 50 | | → | ............ |
| 10 | Project/product life | Product life (years) | 2 | 5 | 10 | 15 | 20 or more | | | |
| | From R & D time to build sales to 50% peak | 0.5 | 100 | 120 | 140 | 160 | 180 | | → | |
| | | 1 | 80 | 100 | 120 | 140 | 160 | | → | |
| | | 2 | project infeasible | 80 | 100 | 120 | 140 | | → | |
| | | | | | | | | | | → ....... |
| | | 3 | project infeasible | 60 | 80 | 100 | 120 | | → | |
| | | 5 | project infeasible | project infeasible | 60 | 80 | 100 | | → | |

| Standard ratings: more than 600 excellent 500–600 good 400–499 fair less than 400 poor | | | Total score = | |
|---|---|---|---|---|

Figure 12 A measured checklist (after de la Mare, 1982)

# Limitations of techniques

One of the main problems associated with these and similar techniques is that they all require estimates to be made of the cash flows that will be realised throughout the economic life of a project and also of the probabilities of the different outcomes. Putting this another way, they assume, for a capital investment project, say, that it is practicable to supply the information shown in Figure 13. This may patently not be the case when a proposal has not even reached the drawing board stage. The costs of gathering such information are usually too substantial to be incurred lightly. Sometimes the only alternative is to accept the risks that are inherent in making decisions based on hunches and incomplete information and to try to keep some of the rejected options open until the front-runner has been evaluated more fully. Another approach is to use sensitivity analysis, in which we try out different values for some of the main parameters and see how these affect the final decision. Hence, we can determine how sensitive the result is to variations in the data and can make more informed decisions.
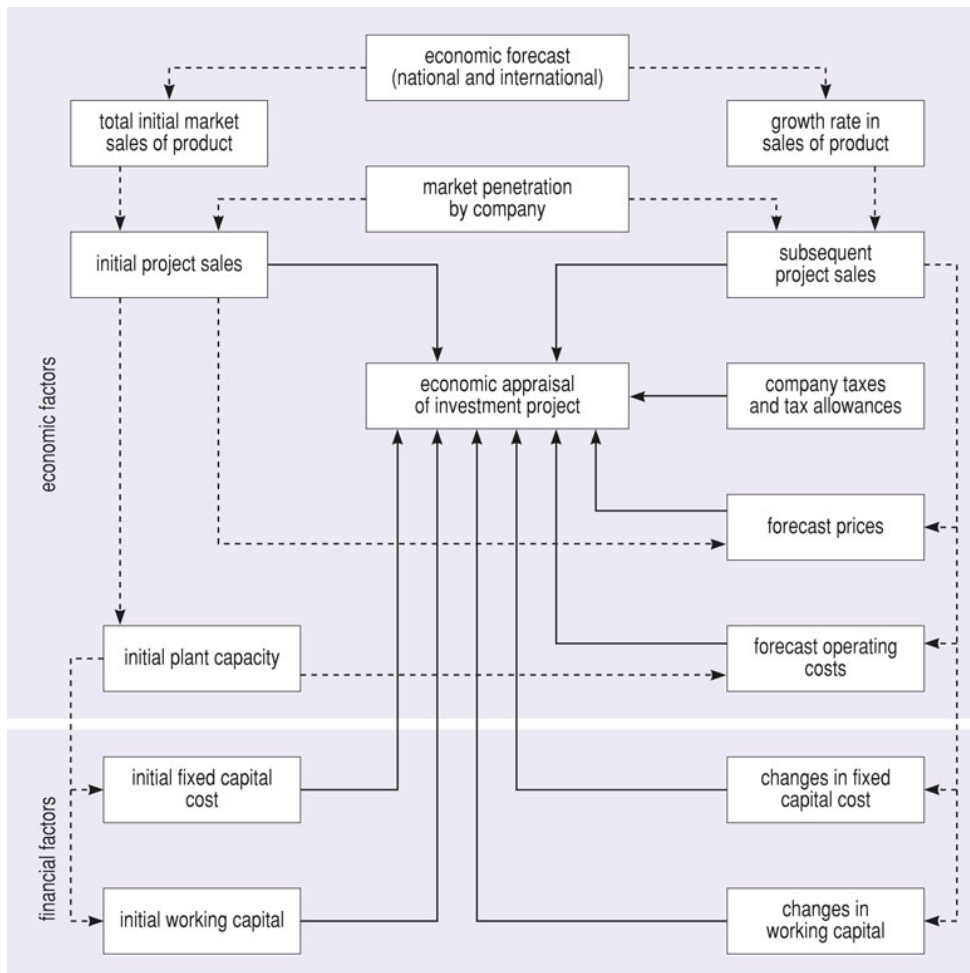


Figure 13 The information needs of a prospective capital project (de la Mare, 1982)

## 3.3 Summary

The creation of a project from organisational plans through proposals to decisions is often a protracted process which in itself calls for the use of special management skills and

techniques. Certain questions need to be asked; these are shown in Figure 14 and they are phrased in everyday jargon-free language. The decision maker in the diagram is the person or people responsible for authorising a proposal.
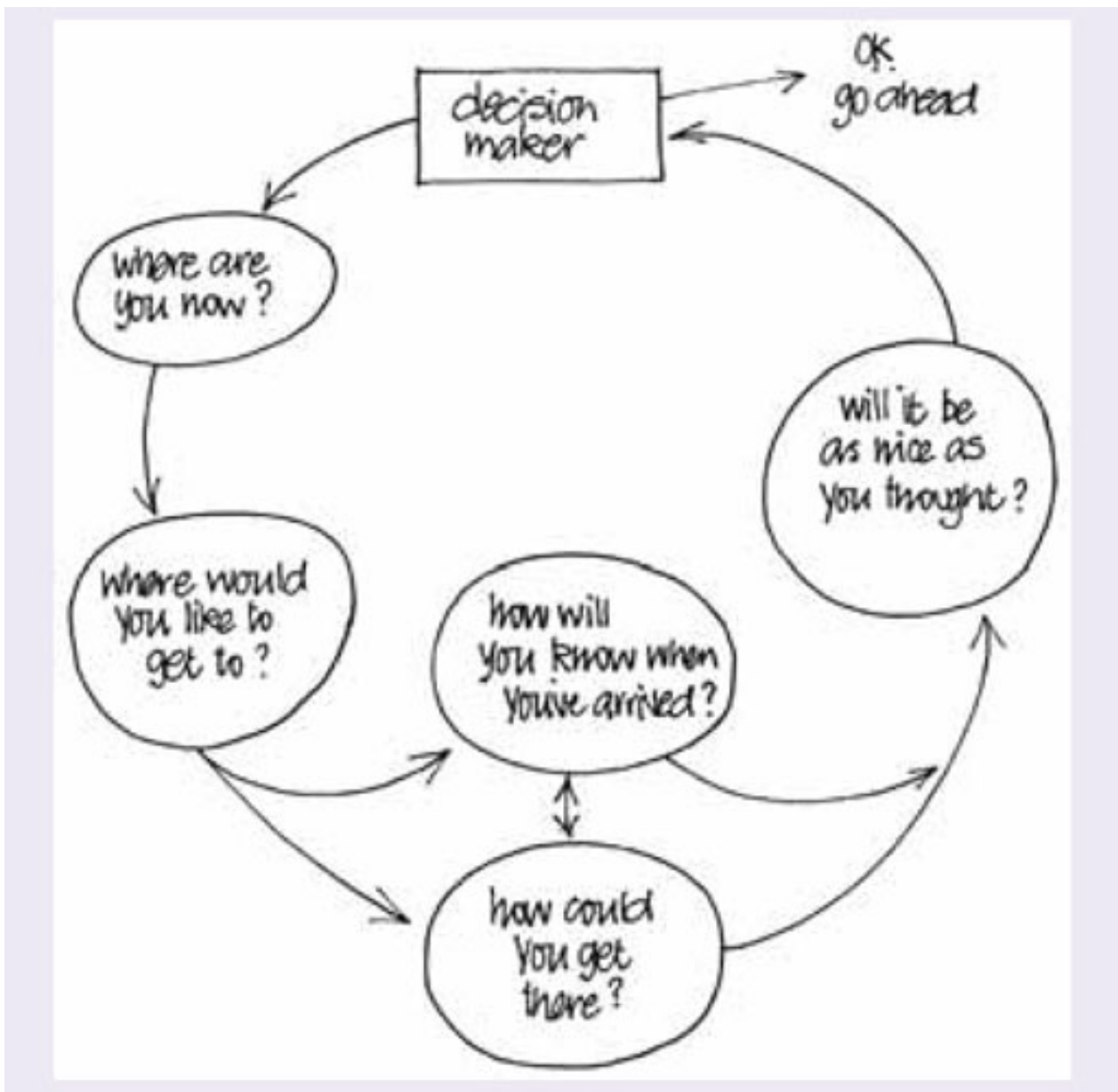


Figure 14 Decision maker's questions

If we define a project as the means whereby an existing state of affairs is transformed into a desired state of affairs, then before the project begins we have to be able to specify both the existing and the desired states. The difference between the two defines what needs to be done. Even in cases where the existing and desired states of affairs are the same, the organisation must be aware that the desired state can deteriorate in the future into something undesirable. In such a case the organisation needs to do something to prevent the future adverse state of affairs from arising. Of course the gap between an existing and a desired state of affairs is not necessarily sufficient stimulus to cause an organisation to embark upon a project: the organisation will pay attention to those problems and opportunities which the value system of that organisation suggests are important.

When proposals reach a stage where a decision is required it is important to base the decision on solid evidence and to avoid political expediency and the personal inclinations of the decision maker. A proposal needs to demonstrate an internal consistency: the parts need to fit together in a way which suggests that no part is grossly out of scale with the other parts. Decision trees can assist in guiding decisions, as can proposal-ranking formulas (when expenditure is estimated to be low), selection indexes, checklists and measured checklists. However, all these techniques require estimates of cash flows to be made for the economic life of a project: something that may not be feasible at the time the decision whether to proceed is required. Sometimes it is necessary to accept that a decision can be based on incomplete information. If that is the case, then it is important to keep other options open.

Having studied this section, you should be able to:

- describe an appropriate model for deciding which proposal to pursue
- explain why it is necessary to calculate profitability in the same way for proposals which are being compared in order to choose from them
- calculate expected monetary value (EMV) for possible outcomes in a decision tree
- explain how proposal-ranking formulas work
- use a checklist or measured checklist
- state the main limitation of these techniques
- list some of the questions a decision maker needs to ask before making a decision.

# 4 Projects: the life cycle, the project manager and success

Once a feasibility study has been undertaken, presented to management and then identified as an area in which a programme of change or one or more projects should be authorised, we should be able to identify the project's 'birthday' and think about the life that lies ahead.

## Learning outcomes

At the end of Section 4, you should be able to:

- describe the basic and extended life cycles that are used for the management of projects
- describe the product life cycle and understand the potential variation in the processes used for different products
- list the criteria and factors that are used to promote project success
- list the main activities and tasks of a project manager.

# 4.1 Project life cycles

Buchanan and Boddy said that a project is: 'a unique venture with a beginning and an end' (1992, p. 8). The bit in the middle is where most of the work is done. We say that a project has a *life cycle*, based on an analogy with living things which are born, grow, live for a period of time doing things such as consuming food and water, breathing, moving, and then finally end (death). The concept of a birthday is readily associated with the formal approval of a project, which is often associated with a contract between the client and the supplier. A fuller analogy with living things, like humans, involves a project's conception and the gestation period before it is born. Different kinds of animal have variations in their particular life cycles and, just like projects, every living thing is unique in some sense or other.

There is much discussion about whether there is only one 'true' model of a project life cycle or many, and whether any of these are reasonably accurate descriptions of what happens in real life. Some writers include the feasibility study as part of the project life cycle; others believe that the project proper only begins once the feasibility study is completed and the proposal accepted, or only when cost codes and a budget for the project are defined by the company accountants. We will use the point of conception, even though the actual circumstances can make that gestation period rather cloudy or uncertain. The practical starting point is often considered to be the birthday, since management normally give approval after they have been presented with the feasibility study and decided to go ahead with further work. If you find it helpful, you can think of the work needed to carry out a feasibility study as being a mini-project in its own right.

Even with the best of plans and most stringent of controls, real life is always more chaotic than the models we apply to it; the same is true of projects. Nevertheless, in the case of projects, models are useful to help us recognise different ways of moving from the project's beginning to its end, and the broad phases where the activities that take place change from one type to another. Each activity will be undertaken using a known procedure at a given level of formality, starting with a number of inputs from preceding activities that are the basis for further work. On completion of an activity there may be one or more outputs, which are known as deliverables (because they are needed for other activities). So, the order in which these activities are carried out is called a **life cycle**, which outlines the overall process for a given project. A **phase** is the term used to describe a set of interrelated activities that are needed to achieve a particular outcome or deliverable. When a life cycle includes a number of phases, it is usually because some form of evaluation or review is needed to decide when each phase is completed.

There is no single life cycle that applies to all projects, although certain types of project will be associated with a particular life cycle. We begin by describing a basic life cycle and then discuss some variations, which may provide an appropriate model for a given situation. We will use the characteristics of software to illustrate that a project's outcome is more than just a physical object.

In practice, the description of a life cycle may be very general or very detailed: some might only suggest what to do, while others might prescribe what must be done. Highly detailed descriptions might involve numerous forms, models, checklists and so on which have been associated with the term *project management methodology* (see, for example, PMI, 2004).

# The project life cycle

Many writers use four phases when considering life cycles in relation to project management. Turner, for example, used the life cycle of a plant as an analogy to that of a project (1999):

**Table 10**

| Stage | Name of phase |
|-------|---------------|
| Germination | Proposal and initiation |
| Growth | Design and appraisal |
| Maturity | Execution and control |
| Death | Finalisation and closeout |

Other writers, such as Weiss and Wysocki (1994), look at the core activities to come up with five phases such as define, plan, organise, execute and close. The change from one phase to the next is not necessarily abrupt. When there is significant overlap in time between activities in different phases (for example, when planning activities continue at the same time as the organisation is under way and execution may even have begun), we say that these activities exhibit **concurrency**. Since changes are an inevitable fact of project life, there will also be times when activities such as estimating or even recruiting or assigning work have to be done again in response to such changes. The overlapping of phases is also called *fast tracking* (PMI, 2004) as it allows the project to be completed in less time than following a strict sequence of phases.

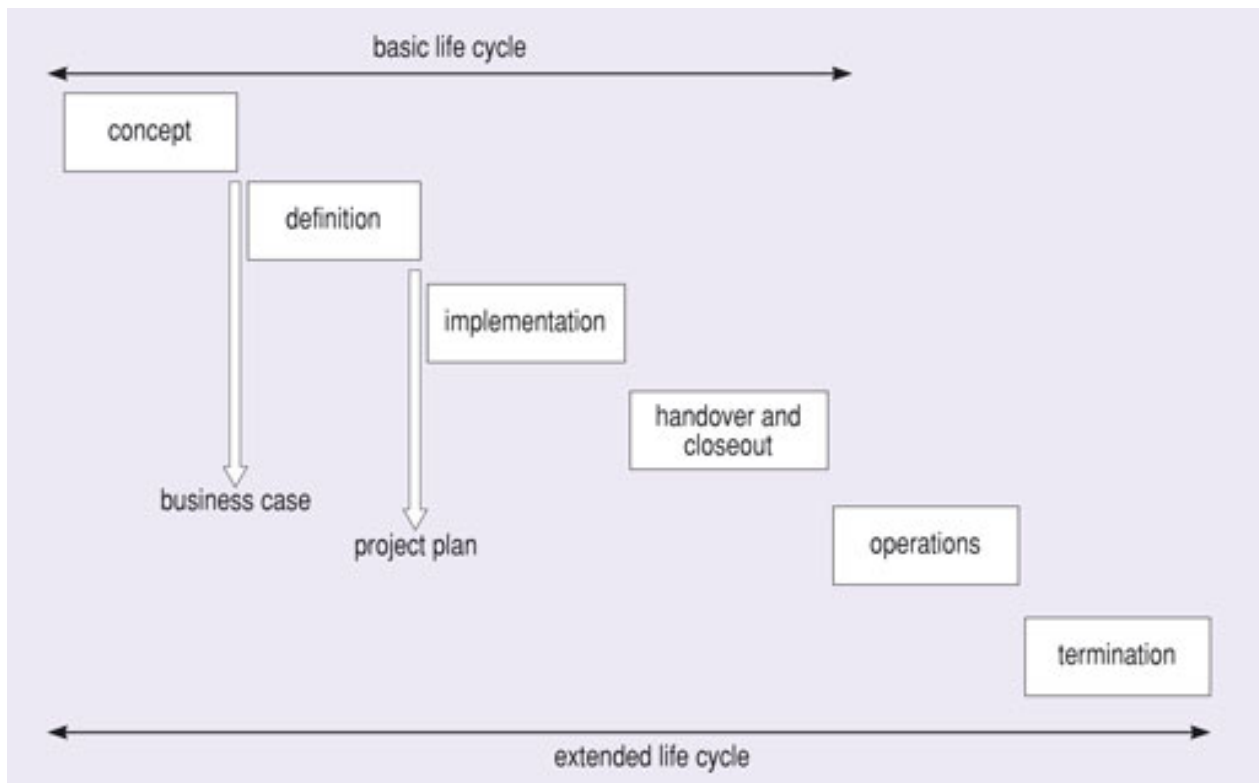The *basic life cycle*, which will fit many projects, is shown in Figure 15.



Figure 15 The basic and extended project life cycles

The generic sequence of phases in the basic life cycle involves (APM, 2006):

**Table 11**

| Concept | The need, problem or opportunity is established for the proposed project. Proposals are prepared and then tested for feasibility. Sufficient plans are made to enable a 'go/no-go' decision to be made, often in the form of a business case that is owned by the sponsor. The decision forms the end of the stage. |
|---|---|
| Definition | Some plans and general costs, of course, will have emerged from the previous phase, but more refinement will need to be done in this phase to create a plan that can be used by the project manager. During the iterative evaluation and optimisation of the preferred solution, the project's scope, time, cost and quality objectives can be affected as the requirements are elaborated in greater detail. |
| Implementation (also known as execution) | The project management plan is put into action. The design of the project deliverables is finalised so that each one may be built. The important activities are: communication with stakeholders, monitoring costs, controlling quality and identifying and managing changes. This is the busiest phase of just about every project that uses the basic life cycle. |
| Handover and closeout | The final project deliverables are handed over to the sponsor. For example, the new facility is installed on the customer's premises. Once the deliverables have been formally accepted, the responsibility and ownership shift from the project team to the sponsor or users. At this point, the project can be reviewed in order that lessons may be learnt from the stakeholders' experiences. |

The *extended life cycle*, which is also known as a product life cycle, also shown in Figure 15 involves supporting and maintaining the deliverables in order to realise the project's intended benefits. The extended life cycle adds two more phases to the sequence (APM, 2006):

**Table 12**

| Operations | The period during which the completed deliverable is used and maintained in service for its intended purpose. |
|---|---|
| Termination | The disposal of the project deliverables at the end of their life. |

Projects related to special events, such as an annual conference or a sporting event, make use of the extended life cycle.

## Deliverables have life cycles too

Each of the project's deliverables, whether it is one that is handed over to the client or one that is produced from one of the intermediate activities, has a life cycle. Such deliverables tend to follow a product life cycle, which is much broader in terms of its general scope than the basic life cycle for a project (Dawson, 2000):

**Table 13**

| Analysis | The initial investigative work done for the product – its idea, feasibility, definition and planning. |
|---|---|

| Synthesis | The work done to develop (and test) the product. |
|---|---|
| Operation | The implementation, use and maintenance of the product. |
| Retirement | The final withdrawal and replacement of the product. |

In general, these four stages are not mutually exclusive and there are common activities that lead to overlaps between stages. For example, a manufacturing organisation might initiate a project to develop and install a new production line. A phased implementation of the new equipment would lead to an overlap of the operation and retirement stages: between the reduced operation of the current production line and the pilot operation of the new one.

In addition, there will be a substantial amount of variation in the product life cycle because of the huge variety in the deliverables needed for projects in the real world. At the time of writing, for example, a new building is being constructed at The Open University for members of the Computing Department and the Institute of Educational Technology. At the same time, there are a number of software applications being developed to support students' learning online. While there may be similarities between the life cycles involved, the actual processes used in construction and software projects have very little in common.

Space does not permit a detailed discussion of the processes used to produce the huge variety of deliverables. However, Section 6 contains a discussion of the different approaches used in software development, which may be used to compare the life cycles and processes used in other industries or problem domains.

## Reviews and learning from your experiences

**Reviews** are a means to assess or make a survey of something. They give you a chance to reflect on what you have just done or produced (such as an assignment). For example, reviews are for testing whether or not the objectives specified in the project plan have been achieved, as well as assessing the achievement of the benefits identified in the business case. The effectiveness and efficiency of a review are improved by having a single focal point. A gate review, for instance, is a formal point in a life cycle where a decision is made whether to continue with the next phase of the project (APM, 2006). Figure 15 indicates that the business case will be the first, formal deliverable to be given a gate review.

Reflecting on your experiences is an important step in learning, which is exemplified in Kolb's learning cycle (1984):

- concrete experiences, followed by
- observation and reflection, leading to
- formation of abstract concepts and generalisations, leading to
- testing of the implications of concepts for future action, which then lead to new concrete experiences.

The learning cycle refers to the process whereby you step back from an activity and review what has been done and experienced. After interpreting the events that have been observed, and making some sense of the relationships among them, you take the opportunity to refine how the original activity might be performed better in the future. In general, the learning cycle implies that making lots of small, incremental improvements may turn into major improvements over time. As a student, for example, you might engage

in the learning cycle after each day's work. Just one thing done differently next time could lead up to 365 improvements over a year!

In Kolb's model, it is assumed that learning takes place when you pursue goals that are appropriate to your needs. So, you should look for experiences and interpret them in the light of those goals. It follows that learning becomes erratic when the goals are not clear. As a result of different behaviour patterns and work experiences, individuals will make different assumptions about what they see and understand through their experiences.

An activity or set of activities, like reviewing the business case, is a potential turning point for the work leading up to the final product. The internal relationships between different stakeholders may lead to misinterpretations of and misattributions to the meanings of the document. The potential consequences are confusion and frustration, which will not make for a healthy project. So, taking stock of the business case is an early chance to assess what might happen in the project as a whole, as well as getting the stakeholders to reflect on their experiences of the conceptualisation of a project.

# Project classification

When making a case for a new project, part of the work includes the choice of life cycle to use in order to achieve its goal and objectives. If an organisation has been using projects for some time, it is likely that it has developed a particular life cycle for the kinds of project that are approved. The simplest way to classify projects is by industry: for example, construction, mechanical engineering, software development, banking or health care.

At the same time, it is also possible to think of projects in terms of their outcomes, which might be some form of product or service. However, the outcome of many projects has been a combination of products and services. For example, the National Health Service in the UK has sponsored a project for a new service that allows general practitioners to make hospital appointments for their patients in real time (service). In order to achieve the project's objectives, a new software application (product) was developed. Hence, we might consider that one way to classify a project is according to the particular result or outcome that we want to achieve. In addition, it is also reasonable to include a consideration of the means by which the desired outcome is to be achieved. By combining a consideration of means and ends (answering the *how?* and the *what?* questions) for a project, there would be four classes of project according to how much is known about what you are trying to achieve and how you are going to achieve it.

In practice, the two extremes permit a simple qualitative assignment of a project into one of four classes. The use of a metaphor for each class of project helps stakeholders engage in it, which Obeng (2003) employs as follows:

**Table 14**

| Type of project | Description | Example |
|---|---|---|
| Painting by numbers | Most stakeholders are sure of what to do and how it is to be done. The project proceeds linearly and sequentially. | Housing construction by a well-established building firm |
| Going on a quest | Most stakeholders are sure of what to do, but are rather unsure about how to achieve it. The project proceeds concurrently and converges according to particular deadlines. | Outcome based on prototypes (like research and development) |

| Making a movie | Most stakeholders are very sure of how to do the work, but not so sure about what is to be done. The project proceeds through a number of checkpoints where clarification is sought before moving on. | Developing new products for the market |
| --- | --- | --- |
| Walking (or lost) in the fog | Most stakeholders are unsure of both what is to be done and how it is to be carried out. The project proceeds with care, 'one step at a time'. | Doing something new for the first time such as a quality or process improvement programme |

As you will see in Section 4.2, such a means of project classification is associated with the two main perspectives that are used to evaluate whether or not a project is successful.

# 4.2 Promoting project success

There has been a substantial amount of research into the evaluation of projects, particularly since the media have a long tradition of reporting on project failures. A number of researchers have established a set of factors which, taken together, indicate that a project has a high likelihood of success. The research is complicated by the fact that different stakeholders give different evaluations of the same project. Furthermore, such evaluations have been found to change over time (see, for example, Fortune and White, 2006).

The two main perspectives on project success follow the simple classification identified in Section 4.1:

- **Success criteria** are those related to the *what?* question, and are a mixture of qualitative and quantitative measures.
- **Critical success factors** are those related to the *how?* question, and are to be found in the project and its environment (a change in any factor is readily linked to project risk).

The success criteria can be identified as part of the case made for a project. Once it has started, the project manager will also have to consider those success factors that will have an influence on the project as it proceeds.

In the broadest sense, project success is about the satisfaction of all the stakeholders. In practice, the success criteria are associated with the basic characteristics of a project so that it can be more readily quantifiable. That is to say, project success is narrowed down to an assessment of whether the time, cost and quality constraints have been met.

Success criteria will differ from project to project according to an understanding of issues relating to their size, complexity and uniqueness. Hence, there is no single checklist that can be used for every project. Most research, such as Turner (1999) and Wateridge (1998), has focused upon the range of criteria from the most readily quantifiable to the broadest qualitative criteria according to the following descriptions:

- the facility is produced to specification within budget and on time
- the facility/project achieves its business purpose and meets
- the project team is happy during the project and with the outcome of the project
- users are happy during the project and with its outcome
- the project is profitable for the contractors
- the project satisfies the needs of stakeholders.

Fortune and White (2006) have reviewed the research into critical success factors and found a set of relationships that can address the fact that each factor can vary over time.

**Table 15**

| Project attributes from a systems viewpoint | Critical success factors |
|---|---|
| Goals and objectives | Clear realistic objectives |
| | Strong business case/sound basis for project |
| Performance monitoring | Effective monitoring/control |
| | Planned close-down/review/acceptance of possible failure |
| Decision makers | Support from senior management |
| | Competent project manager |
| | Strong/detailed plan kept up to date |
| | Realistic schedule |
| | Good leadership |
| | Correct choice/past experience of project management methods/tools |
| Transformations | Skilled/suitably qualified/sufficient staff |
| Communication | Good communication/feedback |
| Environment | Political stability |
| | Environmental influences |
| | Learning from past experiences |
| | Organisational culture/structure |
| Boundaries | Project size/level of complexity/number of people involved/duration |
| Resources | Adequate budget |
| | Sufficient/well-allocated resources |
| | Training provision |
| | Proven/familiar technology |
| | Good performance by suppliers/ contractors/consultants |
| Continuity | Risks addressed/assessed/managed |
| General | User/client/sponsor/champion involvement |
| | Appreciation of different viewpoints |
| | Effective change management |

The sense of uniqueness with regard to projects indicates that each of the above factors will affect projects in different ways. A business case, for example, might contain a prioritised list of critical success factors to reflect the context in which the proposed project will take place. For each critical success factor, it may be possible to identify a qualitative or quantitative measure that can be monitored during the project. Any variation beyond a given threshold for a particular critical success factor can be interpreted as placing the project at risk.

## 4.3 Why manage projects?

It is necessary to develop a specification of what is to be done. (It is important to be aware of the iterative nature of this activity: pilot studies, feasibility studies, the project itself, specifying changes that will inevitably occur while a project is under way, all these result in the need to modify the specification of what is to be done.) In this course we have discussed ways of identifying what is to be done and, at the highest level, how that should be done

Proposals need to be 'scoped' (for effort, elapsed time, cost and likely effects) at an early stage. We discussed this briefly at the start of Section 3.1. Projects that continue after a successful review of their proposals also need to have effort, time, cost and effects planned, and dependencies between tasks and between resources and tasks identified.

Once a project is planned and perhaps put out to tender, it is necessary for the relevant parties to agree what is to be done, by when and at what cost – the contract. It may be an informal contract between different departments of the same organisation or a formal, legal instrument drawn up between two or more organisations.

Effort has to be coordinated and communication has to take place among all the 'players'. It is necessary to organise and manage the team – direct it and coordinate its efforts. It is also necessary to liaise with clients, senior management, potential users and others.

Once a project is under way, it becomes necessary to control the process of getting from plan to reality. Most projects require some degree of change in what they are undertaking even as they progress, so it is also necessary to correct the course of the project in a controlled way.

A disciplined approach is very important in achieving a project's goals and objectives.

## 4.4 What does a project manager do?

What follows is a broad description of the major areas a project manager is concerned with, and the knowledge, skills and tools a project manager will need.

Project management is quite different from line (so-called 'system') management. As noted earlier, projects are designed to change something: the manager must be able to cope with the risk inherent in managing such changes. People working on the project may come from other areas; indeed, they may be contractors or subcontractors or employees of member firms in a consortium.

## Estimating and planning

The project manager, or someone under his or her direction, has to collect information about what exactly needs to be done and how it is to be organised; how much it will cost and how long it will take; and then look at the interdependencies of various tasks, skills and other resources. The results are a project plan and a project budget.

## Assembling a team

A project team can make or break a project. Often the project manager has little say in who works on the project: the team will be assembled from people with the right skills (if they are available) who are not assigned to work of a higher priority than the project. Even

if the project manager has a free choice, the pool of people from whom he or she can select is limited. A project manager's skill lies in assembling a group of people and making them into a team – motivating them, managing conflict among them and ensuring good communication.

## Stakeholder management

Following the definition of a stakeholder, which was given in Section 2, we should note that the project manager is responsible for managing the relationships with the stakeholders (of which the team is a subset). Thus, communication is an essential skill for a project manager to negotiate with and influence stakeholders.

## Reporting and liaising

The project manager is the spokesperson for the project. It is his or her job to liaise with senior management, clients, regulatory bodies and everyone who contributes to the project.

## Putting tools in place

A number of tools exist to help manage and control projects, and to undertake estimating and reporting. Specific tools also exist for specific types of projects: in the case of software projects tools range from appropriate hardware and operating system software, through language compilers and test harnesses to computer-aided software engineering (CASE) tools. The manager has to see that the appropriate tools for the job are available or obtained.

## Managing and coordinating work

Once the project work begins, the project manager's job is to manage the work that is done and to coordinate the efforts of different team members and different bodies within the organisation in order to achieve the project's objectives.

## Managing change

Few, if any, projects end exactly as they were initially planned. Problems arise that require changes to plans: these may be short-term (for example, delaying a particular task because a necessary material or resource is not available at the right time) or long-term. The users or clients may change their requirements as they learn more about the product they will be receiving at the end of the project. The regulatory, legislative or financial climate in which the project operates may change during the execution of the project. Unless someone – normally the project manager – institutes a formal way of noting, estimating and carrying out approved changes (change control) the project can deteriorate into chaos. In a more formal project setting, the responsibility for approving or rejecting changes is given to a group of stakeholders known as a change control board.

## 4.5 Summary

Projects rarely proceed smoothly through a series of well-ordered and well-organised phases to a perfect conclusion. Nevertheless, there is value in having a model for project life cycles. Projects can follow a basic or extended life cycle.

All projects take place in an atmosphere of at least some risk. The occurrence of adverse circumstances may mean that extra time, cost or some reworking of the project plans are required in order to complete it.

Even in the best-organised and run projects the distinction between phases is not always clear-cut: design may overlap to some extent with development, development with implementation, and implementation with operation. The project organisation has to be prepared for setbacks and has to plan so that those setbacks remain minor and do not become so major as to jeopardise the success of the project.

One thing that every project manager or person responsible for a project should do is to see which success factors are present for that project: the more factors present, the greater the likelihood of success. The management of a project is very important and includes a number of tasks that are the responsibility of the project manager: estimating and planning, assembling a team, getting the tools into place, managing and coordinating work, managing change and reporting and liaising.

Having studied this section, you should be able to:

- describe the basic and extended life cycles for managing projects and list some of the tasks that belong to each phase
- describe the product life cycle and compare it with the basic and extended life cycles
- list the areas in which to look for the presence of success factors in any project and state what these factors are
- list the main activities of a project manager.

# 5 Software development

For many years, buying a software application or system meant that almost all of the development was done from scratch. That is to say, each act of development was unique or bespoke, just like the engineering done in the early years of the industrial revolution. Nowadays, less and less software is being developed in this way. Instead, software applications are available in shrink-wrapped boxes containing a CD-ROM or are downloadable from the internet. These are known as commercial, off-the-shelf software or COTS for short. The term product line is used to denote a set of related products that are sold by the same company. Software has also become a major component of mass-produced items, such as motor vehicles, televisions and mobile phones.

## Learning outcomes

At the end of Section 5, you should be able to:

- understand why projects with software content are problematic and suggest ways in which phased development, prototype approaches or agile methods can help

- suggest reasons why projects with a software content are problematic
- describe the elements of a basic software development process
- describe the phased development life cycle
- draw up a brief plan for a phased development project based on a simple scenario of the project requirements
- describe the prototyping life cycle
- explain why agile methods might be chosen over proprietary methods for the development of software
- suggest ways in which phased development, prototype approaches or agile methods can contribute to the development of software.

# 5.1 Software is a different kind of product

Software is considered to be a rather intangible product, which is realised in the form of texts of various sorts: design documents, program code, user and operator manuals, forms and ultimately only in the observable actions of a computer system. Such systems may be highly complex, multi-functional and linked to a wide variety of other systems involving software, computer hardware and networks.

Intangibility and the notorious complexity of software make it prone to error. For example, increasing the size and complexity of the software increases the number of alternative pathways and has consequences for the probability that something might fail during use. If a particular component of the software is not thoroughly tested – something that can be impossible due to the amount of time it takes to test all possibilities in a complex program, or impossible to do because the circumstances in which that component should be activated are not possible to simulate for testing – the error will not appear until it is too late.

There is another factor, known as **malleability**, which contributes to the unique status of software. Software is easy to change. This malleability encourages the desire to change software rather than replace it, based on the assumption that it is easier or less costly to do so. However, every change that is made to the software introduces the possibility of new errors.

Errors in a program's logic, which may lead to a system failure, can often be traced back to errors in the requirements. The importance of requirements and their relationship with project definition has been known for some time. Morris (1996) compared information technology (IT) projects with other kinds of project and found that:

> IT projects do indeed pose a particular class of management difficulty. The essence of this difficulty is the way that information technology is so intimately bound to its organisational contexts. As a result, issues of organisational effectiveness and user involvement are both more complex and more prominent in IT projects than they are in most other project industries. This puts much greater emphasis on the tasks of project definition and user involvement in IT than in other project situations.

(p. 323)

One of the factors involved in such an evaluation is the operational or working life of a product. A new building, for example, is likely to be in use for more than one person's

lifetime. In contrast, a particular software product is rarely used beyond 10 years. Hence, the choice of life cycle is related to the expected lifetime of a proposed product. In broader terms, the choice of appropriate life cycle is context-dependent.

## 5.2 Development processes

The identification of a set of software engineering activities associated with the development of software is the key to meeting the potential diversity of users' needs. It is the primary mechanism for understanding and harmonising these, sometimes conflicting, demands on the development process. Each activity will undertake some clearly defined process, starting with a number of inputs from preceding activities that are the basis for further work. On completion of an activity there may be one or more outputs (deliverables). The sequence in which these activities are carried out defines an overall process for the development of a software application or system.

Through such activities we shall emphasise a disciplined approach to software development. This has three key elements:

- **methods**, which describe the technical activities required to develop software
- **tools**, which allow computer support for the methods
- **procedures**, which provide the glue that holds the methods and tools together; it includes project and quality management activities.

Project management and quality assurance activities are considered to be part of the life cycle of software development. They form an integral part of every software development project, no matter which particular life cycle is used.

A complete life cycle would take us from those first ideas about the need for a software system to its final withdrawal. We shall assume that a customer has assessed the feasibility of some initial ideas with a potential group of users and has decided that a software system *may* be required.

Space does not permit us to describe the many and varied methods used to develop software. They can be found in texts on software engineering such as Sommer-ville (2004). However, each one normally includes the following four activities:

1  **Analysis** This involves identifying the problem and deciding what needs to be done in order to solve it. You need to be able to include all that you consider to be relevant, which is similar to defining a system and its boundary.
2  **Design** You determine how you will solve the problem.
3  **Implementation** You act upon those design decisions.
4  **Testing** You apply what you have done so that you can determine whether or not you have solved the problem.

Some methods subdivide the above activities and some use different names, such as programming for implementation. However, by themselves, the four activities of analysis, design, implementation and testing are not enough to develop a good software system. Other activities are needed to a greater or lesser extent depending on the context, as you will see in this section. For example, you are likely, first, to break most problems up into smaller, more manageable chunks, and then deal with each one separately. If you do this to develop a software system, it will be necessary to bring the chunks together into a unified whole. This process is known as integration and is sometimes identified as a

separate activity. Sometimes, the act of delivering a software system is identified separately, especially when there are contractual implications such as payment.

We expect that a software system will change during its operational lifetime. This is the maintenance activity, which allows a software system to evolve in order to:

- correct errors
- adapt the software to a changing environment
- introduce enhancements required by the customer
- improve the software in anticipation of future change.

The four activities of analysis, design, implementation and testing are the backbone of the practices that turn software development into an engineering discipline. They are the activities you will see most often in diagrams depicting the life cycle of software development. Project management and quality management are the two additional activities that hold the process of development together – the all-important glue for software engineering activities. Maintenance will inevitably involve the activities of analysis, design, implementation and testing, and will itself require managing.

When the five activities of analysis, design, implementation, testing and maintenance are arranged into a *single sequence*, this leads to the classic *waterfall model* for the development of software. But, even assuming that you can complete each activity completely (and correctly), the waterfall model has drawbacks. For instance, a working version of the software system will not be available until late in the testing activity. For larger projects, this could be significant, since it assumes that the customer is patient and the users are not concerned about the delay required to produce a working response to their requirements. In addition, any errors detected in the working version of the software could be disastrous. Real projects rarely follow a purely sequential life cycle.

An alternative life cycle iterates around one or more of its activities, while maintaining a core that uses a sequence of activities. **Iteration** allows the developers to improve the outputs from a given activity or set of activities according to the criteria used in the particular *iterative life cycle*. For example, iteration allows a group of people, usually developers, to perform a review of an activity or the outputs from that activity. In general, reviewing a proposed solution provides the feedback necessary to modify it and solve the problem correctly. Think what happens when you need to tune a guitar or violin. You pluck a string, a note sounds and you adjust the tension on that string. You repeat the process until you get the desired pitch. In practice, of course, you would then tune another string, using the same method, but this may mean that the tuning of the first string has to be repeated. Only when you are satisfied that all strings are individually and collectively tuned would you feel that the instrument, as a whole, has been tuned.

Another way of forming a life cycle involves partitioning a system into independent or semi-independent chunks, known as **increments.** Increments can be developed sequentially or in parallel, depending on circumstances. For example, a small team might choose to develop increments sequentially, according to a priority agreed with the users. Since it is not always possible to partition the users' requirements into independent chunks, some additional activities will be needed to manage the dependencies between the chunks. On large projects, a single developer may be allocated to this role. Each activity will involve identifying the interfaces that allow communication between one chunk and another. Such activities would coincide with the start of each increment and continue at regular intervals.

Incremental development is a way of dealing with the complexity of requirements that comes from the notion of breaking up a large problem into a number of smaller, more

manageable ones (known as **modularisation**). As part of the development process, there will be a number of tasks devoted to putting the pieces back together (integration).

A further refinement of incremental development is known as **timeboxing**, which is the act of setting a fixed-sized period of time in which to achieve an objective. By giving each timebox its own deadline and budget, the intention is to make or deliver something (Stapleton, 1997). The people assigned to each timebox will typically have the freedom to decide how to achieve the objective. As long as there is agreement with the customer or users, a deliverable may be modified in order to meet the deadline.

Whatever the chosen life cycle, it must reflect what actually happens rather than provide a theoretical model of some ideal approach to development. This is not to say that an idealised life cycle cannot be taken as a starting point. But it must be modified as necessary to reflect what actually happens. If this is not done, the project manager will not have an accurate framework for planning and activities will be included in project plans that do not actually happen, while other activities that do take place are excluded.

A method for developing software will provide an integrated set of techniques for carrying out the above activities (as well as any others included in any particular process) in a well-defined way. It will tell you:

- the notation to be used in each activity and the rules for using such notation
- the necessary inputs and outputs (deliverables) required for each activity
- the process to follow; that is, how the activities combine to produce the desired result.

The life cycle provides the framework for the project plan, while the method should allow detailed planning of both the software development process and the quality assurance activities. In principle, a method might be assumed to address every activity and every deliverable product in the life cycle. In practice, this is seldom if ever true. Some methods deal with only part of the development process such as testing, leaving out analysis and design.

By definition, a good software system must be fit for its intended purpose. It should be evident, therefore, that since software is needed for such a variety of purposes there is no single development process that will suit all purposes. For example, consider the following goals that might initiate some development activity:

- to control a series of gates at level crossings
- to control a manufacturing process for chemicals
- to manage an international stock market
- to manage a supermarket
- to manage a public lending library
- to administer the activities of a university
- to help you manage your personal finances
- to book your holidays.

The people who use these systems will have different views about what it means to have a software system that is useful, usable, reliable, flexible, available and affordable. So, it should be no surprise that there are different development methods for different types of system. Indeed, software companies often specialise in developing software for specific kinds of customer, such as education, banking or manufacturing.

The following two examples illustrate how the amount of formality in a development process varies.

## Example 9

Government legislation in the UK often requires software systems to be built to support the new administrative functions. When developers compete to supply such software systems, they are asked to conform to government-approved standards. One of those standards is known as PRINCE, which stands for PRojects INControlled Environments and relates to the management of projects and the quality of the developed software. Commonly, developers must be able to show that their development process conforms to the regulations set out in the PRINCE method. In addition, developers may be required to adopt an approved method for their analysis and design activities.

## Example 10

In certain financial areas, being first on the market to offer some new service is the way to make the most profit. In other words, the time-to-market is critical: miss out and your competitor takes the spoils. When the need for a software system is established for such instances, development is almost a race. Every aspect of the development process has to be tuned to meet the time-to-market. Thus the aim is to do the simplest things needed that could possibly work when delivered. It also means that communication must be minimised, so there will be very few developers (say, two) who work to a minimal set of agreed procedures. There must still be testing so that the software can perform its intended purpose. Better still, if the amount of actual code (Java or whatever the chosen language) is less, the lower the chances of introducing bugs. So, there are fewer tests to do. But there must be some documentation, unless the developers are not afraid of litigation!

Examples 9 and 10 show that it can be inappropriate to fix a development process for all kinds of product. In both examples, the amount of recorded information during development may be different. However, there is a common need to be able to reconstruct the significant events that happened during the development of the software system as you will see later.

Example 9 illustrates the need for a formal development process. Although it is a slow and deliberate course of action, the resultant software system must be able to deal with all the nuances of the legislation. The developers must be able to show that each aspect of the legislation has been incorporated into the final software system. The control and maintenance of the integrity of a project's deliverables (ensuring that they do not become corrupted or inconsistent) is the responsibility of the configuration management activity, which is related to the need for integration described above.

In contrast, Example 10 relates to software that is required for a very specialised purpose with a minimal development time. The developers have the benefit of a narrow scope for the software system, so they expect fewer changes to be introduced during the short development time.

In general, the size of a project influences the choice of development process. As illustrated in Example 10, the amount of formality in the process can be minimal. Small teams of up to eight people can communicate and respond to changes informally. In larger projects, such as in Example 9, a well-defined procedure for controlled development is necessary; an informal communication network on its own is not enough.

One approach to the solution of the problem of large projects is to split the group into smaller teams according to the responsibilities set out in a given development process. Just as modularisation is the way to deal with the complexity of a software system, developers can be assigned different activities and deliverables within a given project. Naturally, this partitioning allows developers to specialise and become analysts, designers, programmers and so on.

At some point in its operational lifetime, a software system will have outlived its usefulness. The developers should include a consideration of the expected lifetime of the software that they produce as part of the risk assessment for each project. In the case of Example 10, the time-to-market is a significant factor, whereas the expected lifetime is likely to be short (because of the nature of financial markets). So, a slow and deliberate development process is viewed as inappropriate in that context.

Iteration can also be applied to a life cycle as a whole. Taking a step back to consider a solution (software system) in a broader context allows you to manage the risks associated with a development project rather than ignoring them. For example, if delays cause the team in Example 10 to miss the market window, it does not matter how much software has been developed, as it is no longer of benefit to the customer and the users.

In a typical project, the major risks are around the requirements. Do you understand them? Have you identified them all? Are they changing too frequently? Anything that you can do to increase your confidence that the requirements you have are both necessary and sufficient can reduce the risk of project failure. You have already seen how prototyping can help in requirements analysis. In general, for every decision you make, there is a risk that your decision is wrong or, at least, inappropriate. This is where a review helps. If the risks cannot be overcome, the project cannot succeed.

In any project there is likely to be a trade-off between what can be delivered in a given time and to a specified budget. Often, the number of desirable features of a solution exceeds those that can be delivered for a given price and within a given timescale so choices have to be made. One way to make such choices is to estimate the risk of not delivering each feature. That is, if a feature were not to appear in the final product, what effect would this have on such things as the usability, usefulness, reliability and flexibility of the product?

## The phased development life cycle

Phased development is a strategy in which the activities of requirements determination, the evaluation of alternatives, design specification and the implementation of the design are repeated in several iterations. Thus it forms a series of closely linked mini-projects (though each may be of considerable size). At the end of each mini-project some portion of the overall project is implemented and reviewed by the users. The feedback from the review is used to help determine the requirements of the next mini-project. Figure 16 shows diagrammatically the life cycle of a project carried out as four mini-projects, each forming a phase of the overall project.
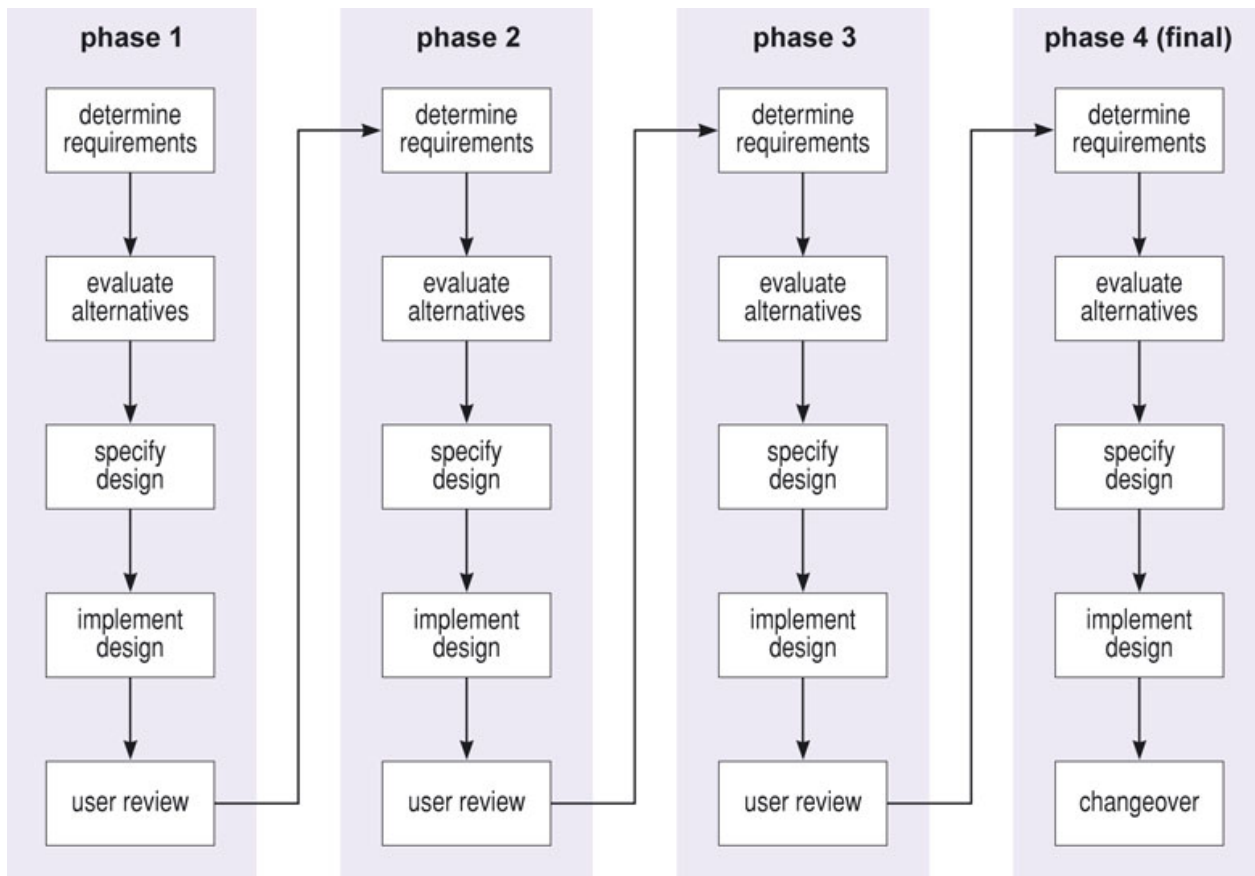
Figure 16 A phased development life cycle (Jordan and Machesky, 1990)

An example will illustrate this. A large insurance company decided to automate the handling of insurance claims. After initial discussions, they decided to undertake the automation in phases.

There were a number of reasons for this:

- previous attempts to automate major functions had resulted in serious problems arising, which had proved costly to fix
- the resources available to undertake the work were few, so there was no possibility of making a concentrated effort to achieve complete automation in the course of a single project
- the disruption to the normal flow of work in the claims adjustment department would be minimised
- training could occur in phases: people would learn to use the system bit by bit, in a natural way
- feedback at the end of each phase from the users would inform the development and implementation of the next phase.

It was decided that the phases would mirror the way a claim entered the claims adjustment department and moved through it to adjudication and issuing of payment.

The first phase of the project concentrated on the claims form submitted by the claimant. This phase of the project resulted in the creation of a form on a computer terminal screen which could be filled in by an operator talking to the claimant over the telephone. At first, the operators simply took handwritten forms and entered them on the screen form, but quite quickly this changed to the operators using lightweight telephone headsets and

entering the information directly on screen. The claim form was then simply printed by the central computer and posted to the claimant for checking and signature.

The second phase made some minor improvements in the form on the screen and the resulting print-out. Furthermore, the central computer, as well as printing the form for checking and signature, passed the form, once approved by the claimant, electronically to the claims adjuster, who no longer worked with a paper copy. The claims adjuster reviewed the electronic form and entered information electronically from quotations from prospective repairers. Any arithmetic needed was performed automatically and then the form was printed out.

The third phase again made minor improvements to the forms and automated the approval by the adjuster and the quality control review by a manager, and simply printed cheques for the claimants in the approved claims, and a printed report of all rejected claims to be used to prepare letters to those claimants.

The final phase used word-processing software to assist the preparation of letters to claimants whose claims either were rejected or required further information: the operator could select standard phrases for inclusion in the letter but could also add customised paragraphs. The letters were automatically printed together with envelopes.

A phased development project life cycle is suitable for projects with a high degree of technological risk attached to them or, as illustrated above, projects where the resources are not available to do everything in one concerted effort. They have the benefit of minimising disruption and of having several stages at which the feedback from users can result in beneficial changes to the end product.

# Prototyping

*Prototyping* is a form of phased development. In prototyping, a model, or prototype, of the proposed system is built quickly and shown to the users in order to obtain rapid feedback. The model may or may not become part of the final system offered to the users. Prototyping reserves the right to throw away a less successful model, build on a more successful model and fine-tune a very successful model. The model may begin as something quite crude (for example, it may ignore function in order to obtain information on, say, ergonomic aspects of the model) and gradually be refined or it may be rebuilt at each iteration or, after several iterations, a 'formal' project may be constituted to turn the approved model into a working artefact or system.

The advantages of a prototyping project life cycle are similar to those of a phased development project life cycle. The disadvantage is that it is far more difficult to estimate costs and schedules (due to the experimental nature of the early prototypes) and more difficult to control.

# Agile processes

Over the years, a number of proprietary processes have been established for the development of software. Most of them demand the production of particular documents conforming to particular standards, with a significant overhead in record keeping. Following all the rules and having to keep all the various records has proved unpopular with software engineers, mainly because they are distracted from their main pursuit of developing software. This potential for heavy bureaucracy has cost implications, which has not been popular with managers. As a project manager, you do not want to lose

control, but you do not want to increase the chances of alienating the software engineers who are your most valuable resource and who you depend upon.

The response has been the emergence of agile methods. People using these approaches realise there is great merit in the informal approaches of small team, small company, software development – what in the United States would be characterised as 'skunk works': that is, a small team operating outside normal company policies, with a tight schedule, and working on an ambitious project, often secretively. Somehow these teams develop quality software at low cost. But how do they do it? How such teams achieve this remained tacit knowledge in the past, while agile methods make it visible and generally acceptable to managers and stakeholders.

The *Manifesto for Agile Development* was drawn up in February 2001 by the Agile Alliance. The original members of the Agile Alliance met to discuss what to do about the bureaucracy of current methodologies and what could be done to release the creative energy of software engineers. They used the concepts of increments, prototyping and timeboxing to establish their principles. For example:

> Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.

> Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.

> Working software is the primary measure of progress.

<div align="right">(http://agilemanifesto.org/principles.html)</div>

Agile methods do not include prescriptions concerning what should be done when: they do not plan in the conventional sense. They recognise that what a software engineer does is contingent on the situation that each one encounters. As a consequence, agile teams are expected to reflect regularly on how to be more effective and adjust their behaviour accordingly.

# Using a life cycle model

Real life is messy and projects, however well organised and run, are likely to run into problems. You may think that there is little value in adopting a life cycle model for a project. In fact, such models are useful in planning, then in guiding the stages of a project and in helping a project manager to manage it, provided that the manager remains aware that the model is only that, a model, and not an exact description of how a project will proceed from start to finish. More important than the life cycle are the *milestones* and *deliverables* agreed as part of the project plan.

# Software quality

We have as yet no widely agreed measures of the 'goodness' of software produced as the result of a project; neither can we measure its quality accurately or positively. Quality measures for software are largely confined to the relative absence of faults. There has been some research effort to quantify and locate the likely source of faults. In one study the percentage of faults by phase was investigated; this is shown in Table 16.

## Table 16 Areas giving rise to faults in software (adapted from Norris et al., 1993)

| Phase giving rise to fault | Percentage of total faults |
|---|---|
| Requirements definition | 38 |
| Maintenance (operation) | 32 |
| Design | 23 |
| Installation | 7 |

Requirements definition occurs at the very beginning of a software project. A software engineer or analyst visits the client and users, and interviews and observes them in order to determine what they require. The problem with this phase is the fact that the eventual product, the software, is intangible and invisible. There is not much that can be shown to prospective clients and users. And unless the users are themselves experts, they may not be fully aware of the capabilities and limitations of software, nor may they be fully aware of its complexities and the problems of integrating new software with existing systems. In any case they may have difficulty in expressing their requirements. The analyst or systems engineer, who is rarely an expert in the client's line of business or the users' tasks, may have difficulty in understanding fully the requirements they do express.

There are no simple answers for the problems of obtaining a sound requirements definition document. The analyst or software engineer prepares the document and then walks through it with the client and perhaps with some end users, but as there is nothing to try out it is difficult to determine from such a walk-through whether all requirements are covered, and whether those that have been are covered satisfactorily. One possible solution is the prototype approach mentioned earlier: an early prototype, perhaps crudely giving the function and feel of the eventual product, can be tried out to see what its deficiencies, limitations and errors are, and the requirements definition can then be refined.

Software design is plagued by the problem of change: since there is nothing tangible, it is easy to think that nothing has been built, and therefore anything can be changed, and that change is simple. However, the complexity of software, which emerges quickly in the design phase, is such that even relatively simple sounding changes can have knock-on effects that are very difficult to determine until the testing phase. Again, prototyping and phased development are approaches which can help in this respect. However, the problems of controlling this type of development and the increase in the time needed to complete a product can make these approaches unsatisfactory.

Installation, interestingly, gives rise to the fewest significant errors. This is perhaps the one task that is relatively straightforward in a software project, although the project team may not think so when they are scrambling to get everything up and working!

Operation reveals another large proportion of errors. This again is related to the complexity of the software. Hence, maintenance can be a significant activity or even a project in its own right. A fix applied in one area may generate problems in other areas and have cascading knock-on effects.

As well as the problems mentioned so far, you should note that software development involves a series of translations. The requirements document has to be translated into designs, and later the designs have to be translated into a programming language, which in turn gets translated into machine language. At each step, it is possible to make errors: to miss part of what needs to be translated, to insert something that was not there before,

to mistranslate. And at each stage, it is also all too easy to make apparently simple errors, such as the substitution of a full stop for a comma, that have enormous effects.

Having read some of the problems associated with software, you may be forgiven if you wonder how any usable software ever gets written. If you have much experience with any software at all, even a simple word-processing or spreadsheet package, you will have found things that do not work as you think they should, or do not work as they are described. Nevertheless, even somewhat flawed software can be an enormous boon in carrying out daily tasks such as letter and report writing and financial record keeping and planning. If your word processor only prints one page at a command instead of a whole document, it may be annoying but it is not threatening. In contrast, the consequences of failure may be much more serious in the software used to fly aircraft, to monitor radar at busy airports, to manage power stations (including nuclear power stations) and even to manage systems in our motor cars.

## 5.3 Summary

Projects with a significant software content are particularly problematic. Software can be treated as a product, although it is less tangible than the familiar products of manufacturing processes such as furniture. Software is difficult to measure (there is wide disagreement about what measures can or should be applied and how they can be used), very complex and subject to human error as the outputs of one project phase are translated for the next phase. This is most serious where the software is critical to human safety. However, software development is similar to engineering when it involves a defined process with clear activities, each of which has one or more products that can be tested against the user's requirements.

Having studied this section you should be able to:

- suggest reasons why projects with a software content are problematic
- describe the elements of a basic software development process
- describe the phased development life cycle
- draw up a brief plan for a phased development project based on a simple scenario of the project requirements
- describe the prototyping life cycle
- explain why agile methods might be chosen over proprietary methods for the development of software
- suggest ways in which phased development, prototype approaches or agile methods can contribute to the development of software.

# Conclusion

This free course provided an introduction to studying Management. It took you through a series of exercises designed to develop your approach to study and learning at a distance and helped to improve your confidence as an independent learner.

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# Acknowledgements

Grateful acknowledgement is made to the following sources for permission to reproduce material in this course:

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Figure 3: Based on de la Mare, R.F. (1982) *Manufacturing Systems Economics*, Holt, Rinehart & Winston;.

Figure 6: Jordan, E.W. and Machesky, J.J. (1990) *Systems Development: Requirements, Evaluation and Implementation*, PWS-Kent Publishing Company

Tables 4.2, 4.3: Based on de la Mare, R.F. (1982) *Manufacturing Systems Economics*, Holt, Rinehart & Winston.

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