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THE ESTIMATION AND MANAGEMENT OF COST OVER THE LIFE CYCLE OF METALLURGICAL RESEARCH PROJECTS

MM ODENDAAL

Hons B Compt

Dissertation in fulfilment of the requirements for the degree, Magister Commercii in Financial Management Sciences, in the Faculty of Economic and Management Sciences at the University of Pretoria

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ABSTRACT

The purpose of this study is to determine whether all costs over the life cycle of metallurgical research projects are included in the initial cost estimate, whether these costs are estimated accurately and whether they are managed throughout the project's life cycle.

The impetus for this study came from the observation that costs in metallurgical research projects are often not accurately estimated and are not managed over the entire life cycle of these projects.

Cost estimation and cost management over the life cycle of a project were an integral part of the project and crucial to its success. The initial cost estimate can seal a project's financial fate. Projects often overrun estimated costs because the costs are not estimated accurately enough and not well managed.

The project leaders of metallurgical research projects are engineers and not always trained to estimate and manage costs effectively. Project management textbooks are of little assistance in this regard because they tend to focus on timeous delivery, and fail to include enough information on cost estimation and cost management.

To facilitate an effective and objective analysis of the survey, an extensive literature review was conducted. Life cycle costing, methods of cost estimation and cost management techniques were examined in detail.

An empirical study was conducted to determine whether these methods of cost estimation and cost management are being used over the entire life cycle of metallurgical research projects, and whether all costs are being included in the initial estimates of costs. It was deemed that results of the empirical study would provide useful information on the factors contributing to the success, failure or early termination of these projects.

This study is a descriptive research study. The research methods used in the research design were structured and quantitative. A survey was used to gather information by way of face-to-face and telephonic interviews as well as an e-mail questionnaire.

The population was small and consisted of the entities involved in metallurgical research projects in South Africa. There were only 12 entities in the population. The 10 largest entities in terms of project size were selected. A nonprobability sampling approach was used. The e-mail questionnaires were analysed manually by means of spread sheets to obtain graphical information. The processed data were used to draw conclusions. The answers to the questions were linked to the theoretical framework by means of interpretation.

It was concluded that all costs over the life cycle of metallurgical research projects are not taken into account in the initial cost estimate of a project, and the cost estimates may therefore not be accurate. The final costs, including discontinuation costs, are often not included in the cost estimates. The costs are mainly managed during the growth phase of a project and not during the introduction phase when 80% of the costs are normally committed.

This study emphasises the importance of including all costs during a project's life cycle, and introduces engineers to modern cost management techniques.

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THE PURPOSE, SCOPE AND METHODOLOGY OF THIS STUDY

1.1 INTRODUCTION

A 2 000-year-old quotation reads as follows:

"*For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he has sufficient to finish it?"* (Luke 14:28, The Holy Bible, King James Version).

One of the grandest undertakings by humanity should have been the Great Pyramid of Cheops setting the last stone in place sometime during the third millennium BC. Despite the lack of sophisticated machinery, the ancient Egyptians were able to construct the pyramids with incredible accuracy. Their managerial ability to plan, organise and control such a project over a 20 year period, must have demanded the organisational capacity of a genius (Nicholas 2001:1-2).

Since the time of the construction of the pyramids, the nature of projects and the environment have obviously changed drastically. However, as long as mankind dwells on earth, there will be projects.

The selection and evaluation of new projects are one of the most difficult tasks in a business. All projects are basically an investment in the future of a business - that is, an outlay of cash today in the expectation of a greater return in the risk-filled future (Ellis 1984:82).

The traditional goals of almost every project are to accomplish work for a client or end user in accordance with *budget, schedule* and *performance requirements*. The budget is the target cost of the work to be done. In an endeavour to stay within the budget, the quality of work may decline, schedules may fall behind and performance may decline. In trying to stay on schedule and meet performance requirements, costs may increase (Nicolas 2001:10). Budgets alone therefore do not seem to be the most effective way to manage the cost of projects.

According to Hilton, Maher and Salto (2003:582), many companies struggle with project cost overruns and project delays. They refer to the firm, *Consumers Power,* in Michigan, which nearly went bankrupt when building a nuclear power plant. The project was about $3 billion over budget and several years late when it was finally abandoned before completion. Cases such as this emphasise the importance of accurate cost estimation and cost management. This is no different in metallurgical research projects.

Anon (2008) on Wikipedia.com defines metallurgy as *"a domain of materials science that studies the physical and chemical behavior of metallic elements, their intermetallic compounds, and their compounds, which are called alloys. It is also the technology of metals: the way in which science is applied to their practical use. Metallurgy is commonly used in the craft of metalworking".* Metallurgical research entails research on the above components of metallurgy and the exploitation of minerals in order to extract metals.

Since metallurgical research projects are often technically complex and require a diversity of skills, while being subjected to constrained resources, limited time and environmental uncertainty, it is also a challenge to stay within the budget and scheduled timeframes and meet the performance requirements.

In today's competitive global markets, project budgets are often depleted before the delivery stage. According to Drury (2008:536), during the late 1980s, criticisms of traditional management accounting practices were widely published and new approaches that are more in tune with today's business environment were advocated. The focus of these traditional management accounting practices was on comparing actual results against a preset standard (typically a budget), identifying and analysing variances and taking remedial action to ensure that future outcomes conformed to budgeted outcomes. These management practices were based in the preserving of the status quo and the methods of performing existing activities were not reviewed. The emphasis of these traditional management accounting practices, was on cost containment rather than cost reduction. The traditional management practices are still being used today. In contrast to the traditional management practices, the new approaches to cost management focus on cost reduction as opposed to cost containment (Drury 2008:536).

It was observed that most companies in the metallurgical research field use budgets in some or other way to manage their costs. The question arises whether the initial estimation of budgeted cost is accurate and whether these budgeted costs are in fact managed over the entire life cycle of the project.

It is not only costs that need to be managed, but also the project itself (Staffurth 1975:1). According to the traditional approach to project management, a project has to be completed within a given time, within the limits of cost, according to an agreed standard of performance. The cash flow should correspond with the original plan.

The primary focus of traditional project management was on the management of the project delivery phase. Life cycle project management (discussed in sec 2.10.3) is a more comprehensive approach and manages a project in which life cycle objective functions are used as criteria for decision making throughout the project's life. Jaafari (2000:45) identifies the following life cycle objective functions:

- financial objectives, such as equity, internal rate of return and cost/worth ratio
- customer satisfaction objectives, such as functionality, operability, aesthetics, quality and user satisfaction
- due diligence objectives, which involve reducing exposure to risks and liabilities, including compliance with statutory requirements

In life cycle project management, the emphasis is on proactive management, which involves early anticipation and prevention of problems as well as the employment of life cycle objective functions as the basis for planning and ongoing evaluation of the status of the project (Jaafari & Manivong 2000:26).

Life cycle costing was developed by the United States Department of Defense more than 40 years ago. According to Dhillon (1989:introduction), a document, prepared by the Logistics Management Institute, Washington DC, entitled *Life cycle costing in equipment procurement,* was published in April 1965. The term ”life cycle costing” was widely disseminated. The study was conducted for the Assistant Secretary of Defense for Installations and Logistics. The result of this study was the publication of a series of three guidelines on life cycle costing procurement by the United States Department of Defense.

Langfield-Smith, Thorne and Hilton (2006:706) define life cycle costing as a cost management approach in which costs are accumulated and managed over a product’s life cycle. They define the term “product life cycle”, as the time from the conception of a product to its abandonment. According to Emblemsvag (2003:17), a typical project has four phases in its life cycle, namely introduction, growth, maturity and decline. These phases will be discussed in detail in chapter 2.

Sakurai (1996:166) argues that life cycle costing has significance for both manufacturers and users. Traditionally, manufacturers were concerned only about the costs incurred up until the time a product is transferred to the user. Not much concern was shown for the costs that accrue to users after the products or equipment have been transferred to them. Intensified competition of today’s market, along with the advance of high technology, means that the responsibility of the manufacturer no longer ends with producing a product that matches specifications. From the outset, a product that improves quality, reliability and support should be designed, in order to optimise performance and profitability for the user (Sakurai 1996:166).

The users of an asset typically measure life cycle costs by means of a cash-flow analysis as part of a capital assets evaluation model. Cash flows are discounted to their present value so that the user can make an optimal selection of assets. When making decisions about operation and maintenance costs incurred during the life of the asset, life cycle costing is also necessary (Sakurai 1996:168).

The literature further distinguishes between *life cycle cost* and *product life cycle.*

According to Sakurai (1996:163), life cycle costs fall into two categories, namely manufacturing and user costs. The former include all the costs the producer will incur over the product's life cycle, while the latter include all the costs the user will incur in obtaining, using and disposing of the asset.

As explained by Hansen and Mowen (2003:506), product life cycle can be refined to revenue-producing and consumable life. The former is the period in which a product generates revenue for the company, while the latter refers to the length of time a product serves the customer's need.

Companies have not always considered the consumer life, but have shown strong interest in manufacturing or purchasing costs. In high technology projects, the post-purchasing costs will often be higher than the purchase/manufacturing costs. There is an increasing need to measure and analyse total life cycle cost, including user costs for operation, maintenance and disposal (Sakurai 1996:164).

This also applies to metallurgical research projects, where final costs such as discontinuation costs are not always included in the initial cost estimates. This point was proved in the empirical study (see sec 5.6.12).

Emblemsvag (2001:17) holds that life cycle costing will become more important as organisations become increasingly aware of both environmental and customer service costs.

In metallurgical research projects, environmental issues are critical because engineers often use harmful chemicals in their projects. The Minister of

Environmental Affairs in South Africa received new powers by the Environment Conservation Amendment Bill, published in the Government Gazette of 1 August 2003, to make regulations concerning the disposal of products considered to be harmful to the environment. The Minister has the power to ban the use of environmentally harmful substances (Paton 2003:39). More stringent regulations on harmful substances will soon force manufacturers to take responsibility for the life cycle of the goods they produce.

The above discussion emphasises the importance of including all project costs over the entire life cycle of a project. These costs also have to be estimated accurately.

Cost and its estimation are an integral part of the project and crucial to its success (Kharbanda & Stallworthy 1988:4). However, after acceptance of a project, cost often declines to a much lower position. Completing the job, safety, functional adequacy, operability and maintainability become increasingly important. For the customer, the cost concerns are now something of the past.

Projects often overrun estimated costs because the cost of a project is not estimated accurately enough and not well managed over the entire life cycle of a project. Schwalbe (2007:6) contends that projects rarely finish according to the discrete scope, time and cost goals originally set.

According to Kharbanda and Stallworthy (1988:6), the three main functions of capital cost estimation in relation to capital investment are as follows:

- to provide an evaluation of possible alternatives
- to provide a more accurate estimate of the investment in a viable project
- to facilitate cost management of the project during implementation

When considering a project and its feasibility, the estimation of cost is the first step management will require. The accuracy of the estimate of cost is fundamental because it not only tells us the magnitude of the project for the purposes of approval, but also serves as a tool for cost management during the later stages of the project (Kharbanda & Stallworthy 1988:3-4; Thompkins 1985:2). The cost estimates will be based on previous experience or advice from those who have estimated a similar project before.

The accurate estimation of costs only does not guarantee the success of a project. These costs need to be managed over the entire life cycle of the project. Eighty percent of a product's costs are committed during the introduction phase of the life cycle. The majority of costs, however, are incurred during the growth phase, but are committed during the introduction phase and therefore difficult to alter. Cost management can be most effectively practised during the introduction phase and not the growth phase when the product design and process have been determined and cost has been committed (Drury 2008:538).

Emblemsvag (2003:2) argues that costs should be managed effectively and efficiently, thus eliminated during the introduction phase and not reduced during the growth phase. The horizon of costs should be expanded from the four walls of the company to the relevant part of the life cycle where value is created, and foresight instead of hindsight should be employed.

From the above, it is clear that costs are committed during the introduction phase in the life cycle of a project. Costs are mainly incurred during the growth phase, and should therefore be managed and eliminated if necessary mainly during the introduction phase, before they are committed. Costs, however, should be measured and managed throughout the life cycle of the project. Project cost management is a vital part of project management. If cost management is ineffective, management will be dysfunctional.

During any project, knowledge is gained and lessons are learnt. Hard-earned experience is often not passed on from person to person and from one project to the next.

It is evident that projects can no longer be treated as static undertakings. A project must be run as a dynamic system subject to uncertainty, risk and pressures, both internally and externally (Jaafari 2000:44).

It can be concluded that project cost estimation and management over the life cycle of a project are an integral part of the project and crucial to its success. The initial cost estimate can seal a project's financial fate. Projects often overrun estimated costs because cost is not estimated accurately enough and not well managed.

This also applies to metallurgical research projects which often involve great technical complexity and are subjected to constrained resources. The current skills shortage in South Africa has a negative impact on these projects (see sec 5.6.7). The shortage of technicians may be a contributing factor to projects not meeting their time schedule. This may have an influence on performance requirements and project costs may increase. Since the entities involved in metallurgical research do not have control over the skills shortage, it is of utmost importance that their initial cost estimates are accurate and include all costs. Moreover, these costs need to be managed over the entire life cycle of the projects, if the projects are to succeed.

1.2 PROBLEM STATEMENT

In order to be competitive and survive in a competitive market, a project's costs should be estimated and managed in such a way that they also meet the time and performance requirements during successive advances throughout the life-cycle of the project.

The impetus for this study came from the observation that costs in metallurgical research projects are often not estimated accurately and are not managed over the entire life cycle of projects.

The research problem can be expressed in the following statement: ***There is not enough emphasis on the accurate estimation of costs and their management over the entire life cycle of metallurgical research projects.***

1.3 RESEARCH OBJECTIVES

The research objectives that will answer the research problem can be formulated as follows:

- to examine different methods that can be used to estimate and manage the total costs of a project during its life cycle
- to determine whether these cost estimation methods are used in metallurgical research projects
- to determine whether these cost management methods are used in metallurgical research projects
- to determine whether all costs over the life cycle of metallurgical research projects are included in the initial cost estimate of a project
- to determine during which phases of the life cycle of metallurgical research projects the costs are determined, most of the costs are incurred and most of the costs are managed

1.4 THE IMPORTANCE OF THE STUDY AND ITS POTENTIAL BENEFITS

There is a wealth of literature on project management. The books that were consulted for this study include the following: *International project management* (Murphy 2005)*, The little black book of project management* (Thomsett 1990)*, Project management: a managerial approach* (Meredith & Mantel 1995) and *Project management for successful project innovation* (Webb 2000*).* However, only a small section in most of these works refers to cost estimation and cost management. In Murphy (2005) project cost is only mentioned on page 9 in the introductory chapter under the topic: "Launch your international project*".* In Thomsett (1990), chapter 4 (of 11 chapters), entitled "The project budget"*,* discusses the project budget, cost components and budget control. In Meredith and Mantel (1995), chapter 7 (of 14 chapters), discusses cost. This chapter is entitled "Budgeting and cost estimation"*.* Webb

(2000) appears to be the most comprehensive book (only for the purposes of this study) of the four cited. Chapter 6, entitled “The cost and value of products”, and chapter 10 (of 13 chapters), entitled “The economics of a project” refer to cost. Chapters 11 and 12 explain how to analyse and manage the risks, while chapter 13 discusses commercial factors such as the price of contracts.

The fact that there is a gap in the literature regarding cost estimation and cost management in project management textbooks, was further confirmed during a conversation with the manager of Research and Development (Du Plessis: 2004), an engineer at Kumba Resources.

During the personal interviews, it was established that the project managers of metallurgical research projects are often engineers, with little experience and training in cost estimation and management techniques. Kharbanda and Stallworthy (1998:iii) argue that engineers need more than their general background and experience in their personal field in order to accurately estimate the cost of a project.

Cost estimation occurs during the introduction phase of the life cycle of the project and then moves to a minor position. Only when the budget has been depleted, do costs or the saving of costs, become the first priority again. Owing to depleted resources, work quality may decrease, performance may decline and time schedules may often not be met.

Project leaders in the industry need to become aware of all costs during a project’s life cycle. The mining industry is often accused of destroying the environment in its exploitation of natural resources. It is expensive to destroy harmful substances responsibly and to rehabilitate the environment - hence the need to include these costs in the introduction phase of the project in the initial cost estimates.

Another major concern is the lack of success of modern and strategic management accounting techniques. The findings of Langfield-Smith

(2008:204) clearly indicate that these techniques have not been adopted widely; nor is the term widely understood or used. To shed some light on these techniques, they were examined in detail in this study.

It can be concluded that accurate cost estimation, including all the costs of a project and their management is a crucial part of the success of a project. The project leaders of metallurgical research projects are engineers and they are not always trained to estimate and manage costs effectively. Project management textbooks tend to be of little assistance in this regard. Life cycle costing, methods of cost estimation and cost management techniques are examined in detail in this study. An empirical study was conducted to determine whether these methods of cost estimation and cost management are used over the entire life cycle of metallurgical research projects, and whether all costs are included in the initial estimates of costs. The results of the empirical study may provide useful information on the factors contributing to the success, failure or early termination of such projects.

1.5 RESEARCH METHODOLOGY

The method of study adopted in this research study is elucidated below:

1.5.1 The literature study

A literature study of recent applicable sources was undertaken to investigate life cycle costing as well as different methods of cost estimation and cost management.

1.5.2 The empirical study

The empirical study was conducted by means of face-to-face and telephonic interviews, as well as an e-mail questionnaire to determine how metallurgical research projects estimate and manage project costs over the entire life cycle of a project. The research methodology is explained in detail in chapter 5 and can be summarised as follows:

- **Design.** This study was a descriptive research study. The research methods used in this research design were structured and quantitative. A survey was used to gather information by means of face-to-face and telephonic interviews as well as an e-mail questionnaire.

- **Population.** The population was small and consisted of the entities involved in metallurgical research projects in South Africa. There were only 12 entities in the population. The 10 entities, which were the largest in terms of project size, were selected. A nonprobability sampling approach was used.

- **Measuring instruments.** Face-to-face and telephonic interviews were used, combined with a questionnaire that was e-mailed to all the respondents. Some of the questionnaires were completed during interviews, while others were returned electronically.

- **Data analysis.** The e-mail questionnaires were analysed manually by using spread sheets to obtain graphical information. The processed data were used to draw conclusions. The answers to the questions were interpreted by linking them to the theoretical framework.

1.6 CHAPTER LAYOUT

Chapter 1 introduced the research and included a discussion of background to the study, the problem statement, the importance of the study and its potential benefits, the research objectives, the research methodology and a review of the dissertation.

Chapter 2 deals with life cycle costing and life cycle project management compared to traditional project management methods. The phases of the life cycle will be explained. The need for life cycle costing and life cycle costing models will be discussed.

Chapter 3 defines the term “costs”, classifies cost in terms of behavior and discusses the time value of money. Different methods of cost estimation, as described in the literature, are then discussed and evaluated.

Chapter 4 deals with the different methods of cost management as described in the literature. The history, principles, implementation and evaluation of each of these methods will be discussed.

Chapter 5 analyses the results of the empirical research. The aim and results of the questions in the e-mail questionnaire are discussed. The literature and empirical study are then reviewed and conclusions drawn in order to answer the research problem.

CHAPTER 2

LIFE CYCLE COSTING

2.1 INTRODUCTION

Most businesses buy something, add some sort of value to it and sell it at a higher price. The difference between the price charged and the costs incurred is measured as profit. In a free market, price is normally a function of supply and demand, while incurred costs are the result of a series of decisions throughout the organisation that may have started prior to the conception of the product. Emblemsvag (2003:2) contends that this chain of decisions leads to costs being committed before they are actually incurred. To manage cost efficiently, it should therefore be eliminated during the commitment stage and not reduced during the occurrence stage.

On the basis of a brief search of global online bookstores, Emblemsvag (2003:preface) found that only a dozen books on life cycle costing have been published. At this stage, one may well ask why one of the few concepts that tries to eliminate costs before they are incurred receives so little attention, while numerous books deal with how to cut and assess costs after they have been incurred. Emblemsvag (2003) states that the reason for the lack of interest in life cycle costing is that it relates mainly to engineering.

As technology advances, product life cycles become increasingly shorter, and product development increasingly more capital intensive. The point of decision making and the point of measuring the effect of the decision, also move closer. Customers start to think beyond the purchase price and want to know the total costs. Life cycle cost can help turn cost management from hindsight to dealing with costs even before they are incurred.

Life cycle costing should also help organisations to apply knowledge about past performance and their gut feelings to future issues of costs and risks. This should not be done in the traditional way of budgeting, but in meaningful predictions about future costs of products, processes, organisation and their associated business risks (Emblemsvag 2003:3; Flanagan & Norman 1983:15; Jaafari & Doloi 2002:162; Sakurai 1996:168-169).

2.2 DEFINITION OF LIFE CYCLE COSTING AND THE LIFE CYCLE

The goal of life cycle costing is to take action and make decisions that promote the planning, marketing, distribution, operation, maintenance and disposal of a product in order to promote the long-term competitive advantage of the company concerned.

In the literature, the terms "life cycle phase" and "life cycle stage" are used interchangeably. To eliminate confusion, for purposes of this study, the terms will be used as follows: A typical life cycle consists of four phases, namely introduction, growth, maturity and decline. There are different stages during each phase, for example the planning and design stage, which occurs during the introduction phase, and the manufacturing stage, which occurs during the growth phase.

Drury (2008:538) states that *life cycle costing* estimates and accumulates costs over a product's entire life cycle to determine whether the profits earned during the manufacturing stage will cover the costs incurred during the pre- and postmanufacturing stages. Cost incurred during the different phases of a project should be identified and will provide insight into understanding and managing the total costs over the life cycle of a project.

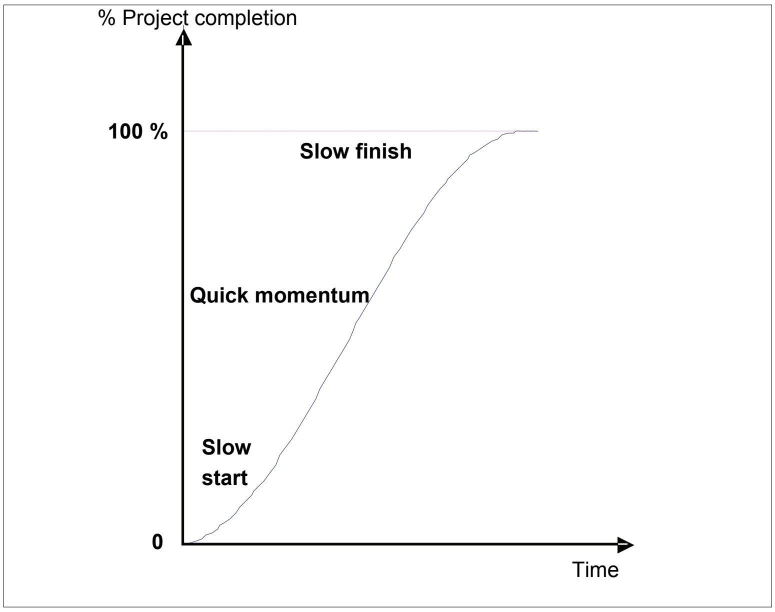
Sakurai (1996:163) defines *life cycle costing* as a method used to calculate the costs of products or equipment over their entire life.

To emphasise the fact that *all* costs have to be taken into account, Hongren, Forster and Datar (2000:439) use the term "cradle-to-grave costing" and "womb-to-tomb costing".

The *life cycle* refers to the use of a product from the time it is manufactured or purchased until it is discarded. According to the Japan CPA Association (Sakurai 1996:167), the life cycle has three elements: initial costs (research and development costs, planning, design, etc), normal costs (manufacturing costs, sales costs, etc), and final costs (repair costs, discontinuation costs, etc). The actual life cycle ends when the product is no longer useful or worn out. The final costs are generally the user's responsibility.

The life cycle differs from one product to the next. For example, the life cycle of a building may be 50 years, while that of electronic toys may be less than a year. Meredith and Mantel (1995:13) define a project's life cycle as the similar stages on the path from origin to completion, as illustrated by figure 2.1.

Figure 2.1 The project life cycle



Source:

Adapted from Meredith and Mantel (1995:13)

It is evident from the above discussion that the definition of a life cycle differs from one decision maker to the next. Emblemsvag (2003:17) provides the most comprehensive perspective of the term "life cycle costing". He differentiates between the marketing, production, customer and social perspectives. He holds that the marketing, production and customer perspectives consider only costs that impact directly on a company's bottom line, while the social perspective includes those activities and the associated costs borne by society. The different perspectives are depicted in table 2.1 below.

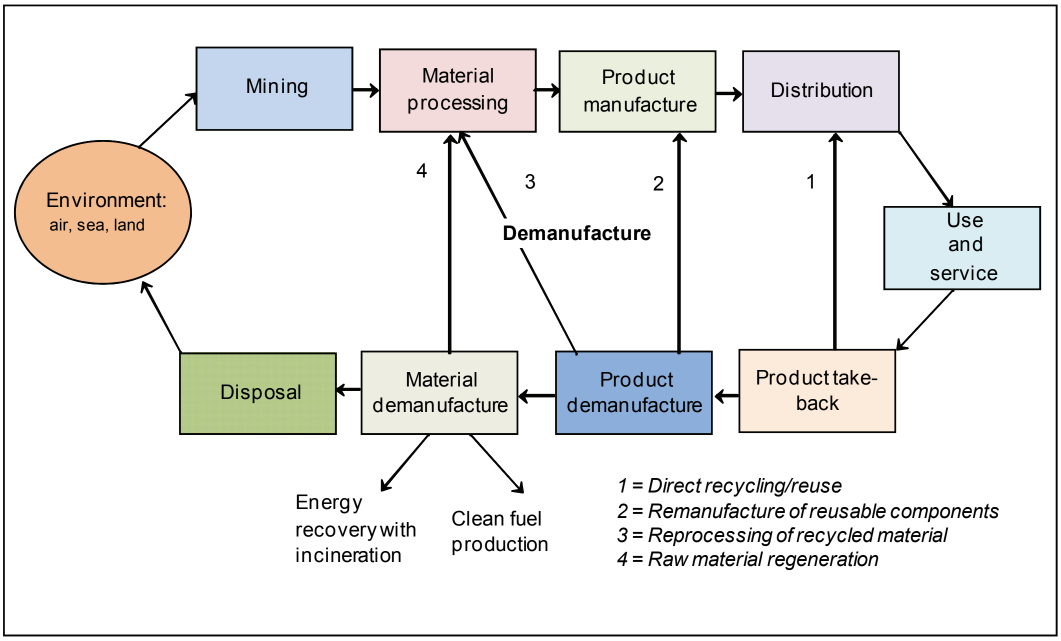
Table 2.1 Interpretation of the term life cycle from different perspectives

	Marketing perspective	Production perspective	Customer perspective	Societal perspective
1	Introduction	Product conception	Purchases	Disposal
2	Growth	Design	Operating	Externalities
3	Maturity	Product and process development	Support	
4	Decline	Production	Maintenance	
5		Logistics	Disposal	

The product life cycle involves all the preceding perspectives except for the marketing perspective. The reason for this is that the product life cycle is at the *individual* level of each product unit, whereas the marketing life cycle is at the *type* level of a product.

Figure 2.2 is a generic representation of the product life cycle.

Figure 2.2 Generic representation of a product life cycle



Source:

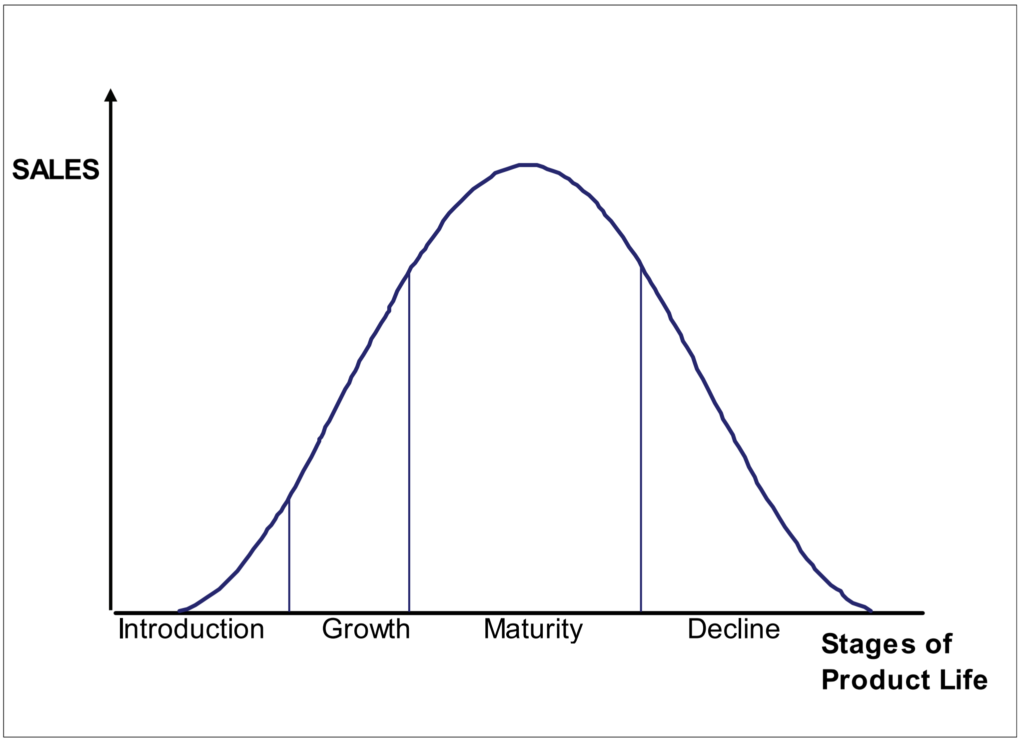
Adapted from Emblemsvag (2003:18)

Figure 2.2 illustrates that the product life cycle comprises the activities an individual part of the product performs, regardless of which decision makers are involved. For each activity or process, more detailed activities can be defined. A manufacturer will focus on the upper half of the figure, and the customer on the right-hand side. Until recently, the lower half of the figure was left to society to handle while the left-hand side was ignored. Because of the increase in environmental problems, more laws and regulations have been made to respond to public demand.

According to the international trend, disposal costs are increasingly becoming the cost of the manufacturer or the user. In both Germany and Norway, take-back legislation exists. Hence it is becoming increasingly difficult for companies to escape their social responsibilities.

The graph in figure 2.3 depicts the market life cycle. The market life cycle is the progression of a specific product from market development to market decline. This cycle is similar to industry life cycles, business life cycles and even human life cycles - they all develop through the same four generic stages, namely introduction, growth, maturity and decline. The shape of the curve will depend on many different factors.

Figure 2.3 Market life cycle



Source:

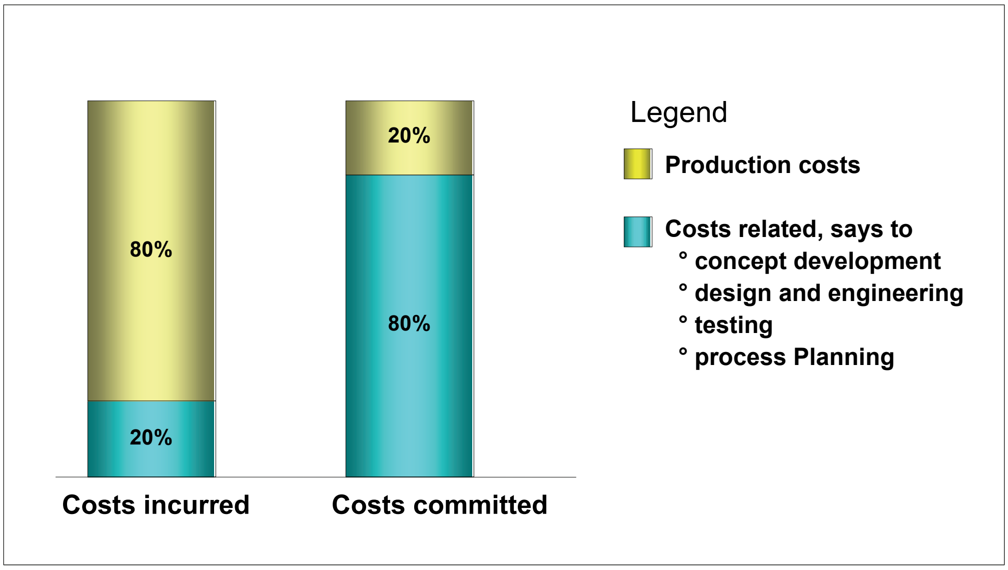
Adapted from Emblemsvag (2003:22)

It is evident that two unique life cycles exist, namely one at the individual product level (the product life cycle) and one at the product-type level (the market life cycle).

The life cycle of a project can also be divided into four major phases, namely introduction, growth, maturity and decline. These phases are discussed in detail in section 2.4.

Up to 80% of a product's costs are committed during the planning and design stage, that is, during the introduction phase. The majority of costs, however, are incurred at the manufacturing stage during the growth phase, but they have become committed during the planning and design stage, in the introduction phase and are difficult to alter. Cost management can be most effectively exercised during the planning and design stage and not during the manufacturing stage when the product design and process have been determined and costs committed. Figure 2.4 illustrates the points argued thus far.

Figure 2.4 Costs committed versus costs incurred



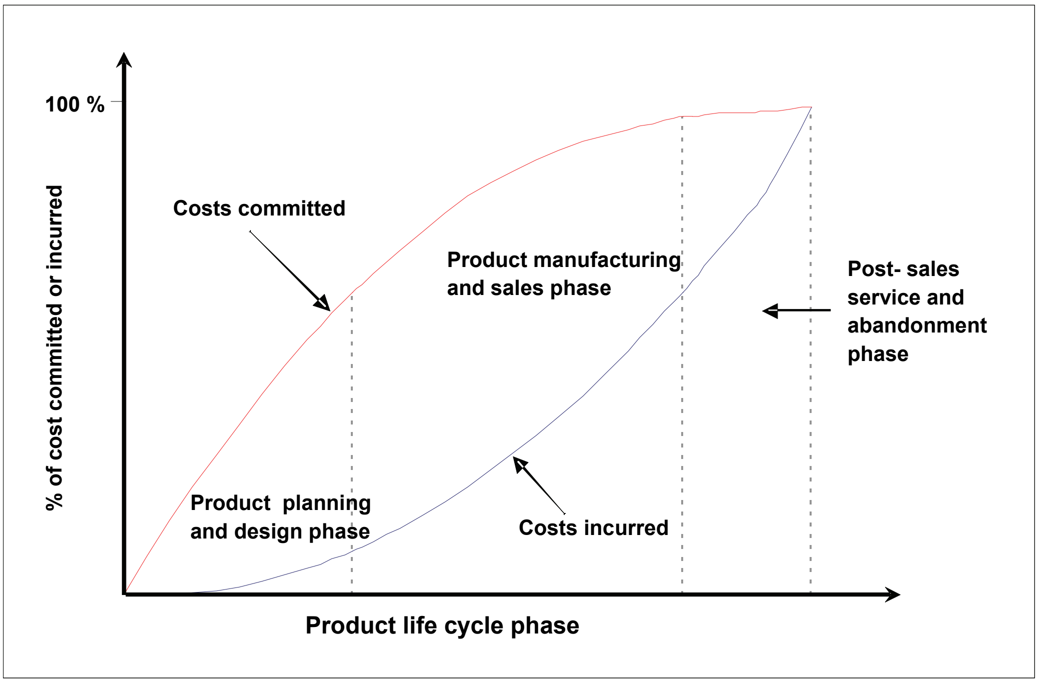
Source:

Adapted from Emblemsvag (2003:2)

Figure 2.4 shows the figures for a manufacturing company. It is clear that although about 20% of the costs are actually incurred in the activities prior to production, these activities commit 80% percent of the costs. The production cost, however, incurs about 80% of the cost, but production improvement efforts impact on only about 20% of the cost commitment.

Figure 2.5 illustrates the distinction between the differential timing of incurred and committed costs. The gap is the greatest in the project planning and design stage during the introduction phase. A low proportion of product costs are incurred, but the decisions made in this phase lock in the cost incurred in the sales stage during the growth phase (Drury 2008:539; Garrison, Noreen & Seal 2003:792).

Figure 2.5 Relationship between cost committed and cost incurred



Source:

Adapted from Drury (2004:945); Garrison et al (2003:793)

It is apparent from Figure 2.5 that cost management can be most effectively exercised during the planning stage of a project and not the manufacturing stage when costs have been committed and product design and processes have been determined. During the manufacturing and sales stage, the focus should be more on cost containment than cost management.

Life cycle costing requires that the effects of time should be considered. Future costs have to be calculated by taking the time value of money (see sec 3.3) into account. Future costs such as operation and maintenance costs have to be converted into their appropriate values before adding them to procurement costs. Inflation should also be taken into account. Inflation has numerous causes, such as excess demand in the economy, high costs and an excessive increase in the money supply. Regardless of the causes behind inflation, it reduces the value of money (Dhillon 1989:29; Drury 2004:549; Emblemsvag 2003:165).

One may conclude from the above definitions that the life cycle cost concept consists of the following major elements:

- The time period or life cycle applicable to all possibilities being evaluated should be identified.
- All costs and revenues attributable to a project should be included, namely initial cost, normal cost and final cost, as well as revenues and proceeds from ultimate sale or other disposal.
- Only costs and revenues directly attributable to the project under consideration should be identified.
- The effects of time, such as inflation and the time value of money should be identified.

In this study, two of the research objectives relate to life cycle costing, namely to determine

(1) whether all costs over the life cycle of metallurgical research projects are included in the initial cost estimate of a project

(2) during which phases of the life cycle of metallurgical research projects the costs are determined, most of the costs are incurred and most of the costs are managed

The answers to the above objectives will be discussed in chapter 5. *All* costs will include initial costs (research and development costs, planning, design, etc), normal costs (manufacturing costs, sales costs, etc), and final costs (repair costs, discontinuation or disposal costs, etc). The project *life cycle* will be based on the phases a project goes through, namely introduction, growth, maturity and decline.

To provide background of life cycle costing, its development will now be discussed.

2.3 DEVELOPMENT OF LIFE CYCLE COSTING

Early in 1965, a study was conducted for the US Assistant Secretary of Defense for Installations and Logistics. A document, entitled "Life cycle costing in equipment procurement", prepared by the Logistics Management Institute, Washington DC, was published in April 1965. The term "life cycle costing" was used widely in the document.

In 1972, a General Accounting Office study revealed that the operating costs of a hospital in its first three to five years of existence typically exceeded the entire cost of construction. As a result, interest was stimulated in cost-effective techniques. A project to formalise a life cycle costing model for use in the health field was initiated.

The US Department of Health, Education and Welfare initiated a project entitled "Life cycle budgeting and costing as an aid in decision making" in 1975. The state of Florida formally adopted life cycle costing in 1974, and in 1978, the US Congress established the National Energy Conservation Policy Act. This Act required every new federal building to be life cycle cost effective.

Life cycle costing has a long history of use in the energy industry. It has been applied to a variety of projects and has been a decision-making aid that has played a key role in the success of many of the profit-oriented elements of the free enterprise system.

The building industry was slow to adopt life cycle costing. Owing to the escalation of operating costs and the prompting of the US General Services Administration and the Department of Energy, builders were becoming aware of the advantages of life cycle costing.

According to Emblemsvag (2003:2), the Japanese were the first to use life cycle costing extensively and continuously in cost management. After World War II, Japan was in ruins and needed to become cleverer than the rest of the world. Another Japanese cost management concept, *target costing,* (see sec

4.6), also emphasises the need for the elimination of costs through design. This leads to proactive cost management (the new paradigm), as opposed to reducing costs after they have been incurred, which is reactive cost management (the traditional paradigm).

Sakurai (1996:186) holds that the Japanese approach to life cycle costing differs from the approach adopted in the USA. While there is an explicit focus on trade-offs between the cost to the user and the manufacturing cost in the USA, the Japanese have actively tried to cope with the life cycle in the same way as quality costing, in order to improve reliability during the period in which a product or piece of equipment is used.

While Emblemsvag (2003:2) states that the Japanese were the first to use life cycle costing in cost management, Sakurai (1996:186) challenges the view that it is more popular in the USA and failed to take hold in Japan because of cultural differences between the two countries. For the Japanese, it is more important to make reliable, high-quality products than find a cost-benefit trade-off between manufacturing and user cost. It is also difficult to fully understand life cycle cost if the manufacturer and the user are in different organisations.

According to Brown and Yanuck (1980:2), life cycle costing is applied in the USA to every new weapon system proposed or under development. The defence and aerospace industries design their products in terms of life cycle objectives. This practice is known as d*esign to cost*. Life cycle costing, included in the frame of capital budgeting, has since been applied to an endless variety of projects and is a decision-making tool used in many businesses.

Life cycle costing will increase in importance in years to come. The post-purchase cost of labour, material and energy is likely to grow as long as inflation resists control efforts and the dependence on scarce energy sources continues. Life cycle costing can also contribute to the conservation of precious fuel supplies (Brown & Yanuck 1980:2-4; Dhillon 1989:introduction; Emblemsvag 2003:2).

Since life cycle costing is not suitable for any product or project, its feasibility of application will now be discussed.

2.3.1 Factors that may influence the economic feasibility of applying life cycle costing

Brown and Yanuck (1980:4) identify the following factors that influence the economic feasibility of applying life cycle costing:

- **Energy intensiveness.** When energy costs are expected to be high throughout a commodity's life cycle, life cycle costing should be considered.
- **Efficiency.** When the efficiency of operation and maintenance cost has a significant impact on overall costs, life cycle costing will be beneficial when savings can be achieved to reduce these costs.
- **Life expectancy.** If a commodity has a long life, costs other than purchase costs are important.
- **Investment cost.** The larger the investments, the more significant life cycle cost analysis will become.

A building will satisfy all four of these criteria. Buildings use a great deal of energy, require many repairs and maintenance, have a long life span and are large investments. Other assets that satisfy these criteria are construction equipment, pollution control equipment, transportation vehicles, heating, ventilating and air-conditioning systems, farm equipment and hospital equipment.

The majority of metallurgical research projects have a duration of more than one year (see sec 5.6.2), require high technical sophistication (see sec 5.6.3) and have a budget of more than R1 000 000 (see sec 5.6.8). Because they are research projects, the efficiency of operation definitely has a significant impact on overall costs. Metallurgical research projects therefore also satisfy the criteria for the use of life cycle costing.

The development of life cycle costing started during the late 1960s, but for various reasons, the idea took a long time to be applied.

2.3.2 Why life cycle costing took so long to be applied

Prior to the 1970s, fuel costs were insignificant, because resources were considered sufficient to provide unlimited energy at a low cost. In the 1950s and 1960s, inflation was extremely low, (between 1 and 2 %), but increased in the 1970s to between 5 and 9%. Operating and maintenance costs increased in relative importance. A lack of understanding of the concept and methodology of life cycle costing is another significant factor. The difficulty of estimating future cost also makes people reluctant to use life cycle costing.

For any cost management technique, the data necessary for effective analysis need to be identified and collected. When life cycle costing is used, it may be difficult to identify operating costs and to determine the interrelationship between running and capital costs. There may also be estimation problems, since the analysis takes account of costs over time. A lack of historical data may influence the decision to use life cycle costing. Inflation may also be a problem because all costs do not escalate at the same rate (Brown & Yanuck 1980:5; Flanagan & Norman 1983:19).

Two errors committed in the management of project costs, which could be solved by life cycle costing, are thinking that a project is completed before it actually is, and thinking the implementation is perfect when it is not (Taylor 1999:3A).

To determine how effective life cycle costing is, it is necessary to compare it with other cost management techniques.

2.3.3 Life cycle costing compared to target costing and the value chain

The value chain (see sec 4.3.2) is a basic tool for systematically examining all the activities a firm performs, and the way the firm interacts is necessary for analysing the sources of competitive advantage.

Correia, Langfield-Smith, Thorne and Hilton (2008:50) define the value chain as a set of linked processes or activities that begins with acquiring resources and ends with providing and supporting goods and services that customers value.

The major difference between the value chain and the life cycle is that the former adopts the perspective of a specific company, while the latter follows the product. Many decision makers such as suppliers, producers and customers are involved in the life cycle. Because a longer chain of activities is involved, the time horizon is greater. The life cycle is therefore a more generic less limiting concept than the value chain (Emblemsvag 2003:24).

Garrison et al (2003:792) claim that life cycle costing draws extensively on the techniques of target costing (see sec 4.6). The target cost for a product is computed by starting with a product's anticipated selling price and then deducting the desired profit. Target costing is more than just a pricing technique. Costs are not only passively measured but also managed. The aim of target costing is to choose product and process technologies that yield an acceptable profit at a planned level of output. Life cycle costing anticipates cost improvements during the manufacturing stage as well as recognising the importance of the design stage. This is sometimes referred to as *Kaizen costing* (see sec 4.5).

Target costing may reveal an unpleasant view of a company's internal operations, exposing uncompetitive practices and processes that were hidden by traditional costing techniques. It may also be too time consuming. It may be appropriate in the car industry, which is based on lengthy product life cycles, and mature technologies, but less appropriate in industries such as electronics, where the rate of innovation is extremely rapid and time to market minimised. Life cycle costing assumes a relatively orderly value chain with a dominant customer.

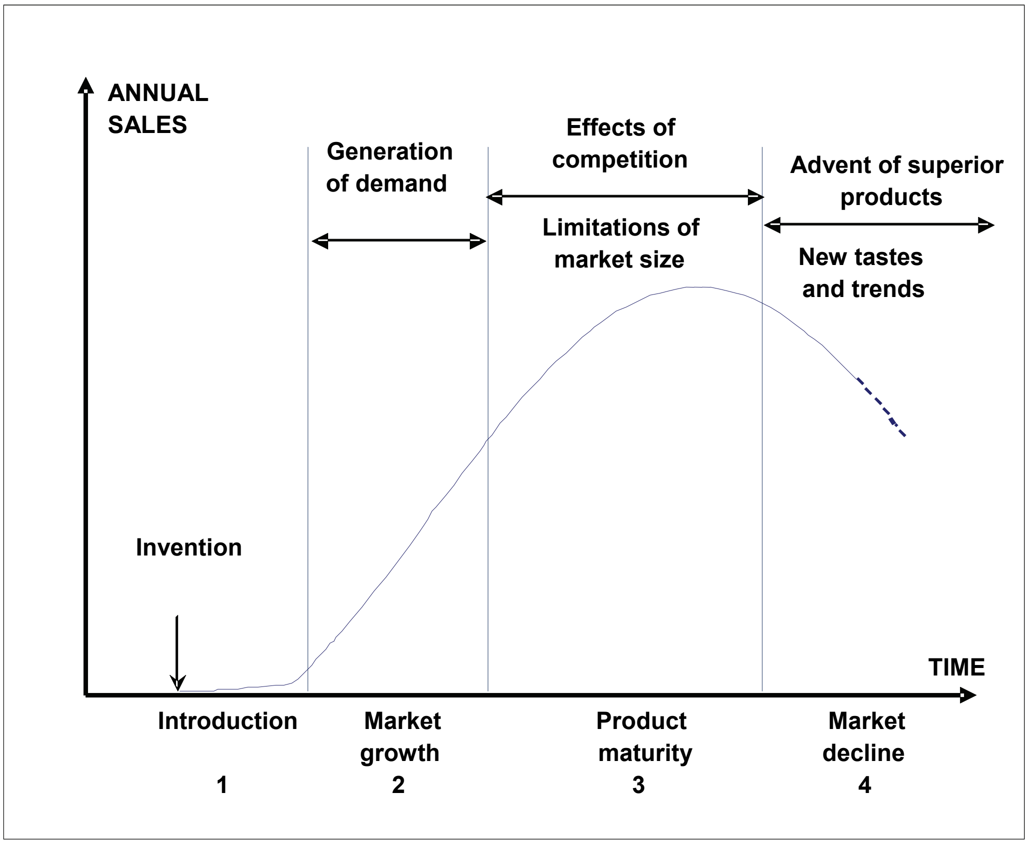
When target costs are specified, it is necessary to incorporate all the product's life cycle costs (Hilton 2002:671).

When analysing life cycle costing, one should remember that almost every product has a finite cycle during which it has a place in the market before losing appeal as more attractive products appear. These life cycles will now be discussed.

2.4 THE PHASES OF LIFE CYCLE COSTING

The life of a product can be divided into four major phases, namely introduction, growth, maturity and decline. Graphically, these phases can be depicted as follows:

Figure 2.6 Typical product life cycle



Source:

Adapted from Webb (2000:22); Emblemsvag (2003:22)

Each phase has implications for project cost estimation and management. According to Flanagan and Norman (1983:24), a life cycle cost approach consists of four components:

(1) life cycle cost planning
(2) full year effect costs
(3) life cycle cost analysis
(4) life cycle cost management

They hold that life cycle cost planning and full year effect costs are used in the introduction phase, whereas life cycle cost analysis and life cycle cost management are used during the growth phase, while the asset is in use.

The view of Flanagan and Norman (1983) that cost management should occur during the growth phase is challenged by later publications, such as that of

Drury (2008:539) and Emblemsvag (2003:3). The latter two authors argue that cost management should be applied during the introduction phase during which the majority of the costs are being committed. This is the perspective adopted in this study. Flanagan and Norman (1983), however, see it as a derivative of life cycle cost analysis. Their perspective will be dealt with in section 2.4.2.

2.4.1 The introduction phase

During the *introduction* phase, the product is developed and money is invested. Since no return can be expected during this phase, all investment is at risk and will be lost if development is not successfully completed. As illustrated by Figure 2.6, only 20% of the costs are actually incurred for the activities in this phase prior to production. However, these activities are responsible for 80% of the costs. Costs should be reduced during this phase, before they are committed.

Life cycle cost planning occurs during the introduction phase. It helps to identify the total cost commitment of the decision to acquire an asset and the option that offers the lowest total life cycle cost. The following steps are followed during life cycle cost planning:

- The total costs of acquisition should be identified. Initial capital cost and subsequent running costs should be expressed in a comparable manner by applying discounting techniques.
- Life cycle cost planning should also facilitate the effective choice between various methods of achieving a given objective. The options will have different capital outlays and running costs. Life cycle cost planning will use techniques to convert the different costs to a consistent measure that will facilitate the comparison of various options.
- Life cycle cost planning deals with the planning of future costs. Cost targets should be set against the solutions that will be measured.
- Data will be collected and manipulated from a variety of sources. Data should be measured and presented consistently.

- Life cycle cost planning should be objective, comprehensive, responsive to alternative demands and accomplished timeously. It should not involve the collection of extensive data not easily available (Emblemsvag 2003:22; Flanagan & Norman 1983:25; Webb 2000:22-23).

During the introduction phase, it is also necessary to establish the actual running costs of a proposed project in the short term. These costs are referred to as full year effect costs. These costs involve the actual running costs of a proposed project in the short term, normally for a period of three years. Future costs are not discounted, but inflation is taken into account. Full year effect costs are the estimated real expenditure for a project, usually expressed as an annual amount (Flanagan & Norman, 1983:27).

2.4.2 The growth phase

Phase 2 begins when the product is introduced into the market. If successful, a period of market growth will be experienced. Both product costs and potential profit will be at their highest in this phase. During this phase, life cycle cost analysis and life cycle cost management occur.

Life cycle cost analysis involves the collection of information on a project's running costs and performance. Because historical costs are used, there is no discounting. Life cycle cost analysis should be linked to details about the physical performance and qualitative characteristics of a project. Four examples of data areas are

(1) cost data
(2) physical data
(3) qualitative data
(4) performance data

The primary objective of life cycle cost analysis is to link running costs and performance data in order to provide feedback to the design team on the running cost of a project.

The steps that are followed in conducting a life cycle cost analysis are lightened below.

- Identify acceptable alternatives.
- Establish common assumptions (eg study period, discount rate and base date).
- Estimate all project costs and their timing.
- Discount future costs to present value.
- Compute the total life cycle cost for each alternative.
- Identify the alternative with the lowest life cycle costing.
- Consider unquantifiable costs and benefits.
- Consider uncertainty in input values.
- Compute supplementary measures of relative economic performance.
- Select the best alternative.

As a management tool, the main purpose of life cycle cost analysis is to identify the actual costs incurred in operating a project or any durable asset. Life cycle cost analysis forms part of overall cost management and should not be regarded as an end in itself. Life cycle cost analysis generates a historical data base that can be used to highlight areas in which cost savings may be achieved in new projects or in the operation of existing projects (Flanagan & Norman 983:27; Humphreys & Wellman 1996:230).

Life cycle cost management is a derivative of life cycle cost analysis. It identifies those areas in which running costs detailed by life cycle cost analysis may be reduced.

The aims of life cycle cost management are as follows (Flanagan & Norman 1983:29):

- determine where performance differs from life cycle cost planning projections, the reason for the differences, whether they will have an influence and whether performance should be changed
- utilise the asset more efficiently

- provide information on asset life
- to provide information that can be used for taxation advice

According to Sakurai (1996:182), life cycle management and not life cycle costing per se, is practised in Japanese companies today. He states that life cycle management attempts to manage and market/use a product or piece of equipment through the various stages of its life cycle. This includes total cost reduction and quality improvement programmes for customer satisfaction.

2.4.3 The maturity phase

During the maturity phase, sales levels tail off as the effects of competitors and the eventual total size of the market combine to limit sales to a stable sustainable figure. The product has now reached maturity, and manufacturing costs are at their lowest. Initial costs (research and development costs, planning, design, etc) will now be moderate, while final costs (repair costs, discontinuation or disposal costs, etc) will rise. The profit potential decreases as price competition increases and more has to be spent on advertising (Hansen & Mowen 2003:508; Webb 2000:22-23).

2.4.4 The decline phase

During the decline phase, sales decline and production will eventually end. This normally happens when the market has become saturated, superior products arrive or tastes and attitudes change so that the original appeal no longer exists. Initial, normal and final costs will now be at their lowest (Emblemsvag 2003:22; Hansen & Mowen 2003:508; Webb 2000:22-23).

The different characteristics and responses relating to the four phases of the life cycle are illustrated in table 2.2.

Table 2.2 Characteristics and responses relating to life cycle phases

Stages of cycle	Introduction	Growth	Maturity	Decline
Characteristics				
Sales	Small	Substantial	Maximum	Falling
Profit	Loss	Accelerating	Declining	Low or negative
Cash flow	Negative	Negligible	Large	Low
Customers	Innovative	Early user	Mass market	Laggards
Competitors	Few	Increasing	Stable	Fewer
Responses				
Strategic focus	Expand market	Develop share	Defend share	Retrenching
Marketing expenditure	Highest	High	Falling	Low
Promotion	Product attributes	Brand preference	Brand loyalty	Eliminated
Distribution	Limited	Broad	Maximum	Selective
Price	Highest	High	Lower	Lowest
Product	Basic	Extensions	Quality	Narrower

Source:

Adapted from Emblemsvag (2003:22)

From the above, it is evident that sales are at their highest during the maturity phase, while cost will reach a high between the growth and maturity phase. A low proportion of product costs are incurred during the introduction phase, but the decisions made in this stage lock in the cost incurred during the growth and maturity phases. Cost management can be most effectively exercised during the introduction phase of a project when planning occurs, and not the manufacturing phase when costs have been committed and product design and processes have been determined. During the manufacturing and sales phase, the focus should be more on cost containment and not cost management.

During personal interviews conducted for the empirical research part of this study, it was determined that the aim of metallurgical research projects is to break even and not to make a profit, but to transfer knowledge. It was also established that the cost of a project is influenced by what the customer is willing to pay. The entities receive income as the project progresses. In a metallurgical research project, the accurate estimate of costs and their management during the introduction phase are crucial. After acceptance of a project, the costs can only be altered if the customer agrees. During the growth phase, the costs committed during the introduction phase will be incurred. Most of the income will be received during the maturity phase. During the decline phase, disposal and discontinuation costs may be considerable.

During the empirical study it was determined that the entities do estimate the majority of their costs during the introduction phase, but only manage these costs during the growth phase after they have already been committed (see sec 5.6.11). The other major concern is that they do not include all costs over the entire life cycle in the initial cost estimates (see sec 5.6.12). The cost of metallurgical research projects is therefore not estimated accurately and not properly managed in terms of the life cycle costing technique.

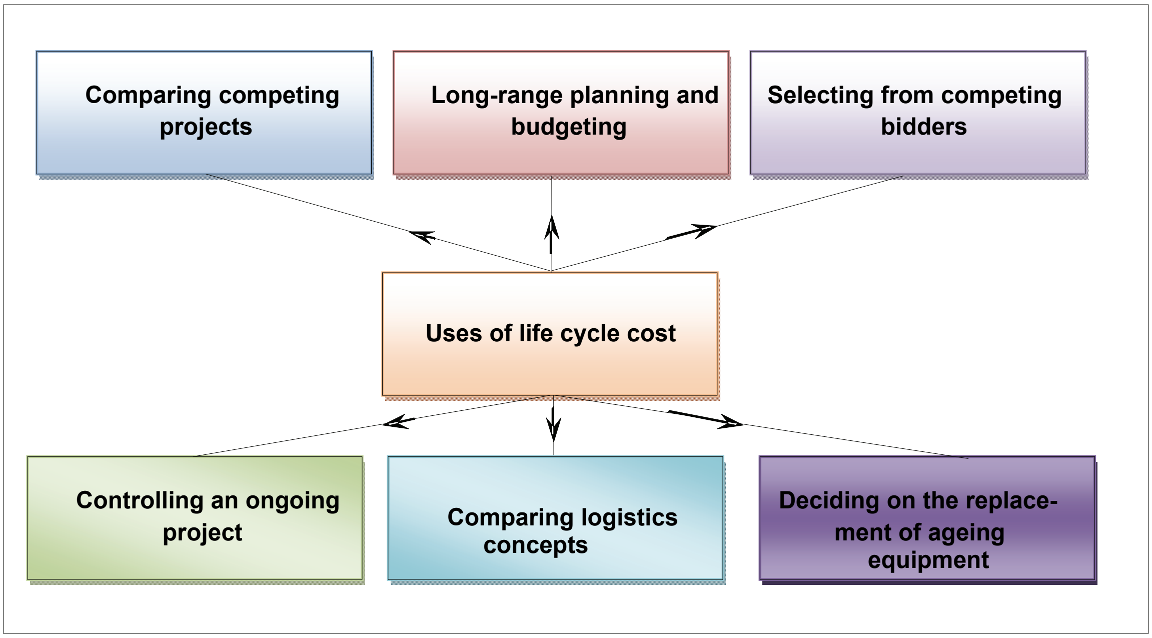
Now that the phases of the life cycle have been discussed, the need for life cycle costing will be determined.

2.5 THE NEED FOR LIFE CYCLE COSTING

Brown and Yanuck (1980:1) notes that the life cycle costing technique is justified whenever a decision has to be made about the acquisition of an asset that will require substantial maintenance and operating costs over its life cycle.

Dhillon (1989:31), takes this a little further by stating that the basic uses of life cycle costing involve comparing competing projects, long-range planning and budgeting, selecting from competing bidders, controlling an ongoing project, comparing logistics concepts and deciding on the replacement of aging equipment, as illustrated by Figure 2.7.

Figure 2.7 Basic uses of life cycle cost



Source:

Adapted from Dhillon (1989:31)

While Brown and Yanuck (1980:1) only consider procurement, Dhillon (1989:31) argues that life cycle costing can be used for more than procurement, namely comparing projects, planning and control and selection. Life cycle costing became more pertinent during the 1980s, in a broader context than only procurement. According to Emblemsvag (2003:4), nowdays life cycle costing serves mainly three purposes, namely

(1) to be an effective engineering tool for use in design and procurement

(2) to be applied proactively in cost accounting and management

(3) to be a design and engineering tool for environmental purposes

These purposes will now be discussed.

(1) Life cycle costing as an engineering tool. Since its inception early in 1965, the concept of life cycle costing has spread from defence-related matters to a variety of industries. For both manufacturer and purchaser, it is vital to assess, eliminate by design and manage downstream costs as well as their risks and uncertainties. Downstream costs consist of marketing, distribution and customer services costs (Langfield-Smith et al 2006:49). Downstream costs after purchasing should play a major role in purchasing decisions because they tend to be extremely significant after purchasing. Knowledge about downstream costs and their associated risks and uncertainties can be used during costs/pricing and risk management. Products can be designed in such a way that they eliminate the costs before they actually occur (Emblemsvag 2003:25).

According to Sakurai (1996:187) it is preferable for an engineer to be in charge of life cycle costing. Accountants are likely to overemphasise the financial elements. In the USA, life cycle costing is sometimes conducted as a financial process, such as capital budgeting. During the financial emphasis, management may become motivated by short-term considerations. Life cycle costing may be more effective as an engineering tool, with accountants helping to meet the information needs of the engineers.

(2) Life cycle costing as decision support for management. Engineers have always been involved in cost management. According to Fleischman (cited in Emblemsvag 2003:24), standard costing was developed by the American Society of Mechanical Engineers in the 1870s, but only used from the 1920s onwards. Factories were technologically simple and labour intensive and product variety was limited. It made perfect sense to allocate costs according to direct labour hours. The situation changed after World War II when major business environmental changes occurred. The invention of the digital computer effected the most significant change.

(3) Life cycle costing as an environmental tool. Life cycle costing not only makes cost management more relevant and pro-active, but can also help companies toward “doing (economically) well by doing (environmentally) good” (Emblemsvag 2003:26; Emblemsvag 2001:17).

In South Africa, manufacturers will soon have to assume responsibility for the life cycle of the goods they produce, with more stringent regulations relating to plastics, glass, rubber tyres and asbestos products being anticipated. A compulsory charge for the sale of plastic bags has already been implemented (Paton 2003:39).

The common denominator of the three purposes, as stated in Emblemsvag (2003:4) is the role of life cycle costing to provide insight into future matters relating to *all costs*. The future, however, is always filled with uncertainty and risk. Business risks are the new focal point of corporate governance.

2.5.1 Corporate governance

Emblemsvag (2003:4) reports that because of numerous corporate scandals in the 1980s and 1990s, many large institutional investors demanded better financial transparency, integrity and accountability. This resulted in the Turnbull Report, published in the UK in 1999, on request of the London Stock Exchange.

According to Ward (2001:5), the Turnbull Report focuses attention on risk management and internal control, but at board level. The areas that directors should be looking at include not only financial, operational or technological risks, but also reputational or environmental risks.

In South Africa, the King Report on Corporate Governance (King I) was published in 1994 by the King Committee on Corporate Governance, headed by former High Court judge, Mervyn King SC. Evolving global economic environment and legislative developments necessitated the updating of King I. The King Report on Corporate Governance for South Africa (King II) was developed and published in 2002 (Dekker 2002). According to a report by the Institute of International Finance (IIF), South Africa rates among the best performers in corporate governance in emerging markets (South Africa Info Reporter 2003).

Ward (2001:8) states that corporate governance ensures that directors understand the business risks and opportunities and know what to communicate and how to talk to the markets and the world at large.

Noncompliance with corporate governance may result in embarrassing disclosure in annual reports, which could attract the attention of the press, shareholder activists and institutional investors.

It is therefore necessary that cost management ideally be expanded to *risk-based* cost management and also focus on total costs. Emblemsvag (2003:4) argues that in the same way the Turnbull Report is about the adoption of a risk-based approach towards a system of internal control and reviewing its effectiveness, life cycle costing should take risks and uncertainties into account if it is to assist decision makers. Life cycle costing should help companies to eliminate costs before they are incurred and manage any crucial business risks relating to costs, cash flow and profitability.

Emblemsvag (2003:5) identifies a shortcoming in life cycle costing. He argues that most life cycle methods cannot credibly handle both of the above issues, except cash flows - hence his development of a new approach, referred to as activity-based life cycle costing.

2.6 ACTIVITY-BASED LIFE CYCLE COSTING

According to Emblemsvag (2003:5), many cost management efforts are ineffective because they are traditionally performed after the fact. He states that the ultimate goal of activity-based life cycle costing is to identify the underlying drivers of business performance, manage them, then settle for “ballpark” numbers and manage the risk. He contends that costs are statistical and cannot be managed unless the underlying drivers are understood. He further uses Monte Carlo simulations to handle uncertainty and risk far more efficiently and effectively than traditional methods. Emblemsvag (2003:85) defines Monte Carlo simulations as the use of random sampling to handle problems that may be deterministic or probabilistic. His new perspective on life cycle costing entails a shift from a partial focus to holistic thinking, from structure orientation to process orientation and from cost allocation to cost tracing. It also manages risk and uncertainty realistically.

Activity-based costing (see sec 3.8.4) assigns the cost of activities to individual products based on their relative consumption of the individual activities. Determining the costs of an activity is crucial to this approach of product costing. Activities consist of the aggregation of many different tasks. Activity-based cost centres are established, whereas in traditional systems, overheads tend to be pooled by departments. Costs are now allocated from cost centres to products. Traditional costing systems trace overheads to products using a small number of allocation bases, normally referred to as overhead allocation rates, which vary directly with the volume produced. The term "cost driver" is used by activity-based costing instead of using the terms "allocation bases" or "overhead allocation rates" (Drury 2008:226; Hansen & Mowen 2003:438).

According to Emblemsvag (2003:6), traditional cost management is predominantly concerned with costs in a fragmented way, as performed by companies today.

- Downstream costs are largely ignored despite the fact that it is evident that they are of considerable importance.
- Historical costs are studied because future costs are believed to be unknown.
- The focus is mainly on variable costs because fixed costs (see sec 3.2.1) are assumed to be fixed.
- Direct costs are better understood than indirect costs because traditional cost accounting systems virtually ignore overhead costs.
- The distinction between costs and expenses cannot be captured and is ignored.

When life cycle costing was first developed in 1965, the first three statements above were addressed. Costs outside the four walls of the organisation were considered, future costs taken into account and all costs treated according to what people think of *total* costs. Activity-based costing not only proposes a solution to the last two statements, but also to the first and third statement.

Decisions in the building industry have traditionally been based on the comparison of initial capital costs. This method was justified for the following two main reasons:

(1) Initial capital costs are principal costs. All other costs are "unimportant" and can be ignored.

(2) Since capital costs are the main costs, the lowest capital cost option will be the lowest cost option, and by implication, there will be no benefits from reducing running costs by increasing capital costs.

Expensive lessons have been learnt from the traditional approach, as discussed above. Initial costs are clear and visible at an early stage, while longer-term costs are not. These longer-term costs often far outweigh initial costs, and should have a stronger influence on decisions. Running costs need to be monitored for a life cycle cost approach to be effective as an essential element of overall cost management (Flanagan & Norman 1983:3; Garrison et al 2003:792).

Traditional cost accounting focuses only on partial cost, because it can only handle a small part of cost. A company should now look further than its four walls.

Life cycle costing influences both the accounting system, and taxation.

2.7 ACCOUNTING SYSTEMS AND TAXATION

Accounting systems normally report on a period-by-period basis, and product profits are not monitored over their life cycles. In product life cycle reporting, costs and revenues are traced on a product-by-product basis over several accounting periods throughout their life cycle. Product profitability cannot be measured accurately if all costs over their life cycles are not traced.

Research and development costs, planning, design and manufacturing were included in traditional cost accounting. Planning, design and manufacturing also appear in traditional product costing, while research and development costs are accounted for either as a product cost or a period cost. All these costs were incurred as the responsibility of the manufacturer. The actual life cycle, however, does not end when the product has been manufactured (Drury 2004:944; Sakurai 1996:164).

A loss-making project can turn into a profitable project if tax planning is done effectively. The ranking order of projects may also change because of effective tax planning. The greater the costs liable to taxation relief, the lower the after-tax costs will be. It is always necessary to differentiate between *capital* and *revenue* expenditure. Revenue expenditure is deductible from taxable income before the tax liability is calculated. All costs incurred as the running costs of a project are deductible against liability for tax (Flanagan & Norman1983:105). Capital expenditure will not be deductible as a business expense for taxation or financial purposes. However, there are exceptions because certain types of capital expenses will be deductible as capital allowances for taxation purposes.

From the discussion thus far, it is evident that life cycle costing can be extremely beneficial for an entity, but also have disadvantages.

2.8 EVALUATION OF LIFE CYCLE COSTING

The advantages and disadvantages of life cycle costing will now be discussed.

2.8.1 Advantages

- Life cycle costing is a whole or total cost approach undertaken in the acquisition of any capital cost project or asset. It assists decision making associated with equipment replacement, planning and budgeting.
- Effective choices can be made between the competing proposals of a stated objective. This caters for different solutions to the different

variables involved and formulates hypotheses to test the confidence of the results achieved.

- It serves as a management tool that allows the operating costs of projects to be evaluated at frequent intervals.
- It is useful for control programmes and reduces total costs.
- The *total* cost commitment undertaken in the acquisition of any asset, instead of only the initial capital cost, is identified.
- An effective choice can be made between alternative methods of achieving an objective. A set of techniques is provided for expressing different patterns of capital and running costs in consistent, comparable terms.
- It is a management tool that details the current operating costs of assets.
- Areas are identified in which operating costs may be reduced.
- The decision maker is compelled to consider the relationship between the important variables, the organisation's objectives and its environment.
- The decision maker is allowed to focus on key issues, to investigate and define the factors that influence the decision variables and obtain a deeper understanding of the factors that influence the final choice (Ashworth 1993:123; BChydro 2003:1; Dhillon 1989:30; Flanagan & Norman 1983:2; Neale & Wagstaff 1985:55).

2.8.2 Disadvantages

- It is time-consuming to collect all the relevant data throughout the life cycle of the project.
- The accuracy of data is doubtful. The project life of a long-lived project is characterised by uncertainty - hence the difficulty of making economic forecasts if the values of variable factors are unknown.
- It may be difficult to obtain data.
- The relevant costs are a combination of capital costs and running costs. These costs will be incurred at different times and cannot therefore being treated identically. Current and future costs should be presented

in equivalent terms (Flanagan & Norman 1983:219; Humphreys & Wellman 1996:239).

From the above one may conclude that life cycle costing can be used as a management tool to assist decision making. Not only can effective choices be made between different proposals, but alternative methods of achieving objectives can also be identified. Since the total cost commitment over the entire life cycle is identified, it can also be used to control programmes and reduce total cost.

However, it is a time-consuming method. It is difficult to obtain data, and the accuracy of data is often doubtful because of the uncertainty of future forecasts.

Fortunately, there is a solution to this problem. Risk and uncertainty can be analysed to support effective uncertainty analyses and risk management. Various life cycle costing models exist to assist with the difficulties. Some of the models will be briefly discussed below.

2.9 LIFE CYCLE COSTING MODELS

Dhillon (1989:ch 4) discusses 10 general life cycle models and 13 specific life cycle models. The overall objective of all these models is to estimate life cycle cost. Some of the general models are discussed below.

2.9.1 Model I

This model was developed by the US Navy for major weapon systems. The total life cycle cost comprises five components: The research and development cost (RDC), the operating and support cost (OSC), the associated systems cost (ASC), the investment cost (IC) and the termination cost (TC). This model is mathematically expressed as follows:

$$L_{cc} = RDC + OSC + ASC + IC + TC$$

where L_{cc} is the life cycle cost. The RDC is the validation cost and the full-scale development cost. The OSC comprises of the following:

- the depot supply cost
- the operating cost
- the personnel support and training cost
- the depot maintenance cost
- the second destination transport cost
- the organisational/intermediate maintenance activity cost
- the sustaining investment cost
- the installation support cost

The cost of associated systems has two major components: the investment cost of associated systems and the operating and support cost of associated systems. The investment cost consists of the following (Dhillon 1989:48):

$$IC = PC + GIC$$

where *IC* is the investment cost

GIC is the government investment cost

PC is the procurement cost

The termination cost is defined by:

$$TC = \sum_{j=1}^{N} [S(j)](STC)$$

where *N* is years in the life cycle

STC is the terminal cost of the major system

S(j) is the number of major systems terminated during year j

2.9.2 Model II

Life cycle cost has three components: the procurement cost, the initial logistic cost and the recurring cost. The total life cycle cost is given by

$$L_{cc} = PC + ILC + RC$$

where L_{cc} is the life cycle cost
PC is the procurement cost
ILC is the initial logistic cost
RC is the recurring cost

The total of the unit price is the procurement cost. A one-time cost, such as support equipment, solicitation and training, modification and technical data management, belongs to the initial logistic cost. The elements of the recurring cost include maintenance the cost, the operating cost and the management cost.

2.9.3 Model III

The four components of this model are the research and development cost (RDC), the production and construction cost (PCC), the operation and support cost (OSC), and the retirement and disposal cost (RADC). Mathematically, the life cycle cost can be represented as follows:

$$L_{cc} = RDC + PCC + OSC + RADC$$

where L_{cc} is the life cycle cost.

Jaafari and Doloi (2002:162) developed a simulation model for life cycle project management. They contend that simulation models help one to understand the real-life situation from conceptualisation to actual construction. The effect of changes in process design can be justified and fine-tuned. Although the development of computer-aided process simulation techniques have accelerated in recent years, their use is still not widespread because they are mainly applied in project management education and training.

The purpose of all the models is to estimate total life cycle cost. Some of the models are mathematical and therefore not included in this study. Dhillon (1989:46-74) discusses this topic in depth.

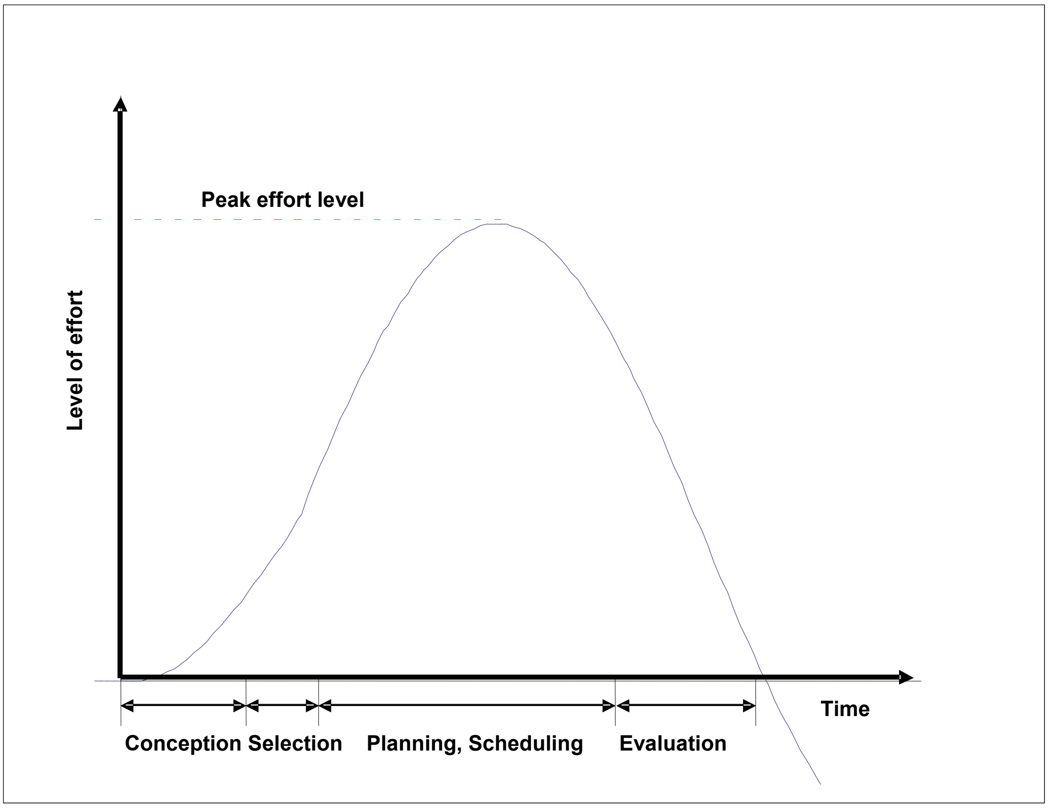
Since this study deals with the cost estimation and cost management of projects, it was deemed necessary to briefly discuss the basic principles of project management and compare traditional project management with life cycle project management.

2.10 PROJECT MANAGEMENT

A project starts when a manager and project team are selected, initial resources are assembled and the work programme is organised. When the work starts, the project builds momentum. Towards the end of the project, all its parts must come together, and completing the final tasks is extremely time consuming. The reason for this could be the changing levels of resources during successive stages of the life cycle. This phenomenon is clearly illustrated in the construction of a home or building.

Figure 2.8 depicts the project effort, in terms of man-hours or resources expended per unit of time plotted against time, where time is broken up into several phases of the project's life.

Figure 2.8 Time distribution of project effort



Source:

Adapted from Meredith and Mantel (1995:14)

2.10.1 The use of project management

The building of the Egyptian pyramids and the Tower of Babel may not have been some of the very first projects, because the cave dwellers probably embarked on projects to gather the raw material for mammoth stew!

Project management emerged mainly for three reasons: the exponential expansion of humankind and human knowledge, the growing demand for a broad range of complex, sophisticated, customised goods and services, and thirdly, the evolution of worldwide competitive markets for the production and consumption of goods and services (Meredith & Mantel 1995:1).

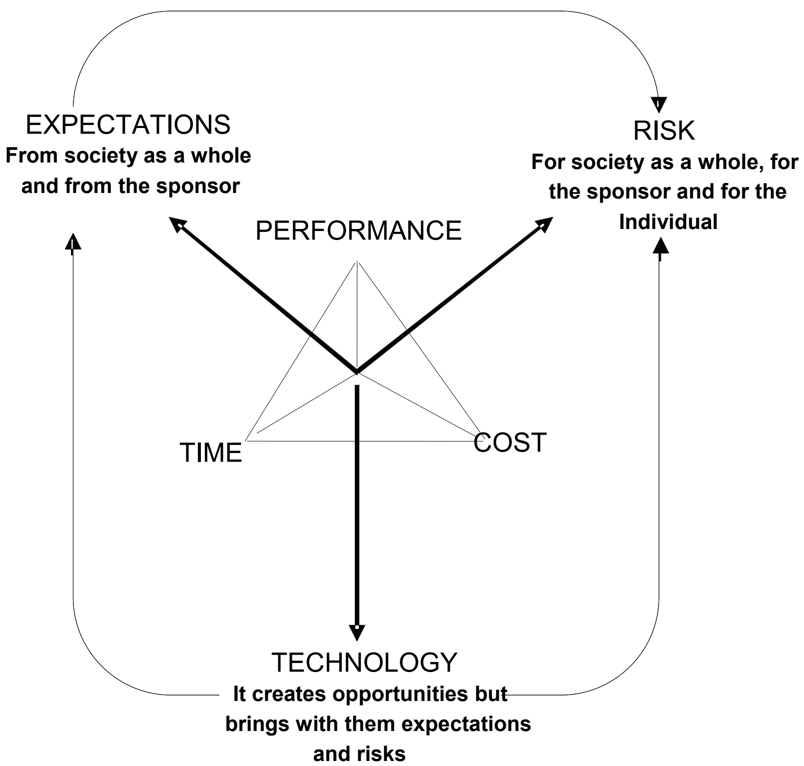
Meredith and Mantel (1995:1) state that project management, initiated by the military, can be used by an organisation as a powerful tool to improve its ability to plan, implement and control its activities, and helps to utilize its people and resources.

The basic purpose of project management is therefore to meet specified performance within cost and on schedule.

Webb (2000:9), however, argues that the role of the project manager as one simply delivering the project in terms of cost, time and performance is too narrow a view.

He designed a new model for project management, adding three components to traditional project management, namely *technology, expectations* and *risks,* as represented in figure 2.9.

Figure 2.9 A new model for project management



Source:

Adapted from Webb (2000:10)

Webb (2000:10) argues that project managers not only have to think in terms of the time-cost-performance triangle, but also have to manage external dimensions. Projects are created to exploit opportunities presented by advancing *technology. Expectations*, however, are raised with each advancement, not only in the technology itself, but also on the part of society as a whole. Each advancement in technology will bring risks that the expectations placed on a project on the part of society as a whole and the sponsor will not be fulfilled. This involves risks for the individual.

Meredith and Mantel (1995:9) mention that better control and improved customer relations are experienced by organisations using project management. Shorter development times, lower costs, higher quality and reliability and higher profit margins are also reported. More benefits entail a sharper orientation towards results, better interdepartmental coordination and higher worker morale.

There are also disadvantages in project management. Project management results in greater organisational complexity. It improves the probability that organisational policy will be violated, because of the autonomy required for the project manager. Higher cost, more management difficulties and low personnel utilisation are also reported (Meredith and Mantel 1995:9). The project life cycle has similar stages and phases as described for life cycle costing.

2.10.2 The project life cycle

Meredith and Mantel (1995:13) define a project's life cycle as the similar stages on the path from origin to completion, as illustrated in figure 2.1.

Initially, minimum effort is required. As activity increases, the real work gets underway. As the project nears completion, effort rises to a peak, and then ceasing when the project is terminated.

In traditional project management, it was thought that performance took precedence over schedule and cost early in the life cycle, during periods of high activity, cost was deemed to be of prime importance, and in the final stages, it was thought that schedule became paramount, when the client demanded delivery. This is actually untrue. Performance and schedule are more important than cost during all stages (Meredith and Mantel 1995:14).

Traditional project management and life cycle project management will now be compared.

2.10.3 Traditional project management versus life cycle project management

The primary focus of traditional project management is the management of the project delivery phase. Life cycle project management is an approach used to manage a project in which life cycle objective functions are used as the criteria for decision making throughout the project's life. The following life cycle objective functions are identified:

- financial objectives, such as equity, internal rate of return, and cost/worth ratio
- customer satisfaction objectives, such as functionality, operability, aesthetics, quality and user satisfaction
- due diligence objectives, which involve reducing exposure to risks and liabilities, including compliance with statutory requirements.

Life cycle project management is necessary because of turbulent environments (particularly shifting markets), the rapid rate at which technology changes, the increasing influence of the host communities and stakeholders, and the environmental, social, safety and legal implications of capital projects (Jaafari 2000:45; Jaafari & Manivong 2000:26).

2.11 CONCLUSION

The conclusion drawn in this chapter is that traditional cost management systems only concern the costs incurred within the four walls of the organisation. Such systems also try to manage costs after they have been incurred, instead of eliminating them before they are committed.

Projects can no longer be handled as static undertakings. A project should be run as a dynamic system subject to uncertainty, risk and pressures, both internally and externally. To stay competitive, projects require not only front-end evaluation, but also a viability definition throughout the project life cycle. Life cycle costing grows in significance as organisations become increasingly aware of both environmental and customer service costs.

It has been established that although up to 80% of a product's costs are committed during the introduction phase of the life cycle, the majority of costs are incurred during the growth phase. Cost management can most effectively be exercised during the introduction phase, and not during the growth phase when costs have been committed.

This chapter examined life cycle costing in depth. The development of life cycle costing, life cycle cost approach and the phases of the life cycle from different perspectives were discussed. The need for life cycle costing, namely to be an effective engineering tool for use in design and procurement, to be applied proactively in cost accounting and management and to assist with environmental issues, was also highlighted. Life cycle costing was compared to target costing, the value chain and traditional cost management methods. The advantages and disadvantages of life cycle costing were discussed. Project management and its use were briefly touched on. The project life cycle was defined and a comparison made between traditional project management and life cycle project management.

Chapter 3 will define the term "cost" and examine cost behaviour and various methods of cost estimation.

CHAPTER 3

COST ESTIMATION

3.1 INTRODUCTION

Cost estimation is the process of estimating the relationship between costs and the cost drivers that cause those costs. Companies estimate cost for three purposes, namely planning, decision-making and control purposes (Hilton et al 2006:410).

When considering a project and its feasibility, the estimation of cost is the first step required by management. The accuracy of the estimate of cost is fundamental. The estimate will not only tell one of the magnitude of the project for the purposes of approval, but it also serves as a tool for cost management in later stages of the project.

Every project manager is concerned about not exceeding the project budget. Cost overruns are quite common and are the norm rather than the exception. Cost overruns are not always the fault of the project manager and project team. Projects end up being inadequately funded in high risk areas involving the development of new products, systems or technologies. A lack of knowledge of the true extent of the effort involved, inadequate reserves to account for technical challenges and unwarranted optimism, which are sometimes needed to gain approval for the project to proceed, may be some of the reasons. This also applies to metallurgical research projects.

It is of vital importance for decision making, planning and control to determine how cost will change with output or other measurable factors of activity. Reliable estimates of costs and distinguishing between fixed and variable costs at different activity levels are necessary for the preparation of budgets, the production of performance reports, the calculation of standard costs and the provision of relevant costs for pricing and other decisions.

Costs, however, are not easy to predict because they behave differently in different circumstances. Drury (2008:595) states that labour costs for example, can be fixed when a fixed number of people are employed and this number is maintained even when there is a reduction in the quantity of activity used. Labour can also be classified as variable when a company uses casual labour hired on a daily basis so that labour matches production requirements. Costs cannot therefore be categorised as fixed or variable without examining the circumstances in which they are used. Despite advanced computer programs, sound estimations remain largely empirical and rely on the experience and judgment of the estimator (Drury 2008:596; Hilton et al 2006:410; Kharbanda & Stallworthy 1988:3-4; Zwikael, Globerson & Raz 2000:53).

In the paragraphs above, the definition, purpose and importance of cost estimation were discussed. The emphasis in this chapter, however, is on identifying and examining cost estimation techniques. Before these techniques are discussed, the term “cost”, cost behaviour and the classification of cost into various cost categories, as well as the cost of quality, will be examined. The following estimation techniques will then be discussed:

- analogy models
- parametric models
- engineering cost models
- cost accounting models (including standard costing, attribute-based costing and feature costing)
- activity-based costing.

3.2 DEFINITION OF COST

According to Drury (2008:27), accounting systems measure costs used for profit measurement and inventory valuation, decision making, performance measurement and controlling the behaviour of people. *Cost* is a frequently used word that reflects a monetary measure of the resources sacrificed or forgone to achieve a specific objective, such as acquiring a good or a service. Before cost can be estimated accurately, the term "cost" must be defined more precisely. This word is rarely used without a preceding adjective to specify the type of cost being considered.

Cost can be categorised in numerous ways. In the management accounting literature, it is evident that the term has multiple meanings and different types of costs are used in different situations. If an adjective is added, the assumptions that underlie cost measurement are clarified. Basic cost terms used from a management accounting perspective are, for example, *variable cost*, *fixed cost*, *opportunity costs* and *sunk cost*. Costs can also be classified from a financial accounting perspective as capital expenses and operating expenses. Capital expenses include fixed capital, working capital and the cost of land and other nondepreciable costs. Operating expenses consist of direct cost, indirect cost and fixed cost.

According to Emblemsvag (2003:28) the two terms, "cost" and "expense", are often use incorrectly or interchangeably, partly because of language simplifications but also ignorance. He states that cost is a measure of resource consumption relating to the demand for jobs to be done, whereas expense is a measure of spending relating to the capacity provided to do a job. For example, a stamping machine costs R600 to operate daily and can stamp ten thousand coins per day. One day, only 5 000 coins are stamped. The expense is R600, because that is the capacity provided, but the cost of stamping the coins is only R300. On this day, there was a surplus capacity worth R300.

A *cost object* is any activity for which a separate measurement of costs is desired. Examples include the cost of a product, the cost of rendering a service, the cost of operating a department or anything for which the cost of resources used needs to be measured.

In two recently published management and cost accounting textbooks, by Drury (2008:28) and by Garrison et al (2006:40), the focus is on the following cost terms, which will be discussed below:

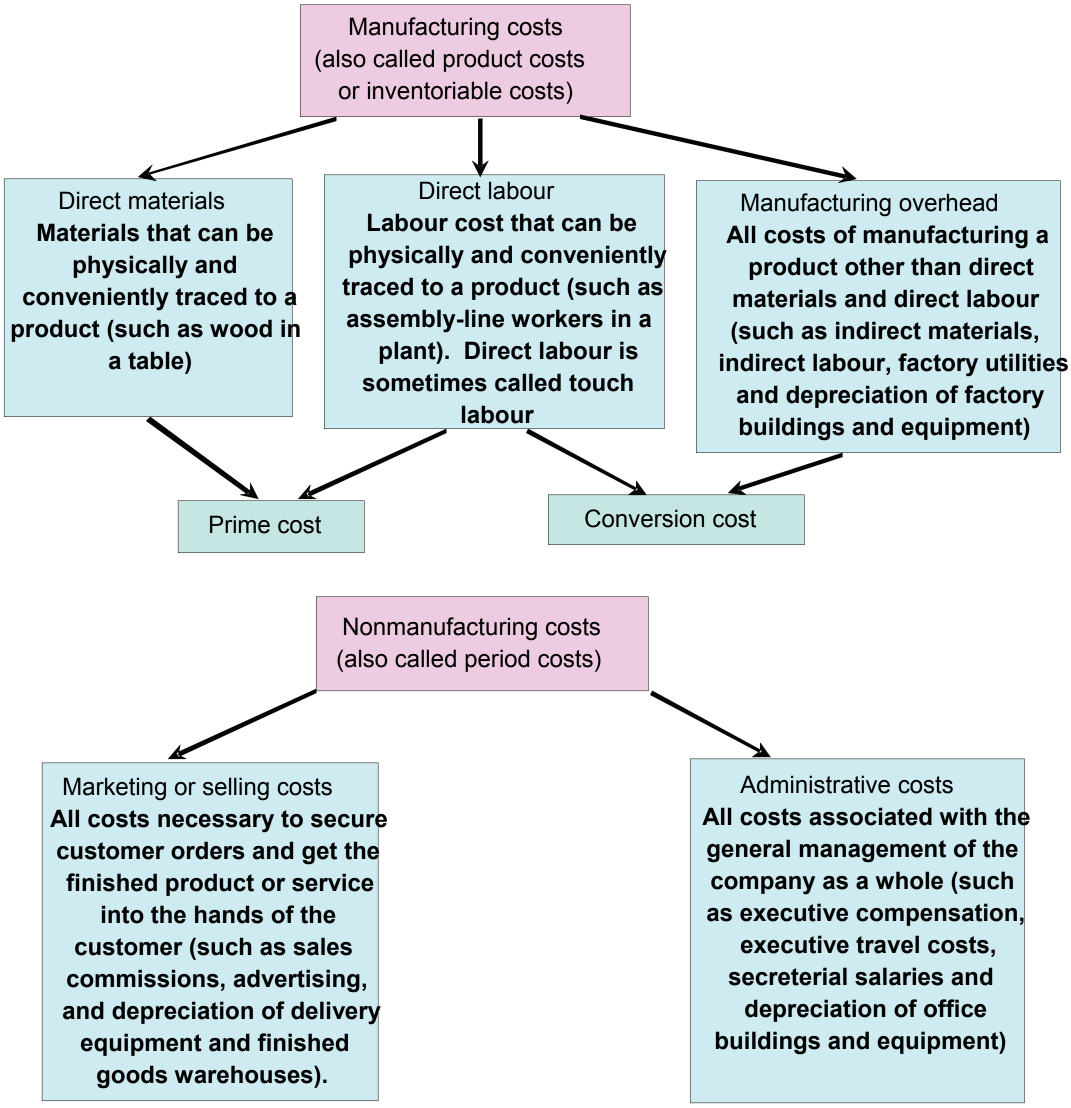
- direct and indirect costs
- period and product costs
- relevant and irrelevant costs
- avoidable and unavoidable costs
- sunk costs
- opportunity costs
- incremental and marginal costs

Costs that are assigned to a cost object can be divided into direct and indirect costs. *Direct* costs can be specifically and exclusively identified with a particular cost object, while *indirect* costs cannot be identified specifically and exclusively with a given cost object. Products are frequently the cost object in a manufacturing concern. In traditional cost accounting, product costs consist of direct materials, direct labour and manufacturing overhead. Direct material and direct labour can be identified with a specific product. Indirect material and indirect labour cannot be identified with a specific product, and are included in manufacturing overheads, which consists of all manufacturing costs other than direct labour, direct materials and direct expenses. Direct material, direct labour and other direct expenses are referred to as *prime costs. Conversion costs* are the costs of converting direct material into the final product, and include direct labour and manufacturing overhead.

Costs are further classified either as a *product* cost or a *period* cost. Product costs include all costs involved in acquiring or making a product. Period costs are all the costs that are not included in product costs and are therefore treated as an expense in the period in which they are incurred (Drury 2008:28-30; Garrison et al 2006: 36-40; Garrison et al 2003:22-25; Hilton et al 2006:42-44; Jackson & Sawyers 2003:34-36; Rayburn 1989:54-57).

Figure 3.1 contains a summary of the cost terms that have been introduced so far.

Figure 3.1 Summary of cost terms



Source:

Adapted from Garrison et al (2006:40)

The manufacturing and nonmanufacturing costs, as summarised in Figure 3.1, can be used for planning and control purposes, but need to be further analysed for decision-making purposes.

For decision-making purposes, costs and revenues can be classified according to whether they are relevant or irrelevant to a particular decision. *Relevant costs* are those future costs that will be changed by a decision, whereas *irrelevant costs* are those that will not be affected by the decision. The terms “avoidable” and “unavoidable” costs are sometimes used instead of “relevant” and “irrelevant costs”. Avoidable costs may be saved by not adopting a given alternative, whereas unavoidable costs cannot be saved. Only avoidable costs are therefore relevant for decision making.

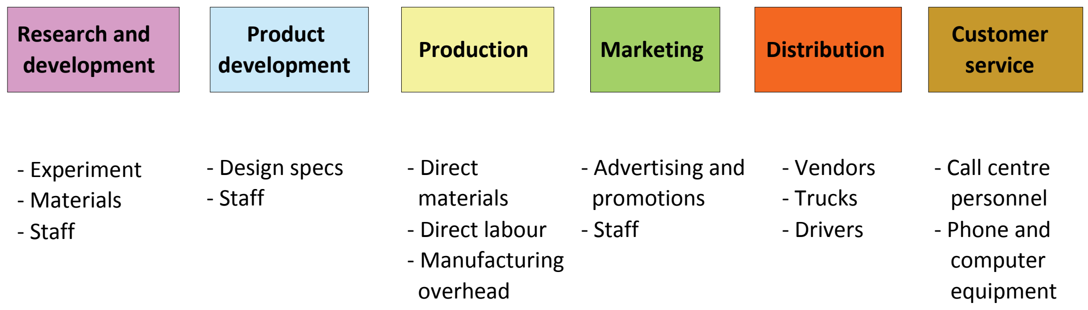
The costs of resources already acquired, where the total will be unaffected by the choice between various alternatives, are known as *sunk costs.* These costs have been created by a decision made in the past that cannot be changed by any decision that will be made in the future. Sunk costs are irrelevant for decision making, but are distinguished from irrelevant costs because not all irrelevant costs are sunk costs.

An *opportunity cost* measures the opportunity that is lost or sacrificed when a choice of one course of action requires sacrificing an alternative course of action.

Incremental costs and revenues (also referred to as *differential costs*) are the difference between costs and revenues for the corresponding items under each alternative being considered. In principle, this type of cost is similar to the concept of marginal cost. The main difference is that marginal cost represents the additional cost of one extra unit of output, whereas incremental cost represents the additional cost resulting from a group of additional units of output (Drury 2008:35-37; Garrison et al 2006:50-53; Jackson & Sawyers 2003:15-16).

The cost terms generally used in cost accounting, which were discussed above, can be categorised as either manufacturing or nonmanufacturing costs. An important aspect of cost, however, often ignored in the estimation of costs, is life cycle costs. Life cycle costs take into account all the activities in an organisation’s value chain. The value chain of an organisation is the set of activities that increases the value of the organisation’s products and services. A typical value chain includes research and development, design, production, marketing, distribution, and customer service activities. Figure 3.2 illustrates life cycle costs and the value chain.

Figure 3.2 Life cycle costs and the value chain



Source:

Adapted from Jackson & Sawyers (2003:37)

It can be seen that life cycle costing includes all the costs incurred throughout a product's life, not only in the manufacture and sale of a product.

According to Emblemsvag (2003:30), four types of costs need to be considered in a project's life cycle, namely usual, hidden, liability and less tangible. These costs are illustrated in table 3.1.

Table 3.1 Categories of life cycle costs

	Usual cost	Hidden costs	Liability costs	Less tangible costs
Capital cost				
1	Buildings	Monitoring equipment		
2	Equipment	Protective equipment		
3		Additional equipment		
Expenses				
1	Labour	Reporting		
2	Supplies	Notification		
3	Raw materials	Monitoring		
4	Utilities	Record- keeping		
5	Disposal	Planning		
6		Training		
7		Inspection		
8		Insurance		
Revenues				
1	Primary product			
2	Marketable by-products			
Other				
1			Legal consultants	Customer acceptance
2			Penalties and fines	Customer loyalty
3			Customer injury	Worker morale
4			Liability from hazardous waste sites	Corporate image
5				Brand name
6				Stakeholder relations

Table 3.1 shows that *usual costs* are the costs that traditional accounting methods usually handle. These costs are normally the largest cost in a

company. The *hidden costs* are typically associated with regulation of some sort. In traditional cost accounting, these costs are usually allocated to overhead cost using direct material or labour as allocation bases, which may lead to large cost distortions and incorrect allocation. Activity-based costing was designed to overcome this shortcoming. *Liability costs* arise as a result of noncompliance and potential future liabilities. Traditionally, these costs are allocated to overhead costs or treated as extraordinary costs. Since liability costs include future liabilities, they are difficult to estimate, especially environmental liability costs. The less tangible costs are extremely difficult to estimate, but far from unimportant. Emblemsvag (2003:30) argues that of huge concern is the fact that the liability cost and less tangible costs are mainly being ignored in cost and management accounting textbooks.

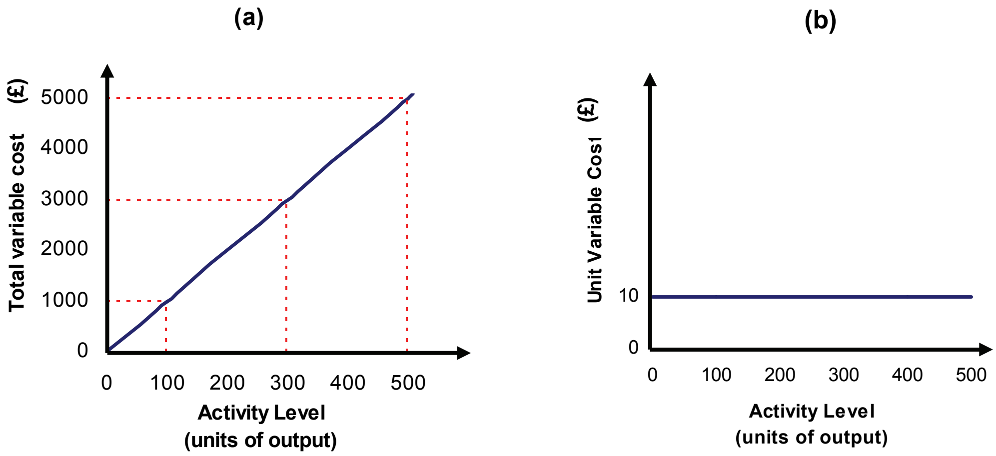
Cost terms have now been discussed. For accurate cost estimation, it is vital not only to understand the various cost terms and categories, but also how costs change with output or other measurable factors of activity. Cost behaviour will now be discussed.

3.2.1 Cost behaviour

Cost behaviour refers to the way in which costs react or respond to changes in the level of business activity. When volume changes, some costs may increase or decrease, while others may remain stable. However, specific costs behave in predictable ways as volume changes. For decision-making purposes, a knowledge of how costs and revenues vary with different levels of activity is essential.

In traditional cost accounting, the terms "*variable", "fixed", "semi-variable"* and "*semi-fixed"* are used in the literature to describe how a cost reacts to changes in activity. *Variable* costs vary in direct proportion to the volume of activity. If volume is doubled, variable costs will also double. Consequently, total variable costs are linear, whereas unit variable cost is constant. This concept is illustrated by Figure 3.3.

Figure 3.3 Variable costs: (a) total; (b) unit

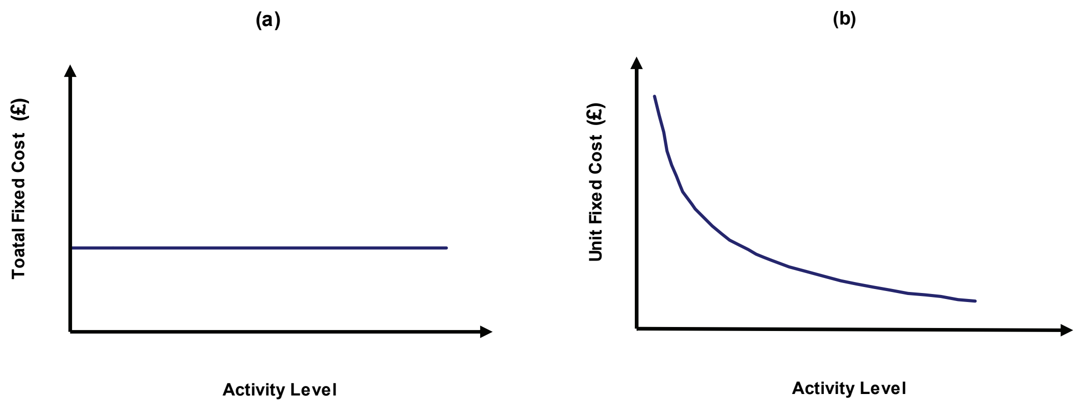


Source:

Adapted from Drury (2008:32); Jackson and Sawyers (2003:132)

Fixed costs remain constant over wide ranges of activity for a specified time period. Examples of fixed costs include the depreciation of factory buildings, the supervisor's salary, insurance and the leasing charges for vehicles or equipment. Fixed costs therefore remain constant in total, but vary per unit when production volume changes. Figure 3.4 illustrates fixed costs.

Figure 3.4 Fixed costs: (a) total; (b) unit

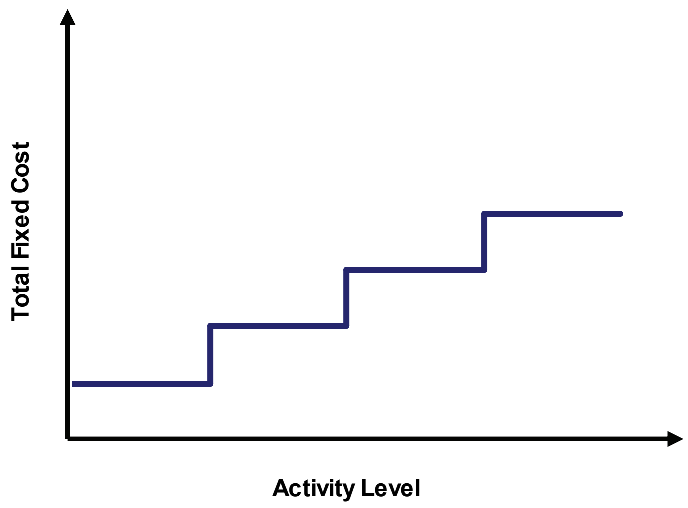


Source:

Adapted from Drury (2008:33); Jackson and Sawyers (2003:132)

In practice, it is unlikely that fixed costs will be constant over the full range of activity. They may increase in steps, as illustrated by Figure 3.5. Costs that behave in this manner are described as *semi-fixed* or step fixed costs. Step fixed costs are fixed within a given time period within specified activity levels, but eventually increase or decrease by a constant amount at various critical activity levels.

Figure 3.5 Step fixed costs



Source:

Adapted from Drury (2004:34); Jackson and Sawyers (2003:132)

Semi-variable or mixed costs should also be considered. These include both a fixed and a variable component. An example of semi-variable cost is a sales representative who is paid a fixed salary plus a commission on sales (Drury 2008:30-35; Garrison et al 2006:48-50; Jackson & Sawyers 2003:132-138).

A critical category of cost, the cost of quality, is often included in the costs discussed thus far. Many companies are currently not aware of how much they spend on quality because these costs are incurred across many different departments and not accumulated as a separate cost object in the costing system.

3.2.2 Cost of quality

Managers need to know the cost of quality and how it changes over time. A product may have a top-quality design that uses high-quality components, but if it is poorly assembled or has other defects, it will have excessive warranty costs and customers will be dissatisfied. A product that meets and exceeds its design specifications and is free of defects is said to have *high quality conformance.* Preventing, detecting and dealing with defects cause costs referred to as *quality costs* or *costs of quality.* Quality costs can be divided into four groups. *Prevention costs* and *appraisal costs* are incurred in an effort to keep defective products from falling into the hands of customers. *Internal failure costs* and *external failure costs* are incurred because defects are produced despite efforts to prevent them. Examples of typical quality costs are summarised in table 3.2.

Table 3.2 Typical quality costs

PREVENTION COSTS	**INTERNAL FAILURE COSTS**
Systems development Quality engineering Quality training Quality circles Statistical process control activities Quality data gathering, analysis and reporting Quality improvement projects Technical support provided to suppliers Quality audits	Net cost of scrap and spoilage Rework labour and overhead Re-inspection of reworked products Retesting of reworked products Downtime caused by quality products Disposal of defective products Analysis of the cause of defects in production Re-entering data because of keying in errors Debugging software errors
APPRAISAL COSTS	**EXTERNAL FAILURE COSTS**
Testing and inspection of incoming materials Testing and inspection of in-process goods Final product testing and inspection Supplies used in testing and inspection Supervision of testing and inspection activities Depreciation of testing equipment Maintenance of testing equipment Plant utilities in the inspection area Field testing and appraisal at customer site	Cost of field servicing and handling complaints Warranty repairs and replacements Repairs and replacements beyond the warranty period Product recalls Liability arising from defective products Returns and allowances arising from quality problems Lost sales arising from a reputation for poor quality

Source:

Adapted from Garrison and Noreen (2003:64); Hansen and Mowen (2003:659)

The above table shows that quality costs do not relate to only manufacturing, but also to all the activities in the life cycle of a company: from initial research and development through to customer service. Secondly, the number of costs associated with quality is large. Unless management give this area special attention, quality cost may be quite high. With the exception of lost sales, customer dissatisfaction and lost market share, all the quality costs are observable and should be available from the accounting records. All the costs in the external failure category are hidden costs. These costs may be significant and should be estimated. Finally, it should be noted how different the costs in the four groups really are (Garrison & Noreen 2003:63-64; Hansen & Mowen 2003:657-660).

This discussion concludes with table 3.3, which summarises the cost categories and terms discussed thus far.

Table 3.3 Summary of cost classifications

PURPOSE OF COST	COST TERM

Preparing external financial statements	• Product costs (inventorial)
	  ◘ Direct materials
	  ◘ Direct labour
	  ◘ Manufacturing overhead
	• Period costs (expensed)
	  ◘ Nonmanufacturing costs
	    ▪ Marketing or selling costs
	    ▪ Administrative costs

Predicting cost behaviour in response to changes in activity	• Variable cost (proportional to activity) • Fixed cost (constant in total)
Assigning costs to cost objects such as departments or products	• Direct cost (can be easily traced) • Indirect cost (cannot be easily traced; must be allocated)
Making decisions	• Differential cost (differs between alternatives) • Sunk cost (past cost not affected by a decision) • Opportunity cost (forgone benefit)
Cost of quality	• Prevention costs • Appraisal costs • Internal failure costs • External failure cost

From the above table, it is clear that costs are used for many purposes, and each purpose requiring a different classification of costs.

For the purposes of this study, life cycle cost of a project is defined as the total costs that are incurred, or may be incurred, in all stages of the product life cycle. (See sec 2.2). This will therefore vary from project to project. It should be noted that life cycle cost is a decision support tool that should match the purpose and not an external, financial reporting system that should obey rigid principles, such as Generally Accepted Accounting Practice (GAAP).

In addition to cost behaviour and the relevance of costs, long-term decisions require a consideration of the time value of money. The cost of money is an integral part of the analysis for determining profitability and establishing net present values and rates of return based on cash flows. These concepts will now be discussed.

3.3 THE TIME VALUE OF MONEY

Humphreys and Wellman (1996:274) define the time value of money as the cumulative effect of elapsed time on the value of money, based on the earning power of equivalent invested funds.

Drury (2008:294) provides a practical definition, namely that £1 received in the future is not equal to £1 received today. Flanagan and Norman (1983:41) formulate a similar definition, namely that money today is in some sense different from money tomorrow.

From the above, it is clear that when an investment involves cash flows over many years, the time value of money becomes important and should be taken into account in investment decisions.

Two techniques are used in capital investment decisions, considering the time value of money: the **net present value** (NPV) method or the **internal rate of return** (IRR) method. The process whereby future money is converted into its equivalent in present money is referred to as discounting. When discounting cash flows to its present value, two simplifying assumptions are made in both methods. Firstly, all cash flows are assumed to occur at the end of each period, and secondly, all cash inflows are immediately reinvested in another project investment. The rate of return earned on the reinvested amount will depend on whether the internal rate of return or net present value method is used. According to the NPV method, cash inflows are assumed to be reinvested at the discount rate used in the analysis, while according to the IRR method, cash flows are assumed to be reinvested at the internal rate of return of the original investment.

3.3.1 Net present value

The net present value (NPV) method requires the choice of a discount rate to be used in the analysis. Many companies use the cost of capital. **Cost of capital** represents what a company would have to pay to borrow or raise funds through equity in the financial marketplace. In NPV analysis, the discount rate is the minimum required rate of return – the rate the company requires for any investment to be profitable. The **discount rate** is adjusted to reflect the risk and uncertainty of cash flows expected in the future. The present value of all cash inflows is compared to the present value of all cash outflows. If the present values of the inflows are greater than or equal to the present values of the outflows (ie the NPV is greater than or equal to zero), the investment is acceptable, because a return at least equal to the discount rate is provided. If the present values of the outflows are greater than the present values of the inflows, the NPV will be negative and the investment rejected. Table 3.4 summarises the results of NPV analyses.

Table 3.4 Summary of net present value

If the net present value is …	Then the project is …
Positive	Acceptable, since it promises a return greater than a required rate of return.
Zero	Acceptable, since it promises a return equal to the required rate of return.
Negative	Not acceptable, since it promises a return less than the required rate of return.

Source:

Adapted from Garrison et al (2003:364)

The net present value of a project can be calculated by using the following equation (Drury 2008:295-297; Garrison et al 2006:654-660; Hilton et al 2003:587; Jackson & Sawyers 2003:248):

$$NPV = \sum_{n=10}^{N} \left[C_n \times (1+d)^{-n} \right]$$

where

C_n = the cash to be received or disbursed at the end of period *n*

d = the appropriate discount rate for the future cash flows

n = the time period during which the cash flow occurs

N = the life of the investment, in years

3.3.2 Internal rate of return

The internal rate of return (IRR) is an alternative technique for making capital investment decisions. The IRR represents the true interest rate earned over the course of an investment's economic life. It is sometimes referred to as **discounted rate of return.** The internal rate of return is the maximum cost of capital that can be applied to finance a project without harming the shareholders. If the IRR is greater than the opportunity cost of capital, the investment will be profitable and yield a positive NPV. If the IRR is less than the cost of capital, the investment will be unprofitable and result in a negative NPV. The IRR is computed by finding the discount rate that equates the present value of a project's cash outflows with the present value of its cash inflows. The IRR is therefore that discount rate that will cause the net present value of a project to be equal to zero (Drury 2008:298; Garrison et al 2006:661; Garrison et al 2003:371).

The two methods will now be compared.

3.3.3 Comparison of the net present value and internal rate of return methods

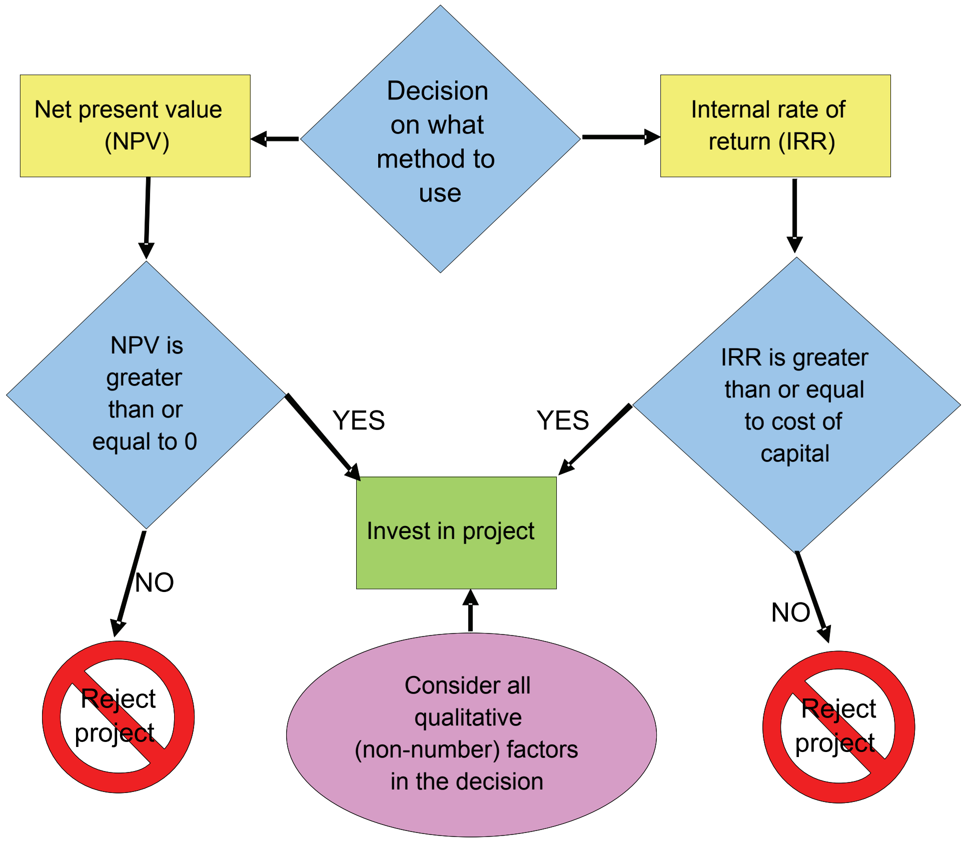
The net present value method has several important advantages over the internal rate of return method. These include the following:

- The NPV method is often simpler to use.
- The assumption made by the IRR method concerning the rate of return earned on cash flows generated during its useful life is questionable. The NPV method assumes that the rate of return is the discount rate, whereas the IRR method assumes the rate of return is the internal rate of return on the project.
- Risk and uncertainty are taken into account by adjusting the discount rate using the net present value. When the IRR method is used, users have to adjust cash flows directly in order to adjust for risk.

When the two methods do not concur about the attractiveness of a project, it is preferable to opt for the net present value method, because it makes the more realistic assumption about the rate of return that can be earned on a project's cash flows. (Garrison et al 2006:662-663; Jackson & Sawyers 2003:252).

Unless there are qualitative reasons for rejecting the project, the investment will be acceptable if the IRR is equal to or greater than the minimum required rate of return (See Figure 3.6).

Figure 3.6 Choosing the right investment evaluation method



Source:

Adapted from Jackson and Sawyers (2003:253)

Future money is reduced (discounted) to its current money equivalent or present value. The rate at which future money is discounted, is referred to as the discount rate and is taken to represent the time value of money.

3.3.4 The main components of discounting

The discount rate is the interest rate used to discount future cash flows to their present values. If a project has a positive NPV, it will earn a rate of return higher than its discount rate. The three main components of discounting are

(1) the time stream of costs and revenue
(2) the discount rate
(3) project life

(1) The time stream of costs and revenues. The objective of discounting and discounted cash flows, when applied to life cycle cost, is to express future flows of cash in their present value. The estimated time stream of expenditure and receipts is therefore a vital component of the analysis. All costs and revenues over the entire life cycle of the project should be identified. Taxation and investment incentives should also be taken into account.

(2) The discount rate. The choice of the discount rate is the second major component of discounting. The choice whether to proceed with a specific project is crucially affected by one's choice of discount rate. The discount rate should be the opportunity cost of capital - the real rate of return available on the best alternative use of funds to be devoted to the project. The appropriate cost of capital is a long-term cost in which the time period refers to the life cycle of a project and cannot be expected to be financed by borrowing in the short-term money markets.

(3) Project life. The estimate of the probable life of a project is the third component of discounting. Many factors will influence this estimate. Specialist suppliers can give estimates, but the estimator will also have to rely on historical data and professional judgment. The shorter the project life is, the more important the estimate of the project life will be (Flanagan & Norman 1983:45-46).

In metallurgical research projects, it was observed during personal interviews that the majority of the respondents used NPV and IRR techniques for the evaluation of projects. However, it is crucial that the cost estimates used for the calculations are accurate.

Depending on the amount of time and resources available, the degree of accuracy and other factors such as data availability, there are different methods of cost estimation. The techniques used to estimate costs will now be discussed.

In this study, two of the research objectives relate to cost estimation, namely:

(1) to examine different methods that can be used to estimate and manage the total costs of a project during its life cycle
(2) to determine whether these cost estimation methods are being used in metallurgical research projects

The different methods of cost estimation will now be discussed, while section 5.6.10 indicates which of these methods are used for metallurgical research projects.

3.4 COST ESTIMATION TECHNIQUES

Cost overruns can lead to cancelled projects, but these projects are often not cancelled before considerable expenditure has already been committed. Cost overruns often lead to either cutbacks in quantity or a compromise on performance. In either situation, valuable resources are wasted. Costs do not simply happen - they are caused by activities. The challenge of managing cost is to identify the activities that cause costs, estimate the relationship between costs and their causes and manage the activities causing the costs. This chapter deals with the estimate of the relationship between costs and their causes.

According to Hilton et al (2003:435), three cost estimation methods commonly used in practice are statistical methods (using regression analysis), account analysis and engineering estimates. Drury (2008:597) lists engineering methods, inspection of accounts methods, graphical or scatter graph methods, the high-low method and the least square method. These methods are discussed in detail in cost accounting textbooks.

Emblemsvag (2003:36), who has a more comprehensive view of life cycle cost compared with Drury (2008) and Hilton et al (2003), holds that there are four main methods of cost estimation, specifically for performing life cycle costing, namely:

(1) Analogy models
(2) Parametric models
(3) Engineering cost methods
(4) Cost accounting models

Since this study is concerned with cost estimation over the life cycle of a project, cost estimation techniques suitable for life cycle costing will be discussed. This will include analogy models, parametric models, engineering cost methods and cost accounting models. Cost accounting will be grouped into volume-based costing systems, unconventional costing methods and modern cost accounting systems. Modern cost management systems such as just-in-time (JIT) costing, target costing and other strategic cost management techniques, will be discussed in chapter 4.

The various methods of cost estimation have different advantages and disadvantages. Organisations often apply more than one approach to be able to compare and verify results. The person who bears ultimate responsibility for cost estimates applies his/her best professional judgment as a final step in the estimation process. Estimation methods should help management to arrive at the best estimates possible, not as the final answer. Estimates should focus on the strengths and weaknesses of cost estimation methods. These methods will now be discussed.

3.5 ANALOGY MODELS

Kharbanda and Stallworthy (1988:64-68) claim to have developed the approach referred to as “estimating by analogy”, first published in 1970. They contend that this approach can be a valuable tool in the preliminary and screening stages of process development. However, they conclude that the lack of the necessary volume of historical data could be a problem in developing a sufficiently reliable equation.

A life cycle costing estimate made by an analogy identifies a similar product and component and adjusts its costs for differences between it and the target product. This method is common in shipbuilding, for example, where mass is the factor to which costs are related. It is also used in the energy sector, where energy serves as a basis for costing. This is a crude way of handling costs because it says nothing about direct labour or overhead costs. It takes into account the historical costs and scales them according to the most important driver. Such methods are effective when extensive historical material is available, the products are produced per unit, one dominant cost driver is used and the products do not differ much. Cost allocation is reduced to virtually nothing, because the products are produced unit by unit. The cost driver should be dominant, otherwise the analogy has no basis. To ensure the relevance of historical data, it is vital for the products not to change too much. According to Emblemsvag (2003:36-37), this method has limited usage, when one considers all the above limitations.

From the discussion above, it is evident that analogy can be used early in the project’s life in order to estimate costs. If there are insufficient historical data, analogy cannot be used for accurate estimation. This method can only be applied if there is one dominant cost driver, the products are produced per unit and they do not differ from one another.

Metallurgical research projects are generally once-off projects. Limited historical data will exist and this method will be unsuitable for accurate cost estimation, unless similar, comparable projects have been done before.

3.6 PARAMETRIC MODELS

Traditionally, cost estimation was largely based on empirical relationships, with the main emphasis on the collection of historical data with little attempt to correlate the various sets of data. Because no historical data were available, this approach was irrelevant for pilot plants and other "first-off" installations. The US Air Force was commissioned in the late 1950s to devise a suitable estimation technique to deal with this situation. During the period 1962 to 1968, several studies were undertaken, resulting in various reports on the methods that had been developed for estimating air-frame and missile costs. A comprehensive report by Large (1963), *Concepts and procedures of cost analysis,* merged in one document all the relevant publications on parametric estimation. The *Manual of cost estimating procedures* (AFSCM, 171-173, November 1967, an air force systems command manual, Cost analysis series) soon followed. This manual included definitions and estimations of relationships over time or for the period between milestones. Further developments followed soon after, including the derivation of time and cost estimation relationships to a common data base and an analysis of the effect of changes on costs and schedules (Kharbanda & Stallworthy 1988:94-95).

Black (1984:93) collated various meanings attached to parametric cost estimation by different authors:

- Gallagher (1982) describes parametric cost estimation as determining the life cycle cost of a programme using a number of parameters and the case histories of similar systems.
- Rice (1970), however, defines it as the cost of estimating any system, comprising various components, through mathematical models involving parameters and derived from prior case histories.
- Koenigsekar (1982) sees parametric cost estimation as the methods that are used in the preparation of an ordinary factored estimate, such as analogy, the estimator choosing from number of parametric factors.

From the above definitions it is evident that parametric cost estimation models use parameters and case histories of similar systems by applying mathematical models.

In many ways, parametric models are more advanced analogy models. A parametric model is based on predicting a product's or component's cost either in total or for various activities by using several models describing the relationships between costs and some product- or process-related parameters. The predicting variables typically include manufacturing complexity, design familiarity, mass, performance and schedule compression. The differences between parametric and analogy models are listed in table 3.5.

Table 3.5 Differences between analogy and parametric models

Analogy models	Parametric models
Depends on a single, dominant cost driver.	Use several cost drivers.
Based on the linear relationship between costs and cost drivers.	Rely on one or more nonlinear regression models.
Use analogy (such as mass) as a driver.	Essentially regression models that can be linear, quadratic or multidimensional.

Parametric models, like analogy models, do not handle overhead costs in a credible manner. They present an assessment number without any further insight, except for a direct consequence of their parameters. Parametric modelling has clear limitations. When it is used to optimise the economic performance of a manufacturing system, the validity of parametric modelling is stretched beyond its limits. However, it is easy to use in optimisation algorithms. According to Emblemsvag (2003:38), parametric models are often found in the engineering literature. They perform well as models in a cost accounting system, preferably one that can handle overhead cost well, such as activity-based costing (ABC). For example, if an ABC model discovers that a product incurs too many disposal costs relating to cutting raw materials, a parametric model can be used to investigate how to reduce the need for disposing of waste (Emblemsvag 2003:37-38).

3.6.1 Steps in parametric cost estimation

The parametric approach involves relationships that link the physical and/or performance characteristics of a system to its cost. Other characteristics, such as the management approach, also enter parametric cost estimation equations. The following steps can be followed:

- **Establish the objectives of the analysis and its scope.** Three common objectives are
  - an estimate of the total cost of a programme to meet budgeting or reporting requirements
  - an estimation of costs to compare competing projects
  - detailed cost trade-offs among between design and operations alternatives

- **Develop a formally structure table of the cost elements to be examined.** The objective of the project will determine the level of detail at which the project should be conducted. The purpose of this cost chart of accounts is to ensure that all costs are taken into account, none are double counted and individual cost elements are consistently and clearly defined. The most detailed structure includes three dimensions, that account for details of the equipment or system being evaluated, the phases of the life cycle for this equipment and the resources required.

- **Develop a cost hypothesis.** A mathematical equation should be established for each element. A selection of independent variables, using reasonably well-defined engineering principles will be used to identify the parameters. A functional form of the mathematical equation must be specified to link cost to these independent variables. The equations assume different mathematical forms, depending on the technical relationship between the variables. The dependent variable we are interested in is cost. The most common forms of these equations are as follows:

- linear: $C = A + Bx$, equation for a straight line
- log: $C = \log A + B \log 2\, x$
- quadratic: $C = A + Bx + Cx^2$

These equations relate to two parameters only, *x* (which is the independent) and C (cost).

- **Collect and normalise data.** The data can be used to verify the postulated cost estimation relationship. Mainly three categories of data sources are used in parametric cost studies, namely:

  - actual data from equipment or activities identical to the ones being studied
  - actual data from analogs to the equipment and activities being studied
  - engineering estimates

Data should be consistently defined prior to their incorporation into the postulated estimation relationship. This includes consistency of both technical and cost information. Data must then be normalised by taking into account changes in price over time, changes in productivity, contract tiring and the cost per unit, based on the quantity provided.

- **Calibrate and verify the postulated cost estimation relationship (CER).** A cost estimation relationship is any equation that facilitates estimation of a cost. There are two types of CERs - those built up from inputs such as material costs, wage rates, time and motion studies, and those relating to output characteristics such as speed, size, power and capacity. The process that uses the latter type of CER is referred to as parametric costing. Mathematical statistics are used in this process for developing coefficients and exponents in the equations. If the relationship is unreasonable, the independent variable, mathematical equation and level of detail for the analysis should be re-evaluated. Least square curve fitting or multiple regression analysis provides well defined and consistent means of determining a specific mathematical relationship. Regression analysis is covered in many cost accounting textbooks and will not be discussed in this study. The ultimate criterion is the reasonableness of the derived relationship. Two of the reasons for the estimation relationship being unreasonable are as follows:

(1) The actual cost-determining variables and variables and the general way in which these variables influence cost, are not identified.

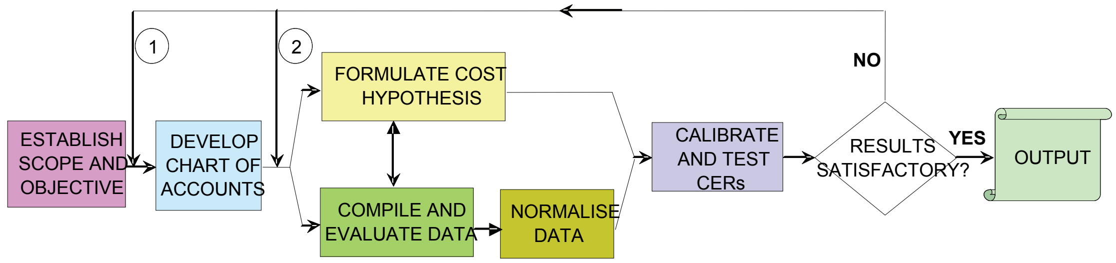
(2) The data may be inaccurate or inadequate.

- **Present the cost estimate.** The result of the parametric cost analysis should be presented clearly and effectively. The assumptions and ground rules should be clearly explained and the data supporting this analysis should be available. Uncertainties in the estimates should be indicated. Uncertainties are one of the primary elements in the presentation of costs.

- **Extend and refine.** Refinements should be made when there are changes in technology, research and development, manufacturing or productivity that could affect costs (Bajaj, Gransberg & Grenz 2002:EST.08.1; Black 1984:81-85; Brown & Yanuck 1980:55; Dodson 1983:1-68; Kharbanda & Stallworthy 1988:95-96; Sachs nd:1-15).

Figure 3.7 contains a summary of parametric cost analysis procedures.

Figure 3.7 Schematic illustration of parametric cost analysis



(1) IF RESULTS UNSATISFACTORY, POSSIBLE REVISION OF LEVELOF DETAIL

(2) IF RESULTS UNSATISFACTORY, REVISION OF HYPOTHESIS AND COLLECTION OF ADDITIONAL DATA

Source:

Adapted from Dodson (1983:5)

In the preceding sections, the sequence of parametric cost estimating was discussed. It should be emphasised that there are numerous interrelationships between them, as illustrated in the figure above.

As in any other costing system, parametric costing has both advantages and disadvantages, which will now be evaluated.

3.6.2 Evaluation of parametric cost estimation

The main features and advantages of parametric cost estimation can be summarised as followed:

- A statistical method is used in the design stage.
- The critical parameters are selected for their cost predictive ability.
- The number of units for the desired production rate is determined on the basis of experience.
- No labour-material split is necessary, as in the case of detailed procedures.
- It has the advantage of speed, ease of computerisation and lends itself to sensitivity analysis.

- The results are obtained quickly once the database has been established and analysed.
- It provides valuable insight into the type of information required when asking suppliers for quotations.
- Interpolation of data is quite simple and the results fairly accurate.

As with any technique, there are practical limitations in this area of estimation, as highlighted below (Dodson1983:1-5; Kharbanda & Stallworhty 1988:99-100).

- Extrapolation should be done carefully and the range of the validity of the estimate should be clearly known and stated.
- It is easy to be misled by the value of the correlation coefficient in judging the utility of a particular parameter.
- Although the parametric cost estimation-based correlations appear as continuous lines, much of the process equipment such as pumps, centrifuges and other than tailor-made equipment is available from the manufacturers only in discrete sizes.
- The correlations assume the purchase of a reasonable number of units at a time. The cost of purchasing only one unit would be much higher than given by the generalised parametric cost estimating correlations.
- The correlations relate to standard equipment. The cost of a nonstandard item is much higher.
- Normal market conditions are assumed.

From the above discussion, one may conclude that parametric cost estimation makes accurate estimation possible early in the project life and can therefore help avoid wasting resources. It differs from other estimation techniques because it can make accurate cost estimations early in a project's life. The chance of unanticipated cost growth decreases, and this can be used to evaluate the cost of different design options in order to identify the most cost-effective project design. However, parametric cost estimation relies on historical data, bases estimation on high volumes of standard equipment and assumes normal market conditions.

This method can be used for metallurgical research projects, but also relies on historical data, which are not available for once-off projects.

3.7 ENGINEERING COST MODELS

According to the New South Wales Government's Asset Management Committee in Australia, "*the engineering cost method is used where there is detailed and accurate capital and operational cost data for the asset under study. It involves the direct estimation of a particular cost element by examining the asset component-by-component. It uses standard established cost factors to develop the cost element and its relationship to other elements (known as the Cost Estimation Relationships.*)". Where statistical methods rely on past data, the engineering method works mainly with the present and the future. (Emblemsvag 2003:37)

Emblemsvag (2003:38) claims that the literature probably mixes the three aforementioned methods of cost estimation, namely analogy, parametric and engineering cost methods, particularly parametric and engineering cost models. He is of the opinion that none of these methods handles overhead costs correctly because none of them captures the complexity of modern organisations. Many of them include only simple mathematical manipulations of already identified costs. The cost estimates that are taken as input are likely to be distorted because they are probably generated by traditional cost accounting systems.

Engineering cost models are appropriate when there is a physical relationship between the cost and the cost driver. An analysis is done on the basis of direct observations of the underlying physical quantities required for an activity and the final results are then converted into cost estimates. The engineer, who is familiar with the technical requirements, estimates the quantities of material, labour and machine hours required for various operations. Prices and rates are then applied to the physical measures to obtain the cost estimates. The models are also useful for estimating cost of repetitive processes where input-output relationships are clearly defined, for example, for estimation costs usually associated with direct materials, labour and machine time because these items can be directly observed and measured. They cannot be used for separating semi-variable costs into their fixed and variable elements.

The models cannot only be used for manufacturing activities, but time and motion studies can also be applied to well-structured administrative and selling activities such as typing, invoicing and purchasing. The use of these methods is most appropriate when direct costs form a large part of total costs and when input-output relationships are stable over time. They may also be applied where no historical data are available to analyse past cost relationships (Drury 2008:598; Emblemsvag 2003:38-39; Hilton, Maher & Selto 2003:447-448).

Cost engineering methods have an advantage over other cost estimation methods and will now be evaluated.

3.7.1 Evaluation of engineering cost methods

The cost engineering method has an advantage over other cost estimation methods because it details each step required to perform an operation. It also does not require data from prior activities, but can be used to estimate costs for totally new activities. It can also identify nonvalue-added activities.

A disadvantage of engineering methods is that methods study, work sampling and time and motion study techniques may be expensive to apply in practice. Another consideration is that it is based on optimal conditions (Drury 2008:598; Emblemsvag 2003:38-39; Hilton et al 2003:447-448).

Owing to the increased automation and use of advance technology, the importance of handling overhead costs correctly is increasing. Although engineering cost models offer much more insight than analogy and parametric models, they are also limited in usage. However, they are particularly useful in engineering and development situations to give an early cost estimate.
Engineering cost methods are mostly utilised for project cost estimation for metallurgical research projects (see sec 5.6.10). A possible reason for this

could be that they do not require data from previous activities but can be used to estimate costs for totally new projects, such as research projects.

Cost management and control are best effected through action at the point where the costs are incurred. Standards should therefore be set in order to control the costs. According to Drury (2008:420), two methods can be used to set standards. Past historical records can be used or standards can be based on engineering methods.

3.7.2 Engineering methods to establish cost standards

When making use of engineering studies, a detailed study of each operation is undertaken on the basis of specifications of material, labour and equipment and on controlled observations and operations. If historical records are used, the standards may include past inefficiencies. The engineering method focuses attention on finding the best combination of resources, production methods and product quality. In practice, the standards derived from average historical usage, however, do appear to be widely used (Drury 2008:420).

3.7.3 How to estimate costs using engineering methods

The classification of costs was discussed in detail in section 3.2. The engineering methods use the cost terms “capital expense” and “operating expense”. Capital expenses are capitalised in the balance sheet and operating expenses are expensed in the income statement as a period cost in the period in which they are incurred.

3.7.3.1 Estimation of capital expenses

According to Ruhmer (1991:138), the intended use will determine the amount of money spent on any estimate of capital costs. This will determine the method of estimation and its probable accuracy. Various procedures are available for preparing estimates, ranging from rapid and low-cost ones to more formal and tedious detailed design ones. The total capital cost, $C_{TC,}$ of a project consists of the fixed capital cost, $C_{FC,}$ plus the working capital costs, C_{WC}, plus the cost of land and other nondepreciable costs, C_L:

$$C_{TC} = C_{FC} + C_{WC} + C_L$$

The accuracy of the estimate depends on the degree of project definition and the fact that project definition is generally vague at the start, improving as the project study and design progress.

Ruhmer (1991:138) classifies estimates in four classes in ascending order of accuracy. The class I estimate establishes the “order of magnitude” only. A class II is known as a “preliminary estimate” and has a tolerance of -15% to +25%. A class III estimate is termed a “definite estimate” with a tolerance of -10% to +10%. A class IV estimate is known as a “detailed or revised estimate” with a tolerance of -5% to +5%. A class IV estimate cannot be made until 40 to 60% of the actual construction work on the project has been completed. The four classes of estimate and the information required to compile them are illustrated in tables 3.6 and 3.7 below.

Table 3.6 Capital estimate classifications

Estimate definition	Estimate description	Target accuracy	Required information
Class I	Order of magnitude	Dependent on available data; range to be indicated on estimate	General site conditions Plant and infrastructure layout Process flow figures Timing of project for escalation
Class II	Preliminary	-15% to +25%	As for class I plus: Major equipment Specification Preliminary piping and installation diagrams based on research and development guidelines Actual plant and infrastructure location and layouts
Class III	Definitive	-10% to +10%	Complete process design Engineering design and layout complete Detailed design 20 to 40% complete Project construction schedule Construction contract
Class IV	Detailed or revised	-5% to +5%	As for class III with detailed engineering design essentially complete

Source:

Adapted from Ruhmer (1991:138)

Table 3.7 Information required to compile estimates

Estimation definition	Basis for estimate		
	Major equipment	**Other materials**	**Labour**
Class I	By comparison with similar work done before, with adjustment for capacity, escalation and site conditions		
Class II	Budget prices/and or recent purchase costs, including freight, adjusted to current rates	By ratio to major equipment costs	Labour material ratios for similar work, adjusted for site conditions and using current rates
Class III	Firm quotations with critical items committed	Firm unit-cost quotations (or current billing costs) based on specified quantity take-off	Estimated man-hour units (including productivity assessment) using expected labour rate for each job classification
Class IV	As for class III with most items committed.	As for class II with material on approximately firm basis	As for class III – some actual field labour productivity may be available

Source:

Adapted from Ruhmer (1991:139)

Other authors have used different labels and different boundaries for the various types of estimates. Ahuja and Walsh (1983:45-46) refer to planning estimates, preliminary engineering estimates, detailed engineering estimates and construction phase estimates. According to Humphreys and Wellman

(1996:7), AACE International (formerly the American Association of Cost Engineers) has proposed three classifications of cost estimates. The major types of estimates proposed by AACE, in increasing order of accuracy, are provided in table 3.8:

Table 3.8 AACE capital estimate classifications

Type	Accuracy
Order of magnitude	-30% to +50%
Budget	-15% to +30%
Definitive	-5% to +15%

Source:

Adapted from Humphreys and Wellman (1996:7)

For the purposes of this study, the estimate classifications used by Ruhmer (1991:139) will be used as guidelines, because this is a South African publication widely used in the industry - for example, Mintek, the developer of the publication, as well as Kumba Resources.

The design, and hence the cost of the plant, depend on the skill and points of view of the design engineers for the project. To cover up errors of judgment, the overdesign of control or safety factors may be used. Many design engineers are reluctant to practise intelligent risk taking.

Factors that tend to increase the capital cost of a plant, include the following:

- overprovision for safety
- overprovision for standby equipment
- unnecessarily robust supporting structures
- building enclosures
- inclusion of nonstandard-sized equipment
- expensive construction materials

Design and process economics are interrelated, and without adequate cost estimates, a satisfactory design is not possible. To avoid uneconomic commitments, management should be supplied with adequate cost estimates so that they can make the necessary decisions. The main steps in preparing a capital cost estimate are as follows (Ruhmer 1991:140-141):

- The initial idea of the process and the specifications of the size and type of operation are formulated.
- Physical and chemical data are collected from the literature or from laboratory experiments.
- A preliminary flow sheet, incorporating the required unit operations, and showing the main items of equipment, is prepared.
- Heat and mass balances are prepared.
- Specifications are drawn up of temperatures and pressures at various points on the equipment flow sheet.
- Design calculations are made to select and size the main items of equipment such as pumps, heat exchangers, reactors, columns and tanks.
- A list of the major process equipment is compiled, including details such as size, capacity, materials of construction pressures and temperatures.
- The cost data are collected from vendors.
- The total delivered cost of all the items of major process equipment is estimated. The purchase cost, quoted by the supplier, may be multiplied by a factor of 1,03 to provide the approximate delivered cost.

For order of magnitude and study estimates, the simplest method of estimating the fixed capital cost of a plant, based on design information, is the Lang factor method. The fixed cost is given by

$$\mathrm{C_{FC}} = \mathrm{f_L} \sum C_{EQ}$$

where C_{FC} is the fixed cost; f_L is the Lang factor, with a value of 3,10 for solids processing, 3,63 for mixed solids-fluids processing and 4,74 for fluid processing; and C_{EQ} is the cost of a major item of process equipment. The original Lang factors were developed in 1948 and were based on a limited range of statistical information. The method is most effective in companies that use the Lang factors based on their own company data. Attempts have been made to improve upon this basic approach but with little success. Although many of these attempts are logical in their approach, it is not possible to ascertain the absolute value of each subfactor for South African conditions because most of the published data are for the USA (Kharbanda & Stallworthy 1988:23; Ruhmer 1991:141).

Another component of capital expenses is working capital which calculated from the following items (Ruhmer, 1991:142):

- inventory of raw materials and supplies - one month's supply (consumption at purchased value)
- inventory of products and in-process material - one month's production valued at manufacturing costs)
- accounts receivable (or extended credit) - one month's production at sales value
- available cash – one month's manufacturing expenses

3.7.3.2 Estimation of operating costs

An estimation of the operation of the production costs of a process is required for the assessment of the economic viability of a metallurgical process. These estimates are almost invariably reported in terms of total annual cost or cost per unit mass of product. The operating cost is estimated from the three basic costs: direct cost, indirect cost and fixed cost. These costs were discussed in detail in section 3.2.

(a) Direct cost

Direct cost (see sec 3.2) is related to the production rate and is the responsibility of the plant superintendent or manager. Direct cost includes the following:

- **Raw material.** This includes the delivered cost of reagents, chemicals, catalysts or other commodities consumed by the process. Quotations should be obtained from vendors.
- **Utilities.** These include electricity, water, gas, steam, compressed air, fuel, vacuum and refrigeration.
- **Labour.** These include wages paid, including benefits. Direct labour is often based on the estimated number of operators per shift. It can also be made from historical patterns of similar plants or installations, if these are available. Supervisor costs can generally be taken as 15% of the cost of direct labour. For simple processes, this percentage should be decreased and increased for complex processes or plants producing valuable commodities.
- **Maintenance labour and supplies.** These depend on factors such as the degree of corrosion affecting the plant and buildings. Variations can be expected between the annual maintenance cost of from 10 to 15 % of the installed equipment costs or from 4 to 8% of the installed cost of the plant.
- **Operating supplies.** The costs of these supplies are generally equal to 15% of the plant maintenance and include stationery, safety equipment, lubricants and fuel for mobile equipment.
- **Laboratory and quality control.** This is the total cost of laboratory equipment such as glassware, plus the total cost of laboratory personnel.
- **Product packaging and shipping.** Costs have to be determined for each plant locality and product.
- **Royalty, patenting or licensing.** These are negotiated on the basis of production volume (Humphreys & Wellman 1996:142-145; Ruhmer 1991:143).

(b) Indirect cost

Indirect costs (see sec 3.2) include the following: medical services, marketing and sales, administration, recreational facilities, public relations, technical services and research and development. These costs have been found to be equal to approximately 50% of the cost of direct labour and maintenance and should be estimated as such if accurate data on their costs are not available.

(c) Fixed costs

Fixed costs (see sec 3.2) include the following:

- insurance premiums, equivalent to 0,75 to 1% of the total capital replacement
- property rates
- royalty, patenting and licensing fees, if payable on the basis of annual payments
- depreciation or amortisation of capital expenditure
- vehicle and other licences
- interest on loans

General guidelines cannot easily be provided on the magnitude of individual costs, because these factors depend on the type and location of the plant. The cost of insurance, rates, rents and licences should be small in comparison with total operating expenses and the annual cost of these can be assumed to be 4% of the total capital cost of the plant. This figure may vary widely in practice. Reference should first be made to the South African Income Tax Act before depreciation is estimated (Ruhmer 1991:143:144).

The fact that almost all the cost engineering textbooks that the researcher consulted, refer only to the estimation of capital and operating costs, is worrisome. Examples are *Basic cost engineering* by Humphreys and Wellman (1996); *Capital cost estimating for the process industry* by Kharbanda and Stallworthy (1988); *Handbook on the estimation of metallurgical process costs* by Ruhmer (1991); *Cost engineering for effective project control* by Ward (1992); and *Cost engineering planning techniques for management* by Black (1984). No or little reference is made to final costs, such as discontinuation or disposal costs, as discussed in section 2.2. As mentioned in section 3.2, the life cycle cost of a project for this study is defined as "the total costs that are incurred, or may be incurred, *in all phases of the product life cycle*". As confirmed in section 5.6.12, the final cost of metallurgical research projects is often not included in the cost estimates of projects and this may lead to budget overruns.

Thus far, three of the methods of cost estimation suitable for life cycle costing, as stated by Emblemsvag (2003:36), namely analogy, parametric and engineering cost methods, have been discussed. The most suitable method of the above mentioned, to be used in metallurgical research projects, is engineering cost methods. Cost accounting methods, including standard costing, attribute costing, feature costing and activity-based costing will now be discussed.

3.8 COST ACCOUNTING MODELS

For the sake of simplicity, the numerous systems contained in the literature are grouped into the following three groups:

(1) volume-based costing systems
(2) unconventional costing systems
(3) modern cost management systems

3.8.1 Volume-based costing systems

Volume-based costing systems, such as standard costing, are often referred to both as conventional costing systems and traditional costing systems in the literature. Since the development of activity-based costing (ABC) in the mid-1980s, volume-based systems have been thoroughly discussed in the literature because their limitations became increasingly apparent to companies, and ABC provided a solution to the problem. Johnson and Kaplan (cited in Emblemsvag 2003:39), explain how early costing systems were focused on decision making, but then became increasingly focused on external financial reporting. This legacy, combined with technological development and the subsequent increase in organisational complexity and therefore in overhead costs, is the main reason why volume-based costing systems perform relatively poorly today. Standard costing will now be discussed.

3.8.1.1 Standard costing

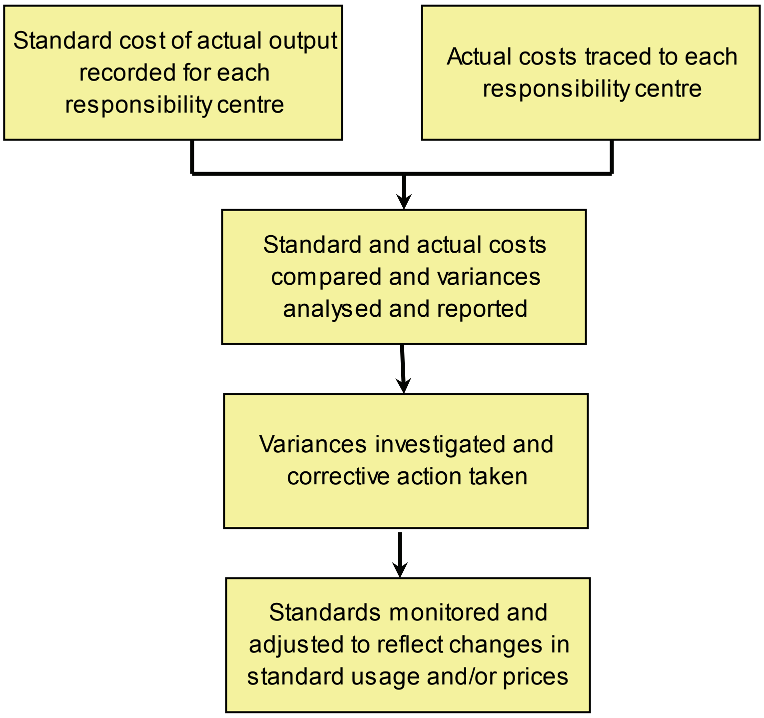
A standard is a norm or benchmark for measuring performance. Managers, assisted by engineers and accountants, set quantity and costs standards for each major input such as raw material and labour time. Quantity standards indicate how much of an input should be used in manufacturing a unit or in providing a service. Cost (or price) standards indicate what the costs of inputs are compared to these standards. Actual quantities and actual costs of inputs are compared to these standards. Any discrepancy is investigated by the manager. The purpose is to find the cause of the problem and then eliminate it so that it does not recur. This approach is referred to as *management by exception.*

Standard costs are not the same as budgeted costs. A budget relates to an entire activity or operation, whereas a standard presents the same information on a per unit basis.

Standard costing is best suited to an organisation whose activities consist of a series of common or repetitive operations and the input required to produce each unit of output can be specified. Standard costing cannot be applied to non-repetitive activities, since there is no basis for observing repetitive operations and consequently, targets cannot be set (Drury 2008:420; Garrison & Noreen 2003:425).

Figure 3.8 provides an overview of a standard costing system.

Figure 3.8 An overview of a standard costing system



Source:

Adapted from Drury (2004:728)

It is clear from the box below the first arrow in figure 3.8 that the operation of a standard costing system also makes possible a detailed analysis of the variance to be reported. Variances should be investigated and should result in appropriate remedial action being taken. If it is found that the variance is due to a permanent change in the standard, the standard should be changed.

Standard costing has numerous advantages but also some disadvantages.

(a) Advantages

- The use of standard costs is a key element in a management by exception approach. As long as costs remain within the standards, managers can focus on other issues. This approach helps managers focus on important issues.

- As long as employees view standards reasonable, they can promote economy and efficiency. Individuals are provided with benchmarks that can be used to judge their own performance.
- Standard costs can simplify bookkeeping. The standard costs for materials, labour and overhead can be charged to jobs instead of recording actual costs for each job.
- Standard costs fit naturally into an integrated system of responsibility accounting. The standards establish what costs should be, who should be responsible for them and whether actual costs are under control.

(b) Disadvantages

- Standard cost variance reports are usually prepared on a monthly basis and often released days or weeks after the end of the month. The information may be so stale that it is almost useless.
- Morale may suffer if managers are insensitive and use variance reporting as a club. Management by exception tends to concentrate on the negative.
- Labour quantity and efficiency standards make two assumptions. First, they assume that the production process is labour paced - if labour works faster, output will increase. Second, they assume that labour is variable costs. Labour, however, may be fixed, in which case the undue emphasis on labour efficiency variances creates pressure to build excess work in process and finished goods inventories.
- A favourable variance may be as bad as or worse than an unfavourable variance. For example, if McDonalds has a standard for the amount of meat in a hamburger, and there is a favourable variance, less meat was used than the standard. This results in a substandard product and possibly a dissatisfied customer.
- The emphasis may be on meeting the standards to the exclusion of other key objectives such as maintaining and improving quality, on-time delivery and customer satisfaction.
- To survive in a competitive market, more than simply meeting standards is necessary, say, continuous improvement.

- Traditional variance analysis of variable and fixed overhead provides little useful information for managers because the relative importance and proportion of overhead grows in comparison to direct material and direct labour (Garrison & Noreen 2003:444; Garrison et al 2003:516; Jackson & Sawyers 2003:346).

In a survey conducted in 1987, 94% of the companies contacted reported that they used labour hours to allocate overhead costs. According to Emblemsvag (2003:39), this is shocking news, given the known limitations of using only direct labour as the allocation base. He argues that most people in the industry do not know what their products cost and that many companies have survived despite their cost management systems. In the 1980 recession, many companies learnt that this is not a desirable situation. Volume-based costing systems are therefore not attractive under any circumstance for life cycle costing purposes, because they perform too poorly.

3.8.2 Unconventional costing methods

The term "unconventional" is used to signify that the approaches discussed are quite different from most common management approaches or unpopular. For the purposes of this study, only two approaches will be briefly discussed.

3.8.2.1 Attribute-based costing

This method is a development of ABC and is simply denoted as ABCII. It provides a detailed cost-benefit analysis of customer needs aimed at improving effectiveness. The focus of ABCII is on planning as opposed to analysis of past costs which may have little impact because 60 to 80% of costs are already locked in at the design stage. The standard ABC approach is used to cost product attributes, that is, it uses drivers and such like, but the problem arises when there is no longer a one-to-one relationship between a certain attribute and a certain activity. ABCII separates the cost of products and services from the cost of the various other external and internal cost objects (Emblemsvag 2003:40).

Walker (1998:18) argues that ABC can provide more useful information for decision making than traditional approaches, but it involves a paradigm change in thinking to make it truly effective. ABCII is a development of ABC that supports management decision making for improved performance effectiveness and cost efficiency. Costs can be identified more accurately and the way is paved for attribute analysis, contribution analysis and value analysis. ABCII uses ABC techniques to accurately cost direct activities to products. Comparing actual and target costs for major attributes reveals where effort and costs can be increased to provide more value and where cost savings can be made without noticeably impacting on customer value.

According to Walker (1999:26) ABCII provides more accurate data on the effects of management decisions than ABC. He proposed a framework (ABCII) using multiple external and internal cost objects to integrate ABC with attribute analysis, target costing and contribution analysis. He states that the objective of ABC is to direct management's attention to the products, *not* to fully recover overheads. A major misconception about ABC is that it simply provides a more accurate method of costing all overheads to products and services, which leads to the mistake of allocating costs using arbitrary bases.

Emblemsvag (2003:40) challenges Walker's (1998; 1999) view and claims that ABCII appears to be a hybrid between ABC, target costing and quality function deployment. In the recorded applications of quality function deployment, which involve costing, target costs are deployed or broken up into product attributes, components and parts and then compared with current quoted costs. He contends that quality function deployment involves a great deal of subjectivity, which explains why such an interesting idea has received so little attention in the literature.

3.8.2.2 Feature costing

Feature costing is another spin-off from the ABC methodology. The product features are the focal point, instead of focusing on the product attributes, as in ABCII. Since the features are easier to link to specific activities, feature costing seems more realistic than ABCII. Feature costing may be an improvement on ABC because it leads to a more direct reduction of costs and an improvement of performance. ABC can be extended to include feature costing. This provides a powerful tool for planning and control (Emblemsvag 2003:40; Hansen & Mowen 2003:631).

Since these unconventional methods are not well known and not even mentioned in the cost accounting literature, they will not be dealt with in more detail here. Modern cost management systems will now be discussed.

3.8.3 Modern cost management systems

The modern cost management systems and some of their derivatives are generally discussed in positive ways in the current cost management literature. These include the following:

- activity-based costing (ABC)
- just-in time (JIT) costing
- target costing
- total quality management (TQM)
- Kaizen costing
- business process re-engineering (BPR)

ABC will be discussed, while JIT costing, target costing, TQM, Kaizen costing and business process re-engineering will be dealt with in chapter 4.

3.8.4 Activity-based costing (ABC)

Garrison et al (2006:315) define activity-based costing (ABC) as a costing method designed to provide managers with cost information for strategic and other decisions that potentially affect capacity and therefore fixed costs.

ABC is based on the concept of assigning costs on the basis of activities that drive costs rather than on the volume or number of units produced (Jackson & Sawyers 2003:99).

ABC assigns the cost of activities to individual products on the basis of their relative consumption of individual activities. Determining the cost of an activity is critical in this approach of product costing. An ABC accounting system offers greater product costing accuracy but at an increased cost (Hansen & Mowen 2003:438; Hilton et al 2003:145).

According to Drury (2008:228), *activities* consist of the aggregation of many different tasks and are described by verbs associated with objects. Typical support activities would include *schedule* production, *set-up* machines, *move* materials, *purchase* materials and *inspect* items, etc. Production process activities would include *machine* products and *assemble* products.

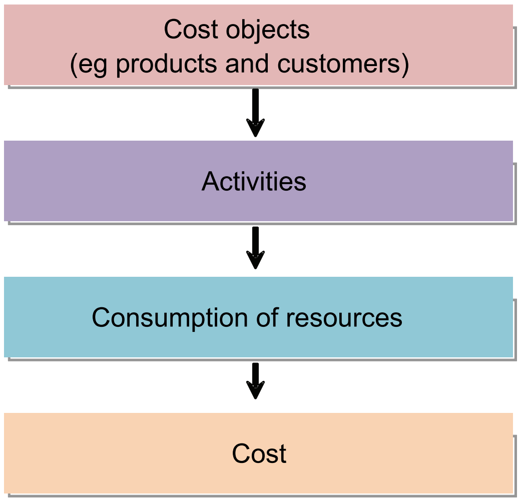
Jackson and Sawyers (2003:100) state that a cost driver causes or drives a cost to be incurred.

From the above definitions, one may conclude that ABC

- provides information for decision-making
- focus on activities that drive costs
- is used to determine the accurate cost of a product

The general structure of an ABC model is explained by figure 3.9.

Figure 3.9 The ABC model



Source:

Adapted from Garrison et al (2006:320)

From the above figure, one can see that cost objects, such as products generate activities. If a customer orders a product, the activity of preparing a production order is required. A production order uses a sheet of paper and takes time to fill out. Consumption of these resources causes costs. ABC attempts to trace these relationships to identify how customers and products affect cost (Garrison & Noreen 2003:320).

Identifying activities forms the foundation of the system. This may be difficult, time consuming and require sound judgment. Activities can be combined into the following five general levels:

(1) Unit-level activities. These are performed each time a unit is produced. The cost should be proportional to the number of units produced. An example would be to provide power to run processing equipment since power tends to be consumed in proportion to the number of units produced.

(2) Batch-level activities. These are performed each time a batch is handled or processed, regardless of how many units are in the batch. Placing an order, setting up equipment and arranging for shipments are examples of batch-level activities.

(3) Product-level activities. These relate to specific products and must be performed regardless of how many batches are run or units are produced or sold. Designing, advertising and maintaining a product manager and staff are product-level activities.

(4) Customer-level activities. These relate to specific customers and include activities such as sales calls, catalogue mailings and technical support not linked to a specific product.

(5) Organisation-sustaining activities. These are performed regardless of which customers are served, which product is produced, how many batches are run or how many units are produced. Cleaning the executive officer's office, providing a computer network, arranging for loans or preparing annual reports are examples.

Activities should be grouped together in the appropriate level when combining activities in an ABC system. It is unlikely that different companies will use the same activity cost pools and activities. There will be considerable variation in the number and definitions of the activity cost pools and activity measures used by companies because of the amount of judgment involved (Drury 2004:382-383; Garrison et al 2006:320-333; Garrison et al 2003:269-270; Hansen & Mowen 2003:455; Hilton et al 2003:147-148).

Identifying the activities that will form the basis of the system is the first major step in implementing an ABC system. The steps for implementing such as system will be discussed in section 3.8.4.3. The history of ABC will now be highlighted.

3.8.4.1 The history of ABC

The limitations of traditional product costing began to be widely publicised during the 1980s. Traditional systems had been designed decades before when most companies were manufacturing a small range of products and direct material and direct labour were the dominant factory costs. Overhead costs were relatively small and inappropriate overhead allocations did not have a significant influence.

Today, companies manufacture a wide range of products; overhead costs are of considerable importance, while direct labour represents only a small fraction of total cost. Allocation rates, using direct labour as a base, can no longer be justified. Intense global competition in the 1980s made decision errors due to poor information more costly. The demand for more accurate product cost was increased by the increased opportunity cost of having poor information and the decreased cost of operating more sophisticated cost systems. Against this background, ABC emerged. It was introduced by Robert Kaplan, Robin Cooper and Thomas Johnson in the late 1980s. ABC is not a recent innovation, because Goetz (1949:142) advocated ABC principles when he wrote:

> *Each primary [overhead] class should be homogeneous with respect to every significant dimension of management problems of planning and control. Some of the major dimensions along which [overhead] may vary are number of units of output, number of orders, number of operations, capacity of plant, number of catalogue items offered.*

A few firms in the USA and Europe implemented ABC-type systems during the 1980s as a result of decreasing information process costs. In 1988, a series of articles were published by Cooper and Kaplan. A considerable amount of publicity was generated and consultants began to market and implement ABC systems before the end of the decade. Between 1990 and 1992, Cooper and Kaplan reported further theoretical advances. ABC ideas are now widely published in management accounting literature and educational courses and many practitioners attend courses and conferences in the topic.

An increasing number of companies around the world are using ABC systems. To name a few, *American Airlines, Hewlett-Packard, Daimler-Chrysler, American Express, IBM, Dana Corporation, Hallmark, Pillsbury and the US Postal service* (Drury 2008:225; Garrison & Noreen 2003:316; Hilton et al 2003:145; Smullen 1997:61).

To get a better picture, ABC will now be compared with traditional costing systems.

3.8.4.2 ABC compared to traditional costing systems

The objective of traditional cost accounting systems is to value inventories and the cost of goods sold for external financial reports in accordance with generally accepted accounting principles (GAAP). In ABC systems, the objective is to understand overheads and a product's profitability, and to manage overheads.

In traditional cost accounting, only manufacturing costs are assigned to products. Administrative, selling and general expenses are treated as period expenses and not assigned to products. Many of these nonmanufacturing costs, however, are part of the cost of producing, selling, distributing and servicing products. Examples of such costs are commission paid to salespersons, shipping costs and warranty repair costs. In ABC, such nonmanufacturing costs are assigned to products to determine the profitability of products and services.

All manufacturing costs are assigned to products in traditional cost accounting, even costs that are not caused by the product. A portion of the factory security guard's salary will, for example, be allocated to each product, even though his salary is totally unaffected by which products are made or not made during a period. In ABC systems, a cost is assigned to a product only if there is good reason to believe that the cost would be affected by decisions concerning the product.

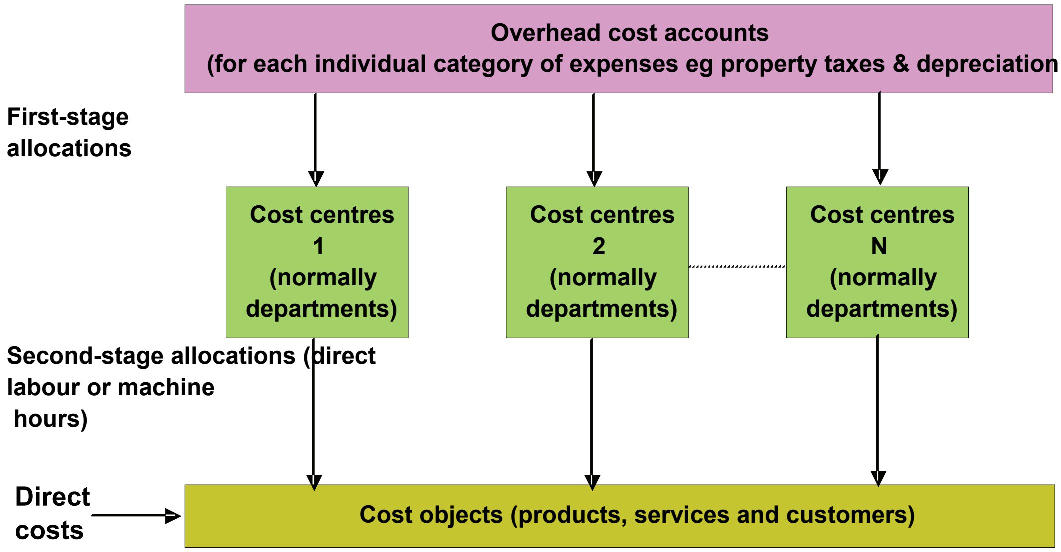
According to Drury (2008:223), both ABC and traditional costing systems use a two-stage allocation process. A traditional system allocates overheads to production and services departments and then reallocates service department costs to the production departments in the first stage. An ABC system assigns overheads to each major activity, and not to departments. In traditional systems, overheads tend to be pooled by departments, whereas in ABC systems, many activity-based cost centres are established.

The traditional costing systems trace overheads to products using a small number of second-stage allocation bases, normally described as allocation rates, which vary directly with the volume produced. The second stage of the two-stage allocation process allocates costs from cost centres to products or other chosen cost objects. The traditional costing methods use the terms "allocation bases" or "overhead allocation rates", while ABC uses the term "cost driver". In traditional costing systems, direct labour and machine hours are the allocation bases that are normally used, while ABC systems uses many different types of second-stage cost drivers, including nonvolume-based drivers, such as the number of production runs or number of purchase orders (Drury 2008:223).

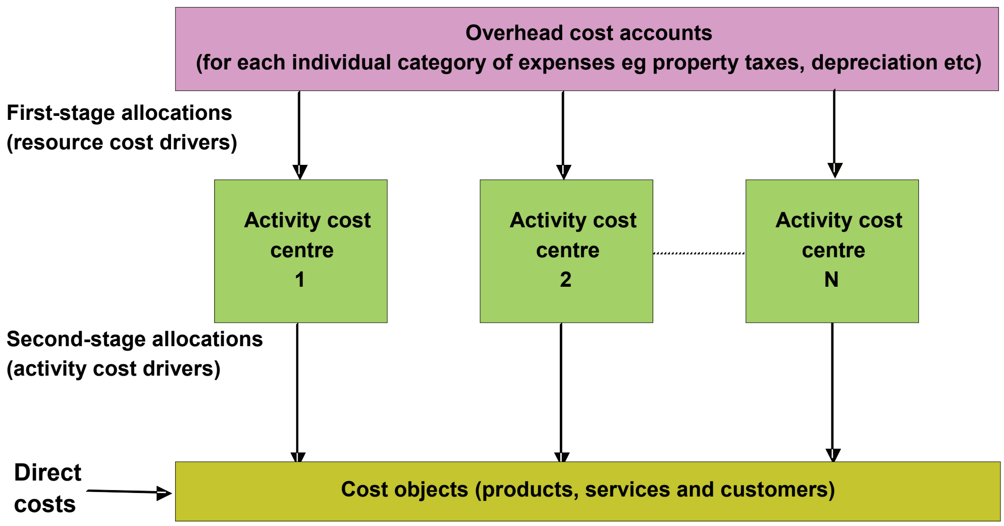
Traditional systems normally allocate service/support costs to production centres. The costs are merged with production cost centre costs and included in the production centre overhead rates. ABC systems tend to establish separate cost driver rates for support centres, and assign the cost of support activities directly to cost objects without any reallocation to production centres. Figure 3.10 illustrates the major differences between traditional costing and ABC systems.

Figure 3.10 Differences between traditional costing and ABC costing systems

(a) Traditional costing systems



(b) Activity-based costing system



Source:

Adapted from Drury (2008:224)

From the above figure it is clear that the major distinguishing features of ABC systems are that in the two-stage allocation process they rely on

- a greater number of cost centres
- a greater number and variety of second-stage cost drivers

Traditional cost systems report less accurate costs because they use cost drivers in which no cause-and-effect relationships exist to assign support costs to cost objects. ABC systems measure the resources consumed by cost objects more accurately by using a greater number of cost centres and different types of cost drivers that cause activity consumption, and assigning activity costs to cost objects on the basis of cost driver usage. Hilton et al (2003:144) state that the advantage of the traditional cost system is its simplicity. However, the saying, “you get what you pay for”, is appropriate here. Managers of traditional cost systems might decide that the costs of implementing a more complex system is higher than its potential benefits (Drury 2004:372-374; Garrison et al 2003:263-264; Garrison & Noreen 2003:316-317; Hilton et al 2003:144; Jackson & Sawyers 2003:98-99).

The steps for implementing ABC will now be discussed.

3.8.4.3 Steps for implementing ABC

An ABC system first traces cost to activities and then to products and other cost objects. The underlying assumption is that activities consume resources, and products and other cost objects consume activities. There are six essential steps in designing an ABC system

(1) Step 1: identify and define activities and activity pools
(2) Step 2: trace costs to activities and cost objects
(3) Step 3: assign costs to activity cost pools
(4) Step 4: calculate activity rates

(5) Step 5: assign costs to cost objects using the activity rates and activity measures

(6) Step 6: prepare management reports

The system will be developed for the specific needs of a company, and will therefore be unique to the company (Drury 2008:228; Garrison & Noreen 2003:322; Garrison et al 2003:269; Hansen & Mowen 2003:446; Hilton et al 2003:146).

3.8.4.4 Evaluation of ABC

ABC, like any other costing system, has both advantages and disadvantages.

(a) Advantages

The advantages are as follows:

- A sophisticated ABC system should generate the most accurate product cost for day-to-day decision making.
- Management can use information provided by ABC to identify activities that are costly and then take steps to reduce their costs by changing the production process or outsourcing these activities.
- Because more accurate costs are provided, management can use the information to negotiate price increases with customers or to discard unprofitable products.
- More accurate information can be used to improve budgets and measures of department and division performance.
- More accurate cost information focuses managers on opportunities for continuous improvement.
- ABC provides benefits relating to the control function of managers.

(b) Disadvantages

The disadvantages are as follows:

- ABC does not handle uncertainty. Since uncertainty is inherent in design, it is vital to understand how uncertainty can affect the solutions.
- The direct association of costs with their respective activities leads to a lack of process information by using large cost pools.
- The relationship between products, processes and production costs is not clearly delineated.
- ABC does not facilitate any methods of simulating changes to see how the changes work. This is true of all costing systems, because they are hindsight oriented. The cost of implementing and operating an ABC system is significantly more expensive than operating a direct costing or traditional costing system.
- The training and software requirements may prohibit small organisations from adopting ABC.
- ABC is not used for external reports for the following reasons:
    - External reports are less detailed than the internal reports prepared for decision making.
    - It is often difficult to make changes to a company's accounting system.
    - ABC systems usually do not conform to generally accepted accounting principles (GAAP). It is possible to adjust the ABC data at the end of the period to conform to GAAP, but this requires more work.
    - Auditors are likely to be uncomfortable with allocations that are based on interviews with the company's personnel.
- Because reports do not conform to GAAP, an organisation requires two costs systems, one for internal and the other for external reporting. This may cause confusion about which system is to be believed and relied on.
- Implementing an ABC system is a major project that requires substantial resources.

- Once implemented, it is more costly to maintain than a traditional direct-labour-based costing system.
- The numbers produced by ABC systems differ from these produced by the traditional system.
- The inclusion of all costs, including idle capacity and organization-sustaining costs may result in overstated costs and understated margins and errors in pricing and other critical decisions.
- Costs assigned to products, customers and other cost objects are only potentially relevant. Managers should identify which costs are really relevant before making significant decisions (Drury 2008:235; Emblemsvag 2003:41; Garrison & Noreen 2003:339; Hilton et al 2003:163; Jackson & Sawyers 2003:109).

From the above one may conclude that ABC provides more accurate information, which may lead to better pricing policies, improved budgets, continuous product and profitability improvement and better control for managers. However, it is expensive to implement and maintain, cannot be used for external reporting, and the results may be overstated because of the inclusion of all costs. ABC is not for everyone, and the benefits of increased accuracy do not come without costs. The cost of implementation may be greater than the expected benefit. However, ABC may still prove valuable for planning and cost reduction efforts. ABC costing is a suitable method of cost estimation for metallurgical research projects.

3.9 CONCLUSION

This chapter examined methods of cost estimation. The first step management requires when considering a project is to estimate cost. This estimation reveals the magnitude of the project and also serves as a tool to manage cost later in the project. The accuracy of the estimation is therefore critical.

Cost terms and cost behaviour were discussed in detail. The time value of money and the techniques used for capital investment decisions, namely IRR and NPV, were also explained. Cost estimation techniques were examined and divided into four groups, namely analogy models, parametric models, engineering methods and cost accounting models. These techniques can be summarised as follows:

- Analogy models identify a similar product and adjust its costs for differences between it and the target product.
- Parametric models use parameters and case histories of similar systems by applying mathematical models.
- Engineering methods give a direct estimation of a particular cost element by examining a project, component by component.
- Cost accounting models, which include the following:
  - Standard costing: standards are set on a per unit basis
  - Attribute-based costing: a development of ABC, not widely used
  - Feature costing: a spin-off of ABC
  - ABC: costs are assigned based on activities that drive the cost, rather than volume

It has been found that the engineering method mainly includes capital and operating expenses. Little attention is focused on final cost such as discontinuation and disposal costs. The discontinuation and disposal of harmful substances often have a major effect on the environment. The fact that these costs are not taken into account is cause for concern.

It is evident from the literature study that ABC seems to be the most accurate method of cost estimation, but may be expensive to implement and maintain. From the empirical study, it was clear that engineering cost methods are generally used to estimate cost for metallurgical research projects (see sec 5.6.10).

Cost management techniques will be discussed in chapter 4.

CHAPTER 4

COST MANAGEMENT

4.1 INTRODUCTION

According to Garrison et al (2006:12), the previous two decades were characterised by tremendous turmoil and change in the business environment. The pace of innovation in products and services has accelerated and competition in industries has increased. Many managers have realised that the old ways of doing business no longer work and that major changes are needed in the way in which organisations are managed and work is done. The management of cost will also have to change if businesses are to remain competitive.

In traditional management accounting control systems, the focus was on comparing actual results against a preset standard, say, budgets and standard costing. Variances were identified and analysed and remedial action taken to ensure that future outcomes conformed to budgeted outcomes. These systems were based on the preservation of the status quo, and the ways of performing existing activities were not reviewed. The emphasis was on cost containment and not cost reduction.

According to Drury (2008:536), the traditional management accounting control systems were widely criticised during the late 1980s and new approaches more in tune with today's competitive and business environment, were advocated. Traditional management accounting control systems were designed for an era in which people worked without computers. People were the predominant resource doing the work, technology was stable and inexpensive and there was a limited range of services. Cost was often the primary measure of quality in cost accounting, but because of its historical focus, it was an extremely limited measure. The structured definitions of cost categories in terms of labour, material and overheads were destroyed by technology. The allocation of costs to products, sales territories and manufacturing plants was overstated as a result of inadequate and incomplete costing methods.

To overcome these problems, cost management systems focusing on cost reduction, instead of cost containment, were developed. As a result of the unprecedented scientific and technological progress coupled with fierce global competition, customer expectations also underwent a major transformation. Customers expect top-quality products, fast delivery and low prices. If a strategy of service excellence is not adopted, an organisation may be forced out of business (Brimson & Antos 1994:1-3).

In cost management systems, cost becomes a mechanism for continuous improvement. Management can use it to achieve a competitive advantage. Cost management can also be used as a performance measure to enable an organisation to incorporate change into the pursuit of the quality product or service (Brimson & Antos 1994:11; Brinker 1992:A1-32; Doyle 1994:11).

However, costs cannot be managed if their origin is not identified. Costs do not simply happen - they are caused by activities. The challenge in managing costs is to identify the activities that cause them, to estimate the relationship between them and their causes and to manage the activities that cause them. To succeed, companies must manage their costs. Many companies and factories have shut down because cost was not effectively managed (Hilton et al 2006:411).

Cost management provides the tools management need at both executive and operational levels to increase productivity and margins and to manage costs proactively. Cost management is also a vital tool for cost-based strategic planning and for monitoring margin performance against the plan for each revenue stream. It helps with planning for future costs and develops projected operating cost scenarios. Management can plan more effectively and measure performance more accurately because they are able to view the same costs in multiple ways (Rayburn 1989:875).

Cost management can be done in both the short and long term. In the short term, organisations are faced with resource constraints. Mathematical techniques such as linear programming may be used to find optimal solutions in a multi-product, multi-constraint world. In the long term, however, constraints can be anticipated through the design of products and processes. Costs should therefore be planned and managed throughout the product's life cycle (Garrison et al 2003:791-792).

Cost management is applied on an *ad hoc* basis when an opportunity for cost reduction is identified. Continuous improvement is possible because the activities of cost accounting are reversed in the following ways:

- Overhead costs are identified and controlled at the point at which they occur.
- Cost allocation is reduced and even eliminated.
- There are fewer transactions and less variance reporting.
- Costs that do not add value to the product or service are identified and minimised or eliminated.
- Other performance measures are enhanced through focused application of the process.

The cost management system becomes operational and not financial. Cost management expands the scope of both cost accounting and financial management. The organisation includes all cost components and the rules to be adhered in pursuit of quality. If top management are involved, the strategic nature of cost management can break loose from the accounting mould by addressing the cost control problems of the organisation of today and tomorrow rather than the organisation of yesterday (Brinker 1995:A1-34; Drury 2004:943-944).

According to Langfield-Smith et al (2006:694-695), the traditional management accounting control systems include a range of financial performance reports and measures to provide managers with information for cost control, while cost management systems also include various tools and techniques that provide information for cost management. They summarised the major differences between traditional management accounting control systems and cost management as follows:

Table 4.1 Traditional management accounting control versus cost management

Traditional management accounting control	Cost management
Managers control costs by bringing them into line with a predetermined goal, such as budgeted or standard cost. The focus is on cost results and outcomes.	Reduces costs by identifying wasted resources and eliminating this waste by identifying the factors that drive costs.
The primary focus is on controlling costs in the organisation.	Not only concerned with controlling cost, but also achieving value for the customer.
Managers control costs by reporting results for responsibility centres on the basis of the functional areas of the business, eg production, marketing and administration.	Recognises that customers' needs are met by processes, which flow across the business and may cross functional areas.

Source:

Adapted from Langfield-Smith et al (2006:694-695)

This chapter will discuss cost management systems and different contributions that have been made to the development of such systems. Cost management will first be defined and cost management information systems then discussed. The cost management systems that will be highlighted include activity-based management, just-in-time systems, kaizen costing, target costing, total quality management, and business process re-engineering.

4.2 DEFINITION OF COST MANAGEMENT

Langfield-Smith et al (2006:694) define cost management as the improvement of an organisation's cost effectiveness by understanding and managing the real causes of cost. They contend that although the predominant focus in cost management is on costs, it also endeavours to improve other aspects of performance such as quality and delivery.

Drury (2008:538) defines cost management as those actions that managers take to reduce costs, some of which are prioritised on the basis of information extracted from the accounting system, while other actions are undertaken without the use of accounting information. Where an opportunity has been identified to perform a process more effectively and efficiently, which has obvious cost reduction outcomes, process improvements should be made. The ideal situation is to take action that both reduces costs and enhances customer satisfaction.

Hilton et al (2006:5) state that cost management involves more than measuring and reporting product and service costs. He defines it as a *philosophy* of seeking increased customer value at a reduced cost, an *attitude* that all costs are caused by management decisions and a reliable set of *techniques* that increases value and reduces costs.

According to Hansen and Mowen (2003:993), cost management identifies, collects, measures, classifies and reports information that is useful to managers in costing, planning, control and decision making.

From the above definitions, one may conclude the following:

- Cost management involves actions taken by managers to reduce cost on the basis of accounting information as well as other information.
- Costs are extracted from the accounting system, while other actions are undertaken without the use of accounting information.
- Management should be aware that all costs are caused by decisions.

- Customer value should increase at a reduced cost.

For the purposes of this study, cost management is defined as those actions taken to reduce cost while enhancing customer satisfaction.

It is clear that much information is needed to manage cost. A proper cost management information system is therefore required, and will now be discussed.

4.2.1 Cost management information systems

In the last two decades, worldwide competitive pressures, deregulation, growth in the service industry and advances in information and manufacturing technology have dramatically changed the nature of the economy and the way in which manufacturing and service industries operate. The focus of cost management systems has been broadened to enable managers to provide more customer value at a lower cost. Value should be added in each step of the production process. Today's cost accountants need to grasp the functions of a business's value chain (see sec 4.3.2) in order to achieve this.

A cost management information system produces outputs for internal users using the inputs and processes needed to satisfy management's objectives. It is not bound by external regulation because the criteria are set by people in the organisation. It has three broad objectives that provide information for the following:

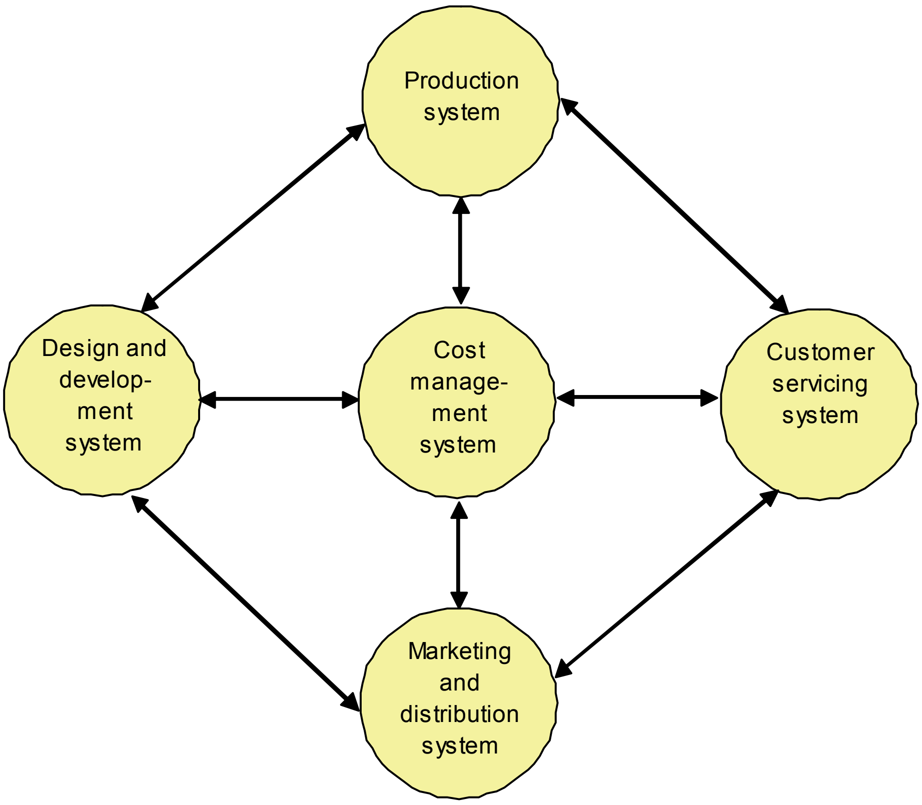
- costing out services, products and other objects of interest to management
- planning and control
- decision making

The object being costed and the reason why management need to know the cost will determine the information required for the first objective. Cost information should help managers to plan and control. They should decide what has to be done, why it should be done, how it should be done and how well it is being done. Cost information is also crucial for many management decisions.

The cost management information system should produce information that benefits the whole organisation. Managers in many different areas of a business, require cost information and should interact with the design and development system, the production, marketing and customer service systems.

The cost management information system should have an organisation-wide perspective and be integrated with the nonfinancial functions and systems in the organisation. In the current competitive environment, companies should pay greater attention to cost management in all functional areas. Figure 4.1 illustrates the expected interactive relationships.

Figure 4.1 An integrated cost management system



Source:

Adapted from Hansen and Mowen (2003:30)

Figure 4.1 implies the cost management information system not only receives information from all operational systems, but also supplies information to these systems. If possible, the cost management information system should be integrated with the organisation's operational systems. Integration reduces redundant storage and use of data, improves the timeliness of information and increases the efficiency of producing reliable and accurate information (Hansen & Mowen 2003:29-30).

A number of techniques have evolved to manage cost, including activity-based management, just-in-time systems, Kaizen costing, target costing, total quality management, business process re-engineering and life cycle management. During the course of the literature study, the researcher found that in management accounting textbooks, only a small section is devoted to a discussion of cost management. The major part of these books still discusses the management accounting control techniques, while only one or two chapters briefly describe cost management.

The researcher also found, during personal interviews, that much attention in the metallurgical research field is focused on feasibility studies before accepting a project. The net present value and internal rate of return approaches (see secs 3.3.1 and 3.3.2) are the primary investment criteria used by mining companies for acceptance of a project. However, it is assumed that cost management techniques are not used to manage cost once a project has been accepted.

According to Albright and Lam (2006:157), it is necessary to understand the historical context of the development of the various modern cost management techniques. Langfield-Smith (2008:204) provides evidence that these techniques have not been adopted widely. Because cost management techniques are not yet widely used in the industry, and are also not dealt with in depth in cost management textbooks, it is necessary to discuss these techniques in detail in this study.

The following two research objectives in this study relate to cost management:

(1) to examine different methods that can be used to estimate and manage the total costs of a project during its life cycle
(2) to determine whether these cost management methods are being used in metallurgical research projects

The above-mentioned techniques, with the exception of life cycle management will now be discussed in detail. The history, elements, objectives and implementation of each of the techniques will be highlighted. They will be compared with other cost management systems and evaluated. Life cycle costing was discussed in detail in chapter 2. Life cycle management is a derivative of life cycle costing and identifies those areas in which running costs detailed by life cycle costing can be reduced. This was dealt with in section 2.4.2. Section 5.6.13 indicates whether these methods of cost management are actually being used in metallurgical research projects.

4.3 ACTIVITY-BASED MANAGEMENT (ABM)

Zimmerman (2006:783) defines ABM as the management processes that use activity-based costing information to improve firm performance by eliminating nonvalue-added activities, making better pricing and product mix decisions, improving manufacturing and administrative processes and designing better products.

Emblemsvag (2003:308) defines ABM as a discipline that focuses on the management of activities as the way to improve the value received by the customer and the profit achieved by providing this value. It includes cost driver analysis, activity analysis and performance measurement. Its major source of information is activity-based costing.

According to Hilton et al (2006:180), ABM is a system used by management to evaluate the costs and values of process activities in order to identify opportunities for improved efficiency.

Hansen and Mowen (2003:991) define ABM as an advanced control system that focuses management's attention on activities in order to improve the value received by the customer and the profit received by providing this value. Opportunities are identified and selected for improvement by using more accurate information to make better decisions.

The most comprehensive definition was found in the glossary of Brimson and Antos (1994). They define ABM as a formal management system that supports excellence by compelling employees to understand their activities and how they contribute to achieve strategic objectives, changes traditional management practices to emulate best practices and establishes process controls to ensure consistently satisfactory performance, and supports continuous improvement by providing new insights into the customers of activities and permitting the adoption of best practices in order to encourage employees to add greater value to the organisation.

From the above definitions, one may conclude that ABM:

- is a formal management system
- focuses on the management of activities
- increases the value the customer receives
- increases the organisation's profit
- uses accurate information for better decision making
- encourages employees to add greater value to the organisation

Drury (2008:544) compares traditional budget and control with ABM. He states that traditional budget and control reports analyse costs by types of expense for each responsibility centre. ABM analyses costs by activities. ABM reporting is also done by subactivities, while traditional reporting is done by expense categories. ABM often reports information on activities that cross departmental boundaries. Table 4.2 illustrates the difference between conventional analysis and ABM analysis in respect of customer-order processing.

Table 4.2 Customer order-processing activity

	R
Traditional analysis	'000
Salaries	320
Stationery	40
Travel	140
Telephone	40
Depreciation of equipment	40
	580
ABM analysis	
Preparing quotations	120
Receiving customer orders	190
Assessing customer's creditworthiness	100
Expediting	80
Resolving customer problems	90
	580

Source:

Adapted from Drury (2008:546)

From table 4.2, it is apparent that the ABM approach provides more meaningful information. More visibility is given to the cost of undertaking the activities that make up an organisation. It may also raise issues for management action that are not highlighted by the traditional analysis, for example, why is R90 000 spent on resolving customer problems? Attention is drawn to specific problems, and this information is vital for managing the cost of activities.

4.3.1 The relationship between ABC and ABM

ABC, as discussed in chapter 3 (sec 3.8), focuses on allocating overhead costs to products on the basis of activities. ABC per se does not result in the process improvements that may be necessary to achieve desired efficiency. ABC is therefore not a comprehensive cost management system. The steps in implementing ABC, as discussed in chapter 3 (sec 3.8.4.3), are as follows:

- Identify and define activities and activity pools.
- Trace costs to activities and cost objects.
- Assign costs to activity cost pools.
- Calculate activity rates.
- Assign costs to cost objects using the activity rates and activity measures.
- Prepare management reports.

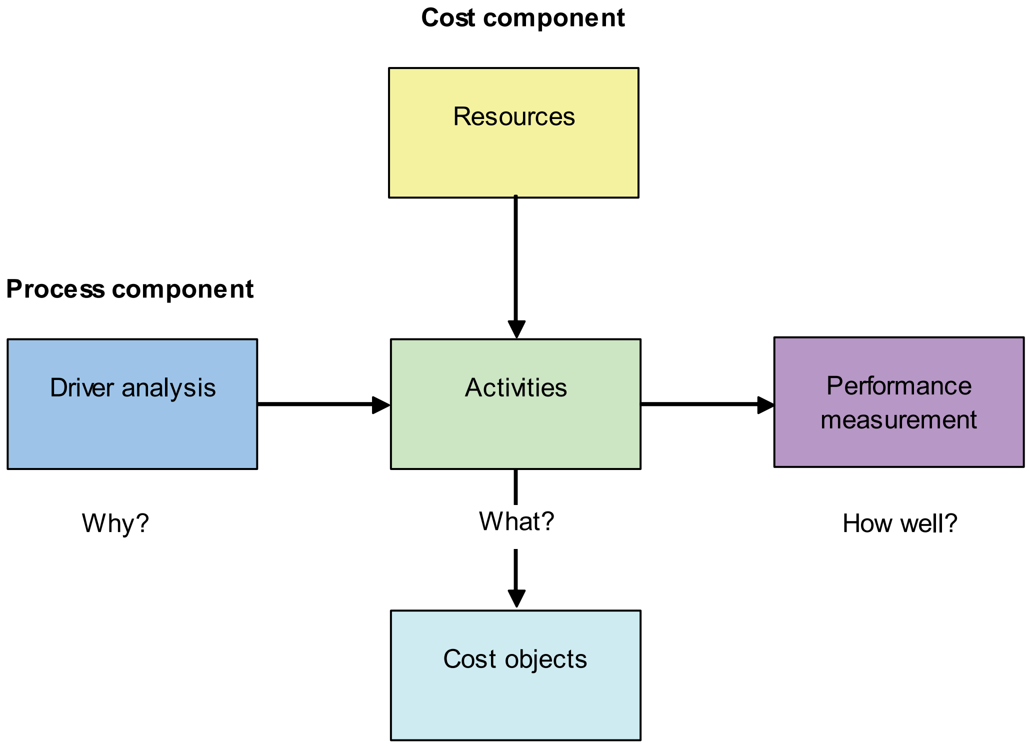
These steps are taken further by ABM and include the following:

- Identify activities as value added or nonvalue-added.
- Score each activity as high or low value added as seen from the customer's point of view.
- Identify opportunities to reduce or eliminate nonvalue-added activities and enhance value-added activities.

ABM is an advanced control system that focuses management's attention on activities in order to improve the value received by the customer and the profit received by providing this value. ABC is the major source of information for ABM (Drury 2008:546; Hansen & Mowen 2003:565; Hilton et al 2006:180; Jackson & Sawyers 2003:110-111; Smullen 1997:66).

ABM consists of two components, namely a cost component and a process component. These components are represented in Figure 4.2

Figure 4.2 Components of ABM



Source:

Adapted from Drury (2004:276); Hansen and Mowen (2003:551)

The cost component (vertical box) provides cost information about resources, activities and cost objects such as products, customers, suppliers and distribution channels. The objective of the cost component is to improve the accuracy of cost assignments. The cost of resources is traced to activities and the cost of activities then assigned to cost objects. This component is used for product costing, strategic cost management and tactical analysis.

The process component (horizontal box) relates to cost management and provides information about what activities are performed, why they are performed and how well they are performed. The objective of this component is cost reduction. This component makes it possible to engage in and measure continuous improvement (Drury 2004:276; Hansen & Mowen 2003:550).

ABC can therefore be adopted for both product costing and cost management or applied only to product costing or cost management.

From the discussion above, it is evident that ABC assigns the cost of activities to the individual products on the basis of their relative consumption of individual activities. ABM focuses on managing activities to reduce costs and make better decisions. The goals of ABM are to identify and eliminate activities and costs that do not add value to goods and services, and to identify value-added activities and enhance them.

4.3.2 Value-added and nonvalue-added activities

All activities do not create value. *Nonvalue-added activities* do not add value to the finished product. There is an opportunity to reduce cost without reducing the customer's perceived usefulness of a product or service. If eliminated, activities that do not affect the quality or performance of a product become nonvalue-added activities. Examples include storage of materials, work in process and finished goods, employees' idle time while waiting for work, and so forth. To be competitive, companies should eliminate or minimise nonvalue-added activities. The use of just-in-time (JIT) production techniques (see sec 4.4) can eliminate or minimise nonvalue-added costs associated with inventory storage, product movements and other activities involved in ordering, receiving and handling inventory.

Value-added activities are those activities that customers perceive as adding usefulness to the product or service they purchase, for example, process time (Drury 2008:546; Hilton et al 2003:186; Jackson & Sawyers 2003:110-111).

Kaplan and Cooper (in Drury 2008:547) criticise the classification of activities by means of value-added and nonvalue-added activities. They argue that people cannot consistently define a value-added or nonvalue-added activity. They hold that this has a demotivating impact when employees are informed that they are performing nonvalue-added activities. These authors propose the following simple five-point scale to be used to judge the efficiency of an activity:

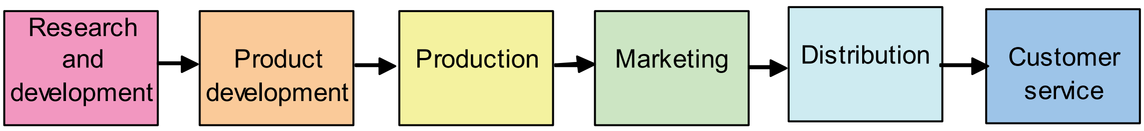
- highly efficient, with little (less than 5%) apparent opportunity for improvement
- modestly efficient, some (5-15%) opportunity for improvement
- average efficiency, good opportunities (15-25%) for improvement
- inefficient, major opportunities (25-50%) for improvement
- highly inefficient, should perhaps not be done at all; 50 to 100% opportunity for improvement

Using the above five categories, activities can be eliminated, performed more efficiently or redesigned in a more cost efficient way (Drury 2008:547).

Kaplan and Cooper's (Drury 2008) opinion was followed for purposes of this study. It can be seen, that not only employees but also customers are influenced by value-added and nonvalue-added activities.

Customers demand top-quality products and services in today's highly competitive market, and a company must strive to add value in each step of the production process. The value chain is the term used to describe this linked set of value-creating activities. Figure 4.3 illustrates the value chain.

Figure 4.3 The value chain



Source:

Adapted from Drury (2008:552); Jackson and Sawyers (2003:111)

The diagram shows that the activities in the value chain include the following:

- research and development: the creation and development of ideas that lead to new services and products
- product development: the detailed development of the ideas resulting in new services and development

- production: the provision of a service or production of a product through the use of resources
- marketing: supplying potential customers with information about the products or services resulting in their purchasing the services or products
- distribution: the delivery of products and services to customers
- customer service: the provision of support or service to customers during and after the sale

The discussion thus far relates to the application of ABM during the manufacturing or service phase of a product's life cycle. ABM systems are also used to influence future costs during the design stage in the target costing process (see sec 4.6) (Drury 2004:955-956; Hilton et al 2003:186; Jackson & Sawyers 2003:110-111).

Successful implementation of ABM will now be discussed.

4.3.3 The successful implementation of ABM

In the implementation of ABM systems, cooperation between accountants, marketing managers, production managers, human resource managers and finance managers is critical. Strong - and long-term commitment from top management in terms of vocal support and the resources provided are required for successful implementation. The success of ABM can be attributed to effective planning. Planning issues include the following:

- the intended scope of the ABC/ABM project
- the resources necessary to plan and implement the project
- resistance to change
- the information to be gathered
- the analysis team responsibility for information analysis and decision making.

Companies that follow a life cycle involving three distinct focus areas, namely cost focus, performance focus and value-added focus, appear to be the most effective at maximising their investment in ABM. The ABM life cycle consisting of the above-mentioned focus areas, is illustrated by figure 4.4.

Figure 4.4 The ABM life cycle

Cost focus	→	**Performance focus**	→	**Value-added focus**
• Understand your cost • Capture "low-hanging fruit" opportunities • Align costs with their value chain		• Focus on enhancing • Links cost with performance measures • Focus is not just cutting costs, but value for money		• Link ABM to shareholder value (SVA) • Align resources with corporate strategy • Focus is on driving towards positive SVA returns
Time frame 1-2 years		Time frame 1-2 years		Time frame Ongoing

Source:
Adapted from Jackson and Sawyers (2003:113)

ABM requires lasting lifestyle changes for an organisation. Significant cost reductions as well as revenue enhancements can be recognised in each phase of the ABM life cycle if it is properly implemented. ABM then becomes a way of life for an organisation, is part of the day-to-day operations and becomes a catalyst helping to move the company towards continuous improvement and market leadership (Hilton et al 2003:198; Jackson & Sawyers 2003:113).

4.3.4 Comparison with other cost systems

The characteristics of a functional-based system and ABM system are compared in table 4.3.

Table 4.3 Comparison of functional-based and ABM systems

Functional-based	Activity-based
Drivers are based on units	Drivers are based on units and non-units
It is allocation intensive	Tracing is intensive
Product costing is narrow and rigid	Product costing is broad and flexible
Focus is on management of cost	Focus is on activity management
Sparse activity information	Activity information is detailed
Individual unit performance is maximised	There is system-wide performance maximisation
Financial measures are used for performance	Financial and nonfinancial measures of performance are used

Source:

Adapted from Hansen and Mowen (2003:45)

The ABM system differs significantly from the functional-based or traditional cost management system. ABM systems focus on the management of activities and not on the management of cost and emphasise the maximisation of system-wide performance instead of individual performance. In ABM systems, financial measures as well as non-financial measures are vital. More accurate information is therefore be available for decision making.

4.3.5 Evaluation of ABM

ABM has the following advantages for an enterprise:

- It provides a foundation for achieving enterprise excellence by eliminating distortions and cross-subsidisation caused by traditional cost allocations.

- It provides a baseline for improving cost and performance.
- Activity cost information provides information on how the mix of an organisation's diverse services and activities contributes in the long run to an organisation's goals.
- Nonvalue-added analysis and analysis of best practices make cost reduction potential possible.
- There is greater product costing accuracy.
- Decision making is improved.
- Strategic planning is enhanced
- There is increased ability to manage activities.

These benefits are not cost free. An ABM system is complex and requires a significant increase in measurement activity, which may be costly (Brimson & Antos 1994:26; Hansen & Mowen 2003:44).

One may conclude that if ABM is successfully implemented, it will contribute the following to cost management:

- Activities are managed by identifying valued-added activities and enhancing them, while eliminating nonvalue-added activities. The saved resources are reapplied to value-added activities. By reducing nonvalue-added activities, costs will be saved.
- It uses accurate information for better decision making, which will improve the organisation's efficiency.
- Customer value is enhanced at reduced costs and increased profit.

During the empirical study, it was determined that ABM is not only used in metallurgical research projects for cost management, but also for cost estimation and project planning purposes (see sec 5.6.13).

The use of other techniques, such as just-in-time (JIT) production techniques can eliminate or minimise nonvalue-added costs associated with inventory storage, product movements and other activities involving ordering, receiving and handling inventory.

4.4 JUST-IN-TIME (JIT) SYSTEMS

According to Langfield-Smith et al (2006:757) JIT inventory and production management has become increasingly popular since the late 1970s. JIT was made famous by Toyota and has been credited as being the key to success of many of the world's largest manufacturers. Companies that have adopted JIT systems have realised tremendous cost savings. These authors define a JIT inventory and production system as a comprehensive system for controlling the flow of manufacturing in a multistage production environment. The production process is simplified by the removal of nonvalue-added activities.

Drury (2008:556) defines a JIT approach as a philosophy of management dedicated to the elimination of nonvalue-added activities. Value-added and nonvalue-added activities are defined in section 4.3.2 above.

Hilton et al (2006:879) state that JIT processes purchase, make and deliver services and products only when they are needed.

Hansen and Mowen (2003:997) and Zimmerman (2006:787) differentiate between JIT manufacturing and JIT purchasing. JIT manufacturing is defined as a demand-pull system that strives to produce a product only when it is needed and only in the quantities demanded by customers, thereby reducing raw material and in-process inventories. JIT purchasing is a system that requires suppliers to deliver parts and materials just in time to be used in production.

Garrison et al (2006:13) define JIT as a production and stock control system in which materials are purchased and units are produced only as needed in order to meet actual customer demand.

Drury's (2008) definition differs from the other authors. He argues that the lead or cycle time involved in manufacturing and selling a product consists of five steps, namely process time, inspection time, move time, queue time and storage time. Only process time adds value to the product. According to the

JIT philosophy, all the other activities add cost, but no value to the product, and are thus deemed nonvalue-added processes. According to Berliner and Brimson (in Drury 2008:557), process time is less than 10% of total manufacturing lead time in many US organisations. Ninety percent of the manufacturing lead time associated with a product therefore does add cost but not value to a product. It is claimed that total costs can be significantly reduced by adopting a JIT philosophy and focusing on reducing lead time. The ultimate goal of JIT is therefore to convert raw materials into finished products with lead times equal to processing times, eliminating all nonvalue-added activities.

From the definitions above, it may be concluded that a JIT system strives to produce a product only when it is needed, only in the quantities demanded by customers, thereby reducing raw material and in-process inventories. It requires suppliers to deliver parts and materials just in time to be used in production and strives to eliminate all nonvalue-added activities.

According to Albright and Lam (2006:157), it is necessary to understand the historical context of the development of JIT.

4.4.1 The history of JIT systems

JIT is a Japanese management philosophy and has been applied in practice since the early 1970s in many Japanese manufacturing organisations. Taiichi Ohno, regarded as the father of JIT, developed and perfected it in the Toyota manufacturing plants to meet consumer demands in minimum delays. Toyota took 10 years to perfect the technique in its plants. During the 1973 oil embargo, the technique gained extended support and was later adopted by many organisations. The oil shock was the greatest blow to Japan after World War II, bringing to a halt a growth period of 10 years. Most companies suffered huge losses and even lost their will to survive. Toyota's financial performance, however, did not decline.

Toyota's approach was different from what was characteristic of the time, and it was able to meet the increasing challenges for survival. Their approach focused on people, plants and systems. For JIT to be successful, Toyota realised that every individual in the organisation had to be involved and committed, the plant and processes had to be arranged for maximum output and efficiency, and quality and production programs had to be scheduled to meet exact demands.

JIT and its advantages are substantially discussed in the literature. Zipkin (in Cheng & Podolsky 1996:3), however, asserts that there is a great deal of confusion about the subject. This has led to a fundamentally different approach to JIT programmes in the West, which has the potential to be more damaging than beneficial. In Japan, strong cultural elements are associated with the emergence of JIT. The Japanese work ethic, which emerged shortly after World War II, is one of the factors. JIT also emerged as a means of obtaining the highest levels of usage of limited resources. Waste is reduced and materials and resources are used in the most efficient manner possible. The key is the input of sustained effort over a long period of time within the framework of continuous improvement. In Japan, the focus on a continuous stream of small improvements is known as K*aizen*. Kaizen costing will be discussed in section 4.5 of this chapter. Another factor is that Japanese firms tend to focus on enhancing long-term competitiveness instead of emphasising the realisation of short-term profits. They are willing to introduce and implement innovative ideas in their firms.

There is a popular misconception that all Japanese manufacturers are JIT producers. Scarbough, Nanni and Sakurai (1991:27-46) concluded that only 20% of 198 Japanese companies in four industries reported using JIT. Thirty percent of the firms in electronic equipment and transportation equipment use JIT, while only 7% of the firms in chemical products and iron and steel manufacturing utilise it.

There is also a belief that JIT cannot work effectively elsewhere in the world because of the differences between the Japanese and other cultures. The role of unions in many Western work environments and the Japanese work ethic are the cultural differences that contribute mainly to this belief. Several

Western organisations, however, have successfully implemented JIT (Cheng & Podolsky 1996:2-3; Cobb 1993:5; Garrison et al 2003:737-740; Hansen & Mowen 2003:959; Hilton et al 2003:278; Japan Management Association 1989:3; Majima 1992:xxi; Satir 1991:5; Zimmerman 2006:731).

For the successful operation of a JIT system, certain key elements are required, which will now be discussed.

4.4.2 Elements of JIT manufacturing

According to Cheng & Podolsky (1996:6-8), the elements that need to be integrated in JIT manufacturing essentially include human resources and production, purchasing, manufacturing and planning and organising. This approach ties in with Toyota's approach mentioned above, which focuses on people involvement, plant and investment and system involvement.

4.4.2.1 People involvement

It is fundamental to obtain the support and agreement of all individuals involved in the achievement of organisational goals. All groups who have an interest in the company should be involved and informed. The support and agreement should be obtained from the following people:

- *Stockholders and owners* of the company should be informed that most benefits associated with JIT will only be realised in the long term, and that short-term benefits should be ploughed back into the company to finance the changes and required investment commitments.
- *Labour organisations* and all employees should be informed about the goals of JIT and how the system influences working practice. Union support is also vital. Because JIT increases the stress placed on workers, it is essential to have sound labour relations.
- *Management's support* is vital and they should set examples for their workers in striving for continuous improvement.

- *Government support* can assist by providing tax and other incentives.

4.4.2.2 Plant and investment

Numerous changes are implemented in plants, and include the following:

- *Plant layouts* are arranged for maximum worker flexibility and set out according to the product instead of the process. Workers are trained to perform many tasks instead of one or two highly specialised tasks.
- *Demand pull production* involves the use of demand for a given period to signal when production should occur. This allows the company to produce only what is required in the correct quantity at the right time.
- *Kanban* is a Japanese word that means *signal* and is usually a tag or a card accompanying a product throughout the plant. The name or serial number for product identification, the quantity, the required operation and the destination of where the part will travel to is indicated on the Kanban in order to link different production processes together.
- Each employee is responsible for s*elf inspection* to ensure that his/her production input adds value to the product and is of high quality. Mistakes and low quality work can be detected and rectified at the place they initially occurred.
- *Continuous improvement* involves a change in attitude towards the overall effectiveness of an organisation. Each member of the organisation should be involved. With every goal and standard successfully met, these goals and standards should be increased to be reasonable and achievable. The organisation will improve continuously, which will lead to customer satisfaction.

4.4.2.3 System involvement

Systems refer to the technology and processes used to link, plan and co-ordinate the activities and materials used in production. Two examples are discussed below:

(1) *Materials requirement planning (MRP)* is a computer-based method for managing the material required for a process. It involves the planning of lower-level products in the product family, such as component parts. MRP can be divided into two parts. The production plan is a broad plan indicating the available capacity and how it will be allocated to the plant, while the master production schedule is a detailed plan of what products to produce at specific times.

(2) *Manufacturing resource planning (MRPII)* is a computer-based program that provides information on financial resources available to implement the plans for MRP.

Garrison et al (2003:738) add another element, namely *striving for zero defects.* Defective units create problems. If there is a defective unit in an order, the company must ship the order with less than the promised quantity or the production line must restart to make only one unit. Although it may be almost impossible to attain a zero-defect goal, companies can come close to this. Motorola, for example, now measures defects in terms of number of defects per million units of product (Cheng & Podolsky 1996:6-8; Garrison et al 2003:738; Hilton et al 2003:280*;* Rayburn 1989:884).

4.4.3 The objectives and goals of JIT systems

JIT management can be applied to the manufacturing process in any company. There are three main manufacturing objectives for JIT, which are universal and homogeneous. JIT can be applied and adapted to organisations that differ greatly from one another. According to Cheng and Podolsky (1996:9-11), the main objectives of JIT are:

- to increase an organisation's ability to compete with rival firms and remain competitive in the long run
- to increase the degree of efficiency in the production process
- to reduce the level of wasted materials, time and effort involved in the production process

The above objectives above are applicable to any organisation. However, every organisation is unique in its production processes and the goals it aims to achieve. The goals for each organisation are therefore unique. The goals of JIT are useful to help an organisation to define, direct and prepare for implementation. Short- and long-term goals include the following:

- identifying and responding to customer needs
- aiming for the optimal quality/cost relationship
- achieving zero inventory
- achieving zero defects
- achieving zero breakdowns
- eliminating unnecessary wastes or nonvalue activities
- aiming for the development of trusting relationship between the suppliers
- designing the plant for maximum efficiency and ease of manufacturing
- adopting the Japanese work ethic of aiming for continuous improvement even though high standards have already been achieved.

The above goals represent perfection and are most unlikely to achieve in practice. Targets, however, are being set and a climate for continuous improvement and excellence created.

According to Drury (2008:556), since the implementation of a JIT system is a mechanism for reducing nonvalue-added costs and long-run costs, it is essential to understand the nature of such a system. The implementation of a JIT system is considered to be one of the major factors contributing to its success.

4.4.4 Implementing a JIT system

Cheng and Podolsky (1996:14) hold that the reason for implementing JIT lies largely in attaining the productivity and quality standards of many Japanese organisations. Increased competition, fluctuations in the economy and consumer demand for high-quality products are also important. Owing to stiff competition, only the most effective and productive firms will survive.

Because production is flexible to meet variable customer demand, the use of JIT manufacturing is not adversely affected by fluctuations in the economy. JIT is also adopted for the potential cost saving associated with it, such as reduced manufacturing cost, material costs, costs of lost sales and customer goodwill.

JIT also focuses on the value added to products. Reducing wastes is closely associated with the value-added concept. Anything other than the minimum amount of equipment, material, parts and working time essential to production is regarded as waste (Drury 2008:557).

The Japan Management Association (1989:17) identifies the seven categories of waste identified in production plants, as:

- waste from overproduction
- the waste of motion
- transportation wastes
- processing wastes
- the waste of waiting or queuing time
- product defects
- inventory cost

In the Toyota production system, waste from overproduction is considered to be by far the worst offence. This waste overshadows all others. Other types of waste provide clues about how to correct them, but waste arising from overproduction provides a blanket cover and prevents the organisation from making corrections and improvements.

The rationale for implementing JIT is discussed above. The prerequisites for implementing a JIT programme will now be discussed.

According to Cheng and Podolsky (1996:18-21), the typical prerequisites for implementing a JIT programme, includes the following:

- **Plant evaluation.** Production and workforce capability should be determined. The workforce should be able to respond to changes in demand and will have to become acquainted with the necessary skills and knowledge. They should be committed, involved and willing to adapt to changes and work in teams. The organisation should also adopt the idea of continuous improvement. The degree of change and difficulty required for the implementation should also be determined.

- **Management influence.** The influence of management will persuade and motivate employees towards a JIT orientation. JIT success will depend on the degree of motivation and commitment to make the process work as a coordinated system.

- **Housekeeping activities.** Visible waste, clutter and obstacles should be reduced and eliminated from the production area. The number of defective products, level of employee morale, frequency of machine breakdowns, flow of materials, employee suggestions and inventory levels are closely associated with housekeeping activities.

- **Organisational flexibility.** The organisation should be flexible in adopting changes. Adjustment to change in volume, modification of the product mix, choice of equipment and people flexibility are the levels in which an organisation should be flexible.

From the above discussion, one may conclude that organisations that are willing and quick to apply innovative ideas to their manufacturing process will have a competitive advantage over those who do not. These firms will survive and show profits in the long term. For the successful implementation of JIT, a company's workforce and management should be involved and the organisation may be required to respond to situations that are different from those accustomed to, because JIT may be a new and foreign experience in the organisation.

4.4.5 Comparison with other costing systems

The major differences between JIT manufacturing and traditional manufacturing are compared in table 4.4, while the contrast between JIT and traditional purchasing will be illustrated in table 4.5.

Table 4.4 Comparison of JIT and traditional manufacturing

JIT	Traditional
Pull-through system	Push-through system
Insignificant inventories	Significant inventories
A small supplier base	Large supplier base
Long-term supplier contracts	Short-term supplier contracts
Cellular structure	Departmental structure
Multiskilled labour	Specialised labour
Decentralised services	Centralised services
Highly involved employees	Low employee involvement
Facilitating management style	Supervisory management style
Total quality control	Acceptable quality level
Buyer's market	Seller's market
Value chain focus	Value-added focus

Source:

Adapted from Garrison and Noreen (2003:206); Hansen and Mowen (2003:517)

In the past, the function of purchasing in an organisation manifested itself as being primarily concerned with obtaining parts at the lowest price. One of the differences in the role purchasing plays in a JIT environment is that the focus shifted towards quality. Table 4.5 summarises these differences.

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Table 4.5 Comparison between JIT and traditional purchasing

Activity	JIT	Traditional
Purchase size	Small lots	Large batches
	Frequent deliveries	Few deliveries
Supplier selection	Long term	Short term
	Single source supply	Multiple source supply
Supplier evaluation	Criteria include quality, delivery and price	Quality, delivery and price
	No rejects acceptable	2% rejects accepted
Inspection	Initial reduction Eventually eliminated	Activities include receiving, counting, and inspecting
Negotiations	Long-term, quality and reasonable price	Obtain lowest price
Transportation	On-time delivery	Outbound freight
	Concern for inbound/outbound freight	Lower cost Supplier has schedule responsibility
Product specifications	Buyer has schedule	Buyer's concern for design specifications
	Supplier innovation	Suppliers are not innovative
	Emphasis on perfor-mance specifications	
Paperwork	Less paperwork	Large volume of paperwork
	Ability to change delivery time and quantity	Purchase orders needed to change delivery time and quantity
Packaging	Small, standardized containers which hold exact quantity	Regular packaging No clear specifications

Source:

Adapted from Cheng and Podolsky (1996:108)

From the above, it is evident that JIT purchasing differs from the traditional approach in the nature of the relationship between the organisation and the supplier, the frequency of deliveries and the number of suppliers. The quality of the suppliers' products, however, is the element of purchasing that is subject to the greatest impact. The primary consideration in the selection of suppliers is quality, and not price, as in the traditional system.

JIT has many advantages. Managers, however, should be aware of the limitations and shortcomings of the system that may be applicable to their organisations.

4.4.6 Evaluation of JIT manufacturing

The following is an overview of potential advantages and disadvantages:

4.4.6.1 Advantages

- When properly adapted, JIT can strengthen an organisation's competitiveness by competing on the basis of cost, service and quality.
- Organisational competitiveness is enhanced by allowing organisations to develop an optimal process for manufacturing their products.
- JIT can reduce the fluctuations that many firms experience contingent upon changing economic conditions.
- JIT allows companies to reduce waste and improve quality and efficiency of production.
- By improving quality, consumer demands are satisfied efficiently and reliably.
- Working relationships between employees improve.
- There will be stronger and more reliable relationships with suppliers.
- Profits will increase in the long term.
- Working capital is increased by the recovery of funds that were tied up in stock.

- Areas previously used to store stock are made available for more productive uses.
- Throughput time is reduced, resulting in greater potential output and quicker customer response.

4.4.6.2 Disadvantages

- It increases worker stress because of high expectations.
- Organisations that rely on safety stock have problems absorbing any increases in demand.
- The benefits associated with JIT may be culturally bound and limited to the Japanese environment. These are difficult to overcome without changes in attitudes and worker philosophy.
- There is loss of individual autonomy because of limited cycle times.
- There is a loss of team autonomy because of the reduction or elimination of buffer inventories.
- Strict methods of production diminish the entrepreneurial spirit of workers.
- JIT success may be industry specific.
- There is resistance to change because every member of the organisation is influenced.
- Redesigning factory layouts, reducing set-up times and increasing quality may increase costs.
- If there is a labour strike, bad weather prevents delivery or demand increases unexpectedly, sales will be lost.
- JIT is inappropriate for organisations required to receive three or more quotations on every project, because it requires a small select group of suppliers to be willing to adhere to the delivery and quality needs of the buyer.
- The absence of inventory to buffer production interruptions is the most glaring deficiency of JIT (Cheng & Podolsky 1996:12-14; Garrison et al 2003:740; Hansen & Mowen 2003:963; Rayburn 1989:885; Zimmerman 2006:732).

From the above discussion, it is clear that JIT was developed by the Japanese in the early 1970s. JIT is a long-term process that cannot be implemented in a short period of time; nor can rewards be realised overnight. Toyota has taken 10 years to perfect the JIT technique in its plants.

If JIT is successfully implemented, it contributes the following to cost management:

- Consumers can be offered higher-quality products than those offered by rival firms.
- A superior service or superior means of production will allow the organisation to become increasingly efficient and productive.
- JIT can integrate and optimise operations and resources, continually improve processes and systems and understanding the customer better in order to satisfy their needs.

However, managers need to understand and be fully aware of the shortcomings of JIT and how these could affect them during implementation. JIT should also not be seen as a remedy for all problems, but as a means of lowering costs and improving efficiency of production.

JIT is not suitable for a research environment, because every project is unique and requires different material and equipment. During the empirical study, it was found that none of the respondents in this study were using JIT for cost estimation or cost management purposes in metallurgical research projects.

4.5 KAIZEN COSTING

According to Barnes (1996:7-8), the Japanese word *Kaizen* is a composition of the words *Kai*, meaning “change” and *zen*, meaning “good” and can be translated as *improvement*. In the management process and business culture, it means continual and gradual improvement. The Kaizen way is not only about doing things better, but specific outcomes include *muda* - eliminating waste, (wasted time, money, materials and effort), raising the quality of products, service, relationships, personal conduct, employee development, cost reduction and ultimately, creating more satisfied customers.

Kaizen was the first holistic movement in business. In Japanese Kaizen companies, an employee is recruited and developed as a whole person, not simply as a utilitarian resource. Employees' and teams' knowledge and participation in every aspect of business and their contribution should improve their workplace and products. The workforce becomes inspired and motivated and produces results greater than the sum of its members' individual contributions.

In a Kaizen system, progress is achieved via unceasing small changes to the hundreds of thousands of details associated with reducing products or services, originating from the idea downstream to the point of sale and after-sales service. There is no such thing as perfection - there is no *status quo*. The perfect product is never attainable: another day or another person may always find an improvement. Outputs are referred to as "standards" or "quotas" rather than targets, because targets can be met, while standards promote efforts to beat targets (Barnes 1996:7-8; Drury 2008:543; Wellington 1995:14).

4.5.1 The history of Kaizen costing

According to Wellington (1995:26), Kaizen as a business concept evolved in Japan during the post-war period. Not every company in Japan, however, is a Kaizen company. Kaizen operates in Japan in a different business environment, where lifetime employment has been the norm for workers in large companies. In the West, Kaizen led to a reduction of jobs, while in Japan, it is not acceptable to cut costs by making employees redundant.

Wellington (1995:17) states that Kaizen in its pure form is neither wholly acceptable to Western thinking and behaviour, nor virtuous and in the best interest of employees. The Japanese are now introducing Western psychology and business practices to create less individually coercive and group-oriented environments in Kaizen companies. They have embarked on this course in direct response to the 1991 recession, criticisms levelled at the country's business and political leaders in the media and as a consequence of what they have learnt in their plants in the UK and USA.

Kaizen is certainly not a new concept. People have been applying it for years, without knowing what it was called. Most people have a desire to improve their work, relationships and lives. In a management sense, however, improvement and Kaizen are not synonymous - Kaizen offers far more.

Barnes (1996:15) contends that a number of techniques and tools have gathered under Kaizen's wing, these are known as Kaizen instruments. Some, like quality circles, total quality management (see sec 4.7) and JIT inventory control (see sec 4.4), were developed and re-exported to the West as standalone processes.

Kaizen instruments are discussed in Barnes (1996:9-20) and Wellington (1995:42-48), and include the following:

- **Suggestion systems.** A Kaizen suggestion system is wholly inclusive, driven by consensus, activated by teams, supervised by team leaders and an imported benchmark of team and team leader performance. In other words, it is a process owned by employees even though it is designed to benefit the company.

- **Quality (control) circles.** These were originally groups of volunteers led by a senior employee whose task was purely to resolve local quality problems. The term "quality circle" no longer fully describes the breadth and horizon over which these groups cast their attention.

- **Process-oriented management.** Kaizen managers are overtly oriented towards the *process* of achieving the required results, whereas Western managers focus primarily on results and are judged on their achievements.

- **Visible management.** Kaizen team leaders are required to be with their teams constantly, training, motivating, coaching, communicating, educating, and leading. They should be visible, devoting themselves totally to their teams and manage them holistically.

- **Cross-functional management.** It is not only an expectation, but also a requirement that projects should be developed cross-functionally from inception.

- **JIT management.** JIT is a production system developed by Taiichi Ohno at Toyota (see sec 4.4 for a detailed discussion).

- **Kanban.** A Kanban is a manual-production scheduling technique controlled by a process operator or machine operator. The purpose of every Kanban system is to activate the next supply station upstream from the initiator (see sec 4.4.2).

- **Statistical Process Control.** Statistical process control is based on relatively simple fundamental principles. It involves process operators periodically sampling the quality of their own outputs and deciding for themselves when to shut down a process before it produce unacceptable products.

- **The PDCA Cycle.** This is a simple but powerful tool used to solve problems. The PDCA cycle is an endless improvement cycle in which teams: **p**lan, **d**o, **c**heck and **a**ct (see sec 4.7.2).

- **Other tools.** These include brainstorming, fishbone analysis, Pareto analysis, histograms and scatter diagrams and checklists.

Wellington (1995:35) criticises the use of Kaizen instruments as standalone processes and arguing that in doing so, two elements of the full Kaizen "equation" were often ignored. Firstly, she states, a Kaizen instrument should not be an end itself - it should be a means to improve production to achieve the real goal, namely provide greater customer satisfaction. Managers and employees do not always understand the connection between the installation of a new system and its benefits to customers. Secondly, if used by only selected staff or departments, any Kaizen instrument will fail to achieve its total potential. Before the advent of total quality management, quality control was an example of how companies in the West ring fenced this function in a specific department. Another example is quality circles in which only some employees were invited to participate.

4.5.2 The principles of Kaizen costing

The classical principles of Kaizen costing, as identified by Barnes (1996:15) and Wellington (1995:17-24), and as practised in some companies in Japan, are as follows:

- **Focus on customers.** The ultimate focus of Kaizen is customer satisfaction. If an activity does not add value to a product or enhance customer delight, it is regarded as an irredeemable cost and should be eliminated. (The primary focus of Kaizen is quality. However, since there is no distinction between producing quality products and fulfilling customer needs, the quality of service is inextricably bound into the manufacturing-selling chain.)

- **Make improvements continuously.** Once an improvement has been implemented in a Kaizen company, the search for ways to improve does not stop. Today's standards will not meet tomorrow's demands and will only last as long as it takes another employee or team to find a way of improving it. A classic example was documented in 1970. It took Toyota's employees four hours to change the dies on large sheet metal presses, while Volkswagen took only two hours to do a comparable job. Shigeo Shingo, a Toyota team leader believed they had to improve. After six months his team had reduced the set-up time to 1,5 hours. However, they did not stop their search for improvement once they had reached the two-hour target; they continued to reduce the time down until they could change the dies within three minutes. The search for improvement never stops In Kaizen.

- **Acknowledge problems openly.** By fostering a no-blame, supportive, constructive, nonconfrontational culture in a Kaizen company, employees feel free to admit errors, point out weaknesses and ask for help. Problems are contained and rapidly resolved.

- **Promote openness.** In a Kaizen company, there seems to be less functional compartmentalisation or ring fencing than in a Western counterpart. Working areas are more open plan and only the most senior executives have individual offices. Symbols of rank or status are rarely seen, which reinforces leadership visibility and communication viability.

- **Create work teams.** Teams are the building blocks of corporate structure in a Kaizen company. Each individual belongs to various overlapping teams: a work team managed by a team leader, a year team composed of employees who joined the company at the same time plus one or more ad hoc quality circles and cross-functional project teams. This draws employees into corporate life and reinforces the feeling of mutual ownership, collective responsibility and company-centredness.

- **Manage projects through cross-functional teams.** Projects are planned and executed using cross-departmental and cross-functional resources, even from outside the company. Those functions directly influenced by the project throughout its life should be represented in a multidiscipline project team from the outset.

- **Nurture the right relationship processes.** Kaizen companies are as concerned and driven by the achievement of financial goals as any company, but are of the opinion that if the processes are sound and relationships nurture employee fulfilment, the wanted outcomes will inevitably follow. In Japan, the word "harmony" carries great weight and is most apparent in the Japanese nation's desire for non-adversarial communication and the avoidance of interpersonal confrontation.

- **Develop self-discipline.** To many Japanese, self-discipline at work comes naturally. Through schooling, religion and social norms, they find conforming to the natural order both comforting and an affirmation of inner strength and wholeness. To Westerners, this is the most difficult principle to accept, because they are less prepared to sacrifice their families and social time for the company or an individual manager on an on-going basis.

- **Inform every employee.** All staff are fully informed about their company at induction and throughout their employment. The right attitude and behaviour are contingent upon a complete understanding and acceptance of the company's mission, culture, values, plans and practices.

- **Empower every employee.** Kaizen employees are empowered to materially influence their own and their company's affairs through multiskilled training, encouragement, decision-making responsibility, access to data sources and budgets, feedback, job rotation and reward.

The obvious simplicity and commonsensical nature of the 10 principles of Kaizen are misleading. Their simplicity does not mean that a single and quick introduction is possible, especially if the existing framework is traditionally Western.

4.5.3 The objectives of Kaizen costing

According to Wellington (1995:15), Kaizen costing is a way of thinking and behaving. Guidelines are provided for individuals and teams in the "company family" and help to direct efforts towards the fulfilment of profit making through product and process improvement designed to enhance customer satisfaction. In a Kaizen company, improvement is everyone's concern. Any employee may consider any initiative that might improve a product, eliminate waste or reduce costs.

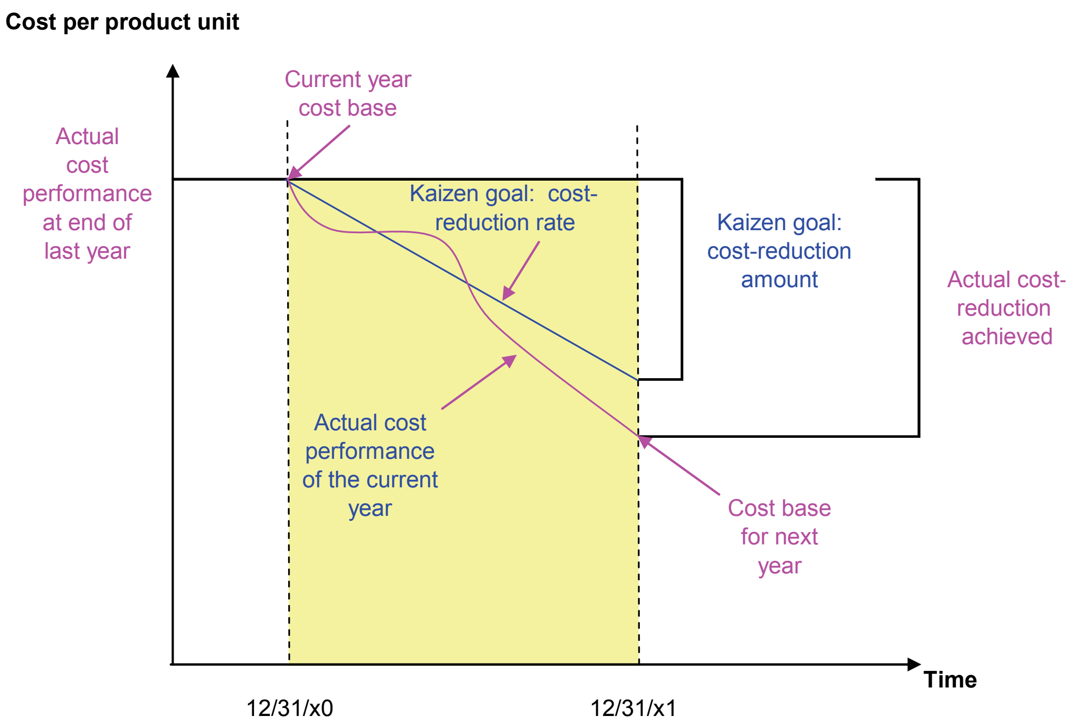
Monden and Lee (1993:22) state that Kaizen costing, which functions in a similar fashion as a budgetary control system, operates outside the standard cost system. The aim is to reduce actual costs below the standard costs, and not meet the standard, which is emphasised by a standard costing system. Daihatsu Motor Company's Kaizen costing calls for the establishment of a cost reduction target amount, and its accomplishment through Kaizen activities – continuous improvement in operations. Daihatsu defines Kaizen activities as those activities that "sustain the current level of the existing car production costs, and further reduce it to the expected level based on the company plan".

Monden (1995:290) holds that the main objective of Kaizen costing is the relentless pursuit of cost reductions at every stage of manufacturing to help close any gaps between target profits and estimated profit.

Drury (2008:543) claims that the aim of Kaizen costing is to reduce the cost of components and products by a prespecified amount.

A typical Kaizen costing chart is represented in figure 4.5.

Figure 4.5 Typical Kaizen costing chart



Source:

Adapted from Hilton et al (2006:671); Monden and Lee (1993:24)

The Kaizen costing chart depicted above is based on one used at the Daihatsu Motor Company in Japan owned in part by Toyota. It is clear that the cost base or reference point is the actual cost performance at the end of the previous year. A Kaizen goal is established for the cost reduction rate and amount during the current year. The actual cost performance throughout the year is compared with the preset Kaizen goal. At the end of the current year, the current actual cost becomes the cost base or reference point for the next year. A lower Kaizen goal is established, and the cost reduction effort continues.

Kaizen goals are met by the continual and relentless reduction of nonvalue-added activities and costs, the elimination of waste and improvements in the management cycle time. The improvement suggestions and Kaizen efforts of all employees are taken seriously by management who implement them when appropriate. This results in a continually more efficient and cost-effective production process (Hilton et al 2006:671; Monden & Lee 1993:24; Zimmerman 2006:638).

From the above, it can be concluded that the objectives of Kaizen costing are

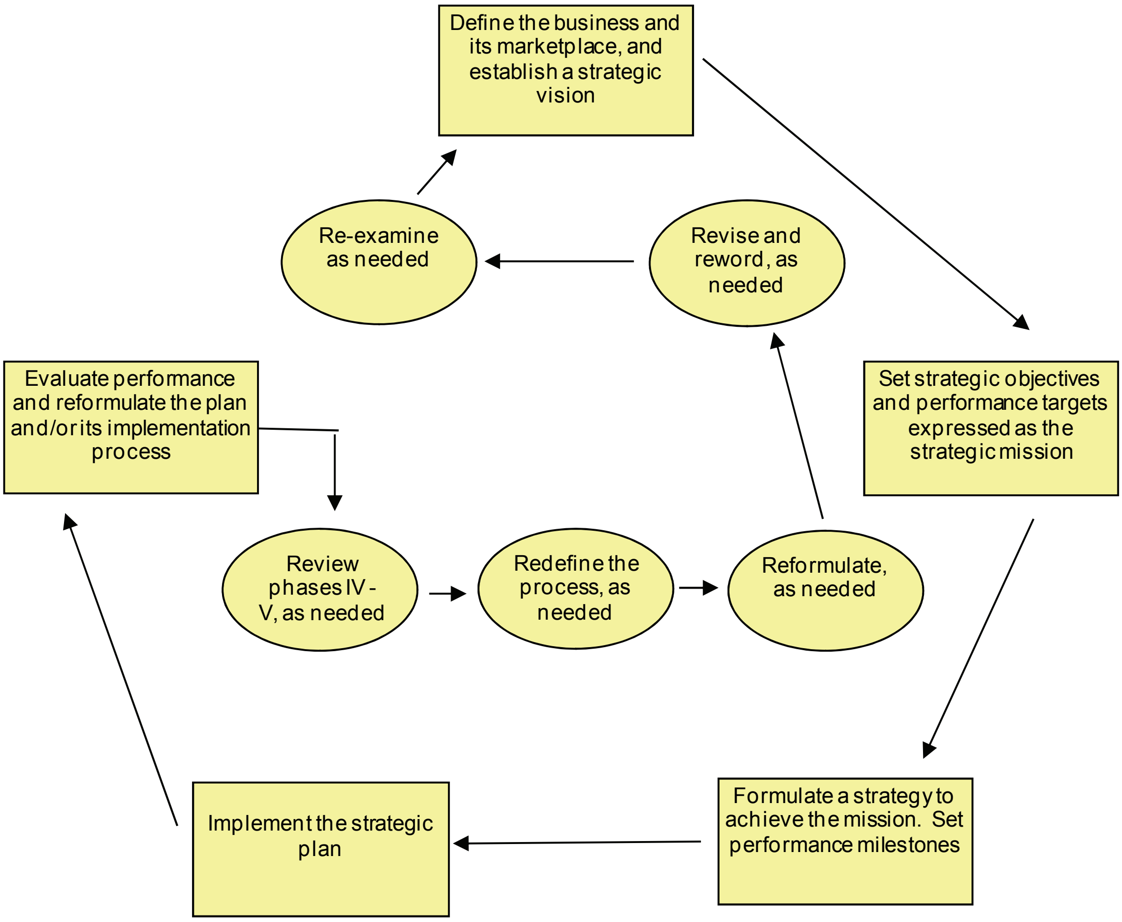
- to provide guidelines for profit making through product and process improvement designed to enhance customer satisfaction
- to eliminate nonvalue-added activities and costs and waste
- to make everyone responsible for improvement
- to reduce actual costs below the standard costs, and not meet the standards, which will result in continuous improvement.

The implementation of Kaizen costing will now be discussed.

4.5.4 Implementing Kaizen costing

According to Wellington (1995:179), the first step in developing and implementing a Kaizen costing model is to formulate a strategy. A strategy is a description of how a company will achieve its formal objectives and goals. Vision is translated into action and, via a regular planning and analysis process, states how the organisation's resources will be used to gain and sustain a competitive advantage and produce benefits for shareholders. Figure 4.6 illustrates the process of formulating a strategy.

Figure 4.6 Formulating a Kaizen strategy



Source:

Adapted from Wellington (1995:179)

When developing and implementing a Kaizen-based strategy, the following are of utmost importance:

- A clear and communicated vision of the framework for the organisation's new values must underpin a fundamental shift in the organisation's culture to eliminate arbitrary actions causing the organisation to lose its way.

- The transformation should not be advanced on a broad front which may dilute management control and intimidate employees by the magnitude of the change.
- Project development groups should be responsible for specific aspects of the transformation process and particular members in groups should be responsible for precise project activities.
- The managing director should support the project through visible leadership.
- As many people as possible should be involved in planning and executing the transformation.
- Performance must be measured and rewarded with respect to the new requirements.
- The development and implementation of a new culture should be broken down into manageable process steps, which can be controlled precisely.
- Be selective – choose which Kaizen instruments will be introduced and over what timescale (Wellington 1995:179).

To determine where Kaizen costing fits into the bigger picture, it will now be compared with other cost management methods.

4.5.5 Comparison with other costing systems

According to Monden and Lee (1993:22-25), the usefulness of standard costing systems, used to control cost by US firms for the last several decades, has recently been questioned by many practitioners and academics. ABM (see sec 4.3) has gained a prominent status in cost management. Daihatsu is using value engineering in the development and design phase, and target costing is effectively used in managing costs in this phase. Kaizen costing supports the cost reduction process in the manufacturing phase. Kaizen costing, employed along with target costing, helps Japanese manufacturers achieve their goal of cost reduction in the entire product design-development-production cycle.

Kaizen costing compared to standard costing aims to reduce costs aggressively. Table 4.6 illustrates the differences between Kaizen and standard costing concepts and techniques.

Table 4.6 Standard versus Kaizen costing

Standard costing concepts	Kaizen costing concepts
Cost control system concept	Cost reduction system concept
Assume current manufacturing conditions	Assume continuous improvement in manufacturing
Meet performance standards	Achieve cost reduction targets
Standard costing techniques	**Kaizen costing techniques**
Standards are set annually or semi-annually.	Cost reduction targets are set and applied monthly. Continuous improvement (Kaizen) is implemented during the year to attain target profit or reduce the gap between target profit and estimated profit.
Cost variance analysis involves standard cost and actual cost.	Cost variance analysis involves target Kaizen costs and actual cost reduction amounts.
Investigate and respond when standards are not met.	Investigate and respond when target Kaizen amounts are not attained.

Source:

Monden (1995:290); Monden and Lee (1993:26)

Barnes (1996:8) argues that if one thinks of total quality management (TQM) (see sec 4.7), one will begin to understand Kaizen, because what the West know as TQM actually stems from Kaizen.

Drury (2008:543) states that the major difference between target and Kaizen costing is that the former is applied during the design stage, whereas the latter is applied during the manufacturing stage of the product's life cycle. The focus is on the product and cost reductions that are achieved primarily through product design with target costing. Kaizen costing focuses on the production processes and cost reductions are derived primarily from the increased efficiency of the production processes. The potential cost reduction will therefore be lower with Kaizen costing because the products are already in the manufacturing stage of their life cycles and a significant portion of the costs will have become locked in. Kaizen costing, unlike target costing, is not accompanied by a set of techniques or procedures that are automatically applied to achieve cost reductions. Workers are given the responsibility of improving the processes and reducing costs.

4.5.6 Evaluation of Kaizen costing

As in any other cost management system, there are not only advantages, but also disadvantages.

4.5.6.1 Advantages

- The consistent connection with the overall planning and budgeting process ensures that the company can monitor its progress towards long-term goals without meeting cost standards and investigating variances in conventional cost control systems.
- It is a powerful tool that offers a great deal.
- It is essential for future competitiveness.
- It leads to higher quality goods and services.
- It can lead to a more efficient organisation.
- Business results are improved.
- It helps to eliminate waste.

4.5.6.2 Disadvantages

- Kaizen costing as compared to standard costing (see table 4.7) aims at reducing costs in a very aggressive manner, which may be very stressful to employees and managers.
- It is difficult to achieve:
  - A complete change in attitude and culture is required.
  - The energy and commitment of all employees are needed.
  - Requires a great amount of time.
- It is difficult to maintain the momentum.
  - Kaizen may be seen by some people as a threat to their jobs.
  - A lot of poor ideas are put forward, as well as good ones, which can be demotivating.
  - There is never complete satisfaction.
- Innovation also needed
  - It may not always be commercially sensible to do things better.
  - It can make people blind for the wider issue.
  - There is a danger of becoming exclusively evolutionary at the expense of revolutionary advances (Barnes 1996:34; Monden et al 1993:26; Wellington 1995:222).

It can be concluded that Kaizen costing was developed in Japan in after World War II. Kaizen costing focuses on customers, continuous improvement and the involvement of all employees.

If Kaizen costing is successfully implemented, it contributes the following to cost management:

- Kaizen costing aims at cost reduction at every stage of the manufacturing stage of a product's life cycle.
- It improves profitability by providing high-quality products, excellent service to customers and the elimination of waste.
- Kaizen costing is far more aggressive than the traditional methods in cost reduction.

Kaizen costing is therefore an aggressive tool that offers much, but at a cost. It sets high standards of work ethics to employees. It is difficult to achieve and to maintain momentum, because there is never complete satisfaction. The danger to avoid is to become exclusively evolutionary at the expense of the revolutionary advances.

The empirical study (see sec 5.6.13) found that Kaizen costing is unfamiliar in the field of metallurgical research. None of the respondents used it either for cost estimation or cost management purposes. It could, however, be a useful method to manage costs during the growth phase of the life cycle of these projects.

Today, management accountants are responsible for more than only traditional transactional accounting. Target costing is one of the most significant of these new responsibilities. Target costing is a fundamentally different way of looking at the relationship of prices and costs and will now be discussed.

4.6 TARGET COSTING

The price of most products is set as the sum of the costs and the desired profit, because a company must earn sufficient revenue to cover all its costs and yield a profit. Drucker (in Hansen & Mowen 2003:857) challenges this view, stating the following: “This is true but irrelevant: Customers do not see it as their job to ensure manufacturers a profit. The only sound way to price is to start out with what the market is willing to pay.”

Since every company has a unique approach, there is no single, simple definition of target costing.

Langfield-Smith et al (2006:709) states that target costing is a system of profit planning and cost management that determines the life cycle cost at which a product must be produced in order to generate the firm’s desired profit, given the product’s anticipated selling price. They clearly indicate that target costing is not a method of product costing, but a technique for cost management.

Hilton (2008:647) defines target cost as the projected long-run cost that will enable a firm to enter and remain in the market for the product and compete successfully with the firm's competitors. Target costing sets the target cost by first determining the price at which a product can be sold in the marketplace and then subtracting the target profit margin from this target price, yielding the target cost.

According to Garrison et al (2006:833), *target costing* determines the maximum allowable cost for a new product and then developing a prototype that can be profitably made for that maximum target cost figure.

The following are common to these definitions:

- Target costing is a process founded on a competitive market environment.
- Market prices drive cost (and investment) decisions.
- Cost planning is essential.
- Management and reduction occur early in the design process.
- All costs over the entire life cycle are taken into account.
- There is cross-functional team involvement.

A market price for a product in a competitive market will therefore first be determined. The cost of the product will then be determined by deducting the required profit from the market price. The product will be designed and developed within the maximum allowable cost, referred to as target cost.

To understand the concept of target costing better, the history of its development will now be discussed.

4.6.1 The history of target costing

The main objectives of an organisation include satisfying customers with top-quality goods and services, quickly and on time; achieving high levels of market penetration; providing a good working environment for employees; and being financially successful. Any business's long-term financial success depends on whether its prices exceed its costs by enough to provide for reinvestment, finance growth and yield a satisfactory return to its shareholders. If demand exceeds supply and there are a few competitors, costs are simply marked up to establish a price that yields sufficient profit. As competition increases and supply exceeds demand, prices are significantly more influenced by markets. In order to achieve a sufficient margin over its costs, a company must manage its costs relative to the prices the market allows or the price the firm sets. Target costing has evolved in the context of these characteristics. The highly competitive environment to which Japanese companies were subjected for a number of years was the main contributor to the development of target costing.

After World War II, upstart companies such as many Japanese manufacturers struggled to make their way. To succeed, they had to offer products at or below market price. Over 80% of Japanese assembly companies and 100% of car manufacturers use target costing. Leading Japanese companies such as Toyota, Nissan and NEC used what has come to be known as target costing. Some North American companies, including Ford and Chrysler, have started to use this approach in order to compete with the Japanese car companies. New computer companies such as Compaq and Dell, have also used it to compete with more established companies such as IBM. Other companies using target costing include Daihatsu Motors, Isuzu Motors, Olympus, Boeing and Sharp (Garrison et al 2003:649; Helms, Ettkin, Baxter & Gordon 2005:49; Howell 1994:2; Langfield-Smith & Luckett 1999:4).

Target costing emerged in Japan in the 1960s as a response to difficult market conditions, but was only documented in the 1990s in both Japanese and Western literature. There are several reasons for this. Firstly, the popularity of the Japanese JIT inventory systems dominated the attention of the industry in the 1980s, at the expense of target costing. Secondly, target costing was still being refined by the Japanese in the 1980s and 1990s. Thirdly, target costing focuses heavily on new product development activities, which are treated with great secrecy in Japan (Langfield-Smith & Luckett 1999:4).

Pierce (2002:30) provides evidence from a survey conducted in the USA which indicates that target costing is a widely used technique by up to 40% of responding organisations, and is significantly more popular than other management accounting innovations, including ABC, despite having received much less publicity. In Europe, however, the technique is less popular, and Irish research evidence shows that target costing is one of the least used techniques in Irish manufacturing companies.

4.6.2 The principles of target costing

There is no single definition of target costing and the target costing process. According to Howell (1994:13-25) and Langfield-Smith and Luckett (1999:5-7), all companies, however, do share a series of general steps:

- establishing the target price in the context of market needs and competition
- establishing the target profit margin
- determining the cost that must be achieved
- calculating the probable cost of current products and processes
- establishing the target cost – the amount by which costs must be reduced

Once the target cost has been calculated, the followings steps are taken to achieve it:

- establishing a cross-functional team, involved in the implementation process from the earliest design stages
- using tools such as value engineering in the design process
- pursuing cost reductions using Kaizen costing once production has started

In the following paragraphs, the sequence of steps involved in a successful target costing process, as described by Langfield-Smith and Luckett (1999:5-7) and Howell (1994:13-25), will be discussed.

- **Establishing target price.** Establishing the target price of the new product is the first step in the process. The first consideration is to determine what the market wants and present and future needs. What the customers want and how much they are really willing to pay for alternative features, is the next step. Lastly, current and future competitive offerings need to be determined.

- **Establishing the target profit margin and allowable cost.** Once the target price has been calculated, a target profit margin should be determined. The target profit margin should be based on the company's long-term strategic and financial objectives and profit planning.

- **Determining the current cost and target cost.** The cost of the new product is determined by using existing product specifications and manufacturing processes. This is frequently referred to as the *engineering cost*. This process is the cornerstone of target costing and needs to be carefully performed to arrive at meaningful targets. Figure 4.7 illustrates the relationship between the target price, target profit margin, allowable cost, current cost and cost reduction objectives.

Figure 4.7 Relationship between target price, profit and cost

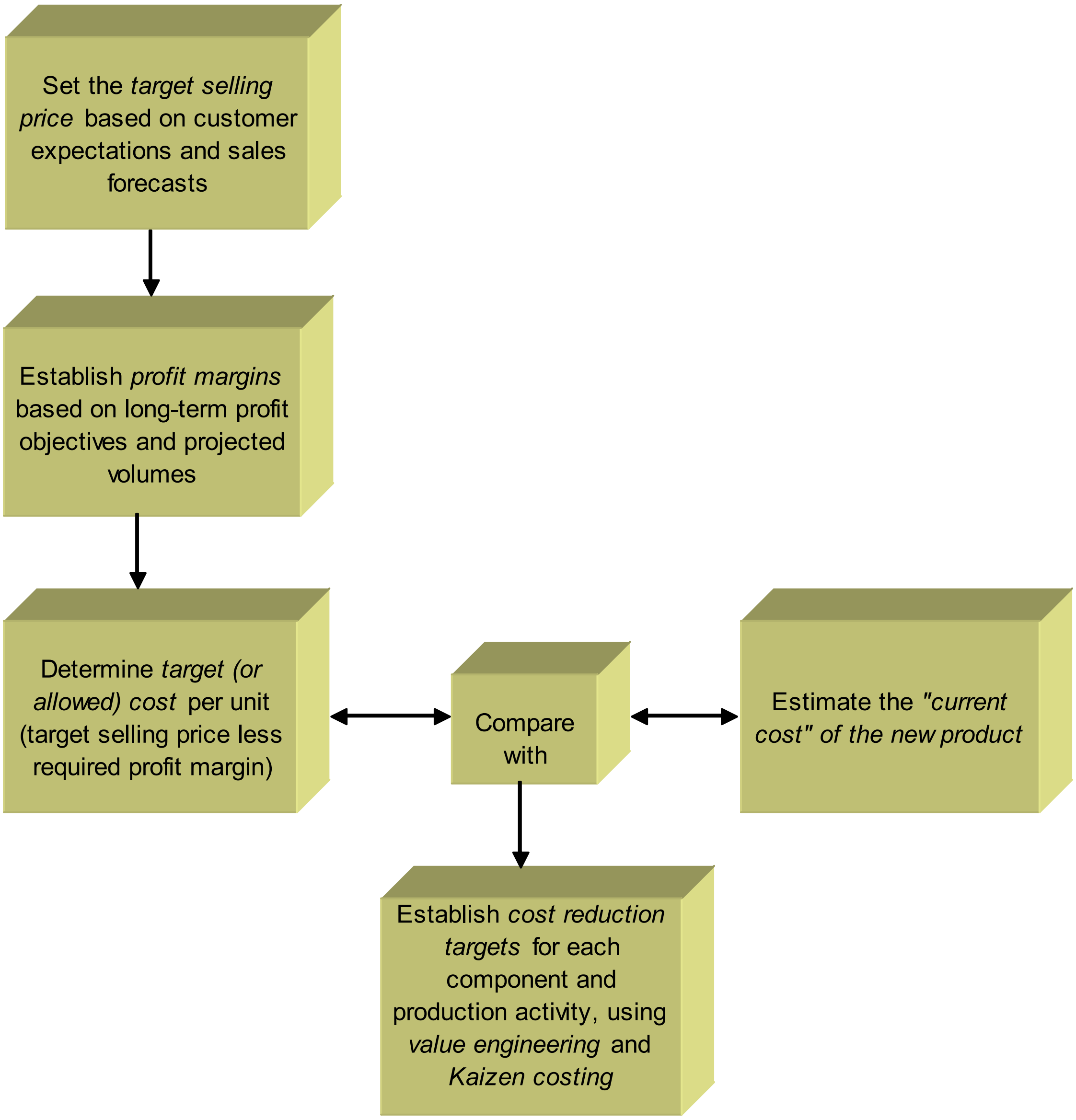
Source:

Adapted from Howell (1994:19)

From the above figure, it is clear that the difference between the target price and the target profit margins represents the target cost. Value engineering and Kaizen costing are used to reduce current cost to achieve the target cost. Value engineering reduces cost during the design and development stage, while Kaizen costing reduces cost during the production stage.

To achieve the calculated target cost, three steps need to be followed. Firstly, a cross-functional team of participants who are affected by and may affect the product and process specification process, is selected. The team's participation early in concept design and development will greatly affect product life cycle costs. Finally, using tools such as value engineering and Kaizen costing to arrive at a product and process design is central to achieving the target cost. Figure 4.8 summarises the steps in the target costing process.

Figure 4.8 Steps in the target costing process



Source:

Adapted from Langfield-Smith and Luckett (1999:6)

4.6.3 The objectives of target costing

According to Monden (1995:12) the two main objectives of target costing are as follows:

(1) The cost of new products should be decreased to ensure the required profit, while the new products meet the levels of quality, delivery timing, and price required by the market.

(2) All company employees should be motivated to achieve the target profit during new product development by making target costing a companywide profit management activity.

These objectives will lead to the following (Clifton, Bird, Albano & Townsend 2004:11; Robinson 1999:6):

- improved profitability
- an improved product development process
- price reliability
- better coordination of production and marketing
- an increased emphasis on cross-functional working
- greater focus on customers and products
- having the right products at competitive prices

From the above, it is evident that the key point is that a target costing system operates at the new product development stage as a highly efficient mechanism to plan, manage and reduce costs by enlisting the cooperation of many people throughout the organisation. It also emphasises understanding the markets and customer requirements. The fundamental objective is to make money, to be able to reinvest, grow and increase value. It is not only concerned with minimising cost, but is also used in conjunction with other continuous improvement tools, such as total quality management, which represents a comprehensive approach to cost management.

4.6.4 Implementing target costing

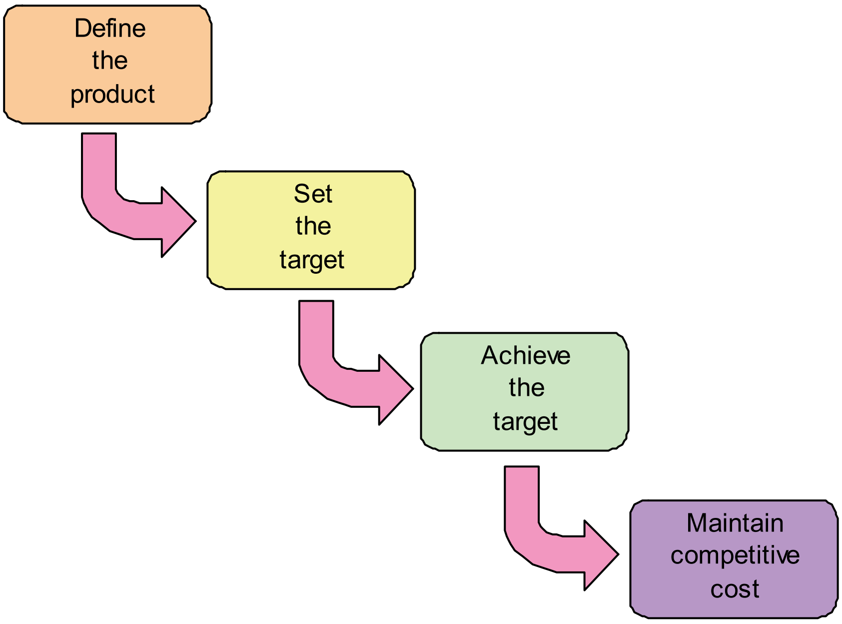
One of the reasons for the development of target costing and its implementation is based on two characteristics:

(1) Companies have less control over price than they would like to think, as prices are determined by the market (supply and demand).

(2) Most of the cost of a product is determined in the design stage. The opportunities to reduce cost come from designing the product in such a way as to minimise costs (Garrison & Noreen 2003:814).

The basic steps to follow when implementing target costing is to define the product, set the target cost, achieve the target and then maintain a competitive cost during the life cycle of the product. Figure 4.9 illustrates the basic target costing process.

Figure 4.9 Basic target costing process



Source:

Adapted from Clifton et al (2004:5)

The first step in the process is to define the product. This step will include the following:

- *Market research* will provide quantitative information about the customers' needs and wants.
- *Competitive analysis* compares the products of competitors currently available to target customers, the customers' perception of these products and how competitors might react to the introduction of the new products.

- *Product planning* will determine what particular segments to concentrate on, by analysing the market and competitor information (Clifton et al 2004:15).

The next three steps in the Target costing process, according to f igure 4.9, were discussed in section 4.6.2.

4.6.5 Comparison with other costing systems

Garrison et al (2003:651) state that the difference between target costing and traditional methods is that instead of designing the product and then finding out how much it costs, the target cost is set first and the product then designed in order to attain the target cost. On the negative side, the authors contend that a company using target costing may reveal its internal operations, exposing uncompetitive practices and processes that were hidden by more traditional costing systems.

Corrigan (1996:53) points out that Kaizen costing is being questioned on its capability to deliver results in a highly competitive market, and target costing is now promoted as the new management technique that will allow Japan to catapult itself to the force of management practice once again. He also quotes Drucker, who referred to target costing as price-led costing as opposed to cost-led pricing, which has been the traditional method used. Corrigan (1996) further states that accountants fail to realise that 80% of costs are locked into a product's original design. When one looks at improving performance, one considers improving only 20% of the cost. The fundamentals of cost design are challenged by target costing, by focusing on impacting on 100% of product costs, not only the 20%.

Traditionally, prices are set using the cost plus approach. Many companies still use this method. Table 4.7 illustrates the difference between the price setting of a product using target costing versus the traditional cost plus approach.

Table 4.7 Target cost pricing versus the cost plus approach

TARGET COST PRICING	COST-PLUS TRADITIONAL APPROACH
• establishing the target price in the context of market needs and competition • establishing the target profit margin • determining the cost that must be achieved • calculating the probable cost of current products and processes • establishing the target cost	• assessing market needs • evaluating competing prices • developing new products • deciding whether to make or buy products or components • calculating how much to invest in the new process • setting the new process • manufacturing the new product • costing the product • setting the price

Using the traditional approach, one decision leads to another. Prices are based on the preceding steps in the process. When cost increases, prices are often raised to maintain or improve profit margins (Howell 1994:14).

Section 4.5.5 above compares Kaizen and target costing.

4.6.6 Evaluation of target costing

There are few things that offer advantages without at least some associated disadvantages. The advantages of target costing include the following:

- Costs are planned, managed and reduced.
- The relationship with customers and markets is strengthened.
- Product design, development, production and introduction cycle are accelerated by market understanding, cross-functional team participation and the use of underlying tools (eg value engineering).

- Management's attention is focused on cost control during the critical design stage when most costs are controllable.
- It reinforces top-to-bottom commitment to process and product innovation, aiming to identify the issues to be resolved, in order to achieve some sort of competitive advantage.
- By designing and manufacturing products that meet the price required for market success, it helps to create a company's competitive future with market-driven management.
- Management control systems are used to support and reinforce manufacturing strategies. Market opportunities are identified that can be converted into real savings to achieve the best value instead of simply the lowest cost.
- The right products remain at competitive prices while still making a profit (Clifton et al 2004:11; Howell 1994:9; Langfield-Smith & Luckett 1999:4; Zimmerman 2006:636).

The disadvantages include the following:

- It may be too time consuming. It works for products with a long life cycle, say in the motor industry, but not in industries such as electronics, where the rate of innovation is extremely rapid and time-to-market must be minimised.
- Conflict may arise with various parties involved in the cost reduction process, such as suppliers, subcontractors and internal departments.
- The threat of job losses due to cost reduction can result in defensive behaviours and game playing.
- Constant pressure to reduce cost has been found to play a role in the incidence of employee burnout.
- Delays in transporting new products to the market can result in lost opportunities that far outweigh any further cost reductions that might be achieved (Garrison et al 2003:794; Pierce 2002:32).

From the above discussion of target costing, it is clear that it was also developed by the Japanese, and was documented for the first time in the

1990s. The main difference between target costing and other costing systems is that instead of designing the product and then finding out how much it costs, the target cost is first set and the product is then designed to attain the target cost. Target costing is applied at the new product development stage to plan, manage and reduce cost.

However, it is however a time consuming process and works better for products with a long life cycle, say in the motor industry. Conflict with the parties involved, such as suppliers and employees may arise in the cost reduction process.

If properly implemented, it can contribute the following to cost management:

- highly efficient mechanism for planning, managing and reducing costs by enlisting the cooperation of many people throughout the organisation
- emphasises an understanding of the markets and customer requirements

The empirical research has provided evidence that target costing is not only used for project cost estimation, but also for project management in metallurgical research projects (see sec 5.6.13).

The fundamental objective of a business is to make money, to be able to reinvest, grow and increase value. Target costing is not only concerned with minimising cost, but, if is also used in conjunction with other continuous improvement tools, such as total quality management, it represents a comprehensive approach to cost management. Total quality management will now be discussed.

4.7 TOTAL QUALITY MANAGEMENT (TQM)

Quality is a major issue in both the profit and non-profit sectors of the economy. Losing customers because of poor quality should motivate a company to provide quality products and services. The principal changes in companies' strategies in recent years have been to improve customer satisfaction and product quality. Improving quality should be a high priority in today's globally competitive environment (Hilton et al 2006:246).

Because we live in a fast-paced society, keeping up with current changes can be a challenge. Individuals and organisations need to find a way to manage, make sense of and put change into perspective. Jablonski (1992:3) holds that TQM provides us with tools to cope with change in an effective manner, and that in an extremely competitive, price-conscious industry, every organisation needs TQM in order to survive.

Zimmerman (2006:724) defines TQM as a philosophy of continuing lowering costs and improving the provision of services and product to customers. He maintains that quality can be measured in many ways, but the two most common methods involve meeting customer expectations and reducing defects. Opportunistic employees can appear to improve quality if they have the decision rights to redefine the standard used as the benchmark for determining defects.

According to Hilton et al (2006:883), TQM advocates that improvement in quality, as defined by customers, will always result in improved organisational performance because they believe that enhancing quality will improve efficiency as problems are identified and eliminated.

Garrison and Noreen (2003:17) view TQM as the most popular approach to continuous improvement. They state that TQM has two major characteristics, namely the focus on serving customers and systematic problem solving. A variety of specific tools are identified for problem solving. One of these tools, benchmarking, involves studying organisations that are the best in the world at performing a specific task. They regard the *plan-do-check-act (PDCA) cycle*, also referred to as the Deming wheel, as the most important and pervasive TQM problem-solving tool (see sec 4.7.2).

Drury (2008:549) defines TQM as a situation in which *all* business functions are involved in a process of continuous quality improvement. He argues that TQM has broadened from its early concentration on the statistical monitoring of the manufacturing process, to a customer-oriented continuous improvement process that focuses on delivering products or services of consistently high quality timeously. TQM is therefore designed to produce items correctly the first time instead of wasting resources inspecting and repairing these items.

Sisaye, Bodnar and Christofi (2005:27) state that TQM requires management's commitment, ongoing motivation, continuity and sustainability over time because quality features and continuous improvement attributes are integrated into the organisation's day-to-day operating activities.

From the above, it is clear that there is no single definition of TQM. Zimmerman (2006) concentrates on the decrease in cost and improvement of quality, while Hilton et al (2006) claim that if quality improves, it will automatically lead to improved performance. Garrison and Noreen (2003) focus on customer service and problem solving. Drury (2008) states that all business functions should be involved and emphasises the importance of delivering top-quality products to satisfy customer needs. Sisaye et al (2008) add management involvement and commitment to quality improvement.

According to Bergquist, Fredriksson and Svensson (2005:310), negative criticism levelled against TQM is that it lacks consensus on definitions. From the above one can conclude that TQM provides tools and techniques for lowering cost, continuous improvement, based on facts and analysis, and improved performance. Three main ingredients are necessary for TQM to succeed: participative management, continuous process improvement and the use of teams. It also requires ongoing motivation, continuity and sustainability over time as quality features and continuous improvement attributes are integrated into the organisation's day-to-day operating activities. If properly implemented, TQM will result in improved performance. Jablonski (1992:3) states that TQM provides an avenue for coping with change and directing it towards a positive outcome for the future.

Easton and Jarrel (1999:28) summarise the characteristics of TQM as follows:

- The emphasis is on the process concept, with the resulting emphasis on process definition, process management and process improvement.
- The widespread organisational focus is on quality improvement, cycle time reduction and waste (cost) reduction. Prevention is also emphasised.
- The process concept and focus on improvement are applied throughout the organisation, including areas outside production such as product development and business support processes.
- The emphasis is on customer focus, including satisfaction, service, integration of customer information and customer's product development.
- The deployment of systematic fact-based decision making by means of objective data and information is important.
- There is widespread employee involvement in improvement.
- Cross-functional management is explicitly emphasised.
- There is emphasis on supplier quality and service, supplier improvement and supplier involvement and integration.
- TQM is recognised as a critical competitive strategy and thus a primary concern of all levels of management, including top management.

The history of TQM will now be discussed.

4.7.1 The history of TQM

People have been seeking for quality products for hundreds of years. Products have always been inspected before purchase. The Japanese established inspection and protection as management idea. However, these tend to be reactive management ideas in the sense that reaction occurs when poor quality has already entered the product. Quality management has become more proactive, its aim being to eliminate poor quality from the product instead of discarding a poor quality product (Flood 1993:5).

There are many reviews that describe the origin of quality thinking. The following review is representative of the literature studied for this research.

For centuries, building quality into a product was the aim of skilled craftsmen. Pride of workmanship was vital. The Industrial Revolution revolutionised the manufacture of products. Mass production started and apprentices and masters from core positions followed.

At the beginning of the 20th century, Frederick Taylor introduced scientific management in an effort to increase output through mass production. A steam of poor quality products followed because quality was no longer built into products. GS Radford improved Taylor's methods and published his results in *The control of quality in manufacturing* in 1929.

In 1931, WA Shewhart of the AT & Bell Laboratories published the work *Economic control of quality of manufactured product*. A precise and measurable definition of manufacturing control was formulated. Stringent techniques for monitoring and evaluating production and improving quality were laid down.

After World War II, the Japanese faced major problems with poor quality products. They tackled these difficulties by employing and developing quality approaches. During the 1950s, Edward Deming played a major role in the development of quality management. JM Duran was a key role player in the USA. Crosby, Deming and Juran are recognised as the quality gurus. In 1956, Armand Feighenbaum proposed *total quality control* as the next step.

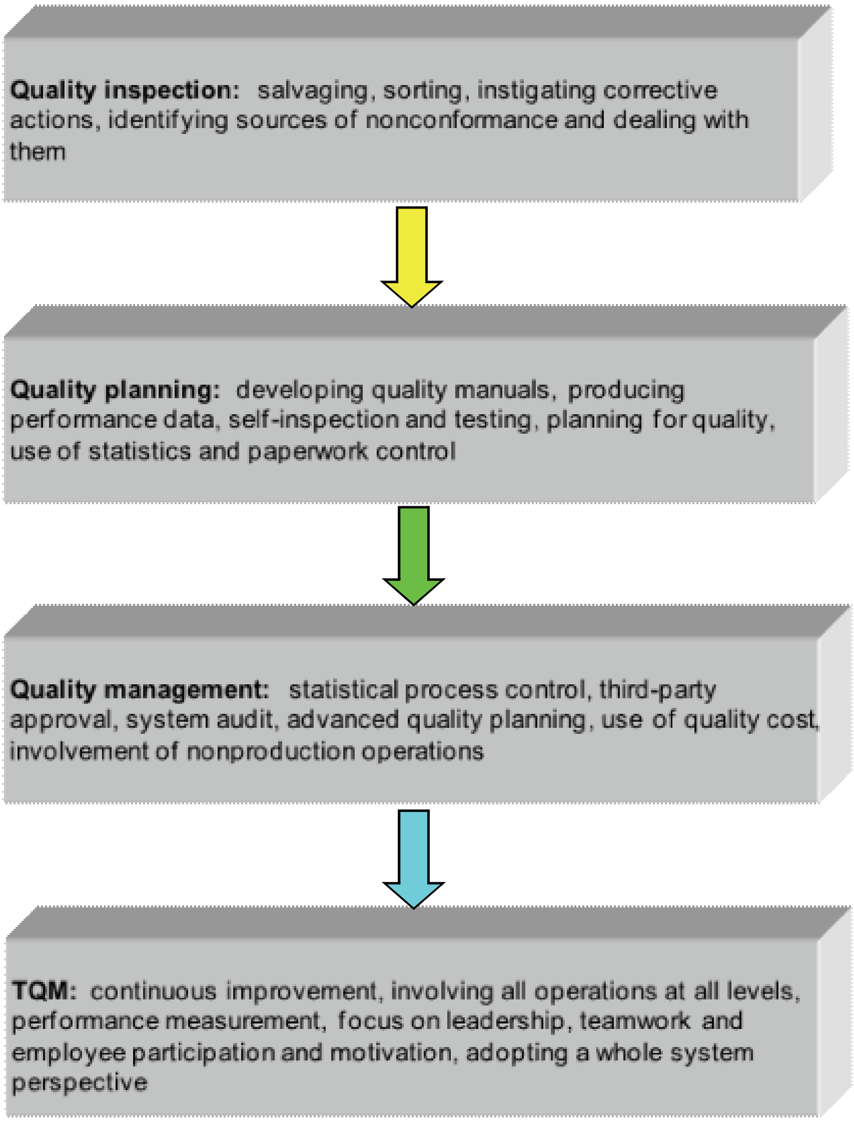
During the 1970s the Japanese became masters at achieving quality in the manufacturing sector. They soon went beyond quality in production, recognising the importance of quality in management. They have not stopped there, and today still look for superior production by continuous improvement in knowledge, methods and techniques.

A direct link between the quality and viability of organisations and economies was made by the 1980s and it became an era of competitive challenge with increasingly more companies adopting quality management. During the 1990s, quality management become an international management philosophy which continued into the next millennium (Capezio & Morehouse 1995:Introduction; Flood 1993:5-10; Garvin 1999:27; Talley 1991:13).

Jablonsky (1992:9) concurs with the above development, but argues that the first hints of TQM date back to the so called “Penny idea” of 1913, and he therefore feels that the name of JC Penny should be added to the above-mentioned developers.

A summary of the process of evolution in quality thinking, as described by Flood (1993:10) is provided in figure 4.10.

Figure 4.10 The evolution of quality thinking



Source:

Adapted from Flood (1993:10)

4.7.2 The principles of TQM

Jablonsky (1992:24) and Capezio and Morehouse (1995:39-40) describe the principles of TQM as follows:

- **Customer focus.** Customers include external customers, internal customers and suppliers. External customers are outside an organization and places order. Internal customers are inside a company and the people one works with on a daily basis, for example, the graphics department providing visual aid support. TQM also assigns value to the relationship with suppliers.

- **A focus on process and the results.** The unmet expectations of customers indicate that something is amiss with the process that produced the goods supplied. Action is taken to rectify the deficiencies and continually endeavour to improve the quality of goods and services.

- **Prevention versus inspection.** Attention is focused on the prevention of defective products and services, instead of the discovery of defects and deficiencies once the resources have been spent.

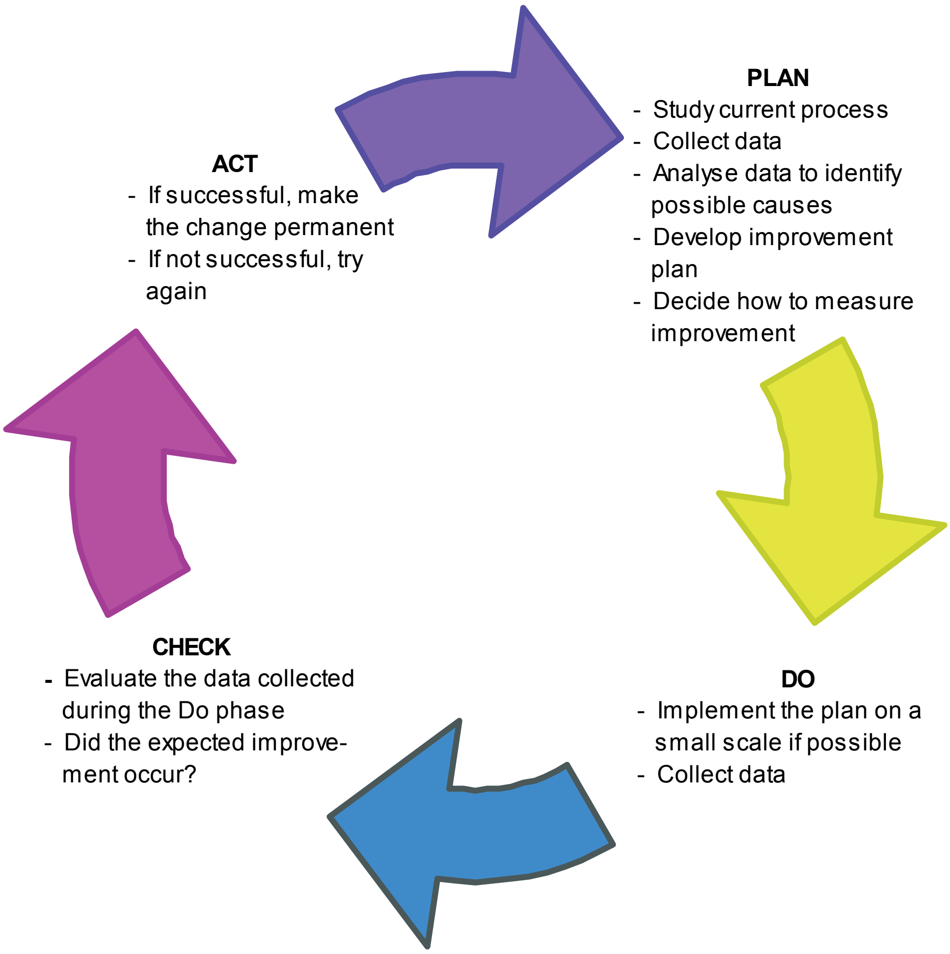
- **Mobilising the expertise of the workforce.** TQM creates new, innovative ways of recognising individuals for their efforts. The workforce represents a tremendous wealth of knowledge and opportunities to improve the way one does business, increases profits and reduces costs. TQM mobilises the expertise of the workforce in positively for the mutual benefit of everyone involved.

- **Fact-based decision making.** The TQM approach recognises everyone involved in the process, including top management, the workforce and customers, and acknowledges that everyone can contribute to a mutually beneficial solution.

- **Feedback.** This principle allows the other principles to flourish. The key is communication.

A vital tool used for gathering the above information and solving problems in TQM is the plan-do-check-act (PDCA) cycle. According to Garrison and Noreen (2003:18), the PDCA cycle is the main TQM problem-solving tool. It is also known as the Deming cycle or the Shewhart cycle. The basic elements of the PDCA Cycle are illustrated in figure 4.11.

Figure 4.11 The plan-do-check-act cycle



Source:

Adapted from Garrison and Noreen (2003:19)

Figure 4.11 clearly illustrates that during the *planning* phase, the problem solving team analyses the data to identify the possible causes of a problem and then propose a solution. During the *do* phase, an experiment is conducted on a small scale. During the *check* phase, the results of the experiment are analysed while during the *act* phase, the plan implemented if the results were favourable; if not, the team returns to the original data and starts all over again (Anon 2006:13; Weaver 1995:228).

4.7.3 The objectives of TQM

During the first few decades, major transformation occurred in the way business should be conducted. All organisations continue to strive for high productivity, but, quality, innovation and value are replacing the drive for short-term efficiency. TQM is being used by business leaders hoping to capitalise on the sources of competitive advantage embodied in the principles and practices of TQM (Lundby, De Matteo & Rush 1999:134).

Wruck and Jensen (1994:247) contend that the principal feature of TQM is "that it improves productivity by encouraging the use of science in decision-making and discouraging counter-productive defensive behaviour".

Drury (2008:594) states that the goal of TQM is customer satisfaction.

According to Capezio and Morehouse (1995:1), the goal of TQM is to provide the highest value for customers at the lowest cost, while achieving sustained profits and economic stability for the organisation.

TQM, however, often fails to live up to expectations. Jacob (in Lundby et al 1999:134*)* points to reports of failed quality initiatives and argues that TQM is nothing more than another management fad. He refers to a survey of 500 companies using TQM, of which only 36% felt that TQM had contributed in any meaningful way to their competitiveness.

Easton and Jarrel (1999:27) challenge Jacob's view that TQM is a fad, stating that if it is, it is one of the longest and most significant fads ever. They contend that the term "TQM" appears to be going out of fashion, but quality management continues to evolve in related approaches and submovements, such as the ISO9000 standards, supply-chain management and re-engineering. Mogab and Cole (1999:373) also conclude in their study that TQM is neither a fad nor a panacea.

Business Week (Lundby et al 1999:134*)* reported another study in which only 26% of the organisations surveyed believed that TQM had contributed to meeting goals such as increased market share and customer satisfaction. According to Day (cited in Lundby et al 1999:134)*,* there have been reports that the lack of positive outcomes derived from TQM has led to the demise of as many as two-thirds of the programmes less than two years old. Since substantial financial and human resources are required to indoctrinate employees and managers in the TQM philosophy, the tangible and intangible losses associated with failed TQM programmes could be significant (Kotter, in Lundby et al 1999:134).

In their paper, Bergquist et al (2005:309) question the effectiveness, utility and use of TQM by many people – practitioners as well as academics. Their findings are that TQM should not be rejected as a whole if one or even many applications fail. However, their paper emphasises the lack of a common interpretation of TQM.

One may conclude that TMQ has it critics, mainly because of a lack of consensus on definitions and common interpretation. TQM, however, not only improves quality, but also enhances customer satisfaction and performance, while lowering cost.

If TQM is to succeed, it has to be part of a business. The implementation of TQM will now be discussed.

4.7.4 Implementing TQM

Capezio and Morehouse (1995:28) developed a TQM implementation model. This model provides a conceptual framework for an organisation to develop its own improvement process. All the components of the model are found in all quality improvement processes. Some of the components are concurrent and others sequential. The factors are all critical to achieve TQM commitment and implementation.

According to Capezio and Morehouse (1995:28), the implementation of TQM consists of the following components: the assessment readiness of individuals and the organisation, customer requirements, training, measurement, use of programmes and customer service and satisfaction. These components, as described by Capezio and Morehouse (1995:28) and Anwar and Jabnoun (2006:278), will now be briefly discussed.

Before TQM can be implemented, a company should assess the readiness of individuals as well as the organisation. Dialogue should be established between supervisors and employees. Confidence and trust will be built, which is necessary for employees to take responsibility for continuous improvement.

In today's global marketplace, customer requirements become the cornerstone upon which a company organises its resources and production in order to succeed. The driving measurement of success should be a company's ability to satisfy customer needs. The customer chain may include a number of suppliers and various internal customers, as well as the end-user, client or ultimate (external) customer.

The success of total quality is dependent of one's ability to integrate people with technology. The training and development focus is on the tools and skills necessary to create a competitive advantage in one's employees. In order to empower employees and management teams, the skills and training required to create a TQM environment should be identified.

Measurement plays a vital role in determining how efficient and effective a company is in serving its customers. Measurement provides critical feedback to the company on how effective and efficient it is at reaching its goals related is provided by measurement. Baseline measurements are a critical component of the improvement process. Baselines respond precisely to customer requirements and set standards of excellence throughout the organisation, and are determined in order to link the voice of the customer and business plans to both team and individual measurements. Benchmarking is used to identify the best practices of those companies that have gained recognition for their excellence in a particular area. Examples are Xerox for the development of human resources and Toyota for customer satisfaction.

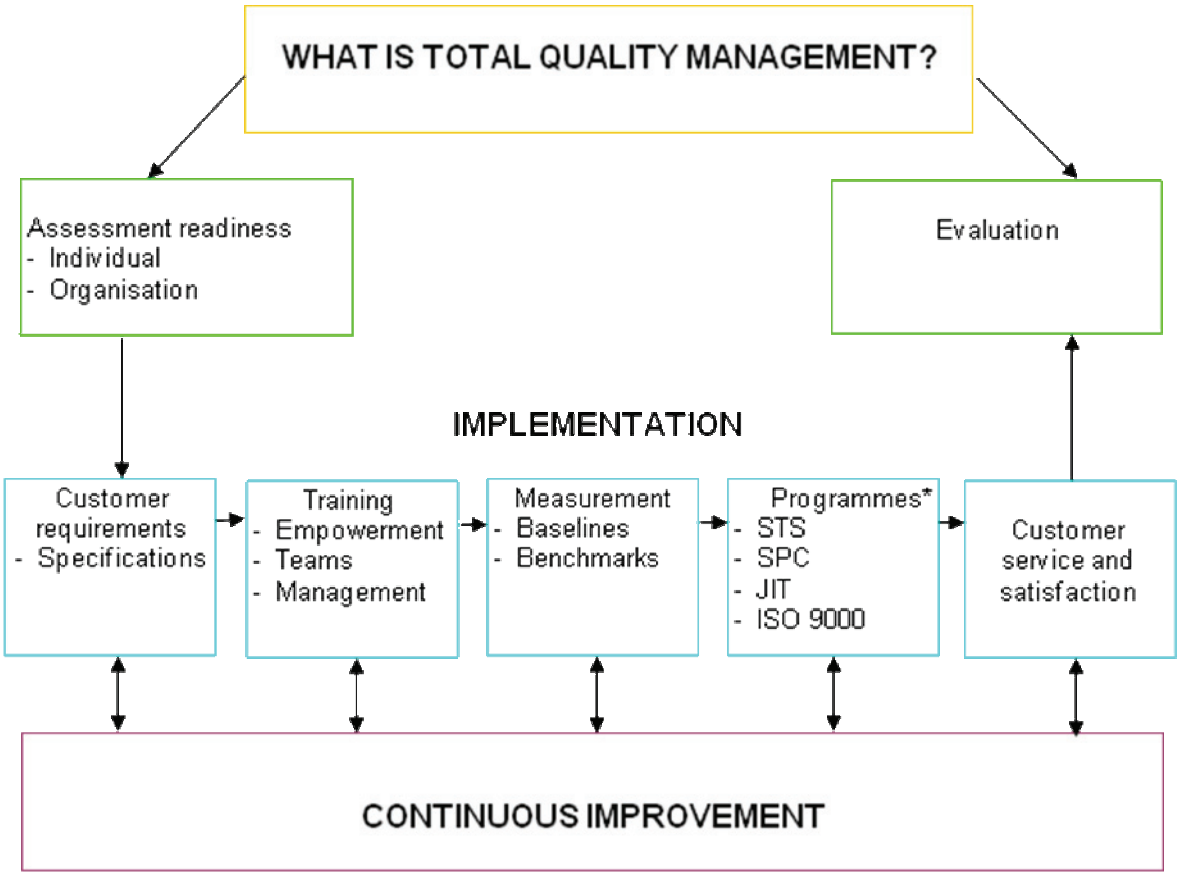
Overall quality in an organisation is improved by integrating people and technology. Programmes aiming to improve work processes and focusing on the technological aspect of TQM include socio-technical systems (STS), statistical process control, (SPC), JIT inventory and the International Organisation for Standardisation (ISO 9000), and these programmes are used worldwide.

The core of any business is customer service and satisfaction. Customer requirements will not only drive business strategy, but also serve as the ultimate measure of quality in assessing performance. Customer satisfaction is synonymous with product satisfaction, resulting in more market share and increased sales income.

The evaluation of TQM is an ongoing process. It is considered during the planning and design stages of each improvement strategy when criteria for success are established in the objectives. Continuous improvement requires that the learning from the evaluation be captured and reflected in the next step of the process (Anwar & Jabnoun 2006:278; Capezio and Morehouse 1995:27-301).

Figure 4.12 summarises the TQM implementation model.

Figure 4.12 The TQM implementation model



Source:

Adapted from Capezio and Morehouse (1995:30)

*Programs

- socio-technical systems
- statistical process control
- just-in-time
- International Organisation for Standardisation

It is clear that the total success of TQM implementation is only possible when all its components have been successfully implemented.

4.7.5 Comparison with other costing systems

Organisations using TQM focus their strategy, operations and employees on listening to the customer. Table 4.8 illustrates the characteristics that differentiate TQM companies from those with more traditional practices.

Table 4.8 TQM companies versus traditional companies

TQM COMPANIES	TRADITIONAL COMPANIES
• Customer driven	• Company driven
• Total customer service	• Customer satisfaction less than 100%
• Long-term commitment	• Short-term profitability
• Continuous improvement	• High-cost production and waste
• Elimination of waste	• High scrap and rework
• High quality and low cost	• Low quality and high cost
• Quality at the source	• Inspection after the fact
• Leading people and measuring variance	• Rating people and measuring performance
• Cross functional teams	• Fortressed departments
• High employee participation	• Top-down hierarchy
• Multilevel communication	• Formal channels of top-down communication

Source:

Adapted from Capezio and Morehouse (1995:10)

The product features and reliability aspects of quality are not the only elements of customer satisfaction. The ability to provide the customer with the product when he/she wants it is known JIT delivery (see sec 4.4). JIT delivery is only achievable at competitive costs when extremely high levels of quality are found at each stage of production. The hallmark of TQM is to continually make improvements in the production process which simultaneously results in reductions in cost, improvements in product quality, increased flexibility and enhanced ability to deliver, according to the customer's schedule (Mogab et al 1999:373).

Anwar et al (2006:159) states that concepts such as JIT have many elements in common with TQM. The difference is that TQM is a holistic approach that covers all aspects of an organisation's activities.

4.7.6 Evaluation of total quality management

A study by Mogab and Cole (1999:383) provided evidence that the TQM firm represents a formidable competitor that will continue to make its presence known in the global markets of the future. The TQM firm is a new paradigm whose strengths and weaknesses we are only beginning to understand. Its strengths include its ability to utilise all the assets that its workers have to offer. The development of human capital will result in a loyal work force that will continuously improve the firm's product and production processes in order to match the qualities that its customers want.

Capezio and Morehouse (1995:1) claim that TQM ensures that an organisation consistently meets and exceeds customer requirements. TQM organisations are focused on the systematic management of data in all processes and practices in order to eliminate waste and pursue continuous improvement.

In a nutshell, the major advantages of TQM, are as follows:

- Improve quality.
- Improve productivity.
- Improve customer satisfaction.
- Reduce cost.

The disadvantages of TQM, are as follows:

- By standardising internal processes, TQM drains innovation from organisations.

- It makes organisations more efficient at what they are doing, irrespective of whether they should be doing it.
- TQM suffers from the so-called “Flavour of the month” syndrome.
- TQM endeavours to change the traditional management style. It calls for handing down responsibility, allowing for autonomy and promoting local decision making.
- TQM advances the idea that colleagues should be regarded as internal customers.
- Hard quantitative measures are needed to make possible the implementation of sophisticated mathematical and statistical control procedures.
- TQM strongly promotes continuous improvement, which encourages slow steady improvement. Competitors may progress in a discontinuous fashion in leaps and bounds, and may get ahead and seize the advantage.
- There is not a single philosophy with a clear line of argument. There is much competition in the claim of ownership over the right approach to quality management.
- Huge amounts of capital have to be invested to develop human capital (Flood 1993:preface xii; Garrison et al 2003:765; Mogab & Cole 1999:384).

TQM developed at the beginning of the 20th century. In the 1970s, the Japanese became the masters of quality.

If TQM is properly implemented, its main contributions to cost management are as follows:

- TQM aims to deliver the highest value to customers at the lowest cost while still remaining profitable.
- It ensured that an organisation consistently meets and exceeds customer requirements.
- It focuses on the systematic management of data in all processes and practices to eliminate waste and pursue continuous improvement.

The major problem with TQM is the lack of consensus about definitions and common interpretation.

Only one of the respondents in this study indicated that he/she uses TQM for the management of costs of metallurgical research projects.

Business process re-engineering is the most aggressive approach to manage cost while improving customer value and will be briefly discussed below.

4.8 BUSINESS PROCESS RE-ENGINEERING (BPR)

Langfield-Smith et al (2006:704) define business process re-engineering (BPR) or process re-engineering as the fundamental rethinking and radical redesign of business processes to achieve a dramatic improvement in critical areas of performance such as cost, quality and delivery. They state that BPR should focus on the strategic processes of a company, which include the processes essential to achieve the company's business objectives and strategies. Such processes may include development of new products, manufacturing products, acquiring customer orders, fulfilling orders and developing human resources. According to Tai and Huang (2007:296), BPR has become popular since its introduction by Michael Hammer in the early 1990s.

Viliris and Glykas (1999:65) found that there is some confusion in the literature about the use of terms such as re-engineering, process improvement and redesign. According to their definition, supported by this study, the term "re-engineering" is synonymous with radical change and process improvement towards incremental change. Both re-engineering and process improvement are included in the definition of redesign. Redesign can be achieved in two ways - incremental and radical. Incremental changes can be classified as methodologies for improvement and simplification. The aim is to improve what already exists in an organisation by eliminating nonvalue-added activities in order to achieve lower throughput rates and the best relocation of resources. Radical changes will challenge the existing organisational framework and may require the introduction of new technology, regardless of the impact it may have on the personnel's behaviour and attitude.

4.8.1 Objectives of BPR

The aim of BPR is to reorganise the way in which work is done by identifying and enhancing the value-added activities and eliminating all the nonvalue-added activities in a process. Langfield-Smith et al (2006:704) list the steps to be followed once a process has been identified for re-engineering:

- A business process map, that is a flowchart of activities that make up the business process, needs to be prepared.
- Management should establish goals for the re-engineering process on the basis of the business sources of customer value. These may include quality and delivery performance, as well as costs.
- The workflow should be recognised in order to achieve the goals.
- Implementation is the final step. Re-engineering involves substantial changes and there may be employee resistance. This problem is best managed by the use of re-engineering project teams that involve employees from all functional areas affected by the process, and from all levels of the organisation.

Viliris and Glykas (1999:65) add a final and vital step, namely continuous control and improvement of the process.

It is necessary to understand the process characteristics. This helps to identify the problem areas in the process, provides the database needed to make informed decisions about incremental or radical changes and forms the basis for setting improvement targets for evaluating results.

Harrington (in Viliris & Glykas 1999:68) lists the characteristics that can be assigned to each process as follows:

- flow: methods for transforming input into output

- effectiveness: how well customer expectations are met
- efficiency: how well resources are used to produce an output
- cycle time: the time taken for the transformation from input to output
- economy: the expense of the entire process

BPR is an extremely aggressive method of cost management compared to other cost management systems.

4.8.2 Comparison with other costing systems

ABC (see sec 3.8.4) makes it possible to identify current processes and activities and provides a sound foundation for BPR. It also provides information on the cost and value status of activities in the business process. ABM (see sec 4.3) focuses on *process improvement*, which continuously improves a process, whereas BPR involves fundamental changes to the structure of the process (Langfield-Smith et al 2006:704).

According to Hilton et al (2006:180), ABM (see sec 4.3) proved to be more enduring than BPR, probably because it embraces continuous improvement as opposed to BPR's radical change. BPR may sound more exciting but has proven to be more difficult to design and implement. BPR often involves computer modelling and simulation of activities that can be explained mathematically.

Garrison and Noreen (2003:20) are of the opinion that BPR is more radical than TQM (see sec 4.7). BPR completely redesigns a process in an attempt to eliminate unnecessary steps in order to reduce opportunities for errors and lower costs. TQM tweaks the existing system in a series of incremental improvements. TQM also emphasises a team approach involving people who work directly with the process, while BPR is imposed from above and uses outside consultants.

From the above it can be seen that BPR is a highly aggressive approach compared to other cost management systems, and should be handled sensitively in order to achieve the best results. It is also difficult to implement.

4.8.3 Evaluation of BPR

Employee resistance is a recurring problem in BPR. The cause of the resistance is the fear that people may lose their jobs. If BPR is conducted insensitively and without regard for such fears, it will undermine morale and fail to achieve its purpose, namely to increase profit. Real improvement should convince employees that the end result will be more secure, instead of less secure jobs. By improving a process, a company can produce a better product at a lower cost, which will improve its competitive strength to prosper. A prosperous company means a more secure employer than one who is in trouble. It is therefore advisable that companies should communicate with employees and ensure them that they are important to the company (Garrison et al 2006:16; Garrison & Noreen 2003:21).

During the empirical study, it was determined that the respondents were not familiar with BPR. They did not use it for either cost estimation or management of costs of metallurgical research projects.

BPR can contribute to the management of cost by the simplification and elimination of wasted effort. All activities that do not add value to a product or service should be eliminated. This is achieved through radical change rather than continuous and slow improvement.

4.9 CONCLUSION

Cost management techniques were discussed in this chapter. It was found that in today’s competitive markets, customers expect top-quality products, fast delivery and low prices. In order to achieve this, managers should take action to reduce cost and increase customer value, while still making profit. The

Japanese developed most of the cost management techniques and are the market leaders. The following cost management techniques were examined in this chapter:

- *Activity-based management* is a system used by management to focus on the management of activities to increase both customer value and the profit of the organisation.
- *Just-in-time* strives to produce a product only when it is needed, only in the quantity demanded by customers, thus eliminating all nonvalue-added activities in the process.
- *Kaizen costing* is used during the manufacturing stage not only for continuous improvement, but also to eliminate waste, enhance quality and create more satisfied customers.
- The aim of *target costing* is to reduce costs during the development and design stages and to determine the life cycle cost at which the product should be produced, in order to make the required profit, given the anticipated price.
- *Total quality management* is used to deliver the highest value for customers at the lowest cost while achieving sustained profits. All business functions are included and current systems are changed and improved.
- *Business process re-engineering* is the fundamental rethinking and radical redesign of business processes to dramatically improve critical *areas of performance.*

Hence the common objectives of cost management are primarily to increase profit by reducing cost. This is achieved by increasing customer value, eliminating waste, improving the quality of product and services, involving employees and continuously improving.

The empirical part of this study provided evidence, indicating that activity-based management and target costing are the two methods generally used for the cost management of metallurgical research projects.

CHAPTER 5

THE RESULTS OF THE EMPIRICAL STUDY AND CONCLUSIONS

5.1 INTRODUCTION

Empirical research was conducted to determine what cost estimation methods and cost management techniques are used and in which phase of the life cycle of a metallurgical research project these costs are estimated and managed. The empirical research involved questionnaires and telephonic and face-to-face interviews. The e-mail questionnaires were sent to the respondents electronically, prior to the interviews.

The e-mail questionnaire, attached as annexure B, contained mainly multiple choice questions, although open ended questions, were also included. In some of the questions, the respondents were required to rank certain options. The questionnaire consisted of 22 questions.

In this chapter, the research design, approach and methods of data collection will first be examined. This will be followed by an analysis of the data collected in the interviews and from e-mail questionnaires.

5.2 RESEARCH DESIGN

Leedy and Ormond (2005:2) define research as the systematic process of collecting, analysing and interpreting information (data) in order to increase one's understanding of the phenomenon about which one is interested or concerned. The research problem is the axis around which the whole research project revolves. The research design should address the research problem.

According to Tustin, Ligthelm, Martins and Van Wyk (2005:82), the research design is the plan to be followed to realise the research objective, and it represents the master plan that specifies the methods and procedures for collecting and analysing the required information. Research designs differ in terms of the research purpose, the research questions and the data collection methods used. Tustin et al (2005) classify research design in three categories, namely exploratory, descriptive and causal research.

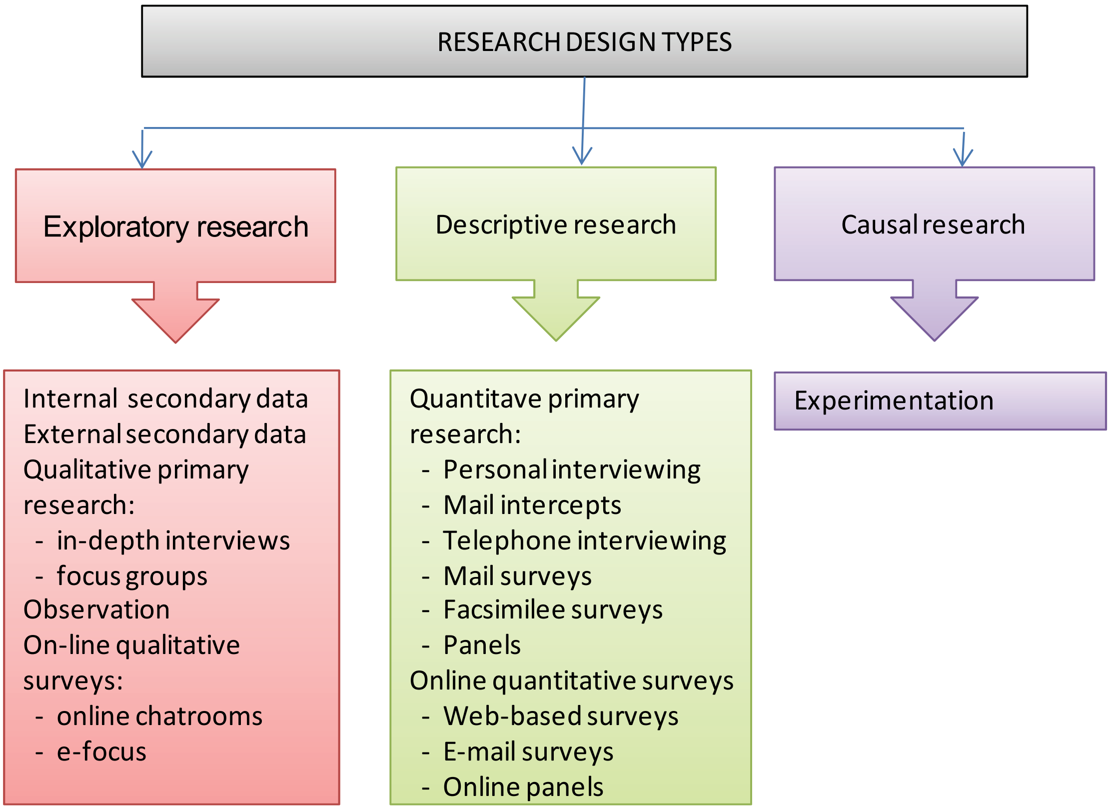
- **Exploratory research.** According to Tustin et al (2005:84), typically there is little prior knowledge on which to build. The research methods used are highly flexible, unstructured and qualitative. Page and Meyer (2003:22) argue that exploratory research seeks ideas, patterns or themes and is therefore an exploration of a problem. Exploratory studies are useful when not much is known about the subject of interest and there is contradictory evidence.

- **Descriptive research.** Descriptive research studies are constructed to answer the "who", "what", "when", "where" and "how" question. The research methods used are structured and quantitative. In-house personal interviews, intercept surveys and on-line qualitative surveys are the common approaches in this type of research.

- **Causal research.** The researcher investigates whether one variable causes or determines the value of another, for example, experiments (Tustin et al 2005:84-87).

The classification of the above-mentioned research approaches and the data collection methods accompanying each design are depicted in Figure 5.1.

Figure 5.1 Classification of research approaches according to the data collection method



Source:

Adapted from Tustin et al (2005:84)

Since some of the data collection methods mentioned above in the descriptive research approach, were used in this study, this approach will now be further analysed.

The following descriptive approaches yield quantitative information: observation studies, correlation research, developmental designs and survey research.

- **Observation studies.** In quantitative studies, observation studies focus on a particular aspect of behaviour. The behaviour is quantified in some way.

- **Correlation research.** The extent to which differences in one characteristic or variable relate to differences in one or more other characteristics is examined. When the increase in one variable causes another variable to either increase or decrease in a predictable fashion, a correlation exists between the two variables.

- **Developmental design.** When a study is made of the way in which a particular characteristic changes, one of two developmental designs are used, namely a cross-sectional study or a longitudinal study.

- **Survey research.** This involves acquiring information about one or more groups of people by asking questions and tabulating their answers. Survey research typically consists of face-to-face interviews, telephonic interviews and written questionnaires (Leedy & Ormond 2005:179-184).

In this study, face-to-face and telephonic interviews and e-mail questionnaires were used to gather quantitative information. The research design therefore complied with the above requirements to be classified as a descriptive research design, using a survey approach.

5.3 RESEARCH APPROACH

Once the research objectives have been defined, the next step is to decide on the method of data collection. Data should be valid and reliable, easy to obtain within an appropriate time scale, affordable and relevant to the research problem. Data are categorised into two main groups: secondary and primary data.

(1) **Secondary data.** Data are already available and include existing company information, data released by other organisations and pooled data sources.

(2) **Primary data.** Data are specifically collected to address the research objective (Tustin et al 2005:88-89; Page & Meyer 2003:96-97).

Both secondary and primary data were used in this study.

When conducting the primary research, the researcher has to decide on the most appropriate research approach (quantitative or qualitative) as well as the most appropriate method of primary data collection. The most appropriate research approach is elucidated below.

According to Leedy and Ormond (2005:94), many researchers' categorise research studies in two broad approaches, namely quantitative research and qualitative research. Quantitative research is used to answer questions about relationships between measured variables in order to explain, predict and control phenomena. This is sometimes referred to as the traditional, experimental or positivist approach. Qualitative research, however, is used to answer questions about the complex nature of phenomena, often with a view to understanding the phenomena from the participant's perspective. This is also referred to as the interpretive, constructivist or post-positivist approach. Page and Meyer (2003:18) argue that the quantitative approach can be conceptualised as focusing on numbers, while the qualitative approach focuses on words and feelings - the quality of an event or experience. As a rule of thumb, the more people oriented the research is, the more qualitative the approach will be.

According to Leedy and Ormond (2005:96), the distinguishing characteristics of quantitative research to explain the purpose of the research, are as follows: to **explain and predict**, **confirm and validate** and **test theory**.

The purpose of this study was to determine the methods of cost estimation and cost management techniques that can be used over the life cycle of metallurgical research projects, and if these methods are indeed being used, in which life cycle this occurs. This study **explained** the methods of cost estimation and management that can be used and **confirmed and validated** whether they are in fact being used in metallurgical research projects. It also **tested the theory** that there is not enough emphasis on the accurate estimation and management of costs over the life cycle of metallurgical research projects. The purpose of this study therefore matches the definition of a quantitative research approach, as described by Leedy and Ormond (2005).

Once the most appropriate research approach has been identified, the researcher has to decide on the most appropriate method of primary data collection. According to Tustin et al (2005:93), the factors that determine the selection of primary data collection methods include the following:

- the volume and variety of the data required
- the objectivity of the data required
- the reliability of the data required
- the duration of the research
- the cost of the research

In this study, the most applicable method of collecting primary data was deemed to be e-mail questionnaires. Before the questionnaires could be designed, the population and sample had to be defined.

5.4 RESEARCH METHODS

The first step in the survey is to define the population and the sample. Tustin et al (2005:96) define a population as the group from which the sample will be drawn and a sample as a subset of a population (Tustin et al 2005:337). The population should include all the role players who will be able to answer the research question. Two sampling approaches exist, namely the probability approach and nonprobability approach. When using probability sampling, the sample elements are selected by chance and the chance is known for each element being selected. When using nonprobability sampling, the chances of selecting elements from the population in the sample are known and rely on the researcher's discretion (Tustin et al 2005:344).

The population in this study was small because only a few entities are involved in metallurgical research. During personal and telephonic interviews, the participants were requested to supply the names of other entities whom they knew were also involved in metallurgical research, and a list of names was then compiled on the basis of this information. The website of the South African Institute of Mining and Metallurgy (SAIMM) was also consulted but revealed no new information. As far as could be determined, there were only 12 entities involved in metallurgical research in South Africa. The ten largest entities in terms of project size were selected to participate this study. Since the selection of the participants was at the researcher's discretion, a nonprobability sampling approach was followed. The instruments used to answer the research question were face-to-face and telephonic interviews as well as e-mail questionnaires.

5.4.1 The research instruments

Two kinds of research instruments were use, namely face to face and telephonic interviews and questionnaires.

5.4.1.1 Face-to-face and telephonic interviews.

Page and Meyer (2003:111) state that interviews are common in exploratory studies, because they make it possible to identify relevant issues where little is known about the topic under investigation. According to Leedy and Ormond (2005:184), in quantitative survey research, the interviews are fairly structured and formal. Face-to-face interviews have the advantage of higher response rates because the participants tend to be more familiar with the researcher. However, time and expense may be prohibitive. Telephonic interviews tend to be less time consuming and less expensive.

In this study, face-to-face and telephonic interviews were held with the participants when this was possible in practice. Owing to the major shortages of skilled personnel in the metallurgical research field at present, as illustrated by question 8 of the questionnaire, many of the participants did not have time for face-to-face or telephonic interviews because their diaries were fully booked for at least a month ahead. One questionnaire was completed during a face-to-face interview, two were completed by means of telephonic interviews (after e-mailing the questionnaires to the respondents), while the rest were sent by e-mail to the respondents, filled in and returned via e-mail. The perception of the interviewer was that the questionnaires filled in via e-mail were more objective than those completed in interviews. During an interview, the respondent normally has a chance to ask questions and may be influenced by explanations provided by the interviewer.

5.4.1.2 Questionnaires

The main purpose of questionnaire design is to collect information to solve the research problem. Two main types of responses can be distinguished, namely open-ended responses (allowing respondents to reply in their own words) and closed-ended responses (allowing respondents to choose between two or more answers). Closed-ended questions can be categorised as dichotomous responses (where only two possible responses are allowed), multiple-choice responses and scaled responses (Tustin et al 2005:98). Open-ended questions as well as all three types of closed-ended questions were used in the e-mail questionnaire used for this study.

The questionnaire was sent to respondents by e-mail, and was attached as a file to an e-mail message. The respondents were requested to reply to the e-mail and indicate their responses as part of the attached file. The respondents did not need to be connected to the internet to complete the questionnaire. This method of interviewing is known as off-line interviewing (Tustin et al 2005:240). After the respondents had completed the questionnaire, they could go online and return the questionnaire. Members of the sample, who did not respond, were contacted telephonically and reminded via e-mail. While most of the questionnaires were returned via e-mail, one was completed personally and two others by means of telephonic interviews.

As prescribed by Tustin et al (2005:99), the e-mail questionnaires used in this study were pre-tested to determine whether

- the respondents would participate and cooperate
- the data collected would be relevant and accurate
- the collection and analysis of data would proceed as smoothly as possible

The pretesting was done in the research section of one of the respondents. The e-mail questionnaire was also reviewed by an expert in marketing research at UNISA's Bureau for Market Research, and adjusted according to his comments.

The e-mail questionnaire was designed to determine whether the methods for cost estimation and cost management identified in the study were used in metallurgical research projects, and in which life cycle of the project cost estimation and management occurred. The e-mail questionnaire included in annexure B, consists of 22 questions. The e-mail questionnaire was available in English only and was sent to the head of the research section of each entity. Some of the section heads delegated the questionnaire to a person he felt would be in a better position to complete it. A letter of consent from the university, attached as annexure A, was included in the e-mail, explaining the purpose of the questionnaire. The response rate was 90%. One of the respondents could not be reached telephonically and failed to reply to the telephone messages left and to numerous e-mails.

5.5 DATA ANALYSIS

The e-mail questionnaires were analysed manually by using spread sheets to obtain graphical information. The processed data were used to draw conclusions. The responses to questions were linked to the theoretical framework by interpretation.

Feedback from the e-mail questionnaires completed by respondents, as well as notes taken during face-to-face and telephonic interviews, will be analysed and discussed in terms of the research problem.

The questions asked in the e-mail questionnaire will now be discussed. The purpose of the questions will firstly be explained, the information gathered from the respondents set out in the form of a table or graph, and finally a conclusion drawn.

5.6 DETAILED ANALYSIS OF THE QUESTIONNAIRE RESULTS

The entities that participate in this study are in alphabetical order: Afrox, Anglo Operations Ltd, Bateman Engineering Projects, BHP Billiton, Exxaro Ltd, Kumba Iron Ore Ltd, Mintek, SGS Lakefield and the University of Pretoria (Dept of Materials Science and Metallurgical Engineering). For the purpose of confidentiality, these entities will now be referred to as A, B, C, D, E, F, G, H and I. They are not in alphabetical order, but in the order in which they have submitted their questionnaires.

The purpose of questions one to three in the questionnaire was to obtain background information on the number of projects, their duration and the technical sophistication required of the entities involved in metallurgical research projects.

5.6.1 Number of projects

Question 1 asked the respondent how many projects his/her section was currently participating in. Table 5.1 indicates the number of projects.

Table 5.1 Number of projects

Variable	Value	Absolute frequency (n = 9)	Relative frequency (%)
Number of projects	1 to 2	0	0
	3 to 5	3	33
	6 to 10	0	0
	More than 10	6	67
		9	100

From the table it is clear that the majority of respondents were participating in more than 10 projects at the time of the research.

5.6.2 Average duration of projects

In question 2, the respondents had to indicate the average duration of their projects.

Table 5.2 indicates the average duration of metallurgical research projects.

Table 5.2 Average duration of projects

Variable	Value	Absolute frequency (n = 9)	Relative frequency (%)
Duration in months	Less than 2 months	0	0
	Between 2 and 6 months	1	11
	Between 6 and 12 months	3	33
	More than 12 months	5	56
		9	100

The duration of the majority of the metallurgical research projects was therefore longer than 12 months. Respondent A indicated that some of the entity's projects had a duration of one week while other strategic projects had a duration of between four and five years. On average, however, the duration of the projects was between six and 12 months.

5.6.3 Degree of technical sophistication

In question 3, the respondents were asked to indicate the degree of technical sophistication required for their projects. This information is provided in table 5.3.

Table 5.3 Degree of technical sophistication

Variable	Value	Absolute frequency (n = 9)	Relative frequency (%)
Degree of sophistication	Very high	1	11
	High	8	89
	Average	0	0
	Low	0	0
	Very low	0	0
		9	100

As can be expected from research entities, the degree of technical sophistication was high for eight of the respondents and very high for one. Respondent A indicated that some of the projects required extremely high technical sophistication, but on average, the projects required high technical sophistication.

From the responses to questions 1 to 3, it is clear that the respondents were predominantly involved in more than ten projects with an average duration of more than 12 months, which required high technical sophistication. The entities were therefore engaged in similar projects and this information could be used for meaningful comparisons.

5.6.4 Academic training

The purpose of questions 4 and 5 was to determine whether the respondents felt that their academic training was adequate and whether or not they required further training.

During the face-to-face interviews, one of the respondents expressed concern that his/her academic training in project and cost management was inadequate. The respondents were mainly trained as engineers with little exposure to management accounting training. As they had moved up the ranks in their careers and received promotion as managers, they had done little engineering work and more administrative work. They then became responsible for managing the costs of projects and also to preparing the budgets for their sections.

Figure 5.2 indicates the number of respondents who felt they needed or did not need further training in both project management and management accounting.

Figure 5.2 Adequate academic education in project management and management accounting

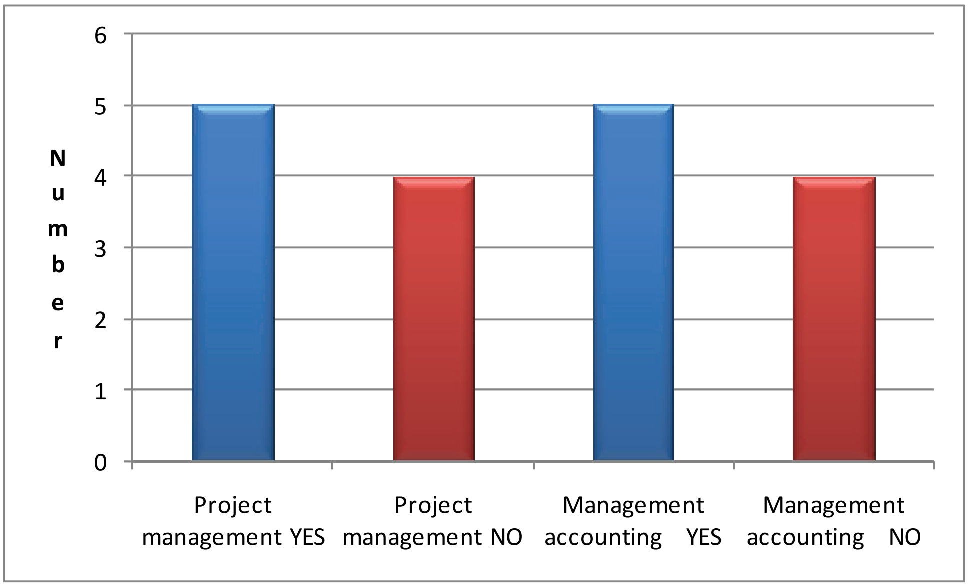
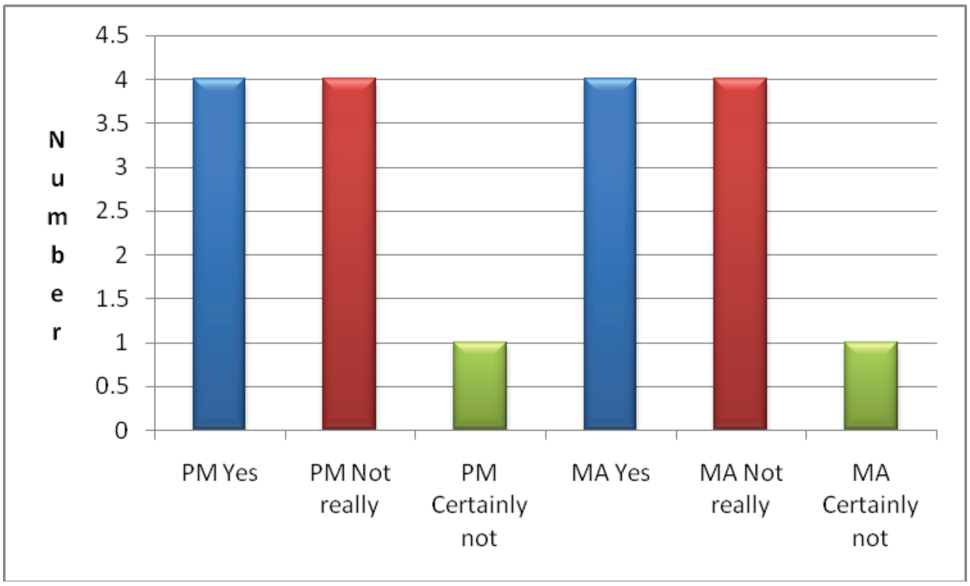


Figure 5.2, shows that five out of the nine respondents felt that they did have sufficient education in both project management and management accounting. During the interviews, some of the respondents indicated that they had received further academic training in project management specifically. From the graph, one may incorrectly conclude that the same respondents felt that their training was adequate for both project management and management accounting. This is certainly not the case. One respondent felt that he did require training in management accounting, but had adequate training in project management, while another indicated that he did have sufficient management accounting training but not enough in terms of project management. The other respondents either felt that they required training in both, or training in none.

Figure 5.3 indicates whether the respondents felt that they required further training in project management and management accounting.

Figure 5.3 Further training required



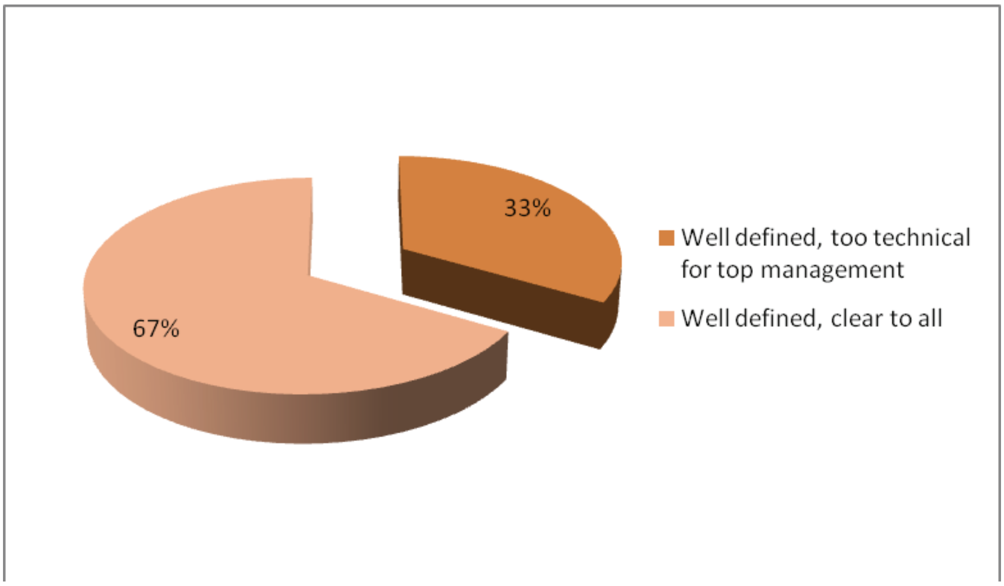
One can infer from figure 5.3, that four out of the nine respondents felt that they did require furhter education in both project management (PM) and management accounting (MA). Hence more project management and management accounting training should be seriously considered in the basic training offered to engineers at university level.

5.6.5 The goals of a project

The purpose of question 6 was to determine the clarity of the goals of current metallurgical research projects. As indicated by question 10, the respondents ranked clearly defined goals as the primary contributing factor that determines the success of a project.

Figure 5.4 indicates how clearly the goals of current projects were defined.

Figure 5.4 Goals of a project



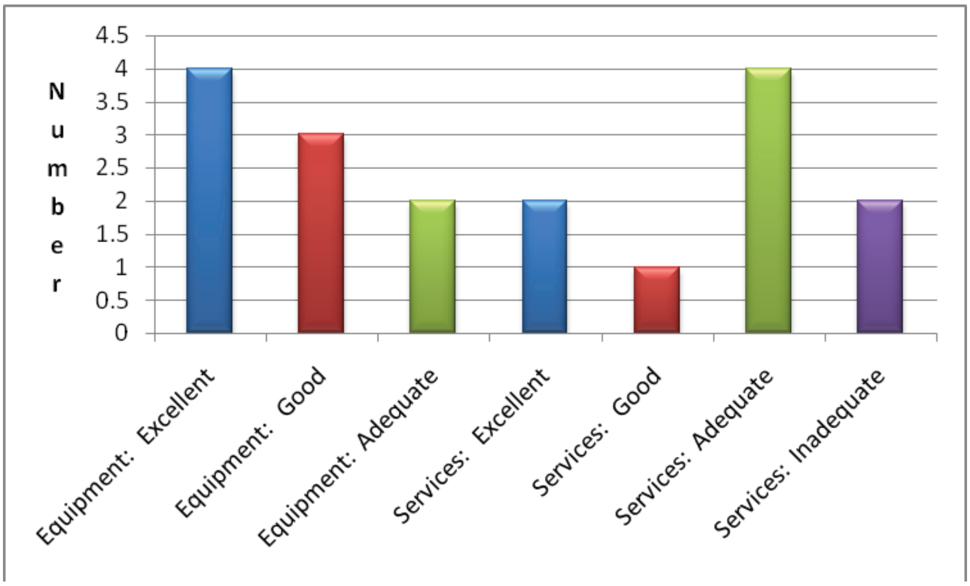
From figure 5.4, it is clear that the majority of goals of current projects were well defined and clear to all. Three respondents indicated that the goals were well defined, but too technical for top management. None of the respondents chose options c (clear to you but not to others), d (vague at present but will become clearer) or e (extremely vague).

5.6.6 The quality of equipment and services

The purpose of question 7 was to determine the quality of services and equipment for metallurgical research projects.

The quality of equipment and services available to research projects is of paramount importance and can have a major influence on the success of a project. As the respondents indicated in question 3, all their projects required at least a high level of sophistication and it was expected that the quality of the equipment and services available to them would also be satisfactory.

Figure 5.5 Quality of equipment and services



From figure 5.5, it is clear that most of the entities' equipment was excellent to good. However, of concern is the fact that services were mostly adequate, while two respondents indicated inadequate services. The question arises whether they would continue to be in a position to maintain high levels of sophistication with services that were merely adequate.

5.6.7 The quality and number of technicians

The purpose of question 8 was to determine the quality and number of technicians available for projects.

At the launch of an apprenticeship training programme of Siemens Southern Africa on 14 March 2007, Chief Executive, Sigi Proebstl, pointed out that South Africa's National Research and Development expenditure for science and technology amounted to R12 billion, or nearly 0.9% of its GDP. By contrast, China had the fastest-growing research intensity at 1.44% of its GDP. Similarly, South Africa was producing only 1 200 engineering graduates a year, compared to Korea and Taiwan, which were producing 30 000 and 10 000 respectively. The same shortfall – although in far greater dimensions in terms of numbers – held for apprentices in training. He stated that the market requires one engineer for every four technicians and every 16 artisans.

Currently, the ratio stands at one engineer for every one technician and two artisans. To remain globally competitive, this shortage needs to be urgently addressed. This skills shortage is also a problem in metallurgical research, as illustrated by figure 5.6.

Figure 5.6 Quality and number of technicians available

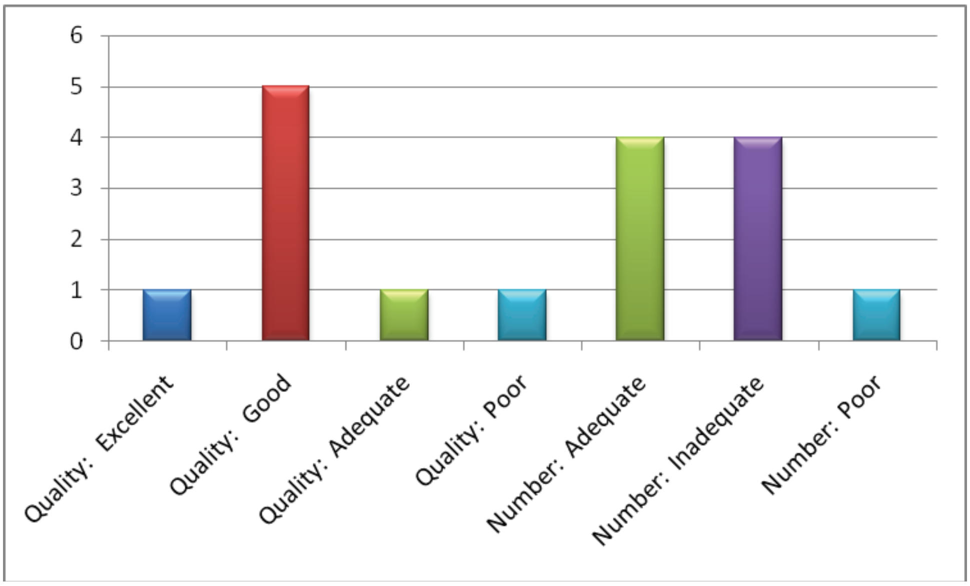


Figure 5.6 underscores the shortage of technicians in metallurgical research projects. As indicated, the quality of technicians is not the problem, but the quantity. During a face-to-face interview with respondent A in August 2007, he stated that the quality of technicians differed. The major challenge in the industry, however, is that the demand for services is increasing but there is a lack of skilled people. In this respondent's research and development section, there were 72 positions, 28 of which were support personnel. Of the remaining 44 positions, only 31 were occupied on the date of the interview. The shortage of technicians could be a contributing factor to projects not meeting their deadlines.

5.6.8 Project budgets

The purpose of question 9 was to determine the magnitude of budgets in metallurgical research projects. The results are tabulated in table 5.4.

It was observed that all entities in the metallurgical research field used budgets in some or other way to manage their costs. The question that arises here is whether the initial estimation of budgeted cost is accurate and whether these budgeted costs are managed over the entire life cycle of the project.

Table 5.4 Project budgets

Variable	Value	(%)
Rand value	Between R0 and R100 000	17
	Between R100 001 and R500 000	23
	Between R500 001 and R1 000 000	24
	More than R1 000 000	36
		100

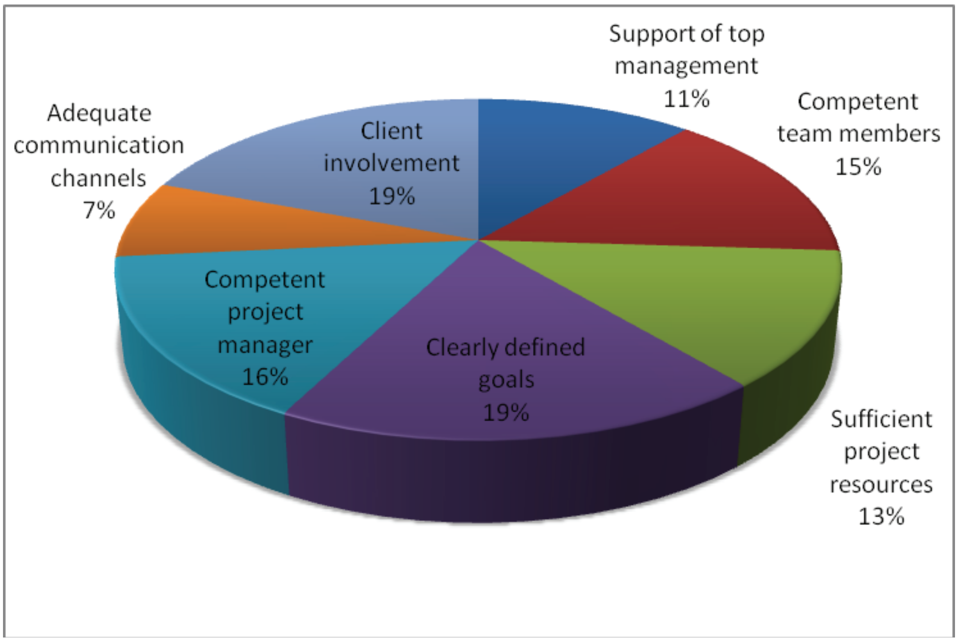
As indicated in table 5.4, the majority of projects had a budget of more than R1 000 000, followed by budgets between R500 001 and R1 000 000. Question 1 showed that 67% of all the entities were currently involved in more than 10 projects. One may therefore conclude that the managers of the research sections are responsible for managing a considerable amount of money – hence the importance of estimating the cost of these projects accurately and managing them with great care.

5.6.9 Determining factors for the success or failure of projects

Questions 10 and 12 dealt with the factors contributing to a project's success or failure. Question 11 measured, on a scale of 1 to 5, the success of a project in terms of various factors.

The purpose of question 10 was to ascertain from the respondents which of the given factors determined a project's success. The results are summarised in figure 5.7 and indicate the sequence of importance as reported by the respondents. Since the most important factor was indicated by 1 and the least important factor by 7, it was necessary to express the chosen number between 1 and 7 as a fraction, with 7 as the numerator and the chosen value as the denominator. The average of these values was determined in order to identify the most important factor.

Figure 5.7 Factors that determine a project's success



To improve the derivation, the results of figure 5.7 are summarised in table 5.5.

Table 5.5 Factors that determine a project's success

Factor	%
Clearly defined goals	19
Client involvement in defining needs and requirements	19
Competent project manager	16
Competent team members	15
Sufficient project resources	13
Support of top management	11
Adequate communication channels	7

The sequence of importance is clear in table 5.5 above. In the opinion of the respondents, clearly defined goals and client involvement are the factors that contribute the most to a project's success, while the support of top management and communication channels are the least important.

The purpose of question 11 was to determine how the respondents rated the success of their projects, measured by specified factors, on a scale of 1 to 5, where 1 being underachievement, 3 full achievement and 5 absolutely outstanding. After the respondents had chosen their options, the average of each option was calculated. The results are shown in figure 5.8.

Figure 5.8 The success of respondents' projects

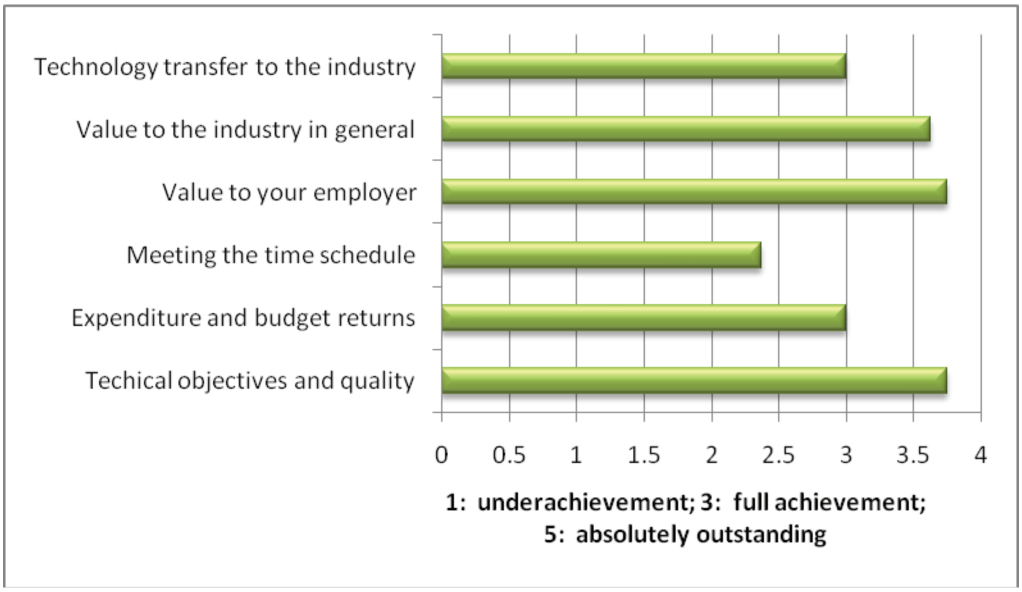


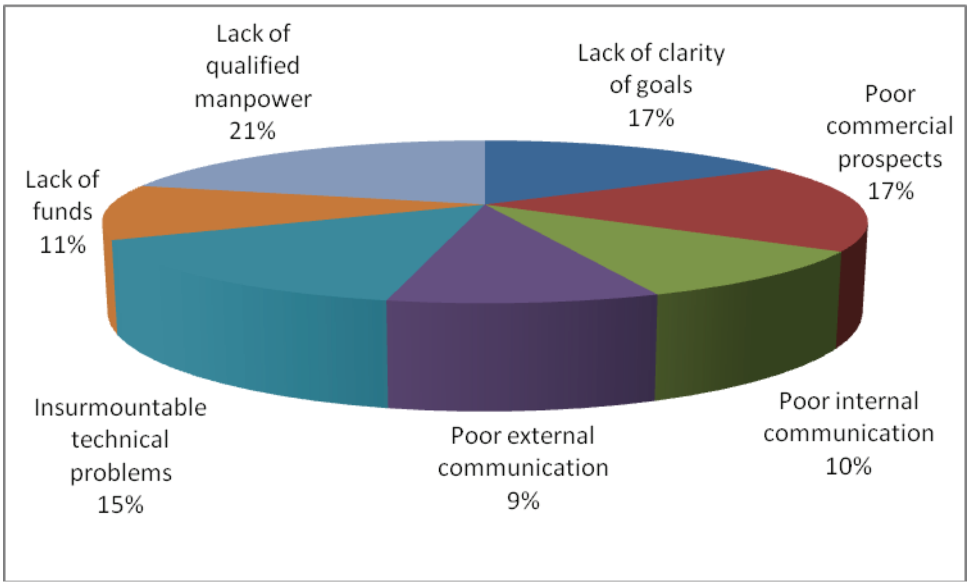
Figure 5.8 shows that the respondents were most successful in terms of technical objectives and quality, and the least successful in terms of expenditure and budget returns, technology transfer to the industry and meeting time schedules. Since this study was conducted in a research environment, one would expect the respondents to be successful in terms of the technical objectives and the value they would add to their employer and the industry. According to respondent A, the aim of research and development is the transfer of knowledge. Of concern is the fact that the respondents appeared to have underachieved in terms of meeting their time schedules. Respondent A indicated that the shortage of personnel, as confirmed in question 8, was the main reason for not meeting the deadlines.

As seen in chapter 1, the goals of almost every project are to do the work for a client or end-user in accordance with the *budget, schedule* and *performance requirements*. In an effort to keep to the budget, the work quality may decline, schedules may slip, and performance may tail off. In trying to keep to the schedule and performance requirements, costs may also increase (Nicholas 2001:10).

One of the three goals of a project, namely to stay within the budget and time schedule, were not achieved by the respondents. This could also have implications for work quality and could lead to cost increases.

The purpose of question 12 was to determine the reasons for failure or early termination of unsuccessful projects. The same procedure was followed as in question 10. The results are provided in figure 5.9.

Figure 5.9 Reasons for failure or early termination of projects



To facilitate interpretation, the results of figure 5.9 are summarised in table 5.6 below.

Table 5.6 Reasons for failure or early termination of projects

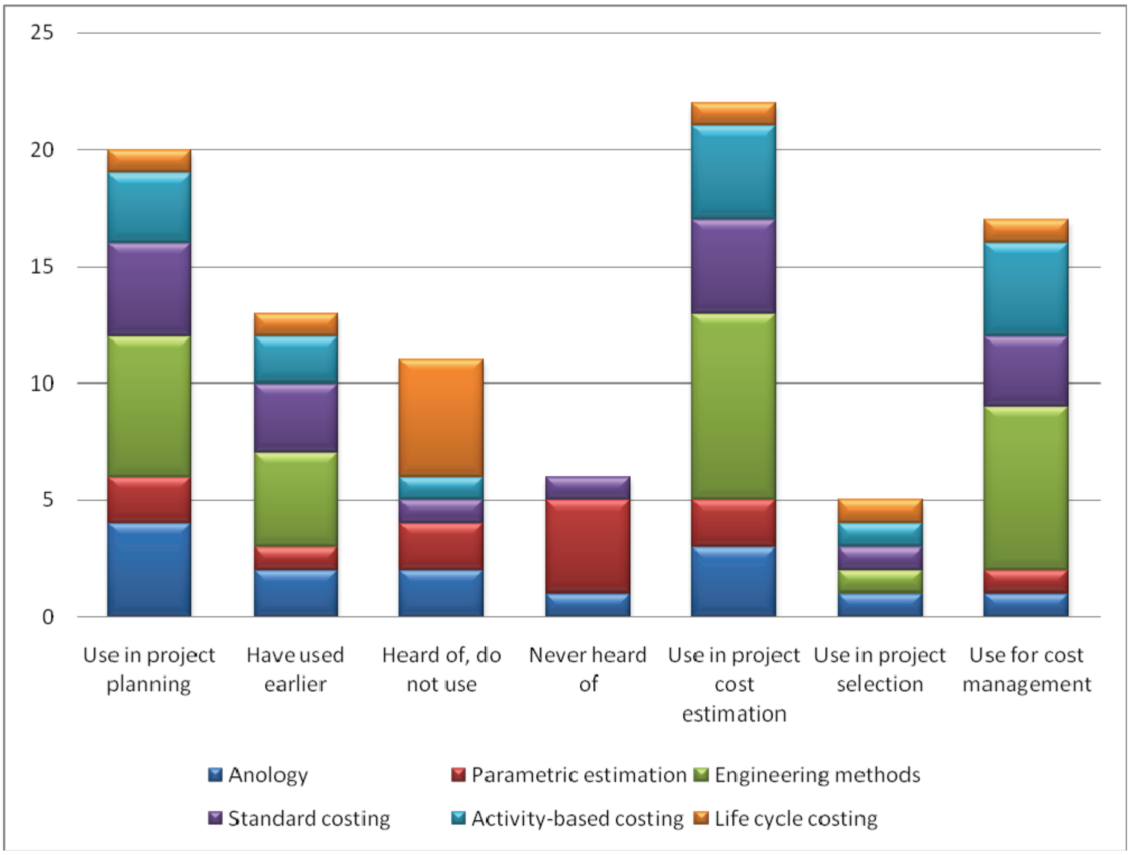
Reason	%
Lack of qualified manpower	21
Lack of clarity of goals	17
Poor commercial prospects	17
Insurmountable technical problems	15
Lack of funds	11
Poor internal communication	10
Poor external communication	9

From table 5.6, is clear that the main reason for failure and early termination of projects was the lack of qualified manpower. This again confirms the result of question 8, namely the shortage of technicians. The lack of clarity of goals as a reason confirms the results of question 10, where clearly defined goals were chosen as the main contributing factor to the success of a project. Poor internal and external communication contributed the least to the failure or early termination of projects. Respondent C stated that one of the primary reasons for failure was the lack of a project champion during the technology transfer phase. Projects are often personality driven and although they may be technically sound, they may not fit in with the current thinking and philosophies of the entity.

5.6.10 Cost estimation

One of the research objectives was to determine whether the cost estimation methods that were examined in the literature study, were being used in metallurgical research projects. The results of question 13 will answer this question. Figure 5.10 analyses the usage of these cost estimation techniques.

Figure 5.10 Cost estimation techniques



To improve the derivation, the results are also tabulated in table 5.7 below.

Table 5.7 Cost estimation techniques

	Analogy	Parametric estimation	Engineering methods	Standard costing	Activity-based costing	Life cycle costing
Use in project planning	4	2	6	4	3	1
Have used earlier	2	1	4	3	2	1
Heard of, do not use	2	2	0	1	1	5
Never heard of	1	4	0	1	0	0
Use in project cost estimation	3	2	8	4	4	1
Use in project selection	1	0	1	1	1	1
Use for cost management	1	1	7	3	4	1

Attribute-based costing and feature costing were omitted from both the figure and the table because they were not used for any of the options in the question.

It is evident from the table that engineering methods are the mainly used for project planning while life cycle costing is used the least. Engineering costing methods were formerly used most frequently. Life cycle costing was the method that most of the respondents have heard of, but had never used. Except for attribute and feature costing, parametric cost estimation was the least known to the respondents. All but one of the respondents were using engineering cost methods for the purposes of cost estimation, while seven were utilising it for cost management. Standard costing and ABC were also used by four of the respondents. Cost estimation methods were not significantly used for project selection.

It is clear that the cost estimation method mainly used for cost estimation was engineering cost methods, followed by standard costing and ABC methods. All the methods identified in the literature study, except for attribute-based and feature costing, were used by the respondents for cost estimation. Most of the respondents used combined methods to estimate costs. None of the respondents mentioned any other method of cost estimation in the open-ended section of the question. Respondent A explained his organisation's method of cost estimation during a personal interview. He mentioned that the major problem with the estimation of cost for research projects, was the fact that almost all the projects were new, and there was no basis to use. The entire calculation of man-hours and procurements was based on estimates.

According to respondent A, his organisation's cost consisted of two components, namely internal labour costs and procurements from outside. Internal labour costs were estimated using estimated hours per person multiplied by a predetermined rate for that rank. Firstly, it was determined how many people would be needed, and their level, say, technician, scientist, engineer, or principal engineer. The charge-out rate per person was then determined by taking into account his/her cost-to-company salary, as well as the recovery of the total operational budget, in this case R45 million per annum. The hours to be spent per person on the project were then estimated. This was often the reason for overspending, because the estimation of man-hours was incorrect. This was also be influenced by the calculation of the charge-out rate.

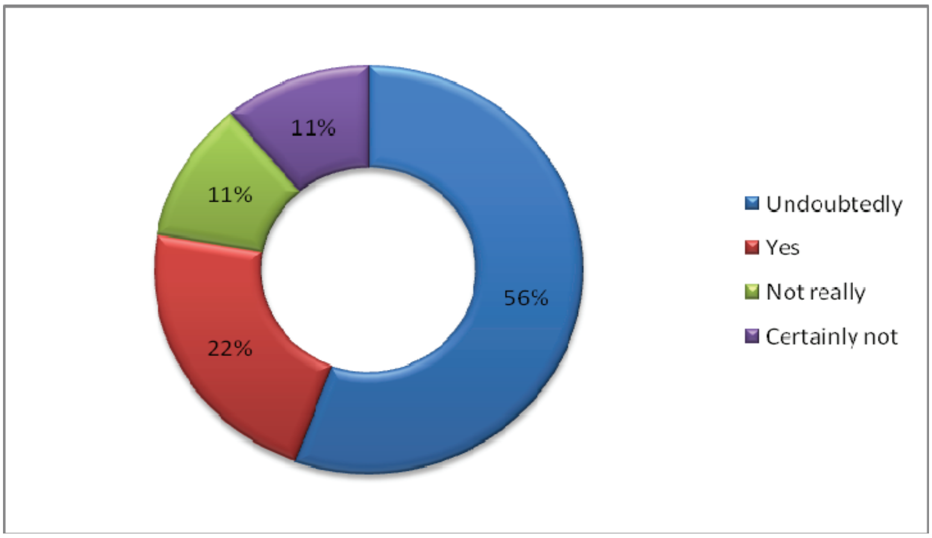
Quotations were gathered for procurement costs, and actual costs were being used. If estimations for procurements are incorrect, this may influence the estimation of cost. This is a combination of engineering cost methods and actual costs.

The question remains on how accurately the costs are being estimated. The purpose of research projects, as confirmed by respondents A and E, is to transfer knowledge and not to make a profit. In order to break even, the price the customer is willing to pay will obviously have a huge influence on the cost estimation. Because procurement costs are based on actual quotations, man-hours are the easiest figure to manipulate in order to break even.

One may therefore conclude that engineering costs methods are mainly used for the estimation of costs in metallurgical research projects, and they are used in combination with other methods.

The purpose of question 14 was to determine whether environmental issues have an impact on projects. It was observed that in the past, the cost of demolishment was not been taken into account when costs were estimated. Because metallurgists often work with harmful chemicals, it is critical to budget for the cost of disposing of these substances, because they cannot be dumped in municipal waste. According to Respondent A, one of the conditions of acceptance of his organisation's new projects, was a study to determine the effect on safety, health and environment (SHE). He was of the opinion that there are numerous hidden costs in this issue. Figure 5.11 summarises the results of question 14.

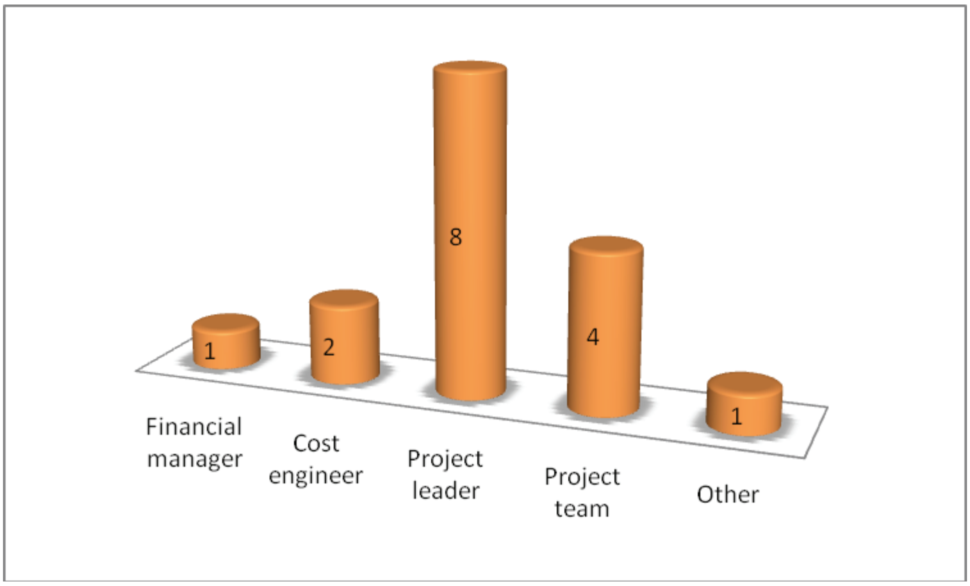
Figure 5.11 The effect of environmental issues on projects



From figure 5.11, it is clear that the majority of respondents felt that environmental issues do have an impact on their projects. Of concern, however, is the fact that some of the respondents felt that these issues do not have an impact.

The purpose of question 15 was to determine who estimates the cost of projects. Here, the respondents could choose more than one option. Figure 5.12 summarises the results.

Figure 5.12 Responsibility for cost estimation



From Figure 5.12, it is clear that the project leaders were mainly responsible for the estimation of costs. Respondent A indicated that the project leader together with the project team was responsible for estimating project costs and that this was signed off by the financial manager. Respondent G indicated that estimators were responsible for cost estimation.

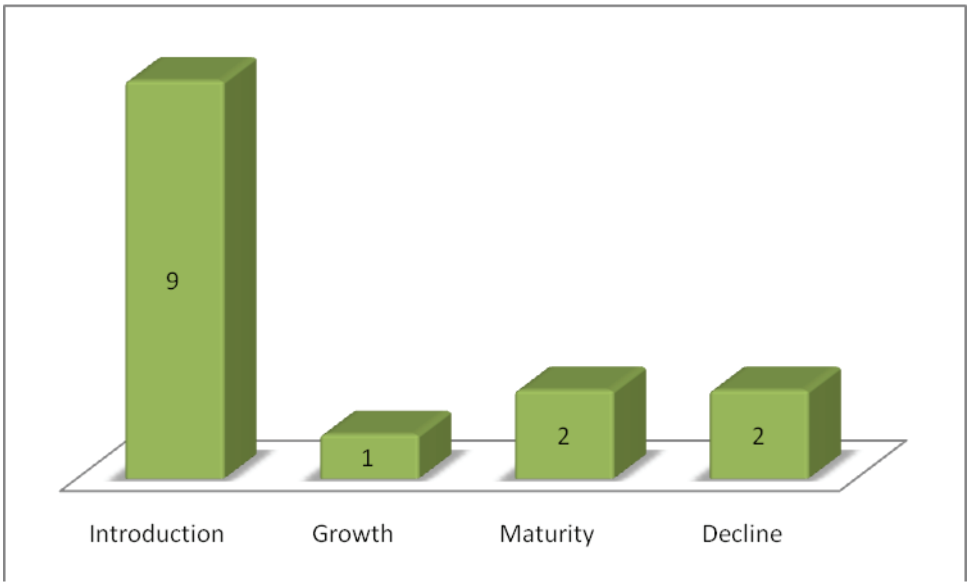
5.6.11 Life cycle costing

The aim of questions 16 to 18 was to resolve part of the research problem, namely to determine during which phase of the life cycle of metallurgical research projects the costs are being determined, during which phase most of the costs are incurred and during which phase the costs are managed.

From the literature study it was clear a typical project consists of four life cycles, namely introduction, growth, maturity and decline. During the introduction phase, only 20% of the costs of a project are incurred, but 80% are committed. It is therefore imperative that the initial cost estimates should be accurate. Most of the costs will be incurred during the growth phase. Cost management, however, may be most effectively practiced during the introduction phase of a project and not the growth phase when the costs have been committed and the product design and processes have been determined. During the growth phase, the focus should be more on cost containment as opposed to management.

Figure 5.13 provides the results of question 16, the aim of which was to determine in which phase of the life cycle costs are determined.

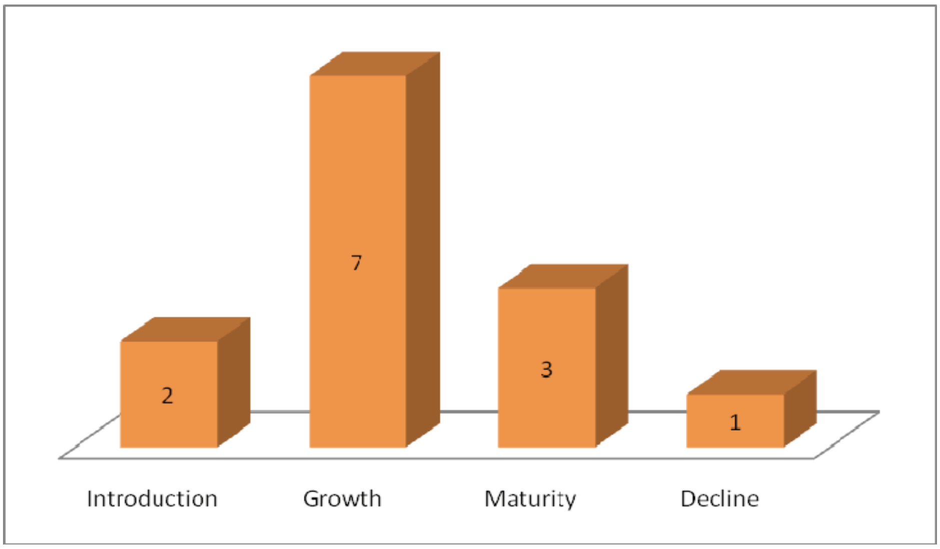
Figure 5.13 Life cycle phase in which costs are determined



Some of the respondents chose more than one option. Figure 5.13 indicates that most of the respondents determined their costs during the introduction phase. It is worrisome that costs are still being determined during the maturity and decline phases.

Figure 5.14 shows the results of question 17, the purpose of which was to determine during which phase of the life cycle costs are incurred.

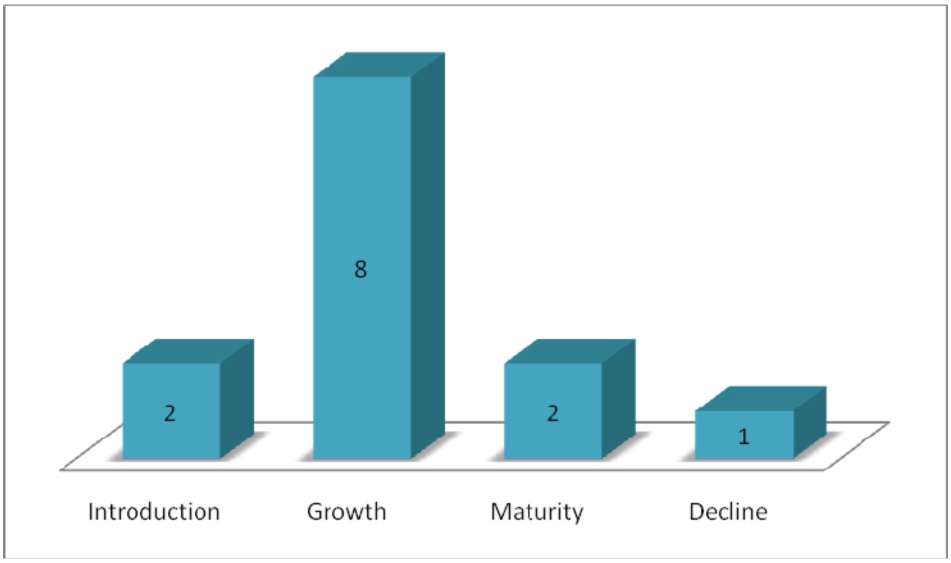
Figure 5.14 Life cycle phase in which most costs are incurred



Some of the respondents chose more than one option. From figure 5.14 indicates that most of the respondents incurred their costs during the growth phase. According to respondent E, costs were incurred uniformly during all four phases of life cycle.

Figure 5.15 shows the results of question 18. The purpose of this question was to determine during which phase of the life cycle the majority of the costs were managed.

Figure 5.15 Life cycle phase in which most costs are managed



Some of the respondents again chose more than one option. Figure 5.15 indicates that most of the respondents managed their costs during the growth phase. According to respondent E, costs were not only incurred, but also managed uniformly during all four phases of the life cycle. Since costs were committed and product design and processes determined during the introduction phase, cost should also have been managed mainly during this phase. During the growth phase, the focus should have been more on cost containment and not cost management.

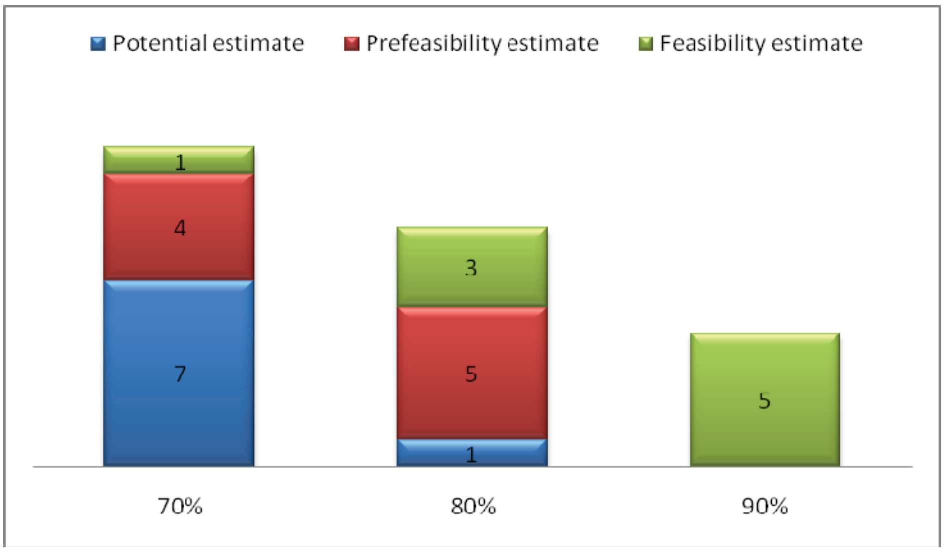
One may conclude from figures 5.13 to 5.15 that the respondents understood the basic principles of life cycle costing in terms of the phases in which costs were committed and incurred. The costs, however, were managed mainly during the growth phase, instead of the introduction phase, which could be a reason for cost overruns, since the majority of costs were already committed and could not be changed.

5.6.12 Accuracy of the cost estimate

The purpose of question 19 was to determine the level of accuracy of the cost estimate during the potential estimate, prefeasibility estimate and the feasibility estimate.

During the pretesting of the e-mail questionnaires, it was determined that the norm for accuracy of cost estimates in metallurgical research projects is 70%, 80% and 90% during the potential estimate, prefeasibility estimate and the feasibility estimate, respectively. Figure 5.16 provides the results of question 19.

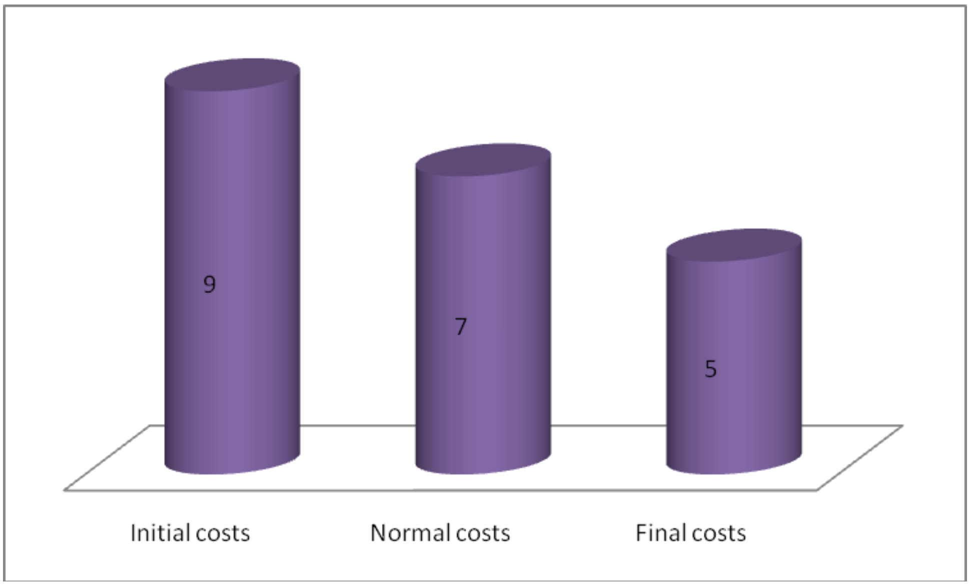
Figure 5.16 Accuracy of cost estimation



One may conclude from figure 5.16 that seven of the respondents were 70% accurate in terms of the potential estimate and one was 80 % accurate. One of the respondents indicated that his/her entity's potential estimate was less than 70% accurate. Four of the respondents were 70% accurate in terms of the prefeasibility estimate, while five were 80% accurate. Five of the respondents were 90% accurate with the feasibility estimate, three 80% accurate and one 70% accurate. The majority of the respondents were therefore in line with the norm as indicated in the pre-testing of the questionnaires. Of concern is the finding that three of the respondents were only 80% accurate in the feasibility estimate, and one only 70% accurate. This could be an indication that there was not enough emphasis on the accurate estimation of the costs of metallurgical research projects.

The purpose of question 20 was to determine whether all costs were included in the cost estimate of metallurgical research projects. All costs, including initial costs, normal costs and final costs should be included during the life cycle of a project. Figure 5.17 indicates which of these costs were included in the respondents' estimates.

Figure 5.17 Costs included in the total estimated project cost

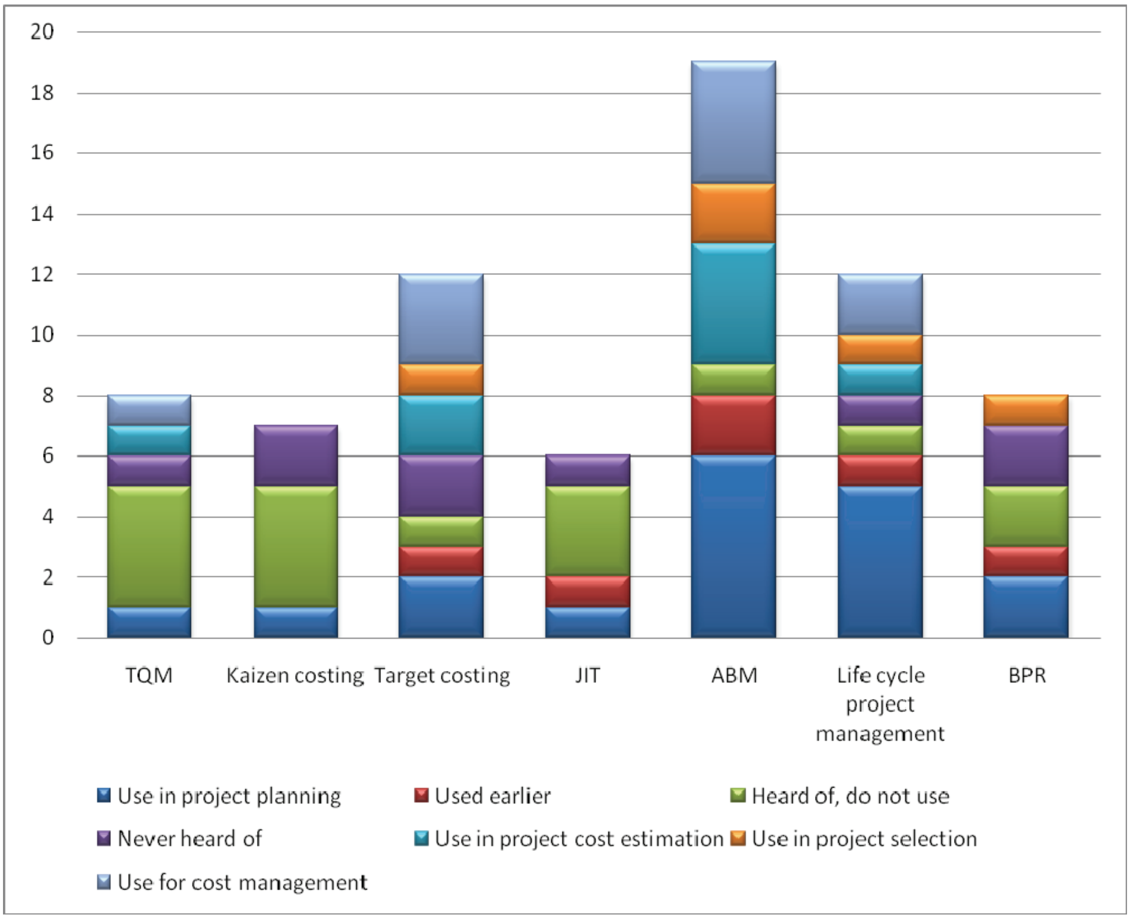


One may infer from figure 5.17 that the respondents did not include all their costs over the entire life cycle in the estimation of their costs. All the responents did, however, include the initial cost, which would typically include research and development, planning and design costs. Normal costs include all manufacturing costs. It is worrisome that the respondents did not all choose this option, because it is highly unlikely that they would not incur these costs. Final costs normally include dicontinuation and disposal costs. Only five of the respondents indicated that they included these costs in their estimates. One of the research objectives was to determine whether all costs over the life cycle of metallurgical research projects are included in the initial cost estimate of a project. The results of this question confirm that all costs were not included in the initial cost estimate, which means that cost estimation was not done accurately throughout the **entire life cycle** of metallurgical research projects.

5.6.13 Cost management

Question 21 was included specifically to provide information on one of the research objectives described in Chapter 1, namely to determine whether the cost management methods as identified in the literature study were being used in metallurgical research projects. Figure 5.18 summarises the results.

Figure 5.18 Methods of cost management



To facilitate derivation, the results are also tabulated in table 5.8.

Table 5.8 Methods of cost management

	TQM	Kaizen costing	Target costing	JIT	ABM	Life cycle project mana-gement	BPR
Used in project planning	1	1	2	1	6	5	2
Used earlier	0	0	1	1	2	1	1
Heard of, do not use	4	4	1	3	1	1	2
Never heard of	1	2	2	1	0	1	2
Use in project cost estimation	1	0	2	0	4	1	0
Use in project selection	0	0	1	0	2	1	1
Use for cost management	1	0	3	0	4	2	0

The following conclusions can be drawn from the data in table 5.8: Activity-based management (ABM) and life cycle project management were mainly used for project planning purposes. The respondents had heard of total quality management (TQM), Kaizen costing and just-in time, but did not use it. ABM was also generally used by the respondents to estimate costs. Target costing and ABM were mainly used for cost management purposes. Not one of the respondents indicated that he/she used other methods of cost management. However, it was established that they all used budgets in some or other form. Respondent A indicated that his/her entity was utilising a program written for their specifications. The program interlinked with SAP and MS Projects. The program was budget-based and compared budgeted and actual information as the project progressed. Any variations from the budgeted figures were to be followed up. Respondent C found it difficult to answer the question because it did not fit in with the type of research and development in which his department operated. His/her entity's approach was driven largely by the customer's (the main source of funding) preference. Respondent E commented during a telephonic interview that budgeting occurred once a year. Once approved, the budget was also used for forecasting. The project leader was responsible for managing the budget.

It is evident from the responses of the participants that ABM, target costing, life cycle project management and TQM were used for the cost management of metallurgical research projects while Kaizen costing, JIT and business process re-engineering (BPR) were not used.

The aim of question 22 was to establish which support systems were being used for the management of project cost. Table 5.9 summarises the results.

Table 5.9 Support systems used for the management of project costs

Support system	Frequency
Costs monitored by finance department only	1
Finance department gives feedback to project leader	5
Project leader monitors costs manually	1
Project leader monitors costs using personal computer	3
Project leader uses personal computer to monitor costs and physical installation concurrently	2
Project leader uses personal computer to monitor costs in conjunction with the finance department	8

From table 5.9, one may infer that the project leader, using a personal computer to monitor costs, in conjunction with the finance department was mainly responsible for the management of the cost of metallurgical research projects.

5.7 CONCLUSION

In this chapter, the research methodology was examined. This study can be classified as a descriptive study. The survey research approach was used to yield quantitative data and the research instruments employed were face-to-face and telephonic interviews as well as e-mail questionnaires.

The results of the empirical study can be summarised as follows:

- At the time of the study, the majority of the respondents were participating in more than 10 projects with an average duration of more than 12 months and their projects required high technical sophistication. The majority of the projects had a budget of more the R1 000 000.

- There is a need for more project management and management accounting training in the metallurgical engineering field.
- The majority of the goals of the current projects in which the entities were engaged in were clearly defined.
- The equipment available for projects was of a high standard, but the services available for projects were only adequate.
- The quality of technicians was acceptable, but the number of technicians available was inadequate.
- Clearly defined goals and client involvement were the principal factors contributing to a project's success.
- The projects were most successful in terms of technical objectives and quality and value to the employer, and least successful in terms of meeting the time schedules.
- The primary contributing factor to failure and the early termination of projects was the lack of qualified manpower.
- Engineering methods, combined with other methods, were the most commonly used in metallurgical research projects to estimate cost.
- Environmental issues did appear to have an impact on metallurgical research projects.
- Project leaders were mainly responsible for the estimation of a project's cost.
- The costs of projects were mainly determined during the introduction phase and incurred and managed during the growth phase.
- Only initial costs were included in all project cost estimations, but not all the respondents included normal costs and final costs in their cost estimates.
- ABM and life cycle project management were the methods mentioned in the e-mail questionnaire that were generally used for cost management. Budgets, which are a cost control method, instead of a cost management method, were still being used by all respondents for cost control purposes.
- Project leaders, in conjunction with the finance department were responsible for the management of costs.

In order to draw a final conclusion in terms of the research objectives, it is necessary to analyse the above results in relation to the literature study, as set out in chapters 2 to 4.

The research objectives of this study, as indicated on page 9, were:

- to examine different methods that can be used to estimate and manage the total costs of a project during its life cycle
- to determine whether these cost estimation methods are used in metallurgical research projects
- to determine whether these cost management methods are used in metallurgical research projects
- to determine whether all costs over the life cycle of metallurgical research projects are included in the initial cost estimate of a project
- to determine during which phases of the life cycle of metallurgical research projects the costs are determined, most of the costs are incurred and most of the costs are managed

Chapter 2 described the life cycle of a project, which consists of the introduction, growth, maturity and decline phases. In a typical life cycle, only 20% of the costs of a project are incurred during the introduction phase, but 80% of the costs are committed. The majority of the costs are incurred during the growth phase but should actually be managed during the introduction phase. From the results of the empirical study, one may conclude that the cost estimates of projects are mainly determined during the introduction phase and incurred and managed during the growth phase. Costs, however, should be mainly managed during the introduction phase when the majority of the costs are committed. During the growth phase, the focus should be more on cost containment and not cost management. This conclusion therefore **answers the final research objective.**

Of concern is the fact that the respondents reported that only initial costs are included in all project cost estimates, but not all of them include normal costs and final costs in their cost estimates. It is therefore inevitable that the cost estimation of such metallurgical research projects will be inaccurate because all the relevant costs are not included in the initial cost estimates. This conclusion **answers the fourth research objective.**

The conclusions drawn in chapters 3 and 4 **conform to the requirements of the first research objective.**

Chapter 3 examined different methods of cost estimation which include analogy, parametric cost estimating, engineering cost methods, standard costing, attribute-based costing, feature costing and ABC. The method mainly used for metallurgical research projects to estimate cost, is engineering methods, followed by standard costing and ABC. The respondents used a combination of methods to estimate project costs. The respondents had never heard of attribute-based costing and feature costing. This result **answers the second research objective.**

Chapter 4 examined different methods of cost management, including TQM, Kaizen costing, target costing, JIT, ABM, life cycle project management and BPR. ABM and life cycle project management were the main methods used for cost management of metallurgical research projects. ABM was the only technique that all the respondents had heard of. Budgets, however, were still being used by all respondents for cost control purposes. The focus of a budget is on comparing actual results against a preset standard, identifying and analysing variances and taking remedial action to ensure that the future outcomes conform to the budgeted outcomes. The emphasis is on cost containment rather than cost reduction. Since metallurgical research projects are mainly once-off undertakings, and budgets ensure that **future** outcomes conform to the budgeted outcomes, budgets are not the most effective method of cost management. This conclusion **answers the third research objective.**

In conclusion, according to the respondents, all project costs over the life cycle of metallurgical research projects are not included in the initial cost estimates and costs are managed mainly by means of budgets, which are not the most effective method of cost management. The costs of projects are mainly determined during the introduction phase and incurred and managed during the growth phase. Estimates of the costs of metallurgical research projects are therefore not as accurate because all the costs are not being included and these costs are not managed during the correct phases of their life cycles.

5.8 TOPICS FOR FUTURE RESEARCH

Possible topics for future research are as follows:

- It is necessary to determine the reasons why methods of cost management are not widely used and investigate the possible influence, if any, of the South African culture.
- Some of the respondents indicated that they did use these cost management techniques. It would be useful to determine which management accounting information is in fact used for these techniques.
- It would be interesting to ascertain how organisations can combine their current systems with these cost management techniques in an effort to manage cost more effectively.

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ANNEXURE A

University of Pretoria

Consent for participation in an academic research study

Departments of Accounting and Financial Management

"The estimation and management of cost over the life cycle of metallurgical research projects"

Research conducted by:

Mrs MM Odendaal
Tel: 011 950 4159
Supervisor: Prof FNS Vermaak
Tel: 012 420 4101

Dear Respondent

You are invited to participate in an academic research study conducted by Mrs MM Odendaal in fulfilment of the requirements for the degree, Magister Commercii (Financial Management Sciences), in the Faculty of Economic and Management Sciences at the University of Pretoria.

The purpose of this study is to determine what methods can be used to estimate and manage cost over the entire life cycle of metallurgical research projects.

Please note the following:

- This study involves an anonymous survey. Your responses will be dealt with in the strictest confidence. It will not be possible to identify you on the basis if your responses.
- Your participation in this study is of paramount importance to us. You may, however, choose not to participate and you may also stop participating at any time, without any negative consequences.
- Please answer the questions as completely and honestly as possible. This should not take more than 30 minutes of your time.
- The results of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.
- Please contact Mrs MM Odendaal (tel 011 950 4159; e-mail: magda.odendaal@buseco.monash.edu) if you have any questions or comments about the study.

Please sign the form to indicate that you:

- have read and understand the above information
- give your consent to voluntary participate in the study

____________________ ____________________

Respondent's signature Date

ANNEXURE B

QUESTIONNAIRE

Please complete the following:

Name: ______________________________

Title: ______________________________

Company: ______________________________

Branch or division: ______________________________

QUESTIONNAIRE INSTRUCTIONS

Mark the most appropriate response to each question by making a cross in the block that best describes your opinion, unless otherwise stated. If a description is required, please briefly express your opinion.

1. Your section is currently participating in:

(a)	1 to 2 projects	
(b)	3 to 5 projects	
(c)	6 to 10 projects	
(d)	More than 10 projects	

2. The projects in which you participate have an average duration of:

(a)	Less than 2 months	
(b)	Between 2 and 6 months	
(c)	Between 6 and 12 months	
(d)	More than 12 months	

3. The degree of technical sophistication required in your projects could be described as:

(a)	Very high	
(b)	High	
(c)	Average	
(d)	Low	
(e)	Very low	

4. Did your academic qualification include adequate project management (PM) and management accounting (MA) training? (Mark both.)

		PM	MA
(a)	Yes		
(b)	No		

5. Do you feel that you need further academic education in project management (PM) and management accounting (MA) in your current position? (Mark both.)

		PM	MA
(a)	Undoubtedly		
(b)	Yes		
(c)	Not really		
(d)	Certainly not		

6. In your view, the goals of your current projects are

(a)	Well defined, but too technical for top management	
(b)	Well defined and clear to everyone involved	
(c)	Clear to you, but not to others	
(d)	Vague at present, but will become clearer	
(e)	Extremely vague	

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7. The quality of the equipment and services available for your current projects are (mark both):

		Equip-ment	Services
(a)	Excellent		
(b)	Good		
(c)	Adequate		
(d)	Inadequate		
(e)	Poor		

8. The quality and number of technicians available to your current projects are (mark both):

		Quality	Number
(a)	Excellent		
(b)	Good		
(c)	Adequate		
(d)	Inadequate		
(e)	Poor		

9. What percentage of your current projects have a budget of (mark one or more):

		%
(a)	Between 0 – R100 000	
(b)	Between 100 001 and R500 000	
(c)	Between R500 001 and R1 000 000	
(d)	More than R1 000 000	

10. Please rank (1 to 7) the factors, which in your opinion, determine a project's success in general.

(a)	Support of top management	
(b)	Competent team members	
(c)	Sufficient project resources	
(d)	Clearly defined goals	
(e)	Competent project manager	
(f)	Adequate communication channels	
(g)	Client involvement in defining needs and requirements	

If there are any other factors, please specify them below:

____

____

11. On a scale of 1 to 5, where 1 is an underachievement, 3 is full achievement and 5 is absolutely outstanding, indicate how you would rate the success of your projects in terms of (mark all):

		1	2	3	4	5
(a)	Technical objectives and quality					
(b)	Expenditure and budgeted returns					
(c)	Meeting the time schedule					
(d)	Value to your employer					
(e)	Value to the industry in general					
(f)	Technology transfer to the industry					

12. Please rank (1 to 7) the reasons for failure or early termination of unsuccessful projects in which you have been involved:

(a)	Lack of clarity of goals	
(b)	Poor commercial prospects	
(c)	Poor internal communication	
(d)	Poor external communication	
(e)	Insurmountable technical problems	
(f)	Lack of funds	
(g)	Lack of qualified manpower	

If there are any other reasons, please specify below:

____

____

13. The following are cost estimation techniques:

(a) Analogy: identifies a similar product and adjusts its costs for differences between it and the target product.

(b) Parametric cost estimating: uses parameters and case histories of similar systems by applying mathematical models.

(c) Engineering cost methods: direct estimation of a particular cost element by examining a project, component by component.

(d) Standard costing: standards are set on a per unit basis.

(e) Attribute-based costing: a development of activity-based costing, not widely used.

(f) Feature costing: a spin-off of activity-based costing.

(g) Activity-based costing: costs are assigned on the basis of activities that drive the cost, rather than volume.

(h) Life cycle costing: all costs throughout the life cycle should be taken into account in the design stage of the project.

Using (a) to (h), indicate which of these techniques:

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
You do use in project planning								
You have already used								
You have heard of, but do not use								
You have never heard of								
You do use in project cost estimation								
You do use in project selection								
You do use for cost management								

If you use any other method to estimate costs, please describe it below.

____

____

14. Do you feel that environmental issues have a significant impact on your current projects?

(a)	Undoubtedly	
(b)	Yes	
(c)	Not really	
(d)	Certainly not	

15. Who estimates the cost of the projects? (Mark one or more.)

(a)	The financial manager	
(b)	The budget committee	
(c)	The financial accountant	
(d)	The cost engineer	
(e)	The project leader	
(f)	The project team	
(g)	Other	

If your answer to question 15 was (g), please state who estimates the cost of projects in your department.

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____

16. During which phase of the project's life cycle do you determine the cost of a project?

(a)	Introduction (development of project)	
(b)	Growth (project commences)	
(c)	Maturity (project reaches maturity)	
(d)	Decline (project ends)	

17. During which phase of the project's life cycle are the most of the costs incurred?

(a)	Introduction	
(b)	Growth	
(c)	Maturity	
(d)	Decline	

18. During which phase of the project's life cycle are the most of the costs managed?

(a)	Introduction	
(b)	Growth	
(c)	Maturity	
(d)	Decline	

19. What is the level of accuracy of the cost estimation during the following phases of evaluation and selection of current projects?

		Accuracy		
	Phases	70%	80%	90%
(a)	Potential estimate			
(b)	Pre-feasibility estimate			
(c)	Feasibility estimate			

20. Which of the following costs are included in the cost estimates of a project's total estimated cost? (Mark one or more.)

(a)	Initial cost, for example, research and developing cost, planning and design cost	
(b)	Normal cost, including manufacturing cost	
(c)	Final cost, for example, discontinuation or disposal costs	

21. The following are cost management techniques:
(a) Total quality management: a management process and set of disciplines that are coordinated to ensure that the organisation consistently meets and exceeds customer requirements.
(b) Kaizen costing: continual and gradual improvement.
(c) Target costing: the difference between the target price and the target profit margins represents the target cost
(d) Just-in-time: a system in which materials are purchased and units are produced only as needed to meet actual customer demand.
(e) Activity-based-management: a system to the evaluate costs and values of process activities to identify opportunities for improved efficiency.
(f) Life cycle project management: an approach to manage a project in which life cycle objective functions are used as criteria for decision making throughout the project's life.
(g) Business process re-engineering: a management approach aimed at radical rather than continuous improvements by elevating the efficiency and effectiveness of the processes that exist within and across organisations.

By using (a) to (g), indicate which of these techniques:

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
You use in project planning							
You have already used							
You have heard of, but do not use							
You have never heard of							
You do use in project cost estimation							
You do use in project selection							
You do use for cost management							

If you use any other method for cost management, please describe it:

____

____

22. Support systems used for managing project cost (mark one or more):

(a)	Costs monitored by finance department only	
(b)	Finance department gives feedback to project leader	
(c)	Project leader monitors costs manually	
(d)	Project leader monitors costs using a personal computer	
(e)	Project leader uses a personal computer to monitor costs and physical installation concurrently	
(f)	Project leader uses a personal computer to monitor costs in conjunction with the finance department	

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