An activity based quality cost and information system

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AN ACTIVITY BASED QUALITY COST AND INFORMATION SYSTEM

By

SALEH HUSSEIN AL-AMOUDI

A Doctoral Thesis
Submitted in partial fulfillment of the requirements
For the award of
Degree of Doctor of Philosophy
of the Loughborough University
May 2001

Wolfson School of Mechanical and Manufacturing Engineering
Loughborough University
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In the Name of Allah, the Most Beneficent, the Most Merciful
ABSTRACT

'An Activity Based Quality Cost and Information System'

Many companies are increasing their competitiveness through quality improvement. However, a widely held view among quality practitioners is that companies simply do not know the true total cost of quality, which are mostly hidden among the general overhead of the business. This problem is often attributed to an inappropriate costing system. Thus, any system that assisted companies in identifying and properly quantifying these costs will be valuable. This research, therefore, was aimed at developing a Quality Cost Information System for manufacturing industry, and to show that such a system could provide a basis for analysing quality costs and developing and evaluating the quality improvement process. A literature review of the quality literature highlighted that the major problems that hindered potential users from implementing an effective and efficient Quality Cost system were: current quality cost measurement systems were limited by their inability to trace quality costs to their source; quality was manageable only if it could be measured, quality cost did not easily fit into the traditional cost accounting structure; traditional accounting systems were unlikely to change radically to accommodate proper quality costing. This literature review was complemented by an industrial survey aimed at identifying knowledge of quality costing and current practices in manufacturing industry. The findings of the literature review and industrial survey formed the basis for the remainder of the study. As part of an integrated solution, three approaches have been proposed and detailed:

1. A graphical model of quality costing in the form of a visual tool to facilitate the introduction and communication of a quality costing information system within the organisation.

2. A proposed integration of Activity Based Costing tools with the theory of quality costing to provide a system that can deliver valuable information.

3. A Software tool for the design of Quality Costing Information Systems. The thesis concludes with the major findings and issues raised from the research undertaken. This is followed by recommendations for the successful pursuit of the beneficial implementation of the proposed quality costing system and tools along with several suggestions for further work and future research potential.
ACKNOWLEDGEMENTS

I wish to acknowledge and express my sincere thanks to my supervisor, John Middle for his supervision, encouragement, suggestions and help throughout this research. His prompt comments and the valuable recommendations he gave helped in the preparation of this thesis.

I want to express my sincere gratitude to Tariq and Salik for their innumerable suggestions during the development of the QCIS software. Special thanks to all colleagues for the assistance and encouragement, in particular: Nassir Al-omim, Dr.Rahim Reza Dr Nbil Shems
DEDICATION

Indeed all praise and thanks are due to Allah, the Lord of all that exists, who has enabled me to complete this endeavour. I would like to dedicate this thesis to my family and wish to express my deep sense of gratitude to them. This effort would not have been possible without the extraordinary love and support given to me by my entire family, and in particular-

Mohammed- My eldest brother who has been like a father to me. He has guided me and supported me financially. I am grateful for his vision and for showing such confidence in me. I will never be able to return the immense favour he has given me

Sayeed- For his unselfish attitude, who, when I was young laid the foundations, enabling me to study. His invaluable support during hardship and his unwavering commitment was a key factor in building up my determination to succeed.

Hassan- Who has been a constant source of strength and encouragement, in times of difficulty as well as ease. His motivation, support and optimism were an inspiration to me.

Special thanks are also due to my wife Shef’aa, and children, Maryam, Abdul Rahman and Meram. During the course of my studies, they have been very patient, supportive and have been a joy to my heart even though I have not been able to devote to them the time and attention they deserved. I appreciate from the bottom of my heart the precious times they have sacrificed for the sake of my studies.
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<thead>
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<td>ABC</td>
<td>Activity Based Costing</td>
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<tr>
<td>ADC</td>
<td>Design Appraisal Costs</td>
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<tr>
<td>AMC</td>
<td>Manufacturing Appraisal Costs</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>CAM</td>
<td>Computer Aided Manufacturing</td>
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<tr>
<td>CAM-I</td>
<td>Computer Aided Manufacturing - International</td>
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<tr>
<td>CAPP</td>
<td>Computer Aided Process Planning</td>
</tr>
<tr>
<td>CED</td>
<td>Clinical Engineering Department</td>
</tr>
<tr>
<td>CIM</td>
<td>Computer-Integrated Manufacturing</td>
</tr>
<tr>
<td>COC</td>
<td>Cost Of Conformance</td>
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<td>Cost Of Non-Conformance</td>
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<td>DPC</td>
<td>Design Prevention Costs</td>
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<td>FAME</td>
<td>Financial Analysis Made Easy</td>
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<tr>
<td>FC</td>
<td>Failure Cost</td>
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<tr>
<td>FMECA</td>
<td>Failure Mode Effects and Criticality Analysis</td>
</tr>
<tr>
<td>GE</td>
<td>General Electric</td>
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<tr>
<td>GNP</td>
<td>Gross national product</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>MBNQA</td>
<td>Malcolm Baldridge National Quality Award</td>
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<tr>
<td>MIS</td>
<td>Management Information System</td>
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<tr>
<td>MPC</td>
<td>Manufacturing Prevention Cost</td>
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<tr>
<td>PAF</td>
<td>Prevention-Appraisal-Failure</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>PDCA</td>
<td>Plan, Do, Check, and Action</td>
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<tr>
<td>PFP</td>
<td>Potential Failure Point</td>
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<td>QA</td>
<td>Quality Assurance</td>
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<td>QFD</td>
<td>Quality Function Deployment</td>
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<td>QOC</td>
<td>Quality Of Conformance</td>
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<td>SME</td>
<td>Small to Medium Enterprise</td>
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<td>Acronym</td>
<td>Description</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
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CHAPTER 1:
INTRODUCTION

1.1 Problem Description

Times are changing at an extraordinary pace, markets are becoming more and more global, competition is intensifying by the minute, and customers are more aware, and demand more (Peters, 1992, 1994). These changes affect an organisation’s vision, mission, core values, management structures, work processes, performance expectation from individuals and teams, the reward and recognition system, and even its business ethics. Success today requires organisations to do what was once considered impossible. They need to increase customer satisfaction, shorten process cycle and response times, reduce costs, and develop innovative new products and services – all at the same time. Not long ago, organisations could succeed by excelling in one or two of these areas.

Many companies are today trying to increase their competitive power against their competitors through quality improvement. They recognise that only improved quality products can result in increased market share, profit, and customer satisfaction. However in less aware companies improvement in the quality of product is often not proactively pursued because the costs are thought to be too high. The classical quality-cost model suggests that there is an optimum level of quality at which total cost is a minimum. However, increased competition in the world-wide market place is forcing companies to look for methods and tools to increase productivity, lower costs and hence lower selling prices while at the same time improving quality and value to the customer. Indeed, the fast moving changes in business environments have transformed the basis of industrial competitiveness.

In the 1990s, constant change in the world of business and in organisations became an accepted way of life. Organisational success in the 21st Century will hinge on the challenges of managing continuous and discontinuous change, i.e. organisations must
excel in both radical innovation and continuous improvement. They must go beyond excellence and acquire the flexibility that can use chaos as the source of market advantage (Peters, 1994).

The economic success of a manufacturing enterprise is associated with its ability to produce quality products which satisfy or surpass market demands yet incur low quality costs. Clearly, producing the product 'right first time' is normally less costly than carrying out a process twice, or alternatively sending the service van after the product as it leaves the factory to make sure the in-built faults are put right on the customer's premises, circumstances all too familiar that complicate business. High quality is clearly a key objective for world class manufacture. There is no alternative to quality improvement in the competitive, one-world environment in which we live. Customers are more and more aware, and quality is becoming a standard requirement rather than an added bonus.

Quality has been shown to be correlated with return on investment and increasing market share (Buzzle et al, 1981). This has resulted in further innovations in computer information technology, manufacturing processes, automation technologies and the organisation and management of manufacturing. The use of computer technologies such as Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), and Computer Aided Manufacturing (CAM) have to some extent helped in attaining a significant competitive edge. Growing attention has also been paid to the creation of methodologies and computer technologies, which enable the design of information systems which can integrate effectively different parts of the modern manufacturing business and its operations (CIM).

This thesis discusses a contribution to one aspect of manufacturing information systems which has to some extent been neglected in the past, that is, quality cost information systems. Talley (1991) proposed that total quality costs can be as high as 30 percent of sales for manufacturing companies, 50 percent of operating expenses for service companies, and 50 percent of operating expenses for software companies. This shows that the quality costs can be large enough to cause substantial damage to the profit of a business establishment, and therefore cannot simply be ignored.
However, despite the above generalisation, Talley (1991) observed that such costs constitute only 2.5 percent of sales for Japanese companies, to many companies the benchmark competitor.  An important question that needs to be investigated is why do these costs constitute only a small percentage for Japanese companies? Unfortunately, Talley (1991) does not give a meaningful explanation for this phenomenon. In light of this, the general observation still holds and these costs cannot be ignored. Added to that, reducing these costs means increasing a company’s profit without investing in new technological based projects (Band, 1989). It is also apparent that investing in the reduction of quality costs can have a greater impact on profitability than increased marketing and sales activity.

A widely held view among quality practitioners is that companies simply do not know the true total cost of quality, much of which is hidden among the general overhead of the business. Thus the figures referred to above are not readily apparent. This problem is often attributed to in appropriate costing system.

Any system therefore, that assist companies in identifying and reducing these costs would prove to be an asset. This research therefore, aims at developing a Quality Cost Information System (QCIS) for manufacturing industry, and to show that such a system could provide a basis for analysing quality costs and for developing and evaluating the quality improvement process in order to increase quality and productivity whilst reducing cost. This seems pertinent and useful, especially in the present situation where increasing consumer awareness about quality and a growing competitive market takes an international dimension. Manufacturing industry has been introducing many management ‘techniques’, such as JIT and Theory of Constraints into manufacturing in an attempt to improve its performance, and a QCIS will go a long way in assisting in this direction.

The research reported here considered the quality-costing concept as the basis of the work and used it in establishing an improvement strategy, which can be applied throughout the whole manufacturing area. This approach, utilising the capabilities and advantages of Activity Based Costing (ABC) as an integral part, seeks to provide a management tool for the design of QCIS to effectively assure customer satisfaction whilst maintaining competitive prices.
The early 1950’s saw an expansion of quality activities in the manufacturing industry, usually inspection and test processes with the inevitable escalation in the level of expenditure necessary. This gave rise to the need for process formulation in the study of quality costs. Manufacturing industry at that time was very labour intensive, focused on mass production volume and large batches, and was much more stable than at present. The current emphasis on quality cost has prompted calls for increased accounting involvement in the quality improvement process. The Traditional Cost Accounting (TCA) system has been used for many years as a decision-making tool to classify and record transactions in monetary terms. Traditionally, allocation of factory and corporate overhead costs to products based on their direct labour cost was not viewed as a difficult task. Also, product costs were not greatly distorted when overhead costs were allocated to products based on direct labour costs because the ratio of direct labour to manufacturing costs was relatively high. The industrial environment today changes so rapidly that the future is difficult to predict. Manufacturing industry is in many areas automated; it uses many advanced improvement tools, and emphasises quality awareness throughout the whole organisation to increase productivity and quality, thereby reducing costs (Cox, 1982, Horngren, 1990).

In assessing the viability of the Traditional Cost Accounting (TCA) method as a tool for quality cost information systems, many authors have expressed concern about its negative influence on operational decision making. Johnson and Lowe (1987) argued that TCA affected the accounting process, and resulted in its complete detachment from the operations of a business enterprise such that the accountants are often asked to work despite being ignorant of the nature of business processes in terms of quality costs.

Another shortcoming of TCA is that it will not provide management with an accurate cost of poor quality, the sources of those costs their allocation to a product or a process. Accordingly, management cannot identify the direction and magnitude of quality improvement opportunities. Information based on the TCA will not be useful in the justification of investment in quality improvement alternatives such as investment in prevention, appraisal activities or equipment. Therefore implementing Quality Costing with TCA will not be effective and efficient.
In summary, the major problems that hindered many potential users from implementing an effective and efficient QC system are summarised as follows:

- Cost effective quality improvement is limited by the inability of cost measurement system to trace quality costs to their source. This limitation hinders managers from identifying where the quality improvement opportunities lie.

- Quality is manageable only if it can be measured (IMA, 1993), and quality cost did not easily fit into the old accounting structure (TCA) (Feigenbaum, 1991).

- Accounting systems are unlikely to change radically to accommodate quality costing (Dale and Plunkett, 1991).

An important aspect of quality assessment is tracing quality costs to their sources. Unfortunately, due to the nature of TCA, it does not provide this ability. This makes it difficult to identify potential improvement strategies using TCA.

Another important aspect of cost management is assessing and managing the quality of both processes and product. Before a manager can manage quality the costs of quality, that is the “costs incurred because actual quality may, or does not, conform to designed quality” (Morse, 1983), must be identified and measured.

Unfortunately, TCA cannot be used to effectively identify and allocate quality costs (Prevention, Appraisal, Internal Failure, and External Failure costs), and this is an obstacle for effective implementation of QCIS. In fact, in TCA, these quality costs are instead ‘buried’ in a wide variety of other costs. For instance, TCA does not consider the allocation of costs to specific products, processes, and activities – lumping costs together with overheads.

Stickler (1991) argues that “left unchecked, the total costs of quality can easily go as high as 30% or even 40% of the cost of goods sold”. Similarly, a study of the Institute of Management Accountants (IMA, 1993) states that “in the 1980s, the cost of poor quality was estimated to be 10 to 20% of sales or two to four times the profit.
for an average company”. When one considers that the cost of poor quality may be
defined as the total cost of unplanned activities it is not hard to understand how they
can reach such proportions.

These problems necessitated the investigation of a method that will be both effective
and efficient in handling most of the quality issues. The next section discusses the
methodology proposed towards addressing these issues.

1.2 Research Objectives

The following can be identified as the main objectives of the research project reported
in this thesis:

1. To study the theory of quality costs and costing and its application to
manufacturing industries.

2. To examine the adequacy of traditional cost account systems in providing relevant
and useful quality cost information to allow quality improvement and cost
reduction.

3. To assess the potential of activity-based costing systems as an alternative to
traditional cost accounting systems in meeting the challenges presented by today’s
competitive environment, giving particular attention to the manufacturing sector
and the measurement and allocation of quality cost.

4. To propose and develop systems and tools for improved quality costing, and to
facilitate the concept’s adoption and implementation.

With these goals in mind, the following specific research questions were set:

1. Will the integration of ABC with QCIS Support Software enable manufacturers to
trace quality cost to their sources?
2. Can Activity-Based Costing yield better quality information as needed by a QCIS more effectively than TCA?

3. What hinders managers from identifying where quality improvement opportunities lie? And thus: Is there a model approach whereby managers can be guided through the various steps of failure detection and elimination to minimise overall quality cost?

1.3 Outline of the Thesis

The report is organised into ten chapters. Following this introduction, Chapter 2 provides a background literature review on Total Quality Management, and the specific and crucial role that the quality cost concepts play in its successful implementation. The successful implementation of TQM, and thus an organisation’s continuous improvement is the context within which this study was initiated and conducted.

Chapter 3 provides a detailed literature review on Quality Costing in general. After defining the concept, the applications of quality costing are presented. This is followed by the developments that have taken place within the techniques of quality costing, and concludes with the challenges it poses, and thus its critical success factors.

To allow for the effective design of a Quality Cost Information System (QCIS) that would satisfy both existing companies as well as companies in the developmental stage, it was deemed important to conduct an industrial survey. The main aim of the survey was to identify current practices regarding quality costing in industry. Chapter 4 presents the details of the study including the study objective and the study design, sample selection and survey instrument design. This is followed by an analysis of the participating organisations.
Chapter 5 presents the findings of the industrial survey undertaken and analyses the current company practices, future challenges and requirements, and concludes with specific findings that form the basis for the remainder of the study.

Chapter 6 presents the first proposed approach to tackle the problems highlighted so far, namely a graphical model of quality costing. A simple-to-use visual model is presented to facilitate the introduction of a quality costing system within organisations, and provide a simple communication tool to educate employees.

Chapter 7 presents the proposed integration of Activity Based Costing tools with the basic theory of quality costing to provide a system that can deliver valuable information. After discussing the shortcoming of the traditional cost accounting systems, the strengths of the activity based costing approach are assessed, and a model for building on them for a Quality Costing Information System (QCIS) is introduced.

Chapter 8 introduces the final piece of the puzzle, and the main tool for the application of a Quality Costing Information System (QCIS) within the organisation, namely the QCIS Software Programme. The basis of the QCIS programme, the logic behind it, and its design are all described. Samples of its application are also presented, and the programme is supported by a detailed ‘user manual’ in Appendix 1.

Chapter 9 provides a summary discussion of the research and the results. The overall conclusions from the study undertaken, and indeed, the lessons learned are then presented. This includes recommendations for the successful pursuit of the beneficial implementation of a quality costing system.

Finally, Chapter 10 offers several research proposals for further work and future research potential.
2.1 Why Is Quality Important

Human society has been dependent on quality assurance since the dawn of history. It has been an evolving concept from as far back as the 16th century BC, when a quality control concept was applied in China's handicraft industry as shown in Figure 2.1 (Juran and Gryna, 1988; ASQC, 1991).

![Diagram of China's ancient organisations for handicraft production and their interrelation (Juran, 1995)]

Today, our daily life depends upon the satisfactory operation of products and services. Furthermore, customers nowadays place a strong emphasis on value as well as price. According to Collins et al (1989) quality is what brings the customer back for a second or third time, and is the sign of competitiveness (Feigenbaum, 1991).

Quality assurance is not only applicable to product manufacture, but can be applied in all human activity. Error is possible, indeed some would say almost inevitable, especially in the absence of programmed error prevention. However, "the consequence of error is either that the result of activities is inferior to the aim or that
more effort must be spent in detecting the effect of the error and correcting them" (Groocock, 1986).

Quality is the driving force which keeps an organisation competitive in the business world today. Quality is no longer a drag on production but is essential for companies to survive. In fact, as Burman (1995) stated “quality should be a company-wide ‘way of life’ which encourages every employee to recognise that he or she can contribute to a culture that aims for perfection in design, manufacture and service to the customer. This is the TQM (Total Quality Management) approach which rejects the idea that quality is up to ‘them’ and accepts it is up to ‘us’”.

It is said that in buying a house the three most important factors are Location, Location, Location! It may also be said that the three most important factors to consider in achieving quality and competitive position are Customer, Customer, Customer! It is an essential goal in most organisations to achieve high customer satisfaction (Burns and Smith, 1991). In the 1950’s Deming taught the Japanese that the consumer is the most important part of the production line (DTI, 1991). The importance of quality nowadays accounts for an increasingly significant proportion of Gross National Product (GNP). For instance quality costs, in 1978, were “estimated by the UK Government to be £10,000 million, equal to 10% of the UK’s Gross National Product (GNP)”, and there seemed to be no reason to suppose that they were any less in the 1990’s (Dale et al, 1991).

The goal of competitive industry, as far as product quality and service is concerned, is to provide a product and service into which quality is designed, built, marketed and maintained at the most economical costs which allow for full customer satisfaction (Feigenbaum, 1991). However, for any business to remain competitive, the objective of that business should go beyond customer satisfaction.

When Japan dominated the world market through quality and price, the West perceived Quality as a key to that success and TQM as the vehicle to achieve it (Wilkinson and Willmot, 1995). Interest began in TQM and the related literature grew enormously, covering theoretical and practical aspects in almost every business sector. Recently, messages in the literature have become mixed, ranging from
regarding TQM as the only source of sustainable competitive advantage, to labelling it ‘Total Quality Management’ (Bermowski, 1995a). Many viewed TQM as part of a ‘Japanaization’ process, subordinate to the emergence of ‘quality circles’ and just-in-time manufacture (Tuckman, 1995).

Many companies were, and are, involved with TQM in one way or another. The Economist (1992), revealed that three quarters of companies in the UK and the USA reported having quality initiatives, while McKinsey & Co. (1989) revealed that 90% of chief executives reported that they enthusiastically supported quality initiatives and considered them critical to their organisations (Wilkinson and Willmot, 1995). However, despite the numerous quality-related programmes in Western organisations, some argue that there is little, if any, management commitment to using quality as a strategic advantage (Yavas, 1995).

The industrial model that dominated the world economies throughout the 20th Century is coming to an end. Today, we are living in a period of transformation; characterised by liberalisation, globalisation and integration of markets for goods, services, and capital. The industrial revolution has given way to the knowledge revolution. In the last few decades, knowledge has accumulated and increased, innovations have been occurring at an unprecedented rate, competition for technology and markets has intensified, and customers are more educated and more demanding than ever. The three giant industries, namely Information Technology (IT), Computing and Communications are converging to create a technological revolution that is turning the world into what has come to be known as ‘a global village’ (Peters, 1994). This has opened doors to the information world, global markets, worldwide customers and products, global services, all going beyond and across political and geographical boundaries. Change is affecting everyone and pushing organisations, and individuals, into a new world of collaboration, speed, and innovation. Organisations are now pushed into setting up a new network of dealings within the context of laws and standards that require a completely overhauled way of individual and organisational thinking and behaviour. It would be foolish to imply that change itself is new to the organisational world, but it is important to understand that its characteristics are markedly different from the past. The scope and pace of change are occurring at an unprecedented rate. It has been estimated that “over the course of the coming decade,
as much change and upheaval is predicted as was experienced during the past 100 years” (Peters, 1996). In such an environment, windows of opportunities open and close before many firms realise they had opened.

In the past business management’s most important trend was to increase production volume rather than quality of product. However, the situation has changed due to the scale of manufacturing, distribution and provision that has expanded, and competition, which has made it easy for buyers to choose what they want at any time. Stephen (1991) indicated that the only way to meet the challenge is to embrace a quality strategy based on the voice of the customer, which aligns and integrates with the business strategy. Therefore, the winners will be those that are capable of accomplishing faster and routinely discovering and implementing ways to provide products and services, which go beyond meeting their customer’s expectations.

Today, there is vertical integration, mergers, new technologies, diagnosis related groups, stockless or just-in-time distribution, captivated contracts, preferred provider organisations, TQM, continuous improvement, business reengineering, and so forth. To survive into the next decade, organisations need to re-think their structures, products, processes, and markets. They must re-establish themselves to be quicker to market, customer focused, innovative, nimble, flexible, and be able to handle rapid change. The future trends that will drive organisational success are (Falconer, 1996; Peters, 1996; Collins, 1989):

1. Growth – organisations should target growth as a main strategy. The cost-cutting era that organisations went through in the 90’s was an aberration and achieved its goals by streamlining organisations (eliminating bureaucracy, optimising IT power, and flattening the organisational structure). The basic ethic of business is growth. In the early 90’s we got frantic calls about the need to cut; now we are getting calls about how to take a new product to market (Falconer, 1996).

2. Quality – wealth in the new regime will flow directly from quality. The premise that ‘quality is a sign of competitiveness’ is substantiated by two facts clearly visible in today’s organisational environment. Firstly, customers nowadays shop more for value than merely for price desiring goods and services that will perform
as specified, be of a durable nature and fulfil their perception of what they need (Peters, 1996).

Secondly, if Quality truly is doing the right thing right the first time, it is obvious that it will enhance productivity. While Quality is the key to satisfying the customer’s needs, and productivity is the key to economic competitiveness (Collins, 1989).

2.2 What Is Quality

Quality is the driving force, which keeps an organisation competitive in the business world today. It must be defined in such a way as to be useful to management, so that the assessment of quality, which is the true need of the customer, can be recognised (Feigenbaum, 1989). Central to the concept of TQM is rejecting the common sense usage of ‘quality’, and the assumption that quality means goodness, or luxury, or shininess, or weight. The following set of definitions encompass how the major quality gurus define quality:

- Quality is simply about meeting customer requirements and current and future expectations (Dale and Oakland, 1991).
- The total composite product and service characteristics of marketing, engineering, manufacture, and maintenance through which the product and service in use will meet the expectations of the customer (Feigenbaum, 1991).
- The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs (BS 4778, 1987).
- Fitness for use (Juran, 1993).
- Quality is a predictable degree of uniformity and dependability at low cost and suited to the market (Deming, 1986).
- Quality is the (minimum) loss imparted by the product to society from the time the product is shipped (Taguchi, 1985).
- Quality is conformance to requirements (Crosby, 1979).
These definitions all have one central theme, which is meeting customer needs. The definition of quality has evolved over recent years. The traditional view of conformance to the organisation’s specification was first replaced by conformance to the customer’s requirement (Crosby, 1979). This was an important breakthrough, as it highlighted the point that quality is what the customer says it is, not what the organisation would like to think it is. The definition of quality then evolved to being regarded as “fitness for purpose” (Juran et al, 1988). The importance of quality to a firm’s long-term success is well acknowledged. This was an important step in the evolution of the definition of quality as it implies knowledge of the need that customers wish to satisfy and hence, considering these demands will allow the organisation to better fulfil the customer’s requirements. This led to corresponding improvements in customer satisfaction, and marked the beginning of organisations behaving pro-actively to satisfy customer needs and expectations.

The definition of quality which emerged was the satisfaction of customer needs, wants and expectations at competitive cost (Hutchins, 1991). By explicitly mentioning the un-stated demands of customers, this definition improves on the “fitness for purpose” definition in implying the need for organisations to determine what customers actually want and then strive to match this expectation, and equally as important, the need to achieve this efficiently.

However, the definition of quality is not static and will continue to evolve further with time. One expected evolution is cited as ‘fitness for corporate culture’, which means the manner in which the entire organisation will become focused on supplying the products that the organisation has decided to manufacture. Another is fitness for community needs and the global environment. This improves the organisation’s effect on its geographical surroundings and the environment of its customers and employees (Shiba et al, 1993). Another aspect of significant importance is that customer needs, wants and expectation increase with time (Juran et al, 1988). It follows that the quality of design and quality of conformance must be continuously improved.

There are two main aspects to quality; quality of design and quality of conformance. Quality of design is how well a given product concept meets customers’ needs, wants,
and expectations. Quality of conformance is how well the design is transformed into
the actual product. These two aspects are equally important, measurable, and
manageable and can always be improved (Juran et al, 1988; Ishikawa, 1985). The
understanding that the measurement, management and improvement of these two key
aspects of product and process quality are possible has resulted in the rise in
importance of quality management in recent years. It is achieving this that is the goal
of modern quality management.

2.3 Total Quality Management

2.3.1 TQM Definition

TQM is a business philosophy founded on customer satisfaction. It aims at building
‘quality’ into every aspect of organisational work by reforming all systems and
interactions to exemplify a commitment to a continuous business improvement
philosophy. The idea behind TQM is that quality does not just happen, it has to be
managed, throughout the organisation, and it is everyone’s job (Wilkinson and
(a) stresses the need for a systematic continuous improvement strategy: “... efforts
should be directed towards constantly seeking opportunities for improvements, rather
than only waiting for a problem to reveal an opportunity” (BS 7850 Part 2, 1992).
The core of the TQM concept is the idea of internal and external customers/suppliers
forming a series of quality chains. Any failure of one of these to meet its immediate
customer requirement finds its way to the organisation’s outside customer (Oakland,
1993). TQM’s main conviction is that it is possible to achieve defect-free work, and
has been given names like ‘zero-defects’, ‘working smarter’, or ‘right first time’. It
comes from the emphasis on prevention, the aim of all quality assurance (Bank,

The definition of TQM (Total Quality Management) can be divided into three parts;
Total, Quality, and Management.

Each of the previously given definitions of quality holds a strong meaning, albeit a
possible limited vision of quality. However, the word Total is very important in the
expression of TQM because it implies the involvement of every function and every person at all organisational levels. A particular feature of competitive and successful Japanese companies is their appreciation of the interactions between each person and each activity (Burns and Smith, 1991). The word **Management** describes a process (Robert and Flood, 1993) of monitoring, measuring, and improving, and does not necessarily refer to company managers only. TQM in a nutshell is “all of those actions taken by an organisation, to assure that the customers ever changing expectations are met or exceeded” (ASQC, 1995). It has also been stressed that although ‘quality’ is everyone’s work, the final and main responsibility to make sure it happens lies with the organisational top management. “Management is ultimately responsible for establishing quality policy and for decisions concerning initiation, development, implementation and maintenance of the quality system” (ISO 9000, Part 4). Bendell (DTI, 1991) noted Crosby’s belief that senior management is entirely responsible for quality. According to Deming (ASQC, 1989) over eighty percent of all quality problems are related to improvement, effectiveness and efficiency in the design of products and processes whilst less than twenty percent are caused during their execution.

### 2.3.2 TQM Concept

The primary objective of TQM is the improvement of the effectiveness, flexibility, and competitiveness of an entire business (Dale and Oakland, 1991). To this, of course, should be added profitability. Total Quality Management has generally been recognised as a major innovation in management thought and has gained widespread acceptance in business and industry (Oakland, 1993). The benefits of TQM have been outlined in the academic as well as the popular press (Dale and Oakland, 1991).

Throughout the vast literature on the topic, almost all the authors and practitioners who discussed TQM presented their own approach. All these approaches contained the same concepts narrated in different ways, and had the same core concepts with relatively similar structures.
The model developed by Oakland (1993), shown in Figure 2.2, is one of the most comprehensive, and will be used here as a skeleton for a TQM preview. The core of the model is the customer-supplier relationship, externally and internally. This is surrounded by two types of foundations; soft (commitment to quality, communication of the quality message, and culture change) and hard (systems, tools, and teams). The following section will present an overview of TQM's main components.

![Figure 2.2 Total Quality Management Model (Oakland, 1993)](Image)

### 2.3.3 Building Blocks of the TQM Model

#### 2.3.3.1 Commitment and Leadership

One of the biggest challenges of TQM is creating a total quality company culture, since the effectiveness of an organisation depends on the degree to which its people and resources are focused and move towards the same objectives and goals (Bank, 1992). The highest rate of success with TQM comes from organisations in start-up time or near to death because both cases find it 'less difficult' to mould the organisational culture towards TQM (Brown et al, 1994). In acknowledgement of the
importance of the organisational culture in TQM, many like Oakland (1993) placed more emphasis on the 'human' side of TQM than the early quality gurus. Oakland (1993) called for establishing a vision framework (guiding philosophy, core values and beliefs, purpose, and mission) that, if adhered to, will eventually mould the organisation's culture. In that context, Drummond (1992) stressed the need to move from human resource management, to managing and developing resourceful humans, and finally to resourceful human managing, i.e. developing resourceful humans and enabling them to manage. The main vehicles to achieve a total quality culture are commitment, leadership, and empowerment.

**Commitment** - This is the main key success factor for any TQM initiative. It must start from the top in a clear and visible way, and be infused and demonstrated within the ranks of middle management who in turn spread it to the lower level and so on (Mortiboys and Oakland, 1991). It is best achieved by involvement. The first step in showing commitment is formulating and publicising a quality policy, which is a fundamental requirement for any TQM programme. It should be a statement from the very top management to show commitment to quality, and dedication to continuous improvement (Oakland, 1993).

**Leadership** - Without leadership from management, TQM will not be taken seriously by the workers. Effective leaders help others do their jobs better, and derive pleasure, not from making the decision, but from assuring that the best possible decision is made (Brown et al, 1994; Manley and Manley, 1996). A successful leader is able to rally people around the vision, create and sustain a climate for teamwork, be a motivator, an excellent communicator, and a role model for TQM.

### 2.3.3.2 Communication

TQM will incorporate many changes in the way organisations operate, and for successful implementation these changes must be communicated by top management directly and clearly to all employees. The communication strategy for TQM should deal with the technical aspect and the human and organisational side (Oakland, 1993). The main basis of any successful communication strategy is to maintain 'open'
communication at all levels: maintaining open offices, managers being accessible to staff, and taking part in day-to-day interactions between employees. Communication can be verbal (direct and indirect), written, visual, or by example. Each type has its own advantages and drawbacks, and careful selection of which type or combination of types to use should be based on the objective of the communication and on the targeted audience (Strantton, 1995).

2.3.3 Culture

Innovation in TQM - Innovation, the main pillar of reengineering, is seen in TQM literature in a slightly different light and has a different emphasis placed on it. It is both the invention and design of radically new products and services, using new ideas and advanced technologies, and the continuous improvement and development of existing products, services, and processes to improve their performance. Thus it entails both the radical discovery concept and continuous improvement (Oakland, 1993). The TQM literature mainly views innovation as product rather than process related, and concentration is focused on continuous improvement rather than innovation in processes. This does not mean that TQM prohibits innovation. Many practitioners like Early and Godfrey (1995) believe that the aim of TQM is to produce rapid breakthroughs and not just incremental improvement, and note that when Juran published his work on quality improvement processes 30 years ago, it was entitled ‘Managerial breakthrough’, thus the failure of TQM to produce rapid breakthrough results is in its implementation and not in the fundamental process.

Empowerment - The concept of involving everyone in the quality process has been advocated by many (Oakland, 1993; Hill, 1991) to such an extent that it can be argued that all employees should be incorporated into the decision-making process in the organisation. At the heart of employee participation concepts is ‘empowerment’ which is where responsibility for quality is pushed down the organisation to the point of production. In effect, this makes those people who actually perform the work responsible and accountable for the quality of the outcome to their customers (internal or external) thus eliminating the need for direct control. Employees are empowered and given extra responsibility, but they have to be trained and given the required
resources, and to truly empower the employee, the company has to focus on continuous education (Bemowski, 1995b). Brown et al (1994) noted that only ‘true’ and full empowerment, like self-directed teams where power is truly shifted, would lead to performance improvement.

Alongside the concept of ‘empowerment’ is ‘disempowerment’, where a ‘power raise’ for the not so powerful must be at the expense of those who have more power (Lammers, 1991). This is simply not considered by many TQM advocates and seen as unproblematic when it is considered, while studies show that major supervisor or middle manager resistance comes from just that (McArdle et al, 1995). However, leaders must not let go of their responsibilities, as this will result in abdication rather than empowerment. Empowerment does not mean leaving employees alone too much or not giving them support when there are tough decisions to be made.

2.3.3.4 Teams

**Teamwork** - As shown in the structure for TQM (Figure 2.2), teams are one of the cornerstones of TQM. For successful TQM, teams must be cross-functional (as opposed to some quality circles, which proved unsuccessful (Oakland, 1993)), and from all levels of employees, and teamwork must be driven by a strategy. Other factors required for effective teams include training, leadership, facilitation, and behavioural analysis (Oakland, 1993; Bank, 1992). One of the biggest causes of failed quality initiatives is poor teamwork (Beck and Yeager, 1996), and a successful team usually has clear objectives and agreed goals, openness, trust, co-operation, and individual development opportunities (Oakland, 1993; Beck and Yeager, 1996). Care should be taken to avoid some problems usually associated with the teamwork approach (Oakland, 1993; Beck and Yeager, 1996): firstly is the fact that some organisations form the teams just because it is fashionable. They remain on paper, hold useless meetings, and people do not improve. Secondly is that some teams are formed and start to solve problems without proper teamwork training: enthusiasm, outrun ability, and the focus becomes analytical tools. Beck and Yeager (1996) warned against becoming too much oriented towards teams to the extent that ‘nothing can be done by individuals’. It should not take a team to change a light bulb!
Structure for Quality - It has been shown (Brown et al, 1994; Numerof and Abrams, 1994) that what is set down on paper about the organisation does affect people’s behaviour, thus, having a clear cut quality department, as is the usual case, will take away the responsibility for quality in each person’s work and put it in the hands of an army of inspectors and testers and create a ‘parallel process’ of quality function bureaucracy, which leads to no one in the ‘line’ being accountable. Normally the responsibility should be in the hands of the person doing the work, and this is what TQM advocate. Oakland (1993) and Brown et al (1994) go further to argue that the very title ‘quality manager’ is not desired since there is no way one person or one department can manage quality alone, but one person, the CEO must take the responsibility.

In TQM most of the organisational structure is team based, and a typical one will include (Oakland, 1993):

**Quality council** - chaired by the CEO, this group meets at least monthly to review strategy, implementation progress, setting plans, and improvement.

**Quality steering committee** - could be the same as the council in small companies, and is responsible for the quality improvement teams, selecting projects, providing project outlines, and monitoring.

**Quality improvement teams** - “a group of people with the appropriate knowledge, skills, and experience who are brought together by management to tackle and solve a particular problem, usually on a project basis. They are cross-functional and usually multi-disciplinary” (Oakland, 1993).

**Quality circles** - “a group of workers doing similar work who meet voluntarily, regularly, in normal working hours, often under the leadership of their supervisor to identify, analyse, and solve work related problems to recommend solutions to management” (Oakland, 1993). From the Japanese experience, quality circles can achieve excellent results, and were by far the most publicised aspects of the Japanese approach to quality. Yet, on application in the West, many failures have been reported and much criticism and disappointment surrounded the concept.
Throughout the TQM philosophy there is no direct responsibility for a certain group to come up with the improvement projects, this is the responsibility of every group and they are all encouraged to take on the functions of a self-managing unit (set direction, design unit and context, manage and monitor, and execute work) (Bank, 1992).

**Reward and Recognition System** - A reward and recognition system for positive reinforcement to maintain achievement and continuous improvement is essential to a company’s TQM programme. It is desirable to try and introduce and sustain the TQM initiative without direct financial incentives. It is, however, possible to introduce reward and recognition in the context of the pay structure, provided that the motivational impact of the incentive does not undermine the total quality initiative (Oakland, 1993). Overall, TQM should be accompanied by a strategy to achieve a reward structure that does not conflict with it. Such a system would incorporate (Oakland, 1993; Weber, 1995):

1. Reducing the proportion of earnings flowing from an incentive bonus.
2. Moving from individual or very small group schemes to larger group schemes.
3. Introducing multi-factor schemes that balance the volume emphasis against some measures of quality or quality improvement.
4. Avoiding performance appraisals - performance appraisal processes inherently undermine co-operation and teamwork and create fear and mistrust in the workplace. It is a tool for ‘control’ and defies the empowerment concept.

**Training for Quality** - Training is the most important factor in successful implementation of TQM. “Investment in people and training are probably the two most important elements in achieving TQM” (BS 7850, 1992). It should occur at all levels of the organisation (Oakland, 1993) and should establish and maintain procedures for the identification, documentation of the training needs, and the provision of the actual training itself for all its personnel. A famous training approach is the ‘Waterfall’ approach used by Motorola, Digital, and others, where training starts with top managers who train their direct subordinates and this cascades down to reach every employee in the organisation. Brown et al (1994) warned that training will fail if it is: not tailored to its audience, people doubt the company’s commitment,
if it does not start at the top, or lacks follow up. Training 'follow up' in the early stages is essential to maintain commitment and continuous improvement. “Although few people and organisations have actually made the connection, the ultimate objective of TQM is to create a learning organisation, within an environment that encourages continuous learning, making mistakes, and taking risks” (Brown et al, 1994).

2.3.3.5 Quality System Design, Contents, Documentation, and Assessment

A quality system is an assembly of components such as the organisational structure, responsibilities, procedures, and processes. An effective TQM programme requires full documentation of this quality system to ensure that the customer's requirements are clear, that the supplier has the capability to fulfil them, and all the resources are available at an optimum cost (Oakland, 1993). When documenting, many TQM “gurus” advocate designing the system to meet and conform to the requirements of an internationally acknowledged and proven standard, usually ISO 9000, which requires organising the quality system into a quality manual and quality procedures. One drawback, from the TQM perspective, is that the ISO 9000 series specify the requirements for quality systems designed to generate products and services that meet the agreed specifications thus addressing a limited number of activities, e.g. the prescribed quality manual will not address the Personnel or Accounts departments as a requirement, while TQM requires that the documented system should be completely comprehensive and include every activity of the organisation. Once the system has been documented and in operation, the organisation needs a method to ensure error prevention by checking the system, and error/defect investigation and follow-up. The main method in use here is “quality audits” whereby an auditor looks for system strengths and weaknesses, and main areas of risk, investigates errors found to provide information on their causes, notifies related people to take corrective action, records the outcomes, and reports to everyone involved to prevent their re-occurrence (Oakland, 1993).
2.3.3.6 TQM Tools

Design for Quality - As quality has been defined as meeting the customer requirements, the natural first step is to fully determine these requirements. The customer requires, and will consciously or unconsciously ask for the five dimensions of quality: specification, conformance, reliability, value, and delivery (Bank, 1992). The heart of TQM is the notion that customers are not only external to the company (person who is the end user of the product/service) there are also the internal customers (person inside the company who receives the work, adds contribution and passes it along). If the internal customers' requirements are agreed and met, a chain of quality is made that reaches out to the external customer. Once customer requirements have been determined, the organisation must ensure they are fulfilled and start by designing their products/services for quality. A quality design is defined as one that takes care of all the customer requirements (cost, production, ease of use, maintainability, etc.).

A recommended approach for design and design management is Quality Function Deployment (QFD) or the 'house of quality'. QFD designs quality throughout each stage of the development process, and aims at satisfying the customer by translating their needs into design targets and major quality assurance points to be used throughout the production stage (Akao, 1990). The design process itself has to be managed and controlled by having a clear time plan, documented procedures, trained designers with the right resources, clear identification of design input and output requirements, and a design review procedure.

Measurement for Quality - Until now, it has been difficult to find a universally accepted definition to TQM, which made it difficult to use one framework, or standard way of assessing and calibrating the performance of any organisation towards TQM (Oakland, 1993). This is still an area where research is being done, and the outcome, in the form of a set of criteria against which a company can assess its progress will be most valuable. Currently, the most famous sets of such criteria include the Deming Prize criteria, and the Malcolm Baldridge National Quality Award (MBNQA).
In a TQM system, where the aim is never-ending improvement, measurement plays an essential role in identifying opportunities for improvement and comparing performance against internal and external standards. There is no one correct generic list of what to measure and the measures required should satisfy the reasons for establishing them, and people who own the process and are responsible for its improvement should decide what needs to be measured. However, for a successful TQM programme, three areas should be subject to measurement: human, technical, and business components (Oakland, 1993). Measures may include, output or input measures, economic data, customer satisfaction, employee satisfaction, operational measures, etc., and the whole system must be designed to measure progress in five major areas: effectiveness, efficiency, productivity, quality, and impact (Oakland, 1993; Brown et al, 1994).

A very powerful tool in this context is benchmarking. This concept of comparing one company’s performance with another is a reflex of TQM and entails continuously assessing one’s own company and others to discover the best practices, build knowledge, and bring that knowledge to the company. Benchmarking is a continuous process, linked to TQM clearly by the fact that it establishes objectives based on industry best practices and should directly contribute to better meeting customer requirements (Oakland, 1993; Bank, 1992). It takes place along the three components of a TQM programme (Bank, 1992): products and services (to external and internal customers), business processes and procedures, and people (culture, skills, organisation). From their experience with AT&T, Lincoln and Price (1996) noted that for successful benchmarking, the study should be done quickly, choosing a broad-and-shallow or narrow-and-deep scope, and avoiding the best-in-class fallacy.

Overall, much controversy and discussion surrounded the topic of ‘how to measure TQM’s success’ and many authors avoided it altogether, while others stated the results of TQM case studies without concluding how they arrived at them. However, the success of any change programme (including TQM) may be measured on a number of dimensions such as business measures (increased market share, profits), customers (reduced complaints, increased satisfaction), output (less defects, claims, etc.), suppliers (better liaison, reduction of total cost of dealing), inputs (fewer defects), inside organisation (clearer leadership, internal process improvement), and
people (morale, job satisfaction, content staff, teamwork). A common pitfall is measuring the 'wrong' indicators, like the number of training hours per employee or number of suggestions made, and so on. While easy to measure, these indicators are ineffective and should be replaced by something like percentage of individual training plan objectives met, number of suggestions implemented, etc. (Brown et al, 1994). Finally, a highly successful measure for quality efforts is the cost of quality.

**Costs of Quality** - The costs of quality are all those incurred in achieving a quality product or service. These include (Bank, 1992; Mortiboys and Oakland, 1991):

1. **Cost of conformance:** Prevention costs (e.g. costs of design, implementation, and maintenance of the quality system, training, planning, etc.) and appraisal costs (e.g. inspection, checking, and auditing).

2. **Costs of non-conformance:** Internal failure costs (costs of failures to reach designed quality standards that are detected before transfer to the customer (e.g. scrap, and rework); External failure costs (costs of failures to reach designed quality standards that were not detected until after transfer to the customer such as warranty, or unplanned field service); costs of exceeding customer requirements (such as unread reports, redundant documents, unwanted sale calls that add nothing to competitiveness or profitability)

Quality costs are a true measure of the quality effort, and can be seen as a method for assessing the effectiveness of quality management, and as a means of determining problem areas, opportunities, savings, and action priorities (Oakland, 1993). Many efforts to establish a quality costing system have not achieved their goals, due to the fact that quality costing cuts across the usual accounting methods. Moreover, many companies notice an increase in quality costs when they measure them for the second or third time, and relate this to work deterioration or TQM failure. The fact is that a quality costing system, like any other process, is subject to a learning curve, and it is usual that in the second and third time of measuring them, the system and people using it have improved and were able to capture more sources of costs (Oakland, 1993).
Note that the quality costs are discussed in further details in Chapter 3.

**Tools and Techniques for Quality Improvement** - In the quest for continuous improvement, numbers and information provide the basis for understanding, decisions, and actions. Thorough data gathering, recording, analysis and presentation in a systematic way is essential. There are many tools available for such tasks, and Table 2.1 provides a list of some of the tools most regularly used (Oakland, 1993; Bank, 1992). Which tools to use and when depends on the complexity of the situation and the aim of the use. Using these tools does need formal training and their effective use requires their application by the people who actually work on the processes (Oakland, 1993).

**Table 2.1: Quality Tools (Oakland, 1993; Bank, 1992)**

<table>
<thead>
<tr>
<th>Tool</th>
<th>Basic use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process flowcharting</td>
<td>what is done</td>
</tr>
<tr>
<td>Check sheets/tally charts</td>
<td>how often it is done</td>
</tr>
<tr>
<td>Histograms</td>
<td>what do overall variations look like</td>
</tr>
<tr>
<td>Scatter diagrams</td>
<td>what are the relationships between factors</td>
</tr>
<tr>
<td>Stratification</td>
<td>further analysis of the scatter diagrams, how is the data made up</td>
</tr>
<tr>
<td>Pareto analysis</td>
<td>which are the major problems</td>
</tr>
<tr>
<td>Force-field analysis</td>
<td>what will obstruct or help the change or solution</td>
</tr>
<tr>
<td>Emphasis curve</td>
<td>which are the most important factors</td>
</tr>
<tr>
<td>Control charts</td>
<td>which variations to control and how</td>
</tr>
<tr>
<td>Failure mode, effect and criticality analysis (FMECA)</td>
<td>what are the possible modes of failure and their effects on the performance of the product or the operation of the service system</td>
</tr>
<tr>
<td>Statistical process control (SPC)</td>
<td>is the process capable of meeting the requirements now and at any point in time, and what adjustments to make when it is not.</td>
</tr>
<tr>
<td>Measuring quality with time (reliability)</td>
<td>the ability of a product to function satisfactorily over a period of time</td>
</tr>
<tr>
<td>Quality Function Deployment</td>
<td>to integrate customer requirements in the product/service design.</td>
</tr>
<tr>
<td>Poka-Yoke</td>
<td>a quality management technique aiming at a Zero quality control production system, in which no errors are produced.</td>
</tr>
<tr>
<td>Taguchi methods</td>
<td>‘quality engineering’ to reduce costs and improve quality simultaneously.</td>
</tr>
</tbody>
</table>
2.3.3.7 A Process for Quality Assurance (QA)

There are as many varied definitions of quality assurance of which the following may be taken as representative:

- All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy a given requirement for quality (ISO 9000, 1994).
- All those planned and systematic actions necessary to provide adequate confidence that a structure, system or component will perform satisfactorily in service (BS 5882, 1987).
- A management system designed to give the maximum confidence that a given acceptable level of quality is being achieved in a product or service with a minimum total expenditure (Progerson, 1986).

All these definitions emphasise that Quality Assurance is the activity of providing the evidence needed to establish confidence, among all concerned, that the quality function is being effectively performed. However, the third definition stresses that quality should be achieved with minimum cost, also it emphasises on achievement at an acceptable level of quality. Nowadays achieving an acceptable level of quality is not enough for any business to survive. To be in a competitive position an organisation should aim to exceed the expectation of the customer. Customer concern is about value as well as price. From this point of view, research emphasis is placed upon the costing aspects of quality assurance with quality being achieved at minimum cost. Quality Assurance was initially based on inspection (Supper, 1975). The word inspector was derived from the Latin word “specare” which means to look into something. With the arrival of the industrial revolution that brought problems to the manufacturing industry, the breakdown of assignment responsibilities for quality practitioners became divided. This made it necessary to have “checkers”. A checker normally was a foreman who would be responsible for spotting defects and separating good product from bad product.
After World War I, production increased and manufacturing companies became more complex. Therefore, it became important to have full time employee inspectors which later developed into Quality Control Departments. In the 1940’s, statistical methods of sampling and inspections were introduced principally to reduce the amount and cost of inspection effort whilst retaining a measure of the risk. The inspectors, using a statistical method for quality control, were responsible for ensuring product specification. Their influence was localised to the shop floor and did not embrace the total company (Supper, 1975). The inspection departments began to consider the cost of defective products, and to find ways of preventing or reducing problems. This thinking enabled them to make critical comments on design and checking devices and to use information in a feedback and improvement process.

A new word, “Quality”, came into the inspector’s vocabulary. It became apparent that the title ‘inspector’ was too restrictive and the title “Quality Assurance Engineering” was born (Supper, 1975). In the 1970’s the British Institution of Engineering Inspection changed and became known as the Institute of Quality Assurance ((Khan and Hashim, 1983). Quality Assurance plays a vital role in providing protection against quality problems before the event. For instance early warnings play an important role in the prevention of internal and external failures (Juran and Gryna, 1988). It is intuitively obvious that, in almost all cases, prevention activities will be more cost effective than reacting to failures.

A commitment to Quality Assurance will change the way things are done at present and require that discipline be imposed on the whole of an organisation from the top down. Quality Assurance comprises the following concepts:

- Quality Audit (internal and external)
- Quality System
- Quality Survey
- Product Audit
The main purposes of Quality Audits are to enable the manufacturers to evaluate their own quality performance and the performance of their suppliers. The aim is to have independent assurance that will contain the following points:

- Products are safe for the user and fit for use.
- Regulations standards are followed.
- Specifications are fulfilled in design.
- Deficiencies are identified and corrective action is taken.
- Opportunities for improvement are identified.
- The QA system is maintained and effective.

The usual purposes of a Quality Survey are to provide a broad and strategic view and give answers to upper management on some vital questions that were missed by audits.

- To discover where the company wants to be with respect to quality.
- To discover where the company is now with respect to quality.
- To recommend plans and policies which can economically move the company closer to its objectives.

These factors are among those for which appropriate performance measures, possibly costs, are required. The definition and purposes of Product Auditing are to determine fitness for use and conformance to specification, and is, again, looking at factors for which performance measures are crucial. It is also an independent evaluation of product quality. It includes:

- Estimating the level of quality and delivery of goods and services to the customer.
- Evaluating the effectiveness of the inspection decision.
- Providing information useful in improving the outgoing product quality level.
- Providing additional assurance beyond routine inspection.

In conclusion therefore, the secret to a successful integrated quality management programme is the selection, development, implementation, and deployment of proper
Quality Assurance followed up with the development of specific and prescriptive quality plans (ASQC, 1995).

2.4 Quality, Quality Costs, and Organisational Profits

One of the primary objectives of quality management is a series of performance standards which satisfies customers requirements at minimum cost. TQM can help organisations lower costs and improve profits. Any business should have two quality objectives which are:

- To supply goods or services to customers according to their requirements.
- To minimise total quality costs (Groocock, 1986).

The implementation of TQM can have a profound effect on Quality Costs. These quality costs can be expected to provide potential benefits whilst the analysis of Quality Costs can lead to the setting of realistic goals for the TQM programme. Total Quality Costs were estimated to be between 5 and 25% of an organisation’s turnover (Granja et al, 1993). For many decades there was widespread belief that to establish a better quality programme required much higher costs. This understanding of the directly proportional relationship between quality and costs was a mistaken notion. Furthermore, poor quality can be a result of unsatisfactory resource utilisation; for instance waste of labour, equipment time and material, consequently involving higher costs. As Feigenbaum noted (1991), “Satisfactory product and service quality goes hand-in-hand with satisfactory product and service cost”.

Since 1950 the relationship between Industry and Customer has changed. Customers have demanded high quality products, and as a result industries are required to address how to improve quality. Quality costs have thus become a serious matter for both manufacturing and services industries. In 1991, Dale and Plunkett noted that, “Quality costs have become very high. For many companies they may be much too high if these companies are to maintain and improve their competitive position over the long run”.

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Quality assessment and evaluation of quality costs should take place throughout the entire industrial cycle. The traditional Quality functions used in the past identified four elements of Quality Costs namely Prevention, Appraisal, Internal Failures and External Failures. Typically, appraisal and failure had the highest costs and the cost of prevention was the smallest. Once the cost associated with appraisal and failure has risen, it is very difficult to reduce them. However, tackling failure and appraisal costs leads to an increase in prevention costs (ASQC, 1974).

![Figure 2.3: Increasing prevention decreasing failure – Quality Costs Concept](Adopted from ASQC, Larson, 1991)

Prevention costs are included in making the product right first time, in other words they prevent defects from occurring in the first place. As a result of increments in prevention costs a substantial cut in failure cost, and appraisal costs should take place, as illustrated in Figure 2.3. As discussed later, this model is not properly representative of the cost and quality relationship in a TQM environment, (see figure 3.4).

Thus a reduced number of defects means reduced inspection (appraisal), costs and also reduced customer problems, therefore, in general there will be better quality at a reasonable price (Feignebaum, 1956; Schottmiller, 1996). In many cases, quality assessment identified failure and appraisal as carrying the highest proportion of costs with 95% of quality cost being spent on appraisal and failure (Dale and Plunkett, 1991).
Feigenbaum (1991) noted that “it would not be far wrong to assume that internal and external failure costs may represent about 65 to 70 cents of every quality-cost dollar and appraisal costs probably range in the neighbourhood of 20 to 25 cents. In many businesses, however, prevention costs probably do not exceed 5 to 10 cents out of the total quality-cost dollar. Reducing failure costs can be achieved through co-operation between buyer and suppliers. The adoption of a successful Quality Cost Management system falls under the umbrella of TQM, and thus must be clearly defined and measured. Quality costs should be regularly monitored and reported to management; the quality cost system itself must be monitored and reviewed regularly for its effectiveness”.

However, before attempting to discuss the concept of quality costs (Chapter 3), and thus discuss quality costs information systems, it is important to understand the main ethos of Quality costs, the effects of Quality on organisational profits, and thus the importance of a Quality Costs Information System, and the main building blocks of a generic Management Information System.

It would seem almost intuitive that there is a direct relationship between quality and profits. Higher quality reduces the “scrap and rework” cost of defective units, and has the potential to increase market share and revenue. It is axiomatic that any activity that reduces cost and increases revenue will necessarily have a positive impact on profits (Elshazly, 1999).

An analysis by Deloitte and Touche (1993) of 20 studies on quality concluded that “TQM is having a widespread, generally positive impact on organisation performance, that non-financial measures of performance are affected first, followed by a variable but often substantial impact on financial measures of performance”.

Elshazly (1999) noted that “the majority of quality costs are associated with conformance rather than design, businesses should focus on ways to reduce these types of costs in order to increase profitability”. Quality costs (discussed in 2.3.3.5) generally are classified into four types (Oakland, 1993; Elshazly, 1999):
1. Prevention costs – the costs incurred to prevent the production of defective products and services. Quality engineering, quality training, quality circles, quality systems, preventive equipment maintenance, and supplier evaluations are examples.

2. Appraisal and assessment costs – those costs incurred to detect defective products or services. Inspection planning, inspection of incoming materials, product tests, depreciation and maintenance of test equipment, and supplies used in testing and inspections are examples of appraisal costs.

3. Internal failure costs – those costs incurred in fixing defective products before they are shipped to customers. Costs of spoilage and scrap, rework, the disposal of defective products, and downtime due to defects are examples of internal failure costs.

4. External failure costs – those costs incurred to rectify defects discovered after the product has been delivered to the customer. Warranty repair, service calls, product recalls, returned products, product liability lawsuits, and lost sales due to poor quality are examples. Costs in this category can be very large.

Prevention and appraisal costs are known as conformance costs, i.e., they are the costs incurred by the business to assure that defective products are not produced. Internal and external failure costs are known as non-conformance costs because they involve the cost of having to deal with products or services that fail to “conform” to the goods/services design.

There is an obvious trade-off between prevention and appraisal costs and internal and external failure costs. The underlying premise is that the costs of failure exceed the costs of prevention. This trade-off also suggests that savings in failure costs should be more than sufficient to offset any increase in prevention costs. In addition, with the success of prevention efforts in reducing defects, long-run prevention costs will stabilise and require little to no additional spending. It is generally accepted that for a TQM or other quality improvement program to be effective, four things must occur (Elshazly, 1999; Greising, 1994):
1. Quality goals must be established and incorporated into company budgets.
2. Quality performance must be measured, analysed, and evaluated.
3. Quality accomplishments and failures must be reported to all concerned.
4. The reward system must provide incentives for successful quality efforts.

In each instance, the management accountant can, and should, play an active role, since planning, reporting, and measuring are fundamental activities of his or her position.

2.5 The Need for a Quality Costing Information System (QCIS)

As noted earlier, tracking and measuring quality costs lies at the very heart of quality improvement programs. Unfortunately, traditional accounting cost systems do not report quality costs separately; rather, they bury these costs within the traditional cost categories of materials, labour, and overheads (discussed in detail in Chapter 7).

The Accounting Department can help determine for each department how much of its materials, labour, and overhead costs represent a cost of quality. The Accounting Department can then classify these costs into the four previously identified categories of prevention, appraisal, internal failure, and external failure.

Further, the Accounting Department can calculate company-wide costs of quality by summing quality costs for all departments. With quality costs classified by type for each department and for the company as a whole, these costs can be estimated and incorporated into departmental and company budgets. Additionally, to improve quality, a company needs to be able to identify and eliminate quality problems using the available quality tools (discussed previously in Section 2.3.3.6). Although the Accounting Department is not directly responsible for these areas, they will provide most of the information needed for their preparation.

Next, in addition to budgeting and measuring quality costs, the Accounting Department is usually called on to prepare quality cost reports. These reports typically show the type and amount, as well as the trend, of quality costs incurred,
often expressed as a percentage of sales. These reports also reveal whether quality costs are poorly distributed. A poor distribution will show much higher failure costs compared to prevention costs. A quality cost report also serves to pinpoint quality areas in need of attention.

Finally, for quality improvement programs like TQM to succeed, they must be backed by an effective information system. As an information specialist, the management accountant can play an important role in helping the company attain its quality goals. He can do so by preparing budgets for quality activities and their costs and by preparing quality cost reports that can serve as a basis for solving quality failures and as a baseline for budgeting quality spending.

2.6 Management Information System

2.6.1 What is MIS

The crucial role played by management in the philosophy of Total Quality Management has been shown. Such a crucial role requires the provision of resources, sufficient in quantity and quality for performance to be achieved and maintained at peak level. A key resource is that of information and in this section the provision of high quality information for managers through a Management Information System will be discussed.

As business changes as a result of, for example, technological developments and market demand, and changes in the size of the organisation, managers have to consider many factors in decision-making, and, consequently, require more information. Any business has an objective or a goal. To achieve the objective managers at all levels need to make decisions. All decisions are based on information from a Management Information System.

A Management Information System (MIS) uses data to produce information which helps management make effective decisions. There are as many definitions of MIS as there are books and authors. Some definitions that have been attempted are:
MIS is an integrated, user-machine system for providing information to support operations, management, analysis and decision-making functions in an organisation. The system utilises computer hardware and software; manual procedures; models for analysis, planning, control and decision-making; and a database (Davis and Olson, 1985).

MIS is the combination of human and computer-based resources that results in the collection, storage, retrieval, communication and use of data for the purpose of efficient management of operations and for business planning (Lucey, 1997).

A management information system is a formalised, computer-based system able to integrate data from various sources to provide the information necessary for management decision-making (Davis and Olson, 1985).

The third definition emphasises that MIS will provide sufficient, and necessary information to management to enable them to make better decisions. The first two definitions show the extent to which assumptions about the use of computers in modern Management Information System have appeared in recent years. The use of computers in organisations has grown tremendously since 1955, and many of the resulting systems have had a significant impact on the way in which management makes decisions.

2.6.2 MIS Concept

MIS is the central core of an organisation, the nervous system through which the corporate information flows. The aim is to provide management with information (Bowman, 1995). MIS converts data from internal and external sources into communicable information to all levels of management and enables them to make effective decisions (Baxendale, 1995). Figure 2.4 shows that data is collected in the form of hours worked, invoice values, part numbers, usage rates, etc., these facts are then stored, calculated, analysed, compared, and processed to produce messages in the form (information flows) required by the user. Therefore, managers at all levels and
in all functions are given the resources to make timely and effective decisions for planning, directing and controlling the activities for which they are responsible.

**Figure 2.4: Decision focus in MIS (Lucey, 1997)**

The general principles of recording data flow within an organisation are considered in order to specify an integrated Management Information System.

Employing MIS in any business will help to improve the operation of management decision-making (Baxendale, 1994). For instance, Lucey (1997) stated that ‘….a group of American industrialists visiting Japan found that their counterparts were regularly supplied with information on the proportion of products which pass through the factory without re-working or rectification. They found that a typical percentage of products that needed no re-working were 92%. The American managers found that this information was not available to them in their factories at home but on investigation it was found that their ratio was 8%. They then worked on this factor for 6 months at which point the ratio had moved up to 66% and, more importantly, productivity was 25% higher’.

Communication between management with reliable information would result in better quality, improved productivity and reduced failure. The Clinical Engineering Department (CED) in Mexico was able to improve performance, and decrease total cost by implementing MIS. They used a system consisting of data acquisition, synthesis of economic indicators and analysis of information e.g. available hours, cost-effectiveness, closed work orders, efficacy, efficiency, open work orders, total costs, total labour hours, and work order. The department was able to find that a large proportion of labour time was not documented and so reflected an increase in documented service costs, and a consequent decrease in productivity. After analysing...
the information, CED is now able to increment 10% in the quality of a document hour, and decrease total costs by 10% (Granja, 1993).

In 1990, Cobb County in Georgia (US) invested $950 million in an improvement programme for transport and water. Cobb County recognised that an MIS could communicate complete, reliable and accurate information to management (Lazicki, 1994). They believed that this would result in a better quality product at a lower total cost.

Implementing MIS in any business plays a vital role in achieving a better quality and reducing unnecessary costs. On the other hand, incomplete, unreliable and inaccurate data will lead management to poor decisions, resulting in poor quality (Callie and James, 1988).

2.6.3 Components of MIS

In MIS each word is meaningful and significant. A Management Information System, which deals with data processing and management of information flow, consists of three interrelated components... a system-that manages information used in the management of an organisation. Figure 2.5 illustrates the element in each component (Emery, 1987).

![Figure 2.5: Element of MIS Components (adapted from Dixon, 1990)](image-url)
2.6.3.1 System

A system can be defined as “set of rules, principles or practices, forming a particular philosophy” (Oxford dictionary). Another definition defines systems as ... “a group of things that are interrelated to accomplish some purpose” (Murdick and Ross, 1977).

2.6.3.2 Information

“Information is a fact datum, observation, perception, or any other thing that adds to knowledge” (Anthony and Welsh, 1981). Information is a knowledge which can be used to reduce uncertainty and may be obtained by direct observation or by communication. Managers obtain information by communication because it is not possible for them to observe all activities taking place (Lucey, 1997). Information should not be confused with Data (as can be seen from Figure 2.5). Data by itself is not information but represents facts of any kind, however a subset of data is considered information. For example a set of dimensions of a component output from a machine is data. However, when shown as a frequency distribution, this data then presents the machine’s performance over a period of time, and might highlight some trends.

2.6.3.3 Management

There are three levels of management; each level with different responsibilities and each requires different information. Figure 2.6 illustrates all three of these levels of decision-making, each of which relies on data processing for portions of their information. Top management is involved in long-range plans and strategic decisions. Strategic decisions entail a great deal of uncertainty that can be reduced by reliable and accurate information (Collins, 1989). Middle management is involved in the implementation of decisions made at the top level; e.g. plant layout, budget allocation, production scheduling. Lower management or Operational management is concerned with operational decisions, control and day-to-day decisions (Dirks, 1994). According to Schroeder (1989) there are five major responsibilities of lower
management: processing, capacity, inventory, work force, and quality. A data processing system supports the management information system. Data processing is concerned with collecting data as near to its source as possible, processing and storing it. However, a MIS is oriented toward using the stored data to produce management information (Davis and Olson, 1985).

![Levels of Decision Making and their responsibilities]

**Figure 2.6:** Levels of Decision Making and their responsibilities

MIS is geared to providing information required from top to lower management in order that the managers can achieve timely and effective decisions which will lead to a better quality (Schroeder, 1989). Nose (1994) likens a Management Information System to the blood in its important role of carrying energy, which refreshes and reconstructs our body. When the circumstances of a company change the management quickly needs up-to-date, though accurate information. Consequently, the managers or foremen can easily make better decisions about the organisation or function.

However, the literature review conducted and presented so far, has not uncovered specific references that cover quality costs as part of the organisational MIS, nor detailed descriptions of quality information in the MIS. The few exceptions to these findings were those organisations that had ISO 9000 certification, and were obliged
by the standard’s requirements to keep such information, albeit not always integrated, in the overall MIS. This was surprising as quality costs and quality information are crucial for decision-making regarding products and services, and indeed, all organisational aspects.

The current research in particular is concerned with the information requirement of Quality Costing and the development of an effective and practical costing system by incorporating the concept of Activity-Based Costing (ABC). This is discussed in more details in the next chapter.
CHAPTER 3:
QUALITY COSTING, COSTS OF
QUALITY AND COSTING METHODS

3.1 Introduction

A basic commitment of management should be to continuously pursue quality improvement. To achieve the most effective improvement, management should ensure that the organisation has ingrained in its operating principles the understanding that quality and cost are complementary and not conflicting objectives. Traditionally, recommendations were made to management that a choice had to be made between quality and cost, the so-called 'trade-off decision', because better quality would somehow cost more and increase production difficulties. Experience throughout the world has shown, and management is beginning to see, that this is not true. Good quality leads to increased productivity, reduced quality-costs, and eventually to increased sales, market penetration, and profits.

The purpose of quality cost techniques is to provide a tool to management for facilitating a quality program and quality improvement activities. Quality cost reports can be used to point out the strengths and weaknesses of a quality system. Improvement teams can use them to describe the monetary benefits and ramifications of proposed changes. In practice, quality costs can define the activities of a quality program and quality improvement efforts in a language that management can understand and quantify. Any reduction in quality costs will have a direct impact on gross profit margins and can be counted on immediately as pre-tax profit. Nowadays, a clear understanding of the economics of quality and the use of a quality cost system in the management of quality and of quality improvement efforts may make the difference between maintaining current levels of profitability and outperforming the competition.
The present era of global competition is leading all companies toward a renewed commitment to excellence in manufacturing. Attention to the quality of products and processes, level of inventories and improvement of knowledge policies is required of companies aiming to become world-class. However, most companies still use the same traditional costing system and management controls that were developed decades ago for a manufacturing environment drastically different from today (Cooper and Kaplan, 1991). These ‘Traditional Cost Accounting’ (TCA) systems were designed to meet the requirements of mass production enterprises, with organisations producing relatively few products in high volumes and with high direct labour content. In today’s competitive environment, the majority of manufacturing firms deal with producing a wide variety of products, and continuous innovation. This is true for both medium and small-sized enterprises as well as for large ones (Sourwine, 1990). Moreover, due to facing ever increasing global competition and challenges to increase efficiency, effectiveness and productivity, all at the same time, many organisations started to implement several variations of advanced manufacturing technologies (automation, FMS, etc.). The benefits generated from such advanced manufacturing include the ability to produce many different products or parts with low set-up costs, and achieving on-time delivery, lower lead time, improved product quality, higher customer satisfaction, inventory cost reduction, reduced rework, and greater manufacturing flexibility. These advances in manufacturing technology are also paralleled by similarly advanced management systems such as Total Quality Management, which offer a wide array of benefits, but require a change from the traditional ‘command and control’ management style of past decades.

However, TCA systems fail to support the implementation of such advanced technological investments as well as failing to quantify the advantage of the advanced manufacturing processes and quality management systems (Letza and Gadd, 1994). TCA systems emphasise external financial reporting requirements and subsequently tend not to provide relevant, timely and useful information for managers who are faced with operational and strategic decisions. If a management accounting system is to be of maximum value to decision-makers, it must be flexible and adaptable and
must provide quality information on demand that addresses the needs of its 'customers'.

Several researchers and organisations have pointed to the inadequacy and irrelevance of traditional cost accounting in the present competitive environment (Hunt et al, 1985; Jeans and Morrow, 1989; Letza and Gadd, 1994). The majority of these sources have identified the use of inaccurate data to allocate indirect costs as the most serious problem of the traditional cost accounting systems. It is not that traditional cost accounting systems do not work; it is just that the world they have been designed for is rapidly disappearing. Product costs used to consist primarily of direct labour and material. In today’s manufacturing environment, direct labour usually accounts for approximately 15 percent of the cost whilst material account 45 to 53 percent. This leaves overheads within the very high range of 30 to 50 percent. In addition, overheads are no longer considered as a variable cost but as a fixed cost in most investment sectors. In this environment, TCA systems might give the wrong information about product costs, manufacturing efficiency, and effectiveness (Cooper and Kaplan, 1988a). Since the measures of these costs are the basis of decision-making for pricing and marketing strategies, organisations still following TCA systems are risking adopting flawed strategies. The same argument also applies to product quality costs, and, thus, the strategies for planning and implementing quality management systems.

One of the more successful approaches to the problems raised by the TCA systems is the Activity Based Costing (ABC) system. The ABC system is based on the premise that products consume activities, activities consume resources and resources consume costs (Kaplan, 1984). ABC provides relevant and accurate information for strategic decisions concerning product pricing, customer and product profitability analysis, and process improvement.

This is followed by an overview of the traditional cost accounting systems and a discussion of their major deficiencies, and thus the need for a more relevant system such as ABC. This is followed by a detailed look at ABC systems definitions and implementation and a comparison between the ABC and TCA systems.
This chapter discusses the quality costing theories, approaches, and applications. It is worth noting here that many references would use the term “cost of quality (COQ)” to refer to quality costs. However, among the key points emerging from the National Conference for Quality (Campanella, 1999) was the idea that the phrase ‘Cost of Quality’ should never be used since quality is profitable not costly. In this report, the terms “Quality Cost” or “Quality Costing” will be used since they are more widely used.

3.2 What are Quality Costs?

There are several textbook definitions of quality costs. A few examples include:

- Quality related costs are those incurred in the design, implementation, operation and maintenance of an organisation’s quality management system, the cost of resources committed to the process of continuous quality improvements plus the cost of the system or product failures (Dale and Plunkett, 1990).
- The cost of not doing things right first time (Feigenbaum, 1991).
- Those costs associated with the definition, creation and control of quality as well as the evaluation and feedback of conformance with quality, reliability and safety requirements, and those costs associated with the consequences of failure to meet the requirements both within the factory and in the hands of the customers (Feigenbaum, 1991).
- All expenses involved in doing things wrong and what is necessary to get things right (Crosby, 1984).
- Cost in ensuring and assuring quality as well as loss incurred when quality is not achieved (BS6143, Part 2, 1990).
- Quality costs are costs associated with making defective product (Groocock, 1986).

These definitions are varied but essentially they imply the same thing: the quality cost is the combined cost of the efforts to ensure that a product is what a customer requires.
and any additional cost of supplying a customer with a product that does not fulfil the customer's expectations. This is the definition that will be adopted here.

It is important for an individual organisation to specify what it means by quality costs before any useful Quality Costing can be performed (Dale and Plunkett, 1991). The Quality Costing process is the definition, collection, action and the review of the action of quality costs as defined by the organisation. Essentially it is the measurement of quality costs within a Plan, Do, Check, and Action (PDCA) cycle (Zairi, 1992).

3.3 Quality Costing Systems Applications

Quality Costs describe the inputs and results of quality systems in the language of business (Money) (Crosby, 1979; Dale and Plunkett, 1990; Feigenbaum, 1991; Campanella, 1999). It is important that the effectiveness of a quality system be measured in financial terms. The impact of an effective quality system upon the organisation's profit and loss statement can be highly significant, particularly by improvement of operations, resulting in reduced losses due to error and by making a contribution to customer satisfaction. Also, by reporting quality system activities and effectiveness in financial terms, management will receive the results in a business language common to all departments.

The real value of a quality program is determined by its ability to contribute to customer satisfaction and to profits. Quality costing techniques are a management tool for securing quality improvements that contribute to profits. Quality Costs are a measure of the costs specifically associated with the achievement or non-achievement of product quality and customer satisfaction. They include all product requirements established by the company and its contracts with customers and society. Requirements include: marketing specification, end-product and process specifications, purchase orders, engineering drawings, company procedures, operating instructions, professional or industry standards, government regulations, and any other document or customer needs that can affect the definition of a product. Campanella (1999) noted that quality costs are the total of the cost incurred by:
1. Investing in the prevention of non-conformances to requirements
2. Appraising a product or service for conformance to requirements, and
3. Failing to meet requirements

Quality Costs represent the difference between the actual cost of a product or service and what the reduced cost would be if there were no possibilities of substandard service, failure of products or defects in their manufacture (Campanella, 1999).

Quality Costing is supported by the British Standards Institute in BS6143 Parts 1 and 2; the Australian Standards Institute in AS2561 (Wheldon and Ross, 1998); the American Society of Quality Control (ASQC); and quality Gurus such as Crosby (1979), Feigenbaum (1991), Deming (1986), Juran (1993) and Diane (1998). There are a number of world-class organisations that employ Quality Costing as quality performance, which probably suggests the validity of its use. Sun Microsystems use the technique; also the British Steel Company used it for educational purposes at least. This indicates that Quality Costing is a tool that has its uses as part of the refinement of the TQM process since it proves a link between quality improvements and business profits (ASQC, 1991).

Quality Costing is one technique used in driving the senior management team into the decision to initiate the TQM process (Crosby, 1979; Dale and Plunkett, 1990; Feigenbaum, 1991; Juran et al, 1988). It tends to provide a global figure that will shock people into doing something to improve the effectiveness of how quality is managed within an organisation and hence provide the motivation to do something about it, to drive improvement.

Within ongoing quality programmes it is of use as a tool to ensure improvements made are maintained and for assessing how much progress has been made e.g. as a control mechanism (Juran, 1993; Dale and Plunkett, 1991). Quality Costing used in this manner will also highlight important improvements, which need to be made, enabling manufacturers to react to new problems as they arise.
Quality Costing can also be used as a planning tool for budgeting, as it will help to show the full, expected costs (Juran et al, 1988; Dale and Plunkett, 1990). This will allow quality improvement to be planned for as one of the normal activities of the organisation. This is one of the aims of Total Quality Management.

Quality Costing will show how much is currently being spent on quality in the common language of money. It also provides a useful measure for comparing the efficiency of an organisation’s components. This is again useful for assisting quality improvement to become one of the normal activities of an organisation. The use of Quality Costing will allow investment in quality to be considered alongside other investment opportunities so quality improvement need not be seen as an add-on to operations. Quality Costing usage does not exclude the use of other techniques; indeed it is of most use alongside the other ongoing quality activities and performance measures.

Finally, Quality Costing helps to create awareness that quality is everyone’s responsibility and an individual awareness of what certain actions cost the organisation. The cost of doing something wrong is the measure of the importance of a problem. It determines priorities, and is the measure of success in dealing with a problem.

3.4 Concept of, and Approaches to, Quality Costing

In order to implement quality management within an organisation, managers need to be able to measure the various processes and procedures within their company. One of the main ways in which they can do this is known as Quality Costing.

Quality Costing is the term given to the process of converting information related to quality management processes into financial terms so that the true cost and value of such activities can be identified and hence included in the standard ongoing management of an organisation. This role appears to be useful to a wide range of organisations, which use the information they gain for a variety of purposes depending upon individual circumstances. Quality Costing appears to be a powerful
tool to assist with quality management. Such a quality cost information system is what was highlighted as missing from the MIS literature review, and should be integrated to an organisation's MIS to achieve maximum benefits.

Crosby (1984) noted that one use of quality costing is to draw the attention of upper management to quality concerns. Upper management decisions are usually very much fact-driven. In terms of quality this means that managers ask how much quality has to be built into a product. Here, Quality Costing gives a basis for understanding how quality performance affects the financial performance of a company (Garvin, 1988). Thus, quality costing should be regarded as a management tool to measure quality and the financial performance of a company. Besides tools like SPC, Benchmarking, Taguchi models and many others, quality costing tools deliver data about the financial performance of a quality system. The ease of understanding financial data makes Quality Costing a valuable tool. Customer orientation and satisfaction is clearly the prime function in TQM, but only cost efficiency makes a business really worthwhile (especially those businesses in highly competitive environments). Quality Costing gives a valuable contribution to this. It determines how much money is spent on producing quality. It is, therefore, a true measure of quality efficiency. It is a method of assessing the effectiveness of quality management.

Quality Costing can provide more than an evaluation of cost efficiency. It can detect problem areas, opportunities, savings and identify priorities for action. In short, Quality Costing makes more transparent the usefulness of quality efforts in prevention, appraisal or failure activities. Hence, Quality Costing must be regarded as a strategic tool.

Each identified quality performance problem carries with it a tangible recovery cost, which can be assigned a value. This is the essence of quality cost measurement. In a certain percentage of cases, however, the value of the intangible costs involved may go beyond the pure economics of the situation. For instance, if an organisation wanted to investigate the cost of missing an important milestone in a project schedule,
it has to observe that quality problems are more often at fault here than other problems. But the most important of all intangible quality costs is the impact of quality problems and schedule delays on the company’s image in the eyes of its customers, with all its implications for the profit picture and the company’s future.

Placing a monetary value on the effect of intangible quality costs, often called “hidden quality costs”, is difficult, if not impossible. Some manufacturing companies identified a multiplier effect between measured failure and true failure costs. For example, Westinghouse Electric Corporation reported that its “experience indicates that a multiplier effect of at least three or four is directly related to such hidden effect of quality failure” (Brown and Kane, 1987).

Figure 3.1 compares true failure costs to an iceberg with the more commonly measured failure costs as just the “tip of the iceberg”. The bulk of failure costs is “hidden” below the surface and is usually responsible for “sinking the ship”.

![Figure 3.1: Hidden costs of quality and the multiplier effect](image)

Some of the main contributions to the quality-costing concept were the Taguchi methods. Taguchi (Okland, 1993) methods target rapid improvements in cost and quality by optimising product design and the manufacturing process. Taguchi’s methods are both a philosophy and a collection of tools used to apply that philosophy. Taguchi’s philosophy can be summed up as follows:
• We cannot reduce cost without affecting quality
• We can improve quality without increasing cost
• We can reduce cost by improving quality
• We can reduce cost by reducing variation. When we do so, performance and quality will automatically improve

Taguchi disagrees with the “conformance to specification limits” approach to quality. The difference between a product barely within specification limits and a product barely out of specification limits is small, yet one is considered “good” and other “bad”. Rather, Taguchi methods strive for minimal variation around target values without adding cost.

Taguchi defines quality as “... the loss imparted to society from the time the product is shipped”. Fundamental to his approach to quality engineering is the concept of ‘loss’. When we think of loss to society, things that come to mind include air pollution or excessive noise from a car with a defective silencer. Taguchi views loss to society on a much broader scale. He associates loss with every product that meets the consumer’s hand. This loss includes, among other things, consumer dissatisfaction, warranty costs to the producer, and loss due to a company’s bad reputation, which leads to eventual loss of market share.

3.5 The Purpose of Quality Costing Systems

Figure 3.2 displays the traditional relationship between quality costs (prevention and appraisal) and is based on the premise that prevention and appraisal cost were represented exponentially as defect free levels are achieved (Camagnella, 1999), thus resulting in an optimum quality costs level.

However the concept of economics of quality has changed recently. In the late 1950’s Juran and Cryna (1988) suggested a classical model, which was later updated, as described in BS6143 (Part 2) (1990). The former proposed a trade-off between conformance (preventive and appraisal) costs and non-conformance (failure) costs as seen in Figure 3.2.
Figure 3.2: Traditional Optimum Quality Costs Model (Campanella, 1999).

The model is based on the assumption that failure costs can be reduced to an optimal point by increasing preventive and appraisal costs. In economic terms, the optimal point is where the marginal cost of increased conformance costs is equal to the decreased benefit resulting from the reduction of non-conformance costs. This model implies that the optimal level of quality is less than 100% conformance (good). Most publishers have followed the classical approach to Quality Costing. This model might be acceptable if the optimal point on the total cost curve is better than that of the competition.

In today's highly competitive environment, the emphasis is on continuous quality improvement toward zero defects, which can be expressed implicitly as shown in (Figure 3.3). The idea is supported by Deming (1986), Crosby (1984) and Harrington (1987). This awareness leads to an initial increase in appraisal costs. As appraisal is geared towards highlighting sources of improvement, more is spent on prevention. As the preventive action takes effect, prevention, appraisal and failure proportions come into line and reduce (BS6143, 1990).
Therefore the strategy for using quality costs is:

- Focus directly on failure costs in an attempt to drive them to zero
- Identify and invest in those prevention activities most likely to bring about improvement
- Reduce appraisal costs in proportion to results achieved
- Continuously monitor and fine-tune failure-prevention efforts to gain further improvement.

This idea is synonymous with Deming's PDCA cycle of identifying and eliminating the most serious quality problems and leads to continuing reduction in non-conformance (failures) (Ittner, 1993).

The more organisations learn about quality and the importance of customer satisfaction and customer retention, the more the model of Figure 3.2, and the concept of acceptable failure is becoming less acceptable. World-class organisations are adopting new techniques in the 21st century to try and eliminate errors throughout the whole process, namely six sigma improvement methodologies. These organisations subscribe to the modified 'optimal quality level' as shown in Figure 3.4 with zero failures as its objectives.
Generally, interdependence between costs of prevention, appraisal and failure can be seen. If efforts on prevention are relatively low, activities of the quality system focus on controlling and rectifying, which mean unsatisfied customers or high levels of rework and scrap, which depend on appraisal spending. This means that costs of appraisal, as well as internal and external failures are, in comparison to prevention costs, relatively high. It creates a relationship between failure, appraisal and prevention costs. If quality awareness is low, failure costs stand out. As quality awareness increases failure costs diminish.

Increasing inspection can reduce the external failure rate of products although inspection may not be 100% perfect. This leads to the customer receiving a defect-free product thus earning the company a good reputation. However, this solution will increase internal failure costs, as shown in Figure 3.5. The reduction in external failures will not exactly match the increase in internal failures but for a company with high warranty costs such an approach will be a good first step to achieving high quality production. This ultimate solution is to prevent the problem from arising in the first place.

Figure 3.4: New Model of Optimum quality costs (Campanella, 1999)
The goal of any quality cost system is to facilitate quality improvement efforts that will lead to opportunities for the reduction of operating costs.

This strategy is based on the premise that:

- For each failure there is a root cause
- Causes are preventable, and
- Prevention is always cheaper as shown in Figure 3.6.
The most costly condition occurs when a customer finds defects. Had the manufacturing organisation found the defects, through much inspection, testing, and checking, a less costly condition would have resulted. If the manufacturing organisation's quality program had been geared toward defect prevention their resulting costs would have been minimised, obviously, the most desirable condition. Figure 3.7 illustrates the comparative cost of quality.
The company's Quality management System is designed, Planned, and organised for defect prevention and continuous Quality Improvement.

The manufacturing organisation finds and corrects the defects internally.

The customer finds defects in the delivered part or service.

**Figure 3.7: Comparative cost of quality**

In a practical sense, real quality costs can be measured and then reduced through the proper analysis of cause and effect. As failures are revealed through appraisal action or customer complaints, they are examined for root causes and eliminated through corrective action. The elimination of root causes means the permanent removal of the defect. The further along in the operating process that a failure is discovered, that is the nearer to product use by the customer, the more expensive it is to correct. Usually as failure costs are reduced, appraisal efforts can also be reduced in a statistically sound manner, which means as quality is improved, inspection (appraisal) effort will be reduced. Knowledge gained from this improvement can then be applied, through prevention activities or disciplines, to all new work.

As straightforward as this approach may appear, it cannot work unless there is first a basic quality measurement system that clearly identifies those correctable elements of performance failures that represent the best potential for cost improvement. Such a system is designed to use the data from inspections, tests, process control measurements or evaluation quality, and customer complaints as a measure of company performance and a source of determining cost reduction. This measurement is a basic and important part of quality management. The potential for improvement can be determined by accurate and dependable measurements of quality costs.
Since every pound of quality cost saved can have a positive effect on profits, the value of clearly identifying and using quality costs should be obvious. By minimising quality costs, quality performance levels can be improved.

3.6 Quality Costing Systems

There are two conventions for collecting and analysing quality cost information, both outlined in the British Standard on quality costing (BS6143, 1990). The first is the Prevention-Appraisal-Failure (PAF) model put forward by Feignenbaum (1991) which Dale and Plunkett (1999) described as ‘almost universally accepted’. The second is the process model, first used by Marsh (1989) for quality costing, which is advocated as being more in line with the philosophies underlying TQM.

The PAF model looks at the operating quality costs within an organisation and states that they can be collected under three headings (Sigma and Erel, 2000; Giakatis and Rooney, 2000):

1- Prevention – the cost of all activities used to prevent defects. These are the costs that aim to eliminate or reduce the possibility of failure (either external or internal) costs occurring. Typical examples of prevention costs are supplier assurance, quality planning, process planning, and verification of design.

2- Appraisal – the cost of all activities used to appraise goods and services for defects. These are costs associated with activities that aim to ascertain the conformance of the product to requirements. Typical examples of appraisal costs are prototype testing, stock evaluation, receiving and product inspection and materials consumed during inspection and testing.

Some of this is planned and necessary, indeed may be a customer requirement. On the other hand much inspection is carried out solely due to inadequate failure prevention activities.
1. Failure – comprising

1.1 Internal failure activities – the cost of all activities associated with rectifying failure before a good or service leaves the company. Typical examples of internal failure are redesign, manufacturing scrap, lost productive time, and rework.

1.2 External failure activities – the cost of all activities associated with rectifying failure in goods and services after they leave the company. Typical examples of external failure are warranty claims and recall costs and consequential loss of sales.

The relation between these four categories is graphically displayed in Figure 3.8 below.

![Figure 3.8: PAF elements relationship with time/TQM awareness (Millar, 1999)](image)

The process model looks at the costs associated with processes in the organisation and says that they can be categorised in two ways:
1. The cost of conformance (COC) – the intrinsic cost of providing products or services to declared standards by a given, specified process in a fully effective manner.

2. The cost of non-conformance (CONC) – the cost of wasted time, materials and capacity (resources) associated with a process in the receipt, production, despatch and correction of unsatisfactory goods and services.

Millar (1999) has proposed a model for quality cost system implementation, which has been adopted in Figure 3.9 for demonstration purposes.

Figure 3.9: Proposed Model for Quality Costing System Implementation
(Millar, 1999)
3.7 Traditional Cost Accounting (TCA) Systems

3.7.1 Overhead Allocation

After allocating the costs of direct material and labour to a product, and in order to determine the full cost of the product, it is necessary to estimate the amount of indirect manufacturing costs that must be traced to the product. Accounting for overheads is an area in which there are wide differences of opinion among experts as to what should be done. However, most agree on a two-stage cost allocation system (Cooper and Kaplan, 1988a). In the first stage indirect costs and support department costs are assigned to cost pools (cost centres). In the second stage, costs accumulated at the cost centres are allocated to the products (Kaplan, 1987; Partovi, 1991). Most first-stage systems capture the consumption of support department resources more directly and thus reduce arbitrary allocation. For example, an appropriate first-stage allocation basis for power cost would be the rated horsepower of equipment; for heat it would be cubic volume of space used; for purchasing department it would be the cost of material used. Accounting textbooks refer to the second-stage allocation as overhead absorption (Drebin and Bierman, 1978; Anthony and Welsch, 1981). According to Drebin and Bierman this allocation is accomplished by the use of an overhead rate. In TCA, the second stage allocation basis is unit-based (volume). Direct labour (cost or hours) is the most commonly used allocation basis. This is where most of the accounting systems are deficient (Worthy, 1987). According to Cooper (1990), whenever the amount of unit-level inputs (departmental overheads, e.g. utility costs) consumed by a product do not vary in direct proportion to the amount of other inputs (material, labour) it consumes, unit-based cost systems will report distorted product costs.

Since the beginning of the industrial revolution more than 200 years ago, there has been a continual increase in indirect cost supporting mechanisation. Today, a large percentage of a company’s labour force consists of production support staff (inspectors, quality controllers, engineers and managers). The production support staff produces and analyses information, designs new products, modifies the design or production process, and provides marketing, sales and services activities for the company’s increasingly diverse product line and dispersed distribution channels.
The majority of these indirect cost elements are not proportional to the volume of units produced or sold (Cooper and Kaplan, 1992). Instead, they are triggered by batches put into production and by the number of product lines (Johnson, 1992). Thus, TCA systems with unit-based overhead allocation bases fail to measure accurately the cost of resources used to design and produce products and to sell and deliver them to customers. With direct labour as a percentage of total production cost rapidly diminishing, direct labour-based allocation methods have become more and more obsolete. According to Grady (1988), direct labour makes up less than 10 percent of the product cost. In some high-technology firms, the figure is less than 5 percent.

Numerous studies and surveys have been presented over the last decade to support these issues (Murphy, 1990; Chiu and Lee, 1980; Siriwardane, 1994). Chiu and Lee (1980) conducted a survey on practices of overhead accounting and analysis among Fortune 500 industrial corporations. The survey was designed to obtain a broad picture of how factory overheads are recorded and applied and how variances from standards are identified, determined and disposed of. Most respondents named direct labour dollars and direct labour hours as the primary basis used to apply overhead to products. Similarly, Schwazbach (1985) reported the results of a survey of Fortune 500 manufacturing companies, which stated that 35.7% of the respondents used direct labour hours, and 58% used direct labour costs as the allocation basis.

Computer Aided Manufacturing International (CAM-I) co-sponsored a research project with the National Association of Accountants (NAA) in the US (Howell et al, 1987) which attempted to review existing cost management practices with a particular emphasis on those practices perceived as not providing management with adequate information. Survey participants were businesses with less than $100 million in sales, and the majority did not come from advanced manufacturing technology environments. The manufacturing cost of the respondents, on average, consisted of 53% material, 15% direct labour, and 32% overhead costs. Of the respondents, 62% indicated that they were unhappy with the current cost accounting system, which highlighted the existence of a need/performance gap. While this survey did not report the percentage of respondents using direct labour-based overhead allocation methods,
it found that nearly one-third of the respondents used a single overhead rate (the TCA approach). Participants believed the primary improvements that should be made are for developing alternative bases assigning the allocation of indirect costs. Similarly, Drury (1988) referred to a survey of management accounting in Automated Manufacturing Technology (AMT) environments conducted in the UK, which identified the method of charging overheads to products as the major area of concern. The respondents identified the development of alternative bases for assigning overhead costs to products as the most important area that needed to be improved in product costing.

Other studies that attempted to tackle the issue on hand included a survey by Smith and Sullivan (1989) who studied manufacturing companies with at least 50 employees. On average, respondents of the survey reported that 51% of manufacturing cost comprised direct materials, 30% manufacturing overhead, and only 13% direct labour. Similarly, a survey by North American Manufacturing Futures (NAMF) (Siriwardane, 1994) reported 52% material, 35% overhead and 13% direct labour. An interesting finding of the survey was that 50% of the respondents indicated that they had either changed their cost systems or were studying the possibility of doing so. The adoption of an activity-based costing system was the most likely change identified by those making the change.

All these surveys and studies confirm the findings of the study presented in Chapter 5 where 40% of participants were 'unsatisfied' with TCA methods, and of the 12% that were 'very satisfied' with their current costing methods, 40% used ABC. Moreover, 63% of the participants agreed that they would like to use an alternative basis for overhead allocation than that offered by TCA.

### 3.7.2 Traditional Costs Accounting (TCA) Systems Deficiencies

So far we can conclude the overhead allocation had been identified as a major problem of traditional cost accounting. Many researchers have pointed out the use of volume-based drivers (most common is direct labour) in allocating cost from cost centres to products as erroneous (Goldratt, 1983; Johnson and Kaplan, 1987; Brunton,
Kaplan led the argument that traditional overhead allocation has lost its relevance and is not moving in parallel with changes that are taking place in the manufacturing environment (Kaplan, 1984, 1986, 1988). Despite the many companies who have seen the defects in cost allocation as it evolved over the years, and despite the many direct cost accounting methods that have been suggested to deal with it, it still remains the method used with the "General Accepted Accounting Principles". All indirect costs are allocated proportionally to direct costs without analysis of the real impact of these numbers. Many companies, large and small, are equally misled every day by traditional costing methods. They gave up profitable products or emphasise losing ones, because of the cost formula, not because of the realities of the costs. Johnson, and Kaplan (1987) argued that: Today's management accounting information, driven by procedures and cycle of the organisation's financial reporting system, is too late, too aggregated, and too distorted to be relevant for managers' planning and control decisions. This system can lead to misguided decisions on product pricing, product sourcing, product mix, and responses to rival products.

Franklin (1989), a senior engineering manager at the Ford Motor Company once installed a simple electric drill press, which the accounting system combined with an expensive automated machine. The hourly rate on the drill press was very high since the drill had to carry the allocated cost of the automated machine. Franklin's solution was simple, a yellow line was painted on the floor around the drill press, dividing it from the expensive machine, he then separated it in the accounting system by adding it instead to the office equipment column. The overhead rate went down remarkably, pulling down the hourly cost of the drill press to much reduced amount. Franklin had to do this many times, and called it "the paint method of cost accounting". Standard costing methods force sensible people to resort to management contortions to get things done.

From the discussion so far, it is possible to summarise the major Traditional Cost Accounting (TCA) systems drawbacks, and thus the justifications for a new costing system, as follows:
The cost profile of the manufacturing business has changed over the last 30 years (Marrow, 1992). Production and non-production overheads have grown in relative importance, as more resources have been committed to the organisation and management of production and to the provision of quality and services to the customer. The need to control and account for the cost elements has thus become of increasing significance. A TCA system allocates overhead costs to products based on production volume-related attributes such as direct labour cost, machine time or direct material cost, in a manufacturing environment, normally devoted to the manufacturing of a narrow range of products. In today's manufacturing with advanced manufacturing systems, the diversity of production does not allow the application of TCA systems, since such systems cannot keep pace with changes in manufacturing technology. The nature of overhead cost has changed from costs, which were predominantly influenced by the output volume, to a composition determined largely by the complexity and diversity of production (Kaplan, 1984). Increasingly, overhead cost has been generated by the quest to exploit economies of scope as well as economies of scale. Knowledgeable workers, particularly engineers and software specialists, have displaced much of the direct labour force in many plants. In some cases, overhead costs outside the plant engineering, marketing and distribution has increased to where it exceeds that of the direct labour. Many organisational resources exist for activities that are unrelated to physical volume. Non-volume related activities, in a homogeneous product-manufacturing environment, consist of support activities such as material handling, material procurement, performing set-ups, production scheduling and first-time inspection activities. A TCA system, which assumes that products consume all resources in proportion to their production volumes, thus report distorted product costs. The higher the overhead, the higher the chance for distortion in reported costs. As a rule of thumb, overheads that exceed 15 percent of total costs may cause inaccuracies in a traditional cost system (Turney, 1996).

Cooper (1989), Kaplan (1989) and Johnson (1992) identified diversity in production volume and product complexity as two conditions under which cost distortions of traditional cost accounting systems are prominent. Traditional direct labour-based cost systems systematically under-cost low-volume,
customised products, and over-cost high-volume standardised products. Such incorrect information will result in incorrect pricing which will give a misleading picture of an individual product's margins. This will lead to a less than optimum product mix and wrong marketing decisions and will depress earnings.

3. A further major deficiency of traditional cost accounting systems is its deficiency as an operational/managerial control tool (Cooper and Kaplan (1988b). An operational control system must provide accurate, timely feedback to managers on their performance. The system must correspond to the unit manager's level of responsibility and control for known variations in cost behaviour. It must also minimise the incidence of cost allocations (Kaplan, 1988). The costs reported in traditional systems are too aggregated, and thus, difficult to control (Johnson, 1992). For example, the costs of equipment calibration, the inspection equipment, inspection material, if any, and inspection personnel training are all aggregated in 'production inspection' costs. Moreover, they do not provide adequate information on activities, which are the controllable element. TCA systems do not provide non-financial information such as cycle-time (time from design to distribution), and turnover rate in a company. They provide little useful information about what matters to customers (which is the main requirement of any world-class company). Factors such as quality and service are out of their domain (Kaplan, 1984). They report only financial information such as rate of return on investment, profit level and market share. For example, non-financial information including defect rates and throughput rates in each activity, for example, is outside the scope of the traditional costing system.

4. In addition to the shortcomings of TCA systems stated above, traditional performance measurement systems associated with TCA are obstacles to adopting TCA in Quality Costs Information Systems (QCIS). The traditional performance measurement systems are designed to measure the performance of production volume-related attributes. Although the measurements are still considered valuable criteria for judging the efficiency of a manufacturing system, they can lead to several problems. For instance, maximising the utilisation of a machine may result in the following: increases in average inventory levels of work-in-
process and finished goods and degrading a product quality due to frequent machine breakdowns. Traditional financial data is of little value for the purpose of controlling a manufacturing operation. It is usually prepared monthly or quarterly and does not provide direct information on an operational control. So companies need to develop new performance measurement systems, which provide useful information on activities that are important to internal and external customers at the time required.

TCA systems have received much criticism for generating inadequate cost information. Meanwhile, ABC systems have recently received much attention due to their ability to derive more useful cost information (Turney, 1996).

Today, companies need information that is timely, clear, and relevant for managers to understand the root causes of problems, to initiate corrective actions, and to support decisions at all levels of the organisation. With ABC systems cost can be managed in the long-term by controlling the activities that deliver them. In other words ABC systems focus on managing activities rather than costs directly. This makes it possible to quantify strategic long-term intangible benefits of QCIS more reliably than in TCA systems.

Companies are making fundamental changes in the organisation and technology of their manufacturing process, but they ignore the costing system. It is clear from the above discussion that information available from the traditional costing system is not sufficient for continuous improvement programmes, which are essential for companies to compete in a rapidly changing environment. For example, while the costs of scrap, re-work, and waste are all aggregated under TCA methods, companies that are after continuous improvement need to know exactly how much each category costs, the activities that caused these costs, and indeed the reasons for them. The traditional costing system does not give accurate information about the consumption of different resources and the activities of the organisation. The ABC system is an information-rich costing system which is necessary for the success of companies.

An ABC system emphasises the need to obtain a better understanding of the
behaviour of overhead costs, and thus ascertain what causes overhead costs and how they relate to products. ABC recognises that in the long run most costs are not fixed, and it seeks to understand the forces that cause overhead costs to change over time.

ABC systems assume that cash outflows are incurred to acquire a supply of resources (such as labour, materials, and machinery) which are then consumed by activities. In other words it is assumed that activities cause costs and also that products create demands for activities. A link is made between activities and products by assigning costs of activities to products based on an individual product's consumption or demand for each activity. ABC systems simply recognise that businesses must understand the factors that drive each major activity, the cost of activities and how activities relate to products.

3.8 Activity Based Costing (ABC)

3.8.1 What is Activity Based Costing (ABC)?

ABC is a simple concept: 'Products consume activities, activities consume resources'. An ABC system provides valuable information about the past, present and future. It serves as a far greater source of information for managers to arrive at new objectives and strategies as it helps to detect future trends of inefficient activities. ABC is thus more useful in the strategic and objective decision-making process for organisations than the traditional accounting system. Companies striving for success want to see the information on cost, quality and process time for their activities. The ABC system provides information on the cost sector. The information from the ABC system can then be integrated with other data on revenues, customer preferences, process quality, and cycle times.

Kaplan and Atkins (1989) defined an ABC accounting system as: "a method that seeks to understand better the factors that create demand for overhead and support resources based on the demand made by the individual products". The Consortium of Advanced Management International (CAM-I) has defined ABC as "a collection of financial and performance information dealing with significant activities of the business. Activities are repetitive tasks performed by each specialised group within a
company, as it executes its business objectives" (Romano, 1989). Thus, the basic definition that will be adopted in this chapter is “Activity Based Costing is a methodology that measures the cost and performance of activities, resources, and cost objects. Resources are assigned to activities, then activities are assigned to cost objects based on their use. ABC recognises the causal relationship of cost drivers to activities” (Turney, 1996). In the context of quality activities, the activities might be inspection, maintenance, planning. The resource consumed would be material, labour, equipment, and money, and the drivers could be number of manufacturing defects, or the supplied material quality. Once a causal relationship is established between these drivers and the consumption of the quality activities of the resources aforementioned, and how much they cost, an organisation can deploy a systematic approach to minimising quality costs.

3.8.2 The Principles of ABC

The basic premise of ABC is that resource consuming activities are the cause of costs, and each product manufactured incurs costs, based on the activities required for its design, engineering, manufacturing, marketing, delivering, invoicing, and servicing (Romano, 1990). Tatikonda and Tatikonda (1991) defined ABC in simple terms: “ABC traces costs to products according to the activities performed. It assumes that activities consume resources and products consume activities”. An activity connotes people doing work and is properly described with phrases that contain a verb and a noun (Johnson, 1991), for example, move a finished part or order new material. Tatikonda and Tatikonda (1991) described activities as procedures and processes that cause work, which in turn generate costs. A cost driver is an event associated with an activity that results in the consumption of a firm’s resources (Batad and Balachandran, 1993). Therefore, drivers are occasionally referred to as cost generators (Johnson, 1991). More often they refer to things described by a noun – for example, purchase orders, set-ups, and/or inspections. Drivers initiate activities and therefore cause costs. The allocation bases used in ABC are drivers (Cooper, 1988).

Thus, ABC is based on the following main principles:
- Costs represent the expenditure incurred in acquiring resources.
- Activities use or consume resources.
- The amount of activity consumed, and, therefore, the cost is dictated by the appropriate cost driver.
- Activity costs are linked to objects (i.e. products, services, or customers) by means of the appropriate cost driver.

The ABC system not only allocates the overhead costs to activities but distinguishes between used and unused related activities in terms of cost and volume. Or expressed differently and formalised by an example as:

Activity Availability = Activity Usage + Unused Capacity

Or

Cost of Activity Supplied = Cost of Activity used + Cost of Unused Activity

For example, consider the case where ten full-time people are employed at a retail outlet. The monthly costs of a full time employee is £1,500 accumulating to wage costs of £15,000 for all ten employees. Thus the monthly costs of the activity "serving the customer" can amount to £15,000. Say each employee can handle 1,000 requests or customer orders per month, the cost per order is calculated by the wage divided by the number of requests per month (£15,000/10,000 requests = £1.5 per request). Due to a drop in requests, the whole department is asked to deal with 9,000 instead of 10,000 requests a month or 900 instead of 1,000 requests per employee. The ABC costing model would take this drop of demand into consideration. It would still assign £1.5 per request and would calculate a cost of activity used of £13,500 (£1.5 per request times 900 request times 10 employees). Under the ABC system, the remaining £1,500 of monthly operating expenses would be allocated to the unused capacity within the retail outlet's activity. Such a difference is calculated for each organisational activity defined by the ABC system. On the other hand, in TCA, this information would be missing. Initially, and when the production level was at 10,000, the calculation would be £15,000/10000 requests resulting in £1.5 per request. However, when the orders drop to 9,000, TCA would merely recalculate this by evenly spreading the labour costs to be £15,000/9,000 resulting in £1.67 per request.
So instead of indicating some unused capacity, TCA only raises the cost per request, and an improvement opportunity goes unnoticed.

To further illustrate the differences between TCA systems and ABC systems, consider the example of the allocation of the costs of a non-volume-related activity, such as setting up a machine to produce a different product. When changing the machine from one product to another, set-up resources are consumed according to the number of set-ups performed and are unrelated to the number of units produced after completing the set-up. For the purpose of illustration, it is assumed that the resources consumed by set-up activities cost £140,000 and only two products are produced - product L (of which 6,000 units are produced) and product H (of which 55,000 are produced). Product L is produced in batches of 600 units whereas the product H is produced in batches of 11,000 units. Thus product L requires 10 set-ups and product H 5 set-ups. With the ABC system costs are traced to products according to the product's demands for activities. Product L has consumed 10 out of 15 set-ups (two-thirds) and product H has consumed 5 out of 15 set-ups (one-third) of the set-up resources. Thus set-up costs of £93,333.3 (2/3x140,000) would be traced to product L and £46,666.7(1/3x140,000) would be traced to product H. The set-up cost per unit is £15.5 for product L (£93,333.3/6,000 units) and £0.85 (£46,666.7/55,000 units) for product H. However, if TCA systems were used, they would report distorted product costs whenever the cost of non-volume-related activities is significant. In particular low-volume products tend to be undercosted and high-volume products overcosted. Within a TCA, system the set-up costs would be allocated to the production department and then charged to products using volume-related bases such as machine hours or direct labour hours. Assuming that both products required the same number of machine or direct labour hours. Hours per unit then the traditional system would allocate 9.8% (6,000/61,000) of the set-up costs to product L and 90% (55,000/61,000) to product H. Thus set-up costs of £13,770.5 (9.8% x £140,000) would be allocated to product L and £126,229.5(90% x140,000) would be allocated to product H. The overall outcome is that a set-up cost of £2.3 would be attributed to each product (£13,770.5/6,000 units for product L and £126,229.5/55,000 units for product H). Thus, it is clear that the information provided by the TCA would distort the facts, and provide a non-reflective profitability for each of these two products. The message
from the TCA system was to de-emphasis product H and focus on more profitable speciality low volume products similar to product L. In reality this strategy would be disastrous since product H is cheaper to make and replacing the lost output with low volume speciality products will further increase the overheads relating to support activities.

Clearly, the two reporting systems, TCA system and ABC system, provide different information. A periodic financial statement provides information on the cost of resources supplied each month, which is relevant for predicting short term spending. As the spending for resources will not change in the short-term those costs have been described as "fixed" in the traditional accounting system. But measuring the operating expenses is not enough. Information is also needed on why resources have been acquired in the first place, how much of the expenses have actually been needed and what the amount of actual expenditure is likely to be in the future. As the ABC measures the cost of the used and the unused resources, managers can now monitor and predict changes in demand as a result of changes in processes and improvements, technology, design and training. The ABC system enables managers to find out whether the revenues received from a product cover the activities in order to produce it. This has been achieved by allocating separate activity cost drivers for each activity, which terminates the equalisation of the traditional accounting system where the cost of acquired resources represent the cost of used resources.

This is the first dimension of ABC, and is termed the 'Cost Assignment View' from which the resulting information can be used for such decisions as pricing, product mix, sourcing, product design, and setting priorities for improvement efforts.

The second dimension is the 'Process view'. This reflects the need that organisations have for a non-financial category of information, about what causes work, and how efficiently the work is done. Each piece of information on an activity includes a cost driver, performance measures and other information such as the cost of quality. A cost driver describes the workload and effort needed to accomplish an activity measured in pounds. Two types of drivers are used to assign costs to activities,
outputs and customers. The resulting information can be used to help improve performance and to increase value added to the customer.

This two-dimensional view can be further illustrated in the Figure 3.10.

![Figure 3.10: ABC – a two-dimensional view](image)

### 3.8.3 Cost Assignment View

The underlying assumption with the cost assignment view is that cost objects create the need for activities, and activities create the need for resources. The flow of costs, however, is in the opposite direction.

The main elements in this technique are as follows:

1. **Resources**: The most important feature of the ABC model is that it describes resources that are used by activities. In contrast, conventional systems describe the resources that are supplied. The difference between the two is excess capacity as explained in earlier examples.

The excess capacity thus identified should not be treated as a variance. The issue is to focus management attention on the action to be taken in relation to the excess capacity in the medium to long-term. This is another fundamental difference between ABC and TCA. In TCA a short-term view prevails whereby many
overheads costs are treated as "fixed" and the "decision relevant" costs are those incremental costs such as direct labour, which vary in the short-term. Over this time-scale, many of the costs, which will have previously been regarded as "fixed", become variable in their nature and thereby relevant for decision-making purposes.

2. Activities: People can only ever undertake activities, which includes making decisions that subsequently affect future activities. Activities convert inputs into outputs - that is, all activities have a consequence, which in a "world class" company should, whenever possible, add value in the eyes of the customer. If they do not, then their existence should be questioned.

3. Cost Objects: The purpose of ABC is to assign cost to objects, which may be products or customers. This focus is particularly useful for strategic decision-making. TCA systems are unable to identify the cost associated with certain products, and as a result, in many cases the marketing function are being misled into believing that these customers are profitable, and are therefore misdirecting their support and promotional efforts. ABC avoids these problems.

3.8.4 Process View

The process view provides information done in an activity and the relationship of this work to other activities.

A process is a series of activities that are linked to perform a specific goal. Each activity is a customer of another activity and in turn has its own customers. All activities are therefore part of a "customer chain" with all activities working together to provide value to the outside customer. The is analogous to the 'quality chains' concept of TQM whereby every activity in an organisation has its internal customer, and everyone is responsible for delivering quality to that internal customer in order to deliver a quality product or service to the final customer.
On a specific level, ABC includes information about cost drivers, and performance measures for each activity or process in the customer chain. The information is usually non-financial and is useful in helping to interpret the performance of activities and processes:

1. Cost Drivers

A cost driver can be defined as “a factor that determines the workload and effort required to perform an activity”. Cost drivers have a dual role:

- They tell us why an activity is performed – The volume of a particular activity is dictated directly by its cost driver (e.g. the number of design change notifications, may be the cost driver for many different activities throughout the business).

- They tell us how much effort must be expended to carry out the work – cost drivers characterise objects (products or customers) e.g. 1,000 bread rolls may be produced in one batch or ten batches of 100 on ten different occasions. The set up for the former situation is likely to involve one tenth of the effort of the latter. Volume of output is therefore clearly not the driver of the set-up activity, whereas the number of set-ups is.

2. Performance Measures

These describe the work done and the results achieved in an activity. They tell how well an activity is performed. They communicate how the activity is meeting the needs of its internal or external customers. They include the measurements of the efficiency of the activity, the time required to complete the activity and the work done.

Such performance measures should be used to focus the attention of management on the important aspects of activity performance, and should stimulate efforts to continually improve. For example, and in specific relation to a quality activity such as preventive maintenance, performance measures could be the number of breakdowns that occur, the time it takes to complete the preventive maintenance activities (usually a time when machines are down and should be minimised), and so on.
It can be seen that in the two-dimensional ABC model, both cost data and process data join together to produce an extremely powerful tool for management, giving them a total view of work done, facilitating the management of activities and improvement of performance.

### 3.9 Activity Based Costing System Design

ABC is as much an art as it is a science. There are various approaches for designing and implementing an ABC system. There is no "one approach fits all" solution (Turney, 1996). Without a clearly stated purpose, the ABC system resulting from the project will not meet the needs of the organisation in a cost-effective manner. Various authors and practitioners have suggested various design choices (Cooper, 1989; Beaujon and Singhal, 1990; Gunasekaran, 1999; Turney, 1996; Cooper and Kaplan, 1991a).

To be effective, the ABC system must make the appropriate trade-offs between accuracy, flexibility and cost. Here again, the system’s primary objectives must be kept in mind. If the system is to be used to support the improvement process, more details will be required than if its main objective is to understand product line profitability (Rupp, 1995). Many ABC models fail to meet objectives because they include too much information. It is suggested that to improve a model’s efficiency and sustainability, it should be limited to crucial data (Krpincki and Tyson, 1997).

A generic methodology that integrates and builds on the strengths of various approaches will be presented here. The design process begins with defining the objectives of an ABC system and ends with the implementation. Further details of each stage are provided in the discussion below.

#### 3.9.1 Setting the ABC System Goals

It is crucial to start the ABC system design by selecting a specific purpose so that an organisation can then design a system that serves that specific purpose or objective.
The following is a list of objectives that a company can achieve by successfully implementing an ABC system (Turney, 1996; Gunasekaran, 1999).

- To provide information about manufacturing and non-manufacturing activities to support waste elimination and cost reduction programmes, which are some of the goals of TQM in general and quality costing systems in specific.
- To provide design engineers with cost information that guide selection of low cost and high quality product design, which is another goal of TQM to attain zero defects and right the first time manufacturing.
- To provide information to guide market focus (product pricing, product mix, etc).
- To provide product costs and to facilitate studies of relative product profitability.

3.9.2 Forming and Training the ABC Team

The organisation must develop a dedicated ABC team and include members from several disciplines other than finance. The team size depends on the organisation's size, urgency of completion of project and availability of staff but it is essential that it is cross-functional (Turney, 1996). According to Cooper (1991), there should be a minimum of four team members to cover engineering, finance and accounting, production, and management. All team members should be given the required training on ABC principles and skills.

3.9.3 Determine the Required Cost Levels

As discussed earlier, not all-overhead resources are consumed in direct proportion to the number of units produced. "ABC identifies batch level and product level allocation bases in addition to the unit-level bases" (Cooper, 1990). Batch level bases assume that certain inputs are consumed in direct proportion to the number of batches of each type of product produced and product level bases assume that certain inputs are consumed to develop or permit production of different products. ABC recognises that all overhead activities can be categorised into a "cost hierarchy" which can be described as follows:
- Volume/Unit Level - These are activities involved at a unit level, which vary according to the number of units produced, e.g. direct labour, machine hours, number of inspection activities required, etc.

- Batch Level - These are activities involved at a batch level, which vary with the number of batches produced, e.g. set-up, clean-down, material movement, recalibration etc.

- Product Level - These are costs incurred simply because products are produced, e.g. licence fees, supplier assessment and certification, etc.

- Customer level - These are activities incurred simply because the company has customers e.g. order processing, sales force, customer requirements and satisfaction surveys, etc.

- Market level - These are activities incurred because the company is in the market that it is in e.g. advertising, market research etc.

- Plant/Infrastructure level - These are activities incurred to support the plant e.g. building maintenance, security, preventive equipment maintenance etc.

The above hierarchy of activities and examples of activities and cost drivers associated with each level of hierarchy are illustrated in Figure 3.11.

![Figure 3.11: Hierarchy of activities: A graphical illustration using examples](image-url)
By allocating costs to the activities described above, it is possible to diagrammatically show the difference between the TCA and the ABC model as shown in Figure 3.12

![Diagram showing TCA vs ABC model](image)

**Figure 3.12: ABC vs. TCA – an example**

### 3.9.4 Identification of Activities

The next stage is to identify the activities that are undertaken within the identified cost hierarchy. Activities are the process or procedures that cause work to be performed in an organisation. They are aggregations of tasks (whether performed by people or machines) to satisfy the needs of customers (whether they are internal or external) (Miller, 1992). Identification of the activities is the basic step of an ABC system, as it sets the structure and scope of the system (Innes et al, 1994).

Identifying activities must be approached in a systematic way to ensure that all relevant activities are captured. The activities differ in the type and the location from one company to another owing to technology, size and approach of the company (Gunasekaran, 1999). For a small company quality control is an activity, but for a big company quality control involves many activities like inspection of incoming goods,
in-process inspection and finished goods inspection. Quality control activities in world-class manufacturing are dispersed to all employees.

Theoretically, even a small organisation can identify an almost limitless number of activities. The identification process should, however, be guided by materiality and the objectives of the ABC system. For example, if the objective is strategic (e.g. product line profitability, pricing policies), the primary need is to accurately assign costs to cost objects. In such cases, activities can be broadly defined. If, on the other hand, the intent is to improve operations (e.g. eliminate non-value-added processes), the need is for information about activities as well as cost objects. In these cases, activities must be defined more narrowly.

Materiality will also impact activity definitions. For example, an organisation with only two individuals in the purchasing function will not gain as much by dividing the function into twenty separate activities, as will an organisation with fifty individuals.

If an organisation has identified activities very narrowly, they can group some of them in activity centres for the purpose of costing. Activity centres are groups of activities that make up a business process. They are particularly useful when functional areas have been decomposed into large numbers of activities and a major objective of the system is to understand the cost of business processes. In this case, activity centres can be used to simplify an ABC system by taking activities with similar cost behaviour and the same cost driver and combining them into macro-activities.

A best practice of rule-of-thumb that can be used here is the ‘5% rule’ (Turney, 96). In general, the ABC model should not include any activity that takes less than 5% of a person’s time. However, if three or four types of insignificant activities together account for more than 5% of a department’s time, they should be combined under one general category, such as ‘administrative activities’ and added to the model. Again, this depends on the model’s objectives. There is more room to condense and summarise data when the objective is to gain information on strategic planning than if the objective is more tactical like process improvement.
Another factor in the decision on the volume of activities, which should be used as the basis for the system, is based on the degree of cost homogeneity associated with each activity, with level of detail required to give an acceptable cost visibility to management, and with the degree of accuracy required by the management for product costs. The common activity in any organisation includes purchasing, customer order processing, quality control, material handling, production control, inspection, distribution and maintenance.

3.9.5 Identification of Primary Cost Drivers

Having identified the activities, the next step is to identify the “cost drivers” associated with them. Cost drivers are the variables that can be used to explain the behaviour of activity costs. They reflect the consumption of costs by activities and the consumption of activities by other activities, products, or services. Thus, a cost driver is any factor(s) that change the cost of the activity. It is the root cause why work is done. A cost driver is a factor that has direct influence on the cost and performance of the activities. The cost drivers provide the best explanation of why costs in an activity cost pool change over time. Computer Aided Manufacturing International (CAM-I) defined a cost driver as any factor that causes a change in the cost of activity. The primary cost drivers are the link between the resources and the activities. They take a cost from the general ledger and assign it to the activities (Berliner and Brimson, 1988).

The accuracy of a product cost depends on these cost drivers because cost of activity is an aggregation of cost of primary drivers and product cost is an aggregation of the cost of activities. These cost drivers actually show how specific resources are consumed by an activity. Different types of resources are required to perform an activity, therefore, every activity should be analysed in detail to create a list of all the primary cost drivers. The estimation of cost for each driver should be very accurate (Rupp, 1995).

The following guidelines are seen to be good practices when selecting cost drivers (Gunasekaran, 1999):
- The cost driver selected should have a strong correlation with cost level in the activity cost pool.
- The variable should be quantifiable and homogeneous.
- Minimise the number of unique drivers. Cost and complexity should be directly correlated with the number of drivers.
- Select cost drivers that encourage improved performance.
- Select cost drivers that are already available and/or have a low cost of collection.

3.9.6 Determine the ‘Activity Cost Pools’

The activity cost pool is the total cost associated with an activity. Each type of primary cost driver that is traced to an activity becomes a cost element in an activity cost pool; this can be done by identifying all the costs of an activity in terms of cost drivers and then the costs can be directly charged to each cost pool (Gunasekaran, 1999). If some resources are shared by several activities, then some measure of apportionment will be necessary. The basis of apportionment should reflect as closely as possible the extent to which each activity consumes the shared resource. The best estimation of apportionment rate does not affect the accuracy (Keegan and Eiler, 1994).

The elements of cost can be assigned to activities by charging them in some directly measurable manner (e.g. metering electric consumption, charging preventive maintenance via a work order, charging incoming inspection activities for supplies) or estimation (as determined through questionnaires and interviews). In other words, costs can be traceable, when the cost elements (e.g. salaries, supplies) can be traced directly to an activity, business process, or a cost objective. A cost is ‘allocated’ when it is charged to an activity on a basis other than direct traceability. Arbitrary allocations should be minimised whenever possible because they do not improve the understanding of the economics of activities.
3.9.7 Allocate Costs to Cost Objects

Cost object can be any customer, product, service, contract, project or any other work unit for which a separate cost measurement is desired. Most companies have two hierarchies of cost objects, one for products and one for customers (Turney, 1996).

The ideal cost object is "products" which are individual items that are sold to customers. Linking the cost of activities directly to the products that consume the activities is the basis for product costing using the ABC system (Gunasekaran, 1999; Innes et al, 1994). Customer costing makes it possible to assess the profitability of individual customer or groups of customers. It often reveals the levels of profitability that vary significantly from customer to customer. Customer costing is the calculation of the total cost of serving a customer. This cost includes two components, one is the cost of products purchased by customers and the other is the cost of support activities received by customers (Turney, 1996). Therefore, the choice of cost object is different for different companies. However, common cost objects for manufacturing industry and service industry are products and customers, respectively.

3.9.8 ABC System Implementation

The first step in successful ABC implementation is to gain full top management commitment. ABC will require a shift in culture, as well as in organisational procedures, from the traditional approaches. Top management has to be convinced of its benefits and value, and dedicate the required resources for successful implementation.

Another critical success factor is the training of the ABC system user. The user should understand what information is available from an ABC system and how that information should be used in decision-making. The primary aim of the new system is not to create an elegant and technically robust solution, but to provide a solution that will change the behaviour, and allow management to make and improve the
performance of the business (Marrow, 1992). Therefore, the user should be trained to apply the ABC system.

### 3.10 Comparing Traditional Cost Accounting with Activity-Based Accounting

TCA and ABC systems are best compared by the structure of an income statement, as obtained in both cases. A typical structure of an income statement in TCA systems is depicted in Figure 3.13. All overhead costs are allocated to factory cost. Operating expense (selling and administrative) is excluded from the cost of goods sold.

Figure 3.14 shows the proposed structure of an income statement under ABC systems. In this structure, the total expense has been classified into direct material, direct labour, various manufacturing activities, depreciation, non-activities, non-operating costs, and income tax expenses.

As can be seen from Figure 3.13 and Figure 3.14, in TCA systems operating expenses are treated as a period expense, but in an ABC system are assigned to products. The cost element of “other activities” in activity expenses may be service-related activity costs such as sales, marketing, and administration costs.

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<tr>
<th>Total Revenues</th>
<th>Net Sales Revenue Non Operating Revenues</th>
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<td>Cost of Goods Sold</td>
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<td>Factory Cost</td>
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<td>Total Expenses</td>
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<td>Operating Expense</td>
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<td>Non-Operational Expense</td>
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<td>Interest Expense</td>
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<td>Income Taxes</td>
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<tr>
<td>Net Income = Total Revenues – Total Expense</td>
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</table>

**Figure 3.13:** TCA income statement
As shown in Figure 3.14 there are non-activities performed for products. They are: unused activity, waiting time, idle time, and inventory holding costs. Unused activity costs are defined as the remaining portion of activity expenses not assigned to products due to activity excess-capacity. Among non-activity costs, waiting time and idle time activity costs are considered opportunity cost.
<table>
<thead>
<tr>
<th>Total Revenue</th>
<th>Net Sales Revenue</th>
<th>Non Operating Revenues</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct Material</td>
<td>Direct Labour</td>
</tr>
<tr>
<td></td>
<td>Processing Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tooling Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Set-up Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prevention Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Appraisal Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal failure Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>External Failure Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inventory Handling Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Storage Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fork Lifting Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material Moving Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Purchasing Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Computer Software-Related Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other Activities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Depreciation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Waiting time Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Idle Time Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inventory Holding Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unused Activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interest Expenses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Misc Expenses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Income Taxes</td>
<td></td>
</tr>
</tbody>
</table>

Net Income = Total Revenues - Total Expense

**Figure 3.14: Proposed income statement in ABC**

The major differences between TCA and ABC systems are shown in Table 3.1 and discussed subsequently.
### Table 3.1: Comparisons of TCA and ABC system

<table>
<thead>
<tr>
<th></th>
<th>Traditional Cost Accounting</th>
<th>Active-Based Costing (ABC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost Driver</td>
<td>Labour hours, material cost or machine hours</td>
<td>As many as needed</td>
</tr>
<tr>
<td>Capacity Expenses</td>
<td>Budgeted production volume</td>
<td>Practical capacity</td>
</tr>
<tr>
<td>Cost classification</td>
<td>Fixed and variable costs</td>
<td>Variable costs</td>
</tr>
<tr>
<td>Expenses</td>
<td>Fully absorbed</td>
<td>Practically absorbed</td>
</tr>
<tr>
<td>Depreciation</td>
<td>Straight-line</td>
<td>Machine hour-usage</td>
</tr>
<tr>
<td>Administrative, selling</td>
<td>A period expense</td>
<td>Assigned to products</td>
</tr>
<tr>
<td>and marketing expenses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R &amp; D expenses</td>
<td>A period expense</td>
<td>A period expense or assigned to products</td>
</tr>
<tr>
<td>Cause of cost</td>
<td>Products</td>
<td>activities</td>
</tr>
<tr>
<td>Main purpose</td>
<td>Financial reporting</td>
<td>Product costing</td>
</tr>
</tbody>
</table>

Cooper (1990) suggested that the number of cost drivers should be determined subject to the desired accuracy of product costs and based on the complexity of the product mix. It is noted that depreciation expenses in ABC systems are not for tax reporting, but for product costing. Cooper and Kaplan (1991a) recommended splitting R&D expenses into two categories, those that relate to improvements and modifications of existing products and lines and those that relate to entirely new products and lines. In their recommendation, the first category should be traced to the products that will benefit from the development effort, otherwise, the costs will be distributed to products and lines that bear no relationship to the applied R&D program. For the second category they recommend treating the costs as investments in the future.

In order to fully clarify the ABC methodology, and indeed its differences with the TCA systems, the following detailed examples discuss how various cost sources and pools are dealt with under an ABC system.

### 3.11 Cost Allocation in ABC

This section provides practical examples on how ABC allocates the costs of various cost sources and pools.
3.11.1 Direct Material Cost

Direct materials include all the materials (raw materials and parts) that are a part of the final product and that may be traced to product in an economically feasible way. The direct material cost is the sum of the purchase price, delivery charge, and sales tax (if any). All of these costs are assigned to products based on the amount of materials used.

3.11.2 Direct Labour Cost

An hourly rate is computed by dividing the labour cost, which includes all the fringe benefits, by the hours of available labour. The hours of available labour are the pure operation time excluding coffee break, recess, and etc. A product assimilates labour costs based on the amount of hours consumed by the product, multiplied by the hourly rate.

3.11.3 Processing Activity Cost

Processing activity cost normally includes utilities, depreciation, insurance and property taxes, maintenance and repair, and floor space. In terms of depreciation, there are three different types: equipment, property, and building. These depreciation expenses must be handled individually. Depreciation expenses are presented based on a straight-line method under TCA systems and on the use of assets by products under ABC systems. Product costs must be adjusted by subtracting depreciation expenses from the product costs when evaluating investments, because initial investments would be double-counted.

3.11.4 Tooling Activity Cost

Tooling is the function that determines tool requirements, creates the tool design, and performs those activities necessary to prepare the tool for production. Costs
associated with tooling activity may be assigned to products based on the number of tools constructed.

3.11.5 Set-up Activity Cost

Set-up cost is the amount spent on preparing a manufacturing process for a production run. Current market dynamics require the introduction of new products and improvements in existing products. To successfully respond to the market dynamics, a company must reduce the time required for set-up. Quantifying set-up costs provide a company with a cost reduction opportunity. Set-up activity cost should be assigned to products based on the number of set-ups demanded.

3.11.6 Inventory Handling Activity Cost

The average inventory level of raw material, finished products and Work-In-Process (WIP) can be drastically cut through improved process flexibility, higher product quality, and reduced set-up time in an advance manufacturing environment.

Traditional inventory carrying cost is divided here into activity-related and non-activity-related cost. The activity-related cost is the cost associated with storage, such as depreciation, insurance and property taxes, and maintenance on buildings and physical facilities (called inventory-handling activity). Storage cost can be divided into fork lifting and storage activity cost. The number of moves may be the cost driver for fork lifting activity, and the number of locations occupied by raw materials or finished products the driver for storage activity.

Non-activity-related costs include the opportunity costs of the investment tied up in inventory costs, the costs associated with the inventory items such as taxes and insurance on inventory, and the costs associated with the loss of inventory values due to, for instance, obsolescence and shrinkage. This cost will also be discussed in the section regarding non-activity-related cost.
3.11.7 Material Moving Activity Cost

Materials are usually classified as raw materials, work-in-process, or finished products. Material handling activity has often been overlooked even though the cost of its activity has been a significant portion of the total manufacturing cost. In the past, the costs associated with this activity were allocated to a product based on direct labour cost.

3.11.8 Purchase Order Activity Cost

Purchasing is one of the batch-level activity costs. A company creates schedules, and places and co-ordinates purchase orders. This activity cost may be assigned to products based on the number of purchase orders required by them.

3.11.9 Software-Related Activity Cost

The cost of computer-related activities include the cost of designing, developing and maintaining software required for processing, monitoring, and controlling the manufacturing system. This activity cost may be assigned to products based on the cycle time.

3.11.10 Non-Activity Cost

In ABC systems, there are also several non-activity costs which are not directly caused by performing activities on products such as unused activity costs, inventory holding activity cost, waiting time activity costs, and idle time activity cost. This way of viewing the cost of resource clarifies how productively company’s resources are used.
3.11.11 Unused Activity Cost

In ABC systems, every activity has the potential of having an unused capacity position. It implies that not all the costs of a company's resources and capacity are fully absorbed by products. A company must take over the portion of expenses unrecovered by products for inefficient management. The unused activity cost is treated as a period expense in ABC systems.

3.11.12 Waiting Time Activity

Here, waiting time activity is defined as the time a product spends in a manufacturing system other than machine process time. Waiting time activity can be reduced by an efficiently redesigned facility layout; installing advanced material handling and inspection systems; a more efficient scheduling of operations; and planning of the release of work to production coupled with advanced manufacturing techniques. The reduced waiting time activity results in enhanced process flexibility, reducing the capital cost tied up in WIP inventory and eventually improving cash flows.

3.11.13 Inventory Holding Activity Cost

Inventory holding activity cost is a non-activity inventory cost as discussed in the inventory handling activity cost section. This cost is not caused by activity required by products rather it is caused by the effect of the activity already performed.

3.11.14 Idle Time Activity Cost

Idle time activity cost is opportunity cost that is incurred when a machine is not used. When a manufacturing system has a high level of machine flexibility, machines are ready to accommodate the variants of product mix, reducing the idle time of machines.
Measuring and reporting quality cost is the first step in establishing a Quality Cost Information System (QCIS) (Ross and Wegman, 1990). When successfully implemented, the QCIS will be used to highlight major opportunities for preventive and corrective actions and to provide momentum for quality improvement (Ravitz, 1991). The TCA systems described previously cannot satisfy the needs of QCIS measurement. Thus, Oakland (1993) claims that: "quality related costs should be collected and reported separately and not absorbed into a variety of overheads". Table 3.2 provides some generic examples of how quality related activities' costs are allocated in TCA and ABC systems. These examples highlight the fact that within TCA, these costs are absorbed without providing any useful information for continuous improvement, while within ABC they are allocated to products and services, and can be targeted for reduction and improvement.

<table>
<thead>
<tr>
<th>Activity</th>
<th>TCA</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier evaluation</td>
<td>Stores or Quality Function</td>
<td>Product</td>
</tr>
<tr>
<td>Training personnel</td>
<td>Personnel and HR</td>
<td>Product</td>
</tr>
<tr>
<td>Preventive Maintenance</td>
<td>Maintenance Function</td>
<td>Product</td>
</tr>
<tr>
<td>Prototype inspection and test</td>
<td>Research and Development</td>
<td>Product</td>
</tr>
<tr>
<td>Incoming inspection</td>
<td>Stores or Quality Function</td>
<td>Product</td>
</tr>
<tr>
<td>In-process-inspection</td>
<td>Production</td>
<td>Product</td>
</tr>
<tr>
<td>Scrap</td>
<td>Production (aggregated)</td>
<td>Product</td>
</tr>
</tbody>
</table>

The quality cost savings from the continuous improvement of products and processes must be measurable if a TQM implementation is to be self-sustaining. The problem is traditional accounting methods fail to take major business expenses, such as indirect overheads, and properly apply them to products and processes so that quality costs can be related to financial reporting. With ABC, it is possible to trace massive overhead costs down to the product and/or process level, based on activities and
consumption of resources. So true cost of good quality is not only doing things right, it is also the cost of preventing things from going wrong. While ASQC quality cost standards recognise the limitations of traditional accounting systems and require only factory overhead, Hester (1993) argued that: “we are now able to assign all relevant overhead to total quality costs, and to link them to financial reporting systems”. Traditional quality costs are under-estimated because of hidden quality costs and are inaccurate because of the application of irrelevant overheads. The remainder of this chapter discusses the use of ABC to design and implement a successful QCIS.

3.12 Conclusions

It is believed that a quality cost programme will require extensive changes in the accounting system. Traditional Cost Accounting (TAC) systems were not designed to demonstrate the impact of the quality of performance (thought to be a subjective measurement) on overall operating costs (this is discussed in more details in Chapter 7).

Kaplan (1987) said: “Today’s management accounting information, driven by the procedures and cycle of the organisation’s financial reporting system, is too late, too aggregated and too distorted to be relevant for manager’s planning and control decision:

- Accounting information provides little help for reducing costs and improving productivity and quality;
- The systems do not produce accurate product costs for pricing, product mix and responses to competition;
- The system encourages managers to contract to the short-term cycle of the monthly profit and loss statement.

This is why many quality costs have remained hidden or unknown. Identifying and collecting quality costing data must be comprehensive if the system is to be effective. What is required is a quality costing system that will enable:
- The accurate costing of a product;
- Identification of those products which consume a large proportion of overheads in relation to a relatively small production volume;
- Identification and costing of activities which add or fail to add value to a product;
- The obtaining of accurate information which management can use when making decisions.

Without a comprehensive approach to collecting quality costs and a relatively accurate mechanism for determining these costs, the benefits to be derived from any attempted audit will be limited. Creating a Quality Costing management system will inevitably cause problems. Some of these problems are noted by Davies: “Try to introduce a new way of looking at these costs, though, and the barriers start to come up. The threat of a new challenge to the way commercial decisions are made, and the way that costs are managed, is seldom welcomed by all”. Jeeves (1993) discusses the role of quality costing in management accounting, he concludes that: “Despite the difficulties encountered, it has shown that as a regular ongoing addition to existing management accounting, quality costing does have a major role to play in monitoring and controlling the drive towards quality improvement”.

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CHAPTER 4:
QUALITY COSTING PRACTICES INDUSTRIAL
SURVEY STUDY DESIGN, ADMINISTRATION,
AND RESPONDENTS

4.1 Introduction

This chapter reports on the design and administration of an empirical survey conducted to assess the practical approaches to quality costing deployed in industry. The methodology for designing the survey, the instrument, and sample selection came from a literature review in two main areas:

2. Previous surveys and studies in similar areas (Murphy, 1990; Chiu and Lee, 1980; Siriwardane, 1994).

4.2 Study Objectives

Literature on quality costing systems has been reviewed in the previous chapters. From that literature review, it was concluded that previous researchers were concerned mainly with specific aspects of quality costing systems, and few were found to incorporate an accurate and complete calculation of quality costs and their correct allocation to products and activities. The ability to gain an insight into these matters was the main driver behind the survey undertaken.

The study objectives listed below are statements of the outcomes anticipated from the survey. These came from the need to assess the quality costing practices within industry:

1. To gather data regarding the current approaches to quality costing in industry.

   The study’s basic purpose was to investigate:
1.1 The current quality cost measures used in manufacturing organisations.
1.2 The current quality costing activities manufacturing organisations undertake.
1.3 Level of quality costs within industry.
1.4 Approaches used by organisations for their costing systems (traditional accounting, ABC, etc.)
1.5 The current understanding and awareness of Activity Based Costing principles
1.6 The current satisfaction with costing methods and major areas for improvement

2. To gather evidence from current manufacturing organisational practices and approaches to justify the need for a new approach to quality costing, i.e. validate the basis of the approaches proposed in this research.

Based on these objectives, the following fundamental questions were set as the basis for the survey instrument (see Table 4.1 for the alignment check):

1. What are organisations currently measuring in relation to their quality costs?
2. What activities are organisations undertaking relative to quality (prevention, appraisal, etc.)?
3. What are the levels of quality costs in manufacturing industries?
4. Is there a need for a different approach to quality costing?
5. What activities do organisations undertake to reduce the quality costs?
6. What is the level of understanding of Activity Based Costing?

4.3 Study Design and Administration

4.3.1 Survey Instrument Selection and Design

From the literature review conducted on survey design (see Section 4.1), it was concluded that the most suitable instrument would be 'self-administered (mail) questionnaire' – "one of the most frequently used methods for collecting data in research studies" (Bourque and Fielder 1995). This instrument was selected as it provided many advantages:
1. A consistent stimulus to all respondents.
2. Ability to sample a larger group.
3. Cost – one of the most important issues. The available resources were limited and experience (Bourque and Fielder 1995) showed that mail typically costs 50% less than telephone interviews, and much less than personal interviews.
4. Wide geographical coverage – a crucial issue as the study aimed to target leading organisations, irrespective of their location.
5. Easier to implement due to limitation of human resources.

In contrast to these advantages, there are also a number of disadvantages. Having identified them, several attempts were made to minimise them as follows:

1. No control over who responds to the study – to minimise this aspect, respondents were carefully targeted (by position). They were chosen for their perceived interest and experience reflected in their position (mainly senior management and department heads).
2. Questionnaires must be self-explanatory – care was taken in designing the questionnaire so that it was clear, precise, and had clear directions.
3. Response rates are usually low – ‘usual rate is no better than 15-20%’ (Bourque and Fielder 1995). To overcome this aspect, many efforts were aimed at increasing the response rate such as: targeted population (to ensure high involvement with topic, and thus high motivation to participate), making the task clear and the questions easy to read, follow-up contacts, and the results were made available to the respondents.

Literature guidelines (Bourque and Fielder, 1995; Hague, 1993) were followed for designing the questionnaire. The main elements were listed as a direct result of the specified questionnaire objectives. Elements were grouped under subheadings that related to the proposed framework (e.g. Prevention Activities and Costs, Costing Method, etc.).

The actual questionnaire design was developed based on the survey objectives and presented in three main sections:
1. Section 1
This section was designed to collect information on the participating organisation's background; turnover, number of employees, industry sector, product type, degree of automation, invested capital, and so on. This type of information was solicited to study different approaches to quality costing and whether the company size, product type, or industry sector had a clear effect on their quality costing activities. Moreover, the section contained multiple-choice questions to understand what type of costing/accounting system the organisation has, their satisfaction with that system, and consequently what they would like to change to improve the whole system.

2. Section 2
This section was detailed and covered four main subheadings: prevention, appraisal, internal failure, and external failure (as per the classical PAF Quality Costing Model). Each section contained related activities and established whether the participating organisation applied the activity, measured the activity, and the level of that activity (in terms of cost).

3. Section 3
This section was designed to investigate:

a) The understanding of the participating organisation of the concepts of Activity Based Costing.

b) The current costing basis used (product costing or activity costing).

c) Overhead allocation methods used.

d) Activities performed to reduce costs within the organisation.

After preparing the questionnaire, a cross-reference check was performed to ensure that:

1. All the objectives of the study were addressed.
2. All the questionnaire items were relevant.

Table 4.1 shows which of the objectives listed in section 4.2 were addressed by which element. A copy of the questionnaire used is provided in Appendix 1.
Table 4.1: Cross-reference check for questionnaire sections and study objectives

<table>
<thead>
<tr>
<th>Objective</th>
<th>Questionnaire Section #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Section 1</td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>✓</td>
</tr>
</tbody>
</table>

4.3.2 Sample Size And Selection

For the purpose of the study, the main criterion for sample selection was that organisations taking part had to be manufacturing organisations. Moreover, other selection criteria included company size to insure a mix of large and SME organisations and product type to ensure a wide cross section of manufacturing organisations. Finally, the chosen organisations were selected for having a ‘quality’ initiative, e.g. ISO 9000 certification, to ensure they have the basics of quality management in place. Where possible, the contact was the most senior manager in the organisation. However, some people were contacted due to their known involvement in Quality Costing (e.g. Production engineer, QA Manager, etc.).

The countries that were targeted for inclusion in the survey were:

1. United Kingdom: chosen due to easy access to large databases of company information and contacts, and due to a firm reputation for good manufacturing practices.
2. Germany: chosen to sample another European Union country. Germany was also considered due to relatively easy access to information and databases, and for its reputation for advanced manufacturing.
3. Saudi Arabia: chosen due to the author’s interest to investigate own home country, and ease of access to information due to personal contacts.
Although it would have been valuable to include US and Japanese companies, time and resource constraints prohibited obtaining a useful sample from these countries. The decision to concentrate on these three countries as the sample for the study was necessitated by the need to have a fairly quick response to enable the survey to be completed within the restricted time limitations. Moreover, it should be noted that it was not the intention of the study to conduct any form of cross-country comparison and analysis, rather to obtain a useful sample of manufacturing organisations as per the previously mentioned criteria.

The sources for organisational and individual details were: KOMPASS directories and CD 1997-1998, specialised conference delegate lists, and Financial Analysis Made Easy (FAME) database. In Saudi Arabia, the participant organisations were selected based on personal contacts.

The sample size was based on the participants of the study, i.e. an available resource rather than ensuring a sufficient size to emulate the population (this was not an objective). Like most decisions relating to research design, there is rarely a definitive sample size for any given study (Wunsch, 1986; Fowler, 1993). A decision was taken to send out 750 questionnaires (hoping for a response rate of at least 20%).

4.4 Results Analysis Plan

4.4.1 Analysis Tool

The main tool for analysis was SPSS (Statistical Package for Social Sciences), which Cramer (1998) described as “one of the most widely used, comprehensive and flexible statistical programmes”. All responses were coded to facilitate computer analysis.

4.4.2 Data Types

The four types of data collected were:

1. Descriptive data – participants (country, job); involvement with quality costing.
2. Levels of quality costs (five-point Likert scale).
3. Descriptive data on activities and current system (yes/no type questions).
4. Views on attitudes towards new approaches (multiple choice).

4.4.3 Analysis Plan

To achieve the study objectives, the following analysis approaches were determined:

1. Frequency analysis – this was performed for most of the data collected to see what percentage of organisations fell in which category, what activities were practised most, and so on.

2. Cross-tabulation and Correlation analysis – this was the second stage of analysis where the aim was to understand whether there was a relationship between some of the elements under study, e.g. do organisations that undertake prevention activities have a lower chance of needing to undertake appraisal activities, and so on.

4.4 Study Participants

A total of 750 companies were contacted and 150 companies responded and returned questionnaires (20% response rate). Upon initial analysis, it was determined that only 87 questionnaires (58%) were satisfactorily completed, and thus only these were used for the statistical analysis. Useful inferences could be drawn from the 87 responses and these are discussed later in Chapter 5.

However some useful inferences were also drawn from the group of 63 questionnaires that were deemed unsatisfactory for analysis. These questionnaires completed in part and returned by participants, showed they were clearly interested in Quality Costing. The reasons behind the part completion could not be attributed to faults in questionnaire design (e.g. difficult, vague, or too broad) since 87 organisations could fully and clearly complete them. Thus the possible reasons, that have been inferred close visual inspection of these questionnaires, were:
1. Lack of knowledge of quality costing issues – the majority of the non-completed parts fell in Section Two of the returned questionnaires, and this clearly revealed a lack of knowledge of the specific issues of quality costing, especially on the activity measurement side. This lack of knowledge and/or experience with the issues presented is seen as the main reason for the non-completions.

2. Confidentiality – although the questionnaire did not request any detailed information or specific numbers, a handful of participants indicated that information on what they measure is considered competitive intelligence.

Of the participating organisations 95% were manufacturing organisations (the intended sample). The other 5% were not service organisations but rather classified themselves under ‘others’, which included distribution and transport.

Figure 4.1 reveals the distribution of study participants based on number of employees (organisational size); 58% were small organisations (less than 100 employees) and 37% were medium (100 to 1000 employees) and only 5% were large organisations. This is acceptable and is seen to be reflective of the nature of manufacturing where there would usually be few large multinational organisations, and numerous small to medium organisations either as their suppliers or operating in niche markets (the automotive industry is a classic example). If anything, these percentages stress the wide cross-section of the participating organisations, thus providing a non-biased sample.
Again, in terms of annual turnover, there was a similar spread with participants ranging from less than £5 million to over £50 million per annum (see Figure 4.2). This again stressed the wide cross-section of the survey, and thus ensured it to be representative of the actual manufacturing population.

Finally, this wide cross-section was revealed in other organisational characteristics including: production environment, product environment, degree of automation, and
degree of competition witnesses, as revealed in Figures 4.3, 4.4, 4.5 and 4.6 respectively, thus providing more evidence that the sample is cross-sectional and non-biased.

Figure 4.3: Study participants based on production environment

Figure 4.4: Study participants based on product environment
Having analysed the sample of study participants, the next step (Chapter 5) is to analyse the results and study findings, and assess the conclusions they reveal.
CHAPTER 5:
QUALITY COSTING PRACTICES
INDUSTRIAL SURVEY FINDINGS

5.1 Introduction

This chapter introduces the results, analysis, and discussion based on the industrial survey that was undertaken (discussed in Chapter 4). The main tool used for results analysis was SPSS and the following three types of analysis were performed:

1. Results average/frequency – to study the percentage of organisations undertaking certain activities or who subscribe to certain views.
2. Cross tabulation – to study any possible relations or trends between individual attributes.
3. Correlation analysis - a detailed correlation analysis of some of the activities was carried out to see how they relate to each other. Correlation entails the provision of a yardstick whereby the intensity or strength of a relationship can be gauged (Bryman and Cramer, 1997). Generally, correlation coefficients are calculated to provide the clear assessment of the closeness of a relationship between elements. It is hoped that by computing the correlation coefficients of some of the elements of the questionnaire, the validity of the research hypothesis will further be strengthened.

5.2 Costing Methods

The first part of the findings relates to the costing methods that are currently in use within the participating organisations. Figure 5.1 reveals that 86% of the participating organisations use Traditional Cost Accounting methods while only 8% use the Activity-Based Cost Accounting method (6% of the responding companies did not indicate the costing method they used).
A clear conclusion is that the majority of organisations still use a traditional cost accounting method. This is another indication that although ABC has been available as a theory and application package for several years, industry has not yet widely adopted this method. Moreover, this, as shown and discussed in the proceeding sections, affected the precise calculation of the quality costs in both the design and manufacturing processes of these companies.

Regarding the satisfaction of organisations with their costing methods, Figure 5.2 reveals that 40% of total participants were ‘unsatisfied’ with their current costing methods. This is a substantial percentage and is portraying a crucial message. Moreover, of the 12% that were ‘very satisfied’ with their current costing methods, cross-tabulation results run on SPSS revealed that 41% used ABC and out of those using ABC none were ‘not satisfied’. In addition, 45% of the users of TCA were not satisfied. These statistics reflect that a degree of satisfaction with ABC, and the need for improvement on the traditional cost accounting methods. Having noted that, a large percentage are shown to be satisfied with their current TCA method that the author considers might be due to lack of knowledge of any other possible format. Whatever, the reason here, the results do show a larger degree of satisfaction among those who use
ABC, thus providing evidence of its potential. It is on this basis that this research attempts to look into the reasons for this dissatisfaction and come up with an optimum method of quality cost assessment.

![Graph showing satisfaction levels](image)

**Figure 5.2:** Satisfaction with the accounting method currently used by participating organisations

Further on from these results, Figure 5.3a reveals which aspects the organisations would like to see improved within the traditional cost accounting system. Clearly the majority are interested in improving the overhead allocation methods, which (as discussed in Chapter 7) have proved to be the main weakness of traditional cost accounting.

![Pie chart showing proposed improvements](image)

**Figure 5.3a:** Proposed improvements on traditional cost accounting

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A more detailed look at these results (Figure 5.3b) reveals a clear message; organisations using TCA are the ones who are calling for improvements to their costing methods – mainly in the area of overhead allocation. Again, this is the main weakness of TCA and indeed the main strength ABC provides, thus a clear window for improvement.

![Graph](image)

**Figure 5.3b:** Proposed improvements on traditional cost accounting vs. current costing method used

It is interesting to note that out of the organisations that were ‘satisfied’ with their current accounting system, 63% proposed changes to the overhead allocation system, and 15% proposed changes in the inventory evaluation system. These are extremely high percentages (81% overall) the author suggest that the organisations that said they were ‘satisfied’ are possibly accepting the status quo and the ‘way business has been done’ over the years rather then saying they are ‘happy’ with their TCA and that TCA is providing the information they need. Reasons for not initiating the improvements may be resistance to change (this is because TCA seems comfortable, has been ingrained the in way business worked for decades, and somewhat easy with all the expertise organisations have in that area). Another reason already mentioned could be lack of knowledge of possible alternative like ABC (yet another indicator that the ABC message has not spread among industries).

The responding companies were also asked (in the final section of the questionnaire) whether they believe that ABC would be beneficial to their companies, and 49% thought that it would benefit their company, 27% said that it would not while 24% said
they were not sure. This indicates the majority are in favour of ABC or do not know about it.

They were also asked whether they believe the implementation of ABC would improve their costing methods (Figure 5.3c), 18% said there would be no improvement, 30% said there would be no change and, interestingly, 52% said there would be a significant improvement. An interesting result was that no respondent was ‘not sure’ of the improvement to be brought about by the implementation of ABC.

![Figure 5.3c: The ability of ABC to improve the costing methods](image)

Further analysis of the results, and attempts to find any relation between organisational characteristics (size, sector, technology orientation, etc.) and the costing method used revealed no clear correspondence with most characteristics, apart from the following two interesting findings (based on cross tabulation analysis run on SPSS):

1. With reference to product environment, it was found that 100% of those who used ABC were dealing with multi-product (heterogeneous) product environment.
2. With reference to the rate of competition faced in the market, 90% of those who used ABC noted that they are in a highly competitive market (many competitors).

One conclusion that might be drawn from these results is the fact that those organisations that have turned to ABC were involved in complex product situations and highly competitive markets that needed a sophisticated way of accounting to allow meaningful allocation of overheads to the many products, and allow better pricing in a
competitive market. In a sense, these organisations might have been forced to use ABC due to the inability of TCA to provide the information needed for this environment. This, like any advanced management technique, has always been the scenario where companies change because they have to (reactive rather than proactive). In addition, it is an endorsement of ABC and its potential and ability to successfully handle complex situations.

5.3 Failure Prevention Activities

In response to the questions on elements of failure prevention, in terms of performing the activity, measuring the cost involved and the level of cost, the following sections detail the findings.

5.3.1 Which Prevention Activities Are Performed

Figure 5.4 reveals the percentages of participating organisations that perform each of the prevention activities discussed. The figure shows that overall, there is a healthy uptake of prevention activities. It was noted, not surprisingly, that no organisation fell in the category of 'not undertaking any prevention activities'. On the other hand, no organisation was reported to undertake all the proposed activities. The most popular failure prevention activities included:

1. Internal quality audits – an audit is, on the face of it, an appraisal activity, however, here it is considered as a pro-active function planned to give rise to prevention activities as it reveals weaknesses in the system and equipment that need to be improved to prevent failures from occurring.
2. Quality training.
3. Quality administration.

Clearly all of these three activities are highly structured, and relatively easily applied. The author suggests that is hardly surprising in a manufacturing environment. Moreover, these three activities are directly related to structured quality management systems (like ISO 9000), and, thus, may reveal the large influence these standards have
in the manufacturing sector (the biggest proponents of quality standards among other organisational sectors).

![Failure prevention activities performed at participating organisations](image)

**Figure 5.4:** Failure prevention activities performed at participating organisations

On the other hand, the least popular failure prevention activities included:

1. External quality auditing – again, considered as an essential first step of prevention activity to reveal weaknesses in the system that need to be improved to prevent failures from occurring.
2. Quality review and verification – similar to quality audits, this activity is planned and pro-active with the objective of preventing errors occurring, thus classed as a prevention activity.
3. Quality related maintenance – this is perhaps surprising given the popular use of planned preventative maintenance (PM). The author suggests that the motivation for PM may be continuity of production rather than prevention of quality problems.

External auditing, quality maintenance (preventive), and quality reviews are some of the more expensive prevention activities, and this might explain their lack of popularity.
Also the author believes that, the lack of popularity of external quality audit may be explained by the lack of need for ISO 9000:1994 such activities for quality system certification purposes. ISO9001:2000 addresses this weakness as it requires some form of customer auditing. The lack of popularity of quality reviews is a symptom of more dire consequences. It reveals the lack of reviews, performance measurement, and thus the lack of efficient feedback for improvement. Finally, with regards to quality related maintenance, in the author’s experience it seems symptomatic, albeit worrying, of the manufacturing industry to suffer many problems due to lack of focus on maintenance activities.

In general, cross tabulation did not reveal any trends that related the undertaking of prevention activities with organisational characteristics (size, product environment, degree of competition, level of automation, etc.)

5.3.2 Which Prevention Activities Are Measured

Figure 5.5 reveals the study findings in terms of the percentage of participating organisations that actually measure the cost of the failure prevention activities. Overall, a disappointingly low percentage of organisations undertook failure prevention cost measurements (no failure prevention cost activities was measured by more than 45% of the participant organisations). This is a crucial finding as it highlights the lack of organisational will and/or ability to build in efficient feedback loops for improvement, and thus the need for such a quality activity performance measurement system. The author suggests that this could result from one of two reasons (or indeed a combination of both). Firstly, this can be related to the quality costing method currently being used, as over 85% of the responding companies employ the Traditional Cost Accounting method, and this has little or no means of measuring individual activity costs. Secondly, it could be a symptom of a well-known organisational problem, namely, lack of measurement. Studies over the years have proved that organisations are not very good at measurement, and although it has been long advocated that ‘what gets measured gets done’, in the author experience establishing effective performance measurement systems still poses a challenge to many organisations.
Measurement is the main spark and tool for continuous improvement as it provides benchmarks and goals for the organisation to follow. Moreover, it provides an indicator to the level of efficiency of the failure prevention activities. Thus, in the author opinion these activities must be given much more attention.

![Figure 5.5: Failure prevention activities measured at participating organisations](image)

The top three measured activities were:

1. Quality training
2. Purchasing and procurement
3. Quality administration

Not surprisingly these are the same activities, and possibly the only activities that are easily measured by traditional accounting systems. The author suggests that this is probably possibly a symptom of the lack of ability of these systems to provide a capable measurement tool. Another problem that arises is the question of 'what happens to the
other activities? Clearly, organisations are not measuring their costs (and thus efficiency and need for improvement), thus indicating that many organisations might be doing this due to contractual reasons, or requirements of standards (such as ISO9000). This assumption is strengthened by the results that indicate that the activities for which cost is least measured are vendor certification, supplier assurance and quality testing, all of which fall under the category of contractual requirements. Whichever reason, organisations do not seem to be achieving the potential of these activities.

An interesting, and surprising finding, was that organisations that use ABC do not seem to be doing substantially better (albeit marginally better in most activities) at measuring prevention activities costs than organisations that use TCA. This result in itself is not due to lack of ABC’s ability to measure these costs; but rather a misuse (or even absence) of the proper analyses of the data and information provided by ABC. This is an indication that even organisations using ABC are either not using it to its full potential, or possibly do not understand its full capabilities.

![Figure 5.6 Prevention activity cost measurement vs. costing method used](image)
One final interesting point is the three activities: process planning, quality overview, and product design. It can be seen from Figure 5.6 that these activities are measured more by organisations that use TCA. This maybe associated with the fact that these three activities are closely associated with ISO9000 requirements and thus more likely to be measured.

5.3.3 What Are the Levels of Cost Spent on the Prevention Activities

As Figure 5.7 reveals, most failure prevention activities were not considered to absorb high or very high costs. In fact, the figure below reveals that, overall, cost levels were considered low, although 51% gave no response (due to the obvious lack of measurement noted earlier), and of those who answered the majority saw costs absorbed by prevention activities as low or very low. This could be a strong endorsement of prevention activities and goes some way to convince many organisations that quality does not have to be expensive. However, it could also indicate that although organisations do prevention activities, they do not seem to spend much on prevention – hence should demonstrate high appraisal and failure costs – in other words, this low spending on prevention could mean it is not very effective. Further light is shed on this question in the following sections that analyses the appraisal and failure occurrences.

Further analysis and cross tabulation of the cost levels of prevention activities and organisational characteristics (size, degree of automation, etc.) revealed no trends.
5.4 Quality Appraisal Activities

In response to the questions on elements of quality appraisal, in terms of performing the activity, measuring the cost involved and the level of cost, the following sections detail the findings.

5.4.1 Which Quality Appraisal Activities Are Performed

Figure 5.8 reveals the percentages of participating organisations that perform each of the quality appraisal activities discussed. The results reveal that, apart from final inspection, no appraisal activity was undertaken by more than 60% of the organisations. These are low percentages and reveal a worrying approach to quality appraisal, especially when combined with the very low involvement with prevention activities. However, it is observed that more organisations undertake appraisal than they do prevention, which in a way was expected from the poor undertaking of prevention activities. This issue of the need to focus on prevention rather than appraisal has been
the cornerstone of quality management initiatives, but clearly the message has not spread as far as quality professionals would like to think. In general, it was noted, again not surprisingly, that no organisation fell in the category of ‘not undertaking any appraisal activities’. On the other hand, no organisation was reported to undertake all the proposed activities.

The most common appraisal activity by far was final inspection. One obvious reason might be that such an inspection is a very strong customer requirement, and in many cases in manufacturing, a legal obligation as well. This is typical of manufacturing organisations, and indeed those organisations that are still operating under the traditional quality inspection era. These organisations are focusing on inspecting quality ‘in’ rather than building it in. The least popular appraisal activity was incoming material inspection. It could be assumed that organisations that do not undertake incoming inspection rely on supplier quality assurance and vendor certification, but cross-tabulation of the results revealed the opposite; organisations that do undertake supplier quality assurance and vendor certification actually undertook more incoming inspection that those who did not (e.g. 48% of the organisations that undertake supplier assurance also undertake incoming inspection, as opposed to 33% of organisations that do not undertake supplier assurance and do undertake incoming inspection). This is a reflection of the ‘quality’ culture of organisations, i.e. those who are quality conscious seem to undertake incoming inspection and certify their suppliers, where those with no quality awareness seem to miss both aspects. Again this is a symptomatic of the ‘final inspection’ mentality rather than building the quality ‘in’.
Further cross-tabulation between prevention and appraisal activities revealed similar trends in that organisations that undertook prevention activities seem to be the same organisations that undertook more appraisal activities. Again, the possible interpretation of these results would be the quality awareness in these organisations and their focus on quality both in failure prevention and appraisal.

In general, cross-tabulation did not reveal any trends that related the undertaking of appraisal activities with organisational characteristics (size, product environment, degree of competition, level of automation, or nature of the product).

### 5.4.2 Which Quality Appraisal Activities Are Measured

Figure 5.9 reveals the study findings in terms of the percentage of participating organisations that actually measure the quality appraisal activities. Overall, disappointingly low percentages of activities are measured. This is another crucial finding as it stresses the lack of organisational ability to build in efficient feedback loops for improvement (revealed in the previous section), and thus the need for a quality activity performance measurement system. Reasons for this can again be attributed to the same factors as discussed in Section 5.2.2.
Again, the activity that seems to be measured most is final product inspection (although by a very low percentage of organisations 27%). This is again probably due to major customer focus and regulatory requirements imposed on the organisations.

One major deduction that can be made from the fact that appraisal activities get so poorly measured individually is that they are not monitored and, as one would expect from a majority of organisations using TCA, get included in overheads.

### 5.4.3 What Are the Levels of Costs Witnessed Due to Each Appraisal Activity

As Figure 5.10 reveals, most quality appraisal activities were not considered to absorb high or very high costs. However, this is not a major finding as very few organisations actually measured them. This could be because organisations do not do enough of these activities. However, another reason may be that organisations think that appraisal activities are relatively low cost. The reason is probably a combination of both. Moreover, the results also indicated that although most companies do not measure the costs, half of the respondents indicated the level of cost involved in carrying out quality appraisal activities (i.e. not all the respondents who noted the levels of appraisal activities’ costs actually measured these costs!). Still, it seems that their instincts, although not necessarily accurate, enabled them to assume that the costs of the
individual activities would be at such a level, even though their costing method (mostly TCA) did not provide the means or facility for cost measurement. This is an endorsement of quality appraisal activities and goes some way to convincing many organisations that quality does not have to be expensive, be it prevention as discussed earlier, or inspections as revealed here.

![Figure 5.10: Quality appraisal activities cost levels at participating organisations](image)

However, and similar to the prevention activities costs, it was found that organisations that use ABC do not seem to be doing any better (only marginally better as the Figure 5.11 shows, but clearly still inadequate and all below 50%) at measuring appraisal activities’ costs than organisations that use TCA. Again, this is an indication that even organisations using ABC are either not using it to its full potential, or possibly do not understand its full capabilities.
Figure 5.11: Prevention activity cost measurement vs. costing method used

The ‘NonPar Correlation’ function of the SPSS package was executed in order to obtain the Spearman’s rho ($\rho$) of the activities of failure prevention and quality appraisal, and as can be seen from Table 5.19, there was found to be a negative correlation between failure prevention and quality appraisal. All the elements have correlated strongly with each other, since all the coefficients are quite large and all achieve a high level of statistical significance at $p<0$. If we consider our sample size (87), we can conclude that a negative relationship exists within our population, and this implies that if companies spend more on prevention activities this will result in a decrease or possibly even elimination of spending on quality appraisal activities. This is of course intuitive and goes to prove the assertion made by Porter and Rayner (1992) that if a substantial effort is put into prevention there would be no need for appraisal.
Table 5.1: A portion of spearman correlation coefficients of failure prevention and quality appraisal costs

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In general, cross-tabulation did not reveal any trends that related the levels of costs of appraisal activities with organisational characteristics (size, product environment, degree of competition, level of automation, etc.).

5.5 Internal Quality Failure Activities

In response to the questions on elements of internal failure related activities, in terms of performing the activity, measuring the cost involved and the level of cost, the following sections detail the findings.

5.5.1 Which Internal Failure Related Activities Occur

Figure 5.12 reveals the percentage of participating organisations where each of the internal quality failure related activities discussed occurs. Very high percentages are revealed, and some activities such as ‘design failure’ were witnessed by 100% of the participating organisations. These results show a wide occurrence of internal failures, not a very surprising result given the lack of focus on prevention revealed earlier.
In an attempt to study the relation between undertaking failure prevention activities and the actual occurrence of internal failures, the Spearman correlation coefficients of failure prevention and internal failure costs were computed to see whether a relationship between exits them, as well as the level of the relationship. Table 5.2 shows the result obtained.

**Table 5.2:** A portion of Spearman correlation coefficients of failure prevention and internal failure costs

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As can be seen from the table, on average, there is a negative correlation between failure prevention and internal failure costs. All the elements have correlated strongly

**Figure 5.12:** Internal failure related activities that occur at participating organisations
Quality Costing Practices Industrial Survey Findings

with each other, since all the coefficients are quite large and all achieved a relatively high level of statistical significance at \( p<0.001 \). Here, it can be concluded that a negative relationship exists within the population in terms of failure prevention and internal failure costs and this implies that if companies spend more in prevention activities, it will result in a reduction in internal failure. According to Schneiderman (Porter and Rayner, 1992), a substantial amount of effort in failure prevention will result in no defects at all in the products thereby resulting in no failure costs. These result goes to validate Schneiderman's assertion and is again quite intuitive.

Further, a similar statistical analysis to those above was carried out, but this time using quality appraisal with internal failure costs, to see whether there exists a relationship between them, as well as the level of the relationship. Table 5.3 shows the result obtained.

Table 5.3: A portion of Spearman correlation coefficients of quality appraisal and internal failure costs

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A critical observation of Table 5.3 reveals that, on average, there is a positive correlation between quality appraisal and internal failure costs. All the elements have correlated positively with each other, since all the coefficients are quite large and all achieve a relatively high level of statistical significance at \( p<0.001 \). Here also it can be concluded that there exists a positive relationship within the population in terms of
quality appraisal and internal failure costs, and this implies that if companies spend more in quality appraisal it will result in an increase in internal failure costs. This, however, will lead to a high rate of customer satisfaction with the product. Therefore, and from the results so far, the recommended option for companies is to adopt a quality costing method that will enable them to measure costs appropriately as well as to concentrate on failure prevention activities. This should eventually lead to the production of a less defective product which in itself eliminates the need for appraisal.

5.5.2 Which Internal Failure Related Activities Are Measured

Figure 5.13 reveals the study findings in terms of the percentage of participating organisations that actually measure the internal quality failure activities. Overall, low percentages of activities are actually measured. This is another crucial finding as it stresses the lack of organisational ability to build in efficient feedback loops for improvement (revealed in the previous section), and thus the need for such a 'quality activities' performance measurement system.

The internal failures/failure related activities that were measured the most included:

1. Failure analysis – by its nature, this activity is very analytical and cost measurement is usually a built-in aspect of the work performed, i.e. if a person is undertaking a systematic failure analysis procedure, it is more likely that part of the analysis will look at the failure costs.

2. Rework, scrap, repair, and replacement – for obvious reasons, these failures are well recorded and measured. Mainly, they are easy and simple to measure and monitor (in many cases only involves counting). Moreover, the recording of these costs is a requirement in quality standards such as the ISO 9000, and all of them fall within the classic manufacturing ‘quality improvement’ domain. In fact, these internal failure measures have been the usual way manufacturing industries have reported the progress of their quality initiatives, and strongly relate to well known quality management concepts such as ‘zero defects’ and ‘acceptable quality levels’.

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5.5.3 What Are the Levels of Costs Witnessed Due to Each Internal Failure

As Figure 5.14 reveals, most internal failure related activities were considered to absorb high or very high costs. This provides clear evidence that organisations are suffering from high expenditure due to internal failures. This is not surprising and probably a symptom of the earlier findings of lack of quality prevention activities. However, these high costs are a clear indication, and indeed a reminder for all manufacturing organisations of the need, importance and urgency for implementing failure prevention to attempt to reduce internal failures, and improve overall efficiency and capability.

Secondly, the results also indicate that, although these companies do not measure the costs, all the respondents indicated the level of costs they encountered in carrying out internal failure activities. This is a very interesting result, because as opposed to the observed cases in failure prevention and quality appraisal where only a certain percentage of the respondents indicated the level of costs, here none of the respondents failed to answer this question. A possible explanation to this would be that failure tends to impact on peoples’ work and perhaps tends to be more visible. In addition, it can also be said that since these failures are visible, human intuition enabled them to
assume that the costs of the individual activities would be at a certain level and hence assign such a level, even though their costing method does not provide the means or facility for cost measurement of individual activities.

![Graph showing cost levels of various activities](image)

**Figure 5.14:** Internal failure related activities cost levels at participating organisations

When comparing the ability and conduct of measuring internal failure costs, it is revealed (Figure 5.15) that organisations that use ABC are doing better (by a margin of 20-30% in some cases) than organisations using TCA. This result is opposed to the previous findings regarding the use of ABC and measuring quality related costs (Figures 5.6 and 5.11). This is a positive result and an endorsement of the capability of ABC. More importantly, it is a revealing result as the measure (unit being measured) in this case is usually more easily quantifiable (a scrapped product, a repair activity, etc.). Thus, it is safe to say that measuring the costs of internal failure does seem to be easier than measuring the costs of internal failure prevention activities. This is not in any way undermining the potential and usefulness of ABC, however, it does indicate the possibility that organisations do find it easier to utilise the data provided by ABC when the measure is more quantifiable and closer to what they are used to dealing with (organisations have dealt with scrap, failures, and replacement, etc., issues much longer than they have with ‘activities’ whether they are prevention or appraisal). Again an
indication that the full power of ABC can only be realised by focusing training and education on ABC, and indeed a shift of organisational culture from unit-based measurements (products) to activity-based measurement.

![Graph showing internal failure cost measurement vs. costing method used]

**Figure 5.15:** Internal failure cost measurement vs. costing method used

### 5.6 External Quality Failure Activities

In response to the questions on elements of external failure related activities, in terms of performing the activity, measuring the cost involved and the level of cost, the following sections detail the findings.

#### 5.6.1 Which External Failure Related Activities Are Performed

Figure 5.16 reveals the percentage of participating organisations that perform each of the external quality failure related activities discussed. The analysis revealed very high percentages, and some activities such as ‘out of warranty failure’ (possibly as part of the business plan to generate after sales income) ‘administration, and ‘recalls’ were witnessed by 100% of the participating organisations. If anything, these results reveal
an alarming abundance of external product failures, although not a very surprising result given the lack of focus on prevention revealed earlier.

![Quality Cosing Practices Industrial Survey Findings](image)

**Figure 5.16:** External failure related activities performed at participating organisations

Similarly, Spearman correlation coefficient for failure prevention and external failure costs was computed to see whether a relationship exists between them as well as the level of that relationship. Table 5.4 shows the result obtained.
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<td>FPCPDCL - EFCQCL</td>
<td>-.4184 WITH N(87)  .004</td>
</tr>
<tr>
<td>FPCPDCL - EFCADCL</td>
<td>-.3688 WITH N(87)  .000</td>
</tr>
<tr>
<td>FPCPDCL - EFCADCL</td>
<td>-.3790 WITH N(87)  .008</td>
</tr>
<tr>
<td>FPCPDCL - EFCADCL</td>
<td>-.3790 WITH N(87)  .001</td>
</tr>
</tbody>
</table>

As can be seen from the table, on average, there is a negative correlation between failure prevention and external failure costs. All the elements have correlated strongly with each other, since all the coefficients are quite large and all achieve a relatively high level of statistical significance at p<0.001. Here, a similar conclusion as between failure prevention and external failure costs can be deduced. That is, there exists a negative relationship within our population in terms of failure prevention and external failure costs and this implies that if companies spend more in prevention activities, this will result in a great reduction in external failure costs.

Further, Spearman’s correlation coefficients of failure appraisal and external failure costs were computed, to see whether a relationship exists between them, as well as the level of this relationship. Table 5.5 shows the result obtained.
As can be seen from the table, on average, there exists a weak negative correlation between quality appraisal and external failure costs. Relatively, they all achieved a moderate level of statistical significance at p<0.01. If, on the other hand, the sample size (87) is considered compared to this level of statistical significance (p<0.01), it can be concluded that this weak relationship is unlikely to have arisen by chance. Therefore, it can be said that a relationship of this size exists in the population. That is, there exists a weak negative relationship within our population in terms of quality appraisal and external failure costs and this implies that if companies spend more in quality appraisal, the benefits will translate into a reduction in external failure costs.

5.6.2 Which External Failure Related Activities Are Measured

Figure 5.17 reveals the study findings in terms of the percentage of participating organisations that actually measure the external quality failure activities. Overall, disappointingly low average percentages of activities are measured (none were measure by more than 50% and most were less than 30%). This, again, stresses the lack of
organisational ability to build in efficient feedback loops for improvement (revealed in the previous section), and thus the need for such a quality activities performance measurement system. However, it is even more surprising to see that organisations do not measure the costs of external failure. One would expect that these external failures are easier to quantify and measure (as opposed to internal failures) and in many cases these measurements could be required by regulatory obligations. If anything, these results are a strong reflection on the poor ability of organisations to measure even the most obvious of quality costs.

Figure 5.17: External quality failure activities measured at participating organisations

Again, and similar to internal failure costs, it is obvious that by and large, these costs are being absorbed by overhead costs in organisations, thus providing only a vague picture of quality costs, and losing the organisations numerous opportunities for continuous improvement and development. It is surprising, however, to see a very low percentage of organisations who measure the Product Recalls and Product Liability Reserve since these costs are easy to measure, and possibly required by law.
5.6.3 What Are the Levels of Costs Witnessed Due to Each External Failure Activity

As Figure 5.18 reveals, most external failure related activities were considered to absorb high or very high costs. It is therefore evident that organisations are suffering from high expenditure due to external failures. This is a symptom of the early findings of lack of quality prevention and appraisal activities. If anything these results strengthen the earlier comments made about the need for better measurement systems to exploit opportunities to reduce the costs of external failures. Moreover, given the obvious abundance of external failures and their high costs, there are invariably substantial extra costs that result from customer dissatisfaction from these failures, and indeed lost customers.

![External failure related activities cost levels at participating organisations](image)

**Figure 5.18:** External failure related activities cost levels at participating organisations

When comparing the ability and conduct of measuring internal failure costs, it is revealed (Figure 5.19) that organisations that use ABC are doing better (by a margin of 10-20% in some cases) than organisations using TCA. This result is consistent with the
measurement of costs for internal failures (Figure 5.15) and again is opposed to the previous findings regarding the use of ABC and measuring quality related costs (Figures 5.6 and 5.11). This is another positive result and an endorsement of the capability of ABC. More importantly, is a revealing result as the measure (unit being measured) in this case is usually more easily quantifiable (repairs, field visits, etc.).

![Figure 5.19: External failure cost measurement vs. costing method used](image)

**5.7 Costing Methods**

This part of the study aimed to shed more light on organisational costing methods, and their cost reduction activities

**5.7.1 Constituents of Manufacturing Costs**

In response to the question of the main constituents of manufacturing costs (Figure 5.20), 38% of the participants noted that the activities in the processes were the cause of the main manufacturing costs while 58% said the main manufacturing costs were caused by the product produced (material). It does seem highly improbable that 58% of
the participating organisations deal with high value products (i.e. organisations that deal with very expensive material whose costs must be measured), and these results are possibly reflective of the organisational cost allocation systems. This orientation to product costing is probably due to the inability of the TCA methods to provide details of the activities performed on a product (usually measurements are done per product in terms of how much material, labour, and equipment it utilises). Indeed organisations that operate TCA are very much product oriented and few are process and activity oriented. The major downside of such an approach is the improvement opportunity lost, opportunity that could have resulted from value-added activity analysis and improvement.

![Figure 5.20: Constituents of manufacturing costs](image)

5.7.2 Production Process Overhead Allocation

In response to the question on the allocation of the organisational overhead to each individual activity from a production process, 34% indicated that they do undertake the activity, 58% said they do not, and the remaining 8% said that they don’t know (Figure 5.21). This result is in agreement with the findings and conclusions of Datar and Associates (1992), who found that in a Fortune 500 Automobile Company, products responsible for 70% of the costs being charged 30% while products responsible for 30% of the costs being charged 70%. In other words, most organisations do seem to use the ‘peanut butter’ approach of spreading overheads evenly across all products, irrespective of how much resources they consume. Again, this is a major problem that stems from
the discussed weaknesses in TCA, and impact significantly on Quality Costing since so much Quality Cost appears to be rolled into overhead.

![Don't Know 8% Yes 34% No 58%](image)

**Figure 5.21**: Allocation of Overhead to Individual Activities

### 5.7.3 Cost Reduction Initiatives

The responding companies were also presented with several elements, which could lead to cost reduction, and were asked to select the ones that applied to their companies. The results are shown in Figure 5.22.

Overall, a healthy up-take of cost reduction activities has been demonstrated indicating the importance of cost reduction in almost all participating organisations. On the other hand, this is another strong signal for the need for a more suitable approach of costing (like ABC) for a more meaningful activities-based approach to allow value added analysis, improvement, and cost reduction.
The most popular activity for cost reduction (81% noted that they performed it) was asking staff for implementation ideas, i.e. a suggestion scheme or other form of staff involvement scheme such as Quality Circles. This is a good indicator that organisations realise the ability of staff to improve work (one of the basic cornerstones of TQM). However, this could be a very dangerous approach if employees are not well trained and educated. Moreover, while organisations seemed keen on staff involvement, only 11% indicated that they actually provide incentives for production workers to reduce costs. This is a typical paradox where organisations want to involve staff but fail to align the reward and recognition system to enable this involvement. This is a major finding, and does reflect the fact that organisations seem to pay lip service to quality, and, on the whole, do not implement the proper organisational and cultural tools to support it, i.e. they are not ‘walking the talk’. More evidence to support this finding was that only 33% of organisations said they empower production workers to implement ideas.

**Figure 5.22:** Cost reduction activities most performed
Another interesting finding is that, out of all the possible activities for improvement, the second and third most popular activities were consulting the warranty department and consulting the sales department for information and ideas. Clearly both activities are externally focused, reactive and strongly stress the whole theme of final inspection mentality that has been apparent throughout the study findings so far. This might seem a sensible thing to do since the external failure costs are shown to be the highest under the current conditions (Figure 5.19), however, this strategy is clearly a short termed one (quick fix) and will not be able to provide a sustainable competitive advantage based on quality being built in. In that respect, organisations do seem to be failing to perform the activities that build in quality. Specifically, only 38% said they actually consult the Quality Assurance department (arguably the main source for quality improvement initiatives) and even less (32%) consulted the Product Design department (where main failure prevention activities can and should take place).

5.8 Findings Summary and Conclusions

In this chapter, the empirical results of the industrial survey of quality costing practices of business organisations within Europe and Saudi Arabia were discussed. From the preceding discussions, the following summary of findings presents the main highlights:

1. The participating organisations had the following general profile:
   - 95% were manufacturing organisations
   - Most were multi-product companies, specialising in various products rather than just a single product
   - The majority were in highly competitive environments
   - 86% employed Traditional Cost Accounting (TCA) methods

2. There is a need to improve cost accounting methods - Over 35% of respondents indicated their dissatisfaction with their existing costing method, and 63% highlighted the overhead allocation method as the main area for improvement (almost all those who recommended this improvement were organisations that employed TCA).

3. The results revealed low take-up levels of both prevention and appraisal activities. On the other hand, both were reported to have low cost levels by respondents that undertook such activities. Thus, it can be concluded here that although prevention
and appraisal activities are generally not of high cost, organisations need much more education and persuasion to undertake them. In other words, they need tools to show them the possible benefits of the activities.

4. In terms of experiencing internal failures, most companies experience these costs, and some failure types were experienced by as much as 100% of respondents. A similar scenario was revealed for external failures. Thus, failures do seem abundant, and a clear opportunity for improvement is there for organisations to take. Moreover, this finding stressed that the low take-up of prevention and appraisal activities was not due to lack of problems rather than lack of knowledge and initiative.

5. A more alarming result was the consistent failure of organisations to measure the levels of costs associated with activities and failures. This lack of measurement seems endemic in manufacturing organisation, and an area that would require immediate attention to achieve any benefits. It was also noted that organisations that used ABC were only marginally (10-20%) better at measurement, thus even when the tools do exist, measurement still does not seem entrained in organisational culture, and most of the costs seem to be lumped into overheads.

6. It was seen that a relationship exist between failure prevention and internal and external failures, a relationship that indicated that if companies spend more on prevention, this will result into a reduction or even a total elimination of failure costs.

7. It was also seen that a relationship exists between failure prevention and quality appraisal, which indicated that if companies spend more on prevention, there would be less need for appraisal.

8. Similarly, a relationship was seen to exist between quality appraisal and internal and external failures, which indicated that a spending in appraisal leads to an increase in internal failure costs and a decrease in external failure costs.

These findings can now be coupled with the findings of the literature review presented in Chapters 2 and 3, which can be summarised as follows:

1. Quality cost measurement and management is a crucial aspect of successfully applying total quality management, and thus achieving competitive advantage.
2. If an organisation focuses on prevention it can reduce the internal and external failures in its products in a financially feasible manner.
3. The basic theory of quality cost system relies heavily on the ability to gather the right information (i.e. the organisation's accounting and costing systems).

4. Current 'traditional' accounting systems are not capable of providing the required information to successfully implement a quality cost information system.

5. There are a few obstacles in organisational cultures to overcome before successfully applying quality cost information systems, including: convincing middle managers and engineers of its benefits (and the consequences of ignoring it); convincing top management that quality pays for itself in the medium to long-term; and installing a costing system that is capable of providing the required information.

Much of these conclusions and the evidence presented are intuitively obvious, yet needed stating since it is clear that many companies do not react to the obvious, or have little idea of the magnitude of the various costs involved. Perhaps there is an incorrect perception that prevention and appraisal costs are necessarily high.

Based on the conclusions from both parts of the study so far, in the next chapters the following three main approaches are proposed to tackle the issues raised and allow for successful implementation of quality cost management:

1. Provide a comprehensive and simple to use graphical tool to demonstrate the importance of quality costs, the benefits of managing them, and the consequences of ignoring them. This tool should be simple to use so that it could be utilised as a communication tool to convince and gain support from managers and engineers.

2. Develop a system that would integrate the concepts of activity-based costing within a quality cost information management system. This should tackle many of the problems posed by traditional cost accounting. Present a case study to demonstrate the potential of the system.

3. Develop a software programme to facilitate the implementation of quality cost information systems by providing a systematic method that allows the user to tackle their quality problems, decide of improvement actions, and assess the possible benefits of their decisions.

These three proposed approaches are detailed in Chapters 6, 7, and 8 respectively.
6.1 The Need for the Model

The discussion so far has highlighted the importance of looking at the organisation’s quality costs, and the need to optimise them. Cost is a key factor to competitiveness. It is, therefore, crucial for companies to manage their operations efficiently, minimise their costs and keep their operations lean. In today’s economic climate, companies must look into ways to implement quality improvement and cost-saving programmes to stay lean and fit. The primary objectives of measuring cost of quality are to quantify the financial consequences of quality failures, quality improvement and cost reduction. Implementing a COQ system would enable organisations to link their quality improvement efforts to cost reductions.

One of the main pivots of being able to apply a system for cost of quality minimisation is the ability to identify where failures do, or might, occur. The quality management literature has provided many tools to study the potential or actual failure points, like Failure Mode Effects and Criticality Analysis (FMECA) and Quality Function Deployment (QFD) among others. Such tools have proved their efficiency and importance time and time again, but to successfully apply them, there are a few pre-requisites:

1. Staff must be well trained in the use of these tools.
2. The organisation must have identified the points in the overall process where failure might, or does, occur.
3. The organisation must be convinced that efforts and costs incurred in failure prevention or appraisal activities are beneficial and will result in more profitable operation.
The need to ‘convince’ organisations of the benefits of failure identification and prevention, and thus achieve organisation wide commitment to minimising cost of quality, was the main ethos behind the model proposed in this chapter. The model is aimed at providing a graphical tool to allow design and manufacturing personnel (and indeed everyone in the organisation) to identify the Potential Failure Points (PFP) in ‘design to manufacturing’, and to demonstrate the consequences of these failures in order to set prevention and appraisal points. The driver of this model is to provide good quality products and services, quality costs must be understood, identified and controlled (Campnella, 1999; Crosby, 1979).

According to Juran (1995), there are two broad quality cost categories, those traceable to management, and those traceable to individual employee-operators. To be able to control traceable costs, an employee must be able to:

1) Know what he or she is supposed to do. However, it is management’s responsibility to ensure this information is correct.
2) Know what he or she is doing, and
3) Be able to take action on the difference.

If any one of these three criteria is not completely satisfied, it is apparent that the employee is not empowered to control costs, and the situation must be classified as a management, not employee, responsibility. It should come as no surprise that, as Juran (1995)(a) have concluded, more than 85% of all problems are management controllable. Examples here include management’s lack of planning, not being able to capture exact customer requirements, not providing sufficient resources, lack of focus on training and development, and so on. This chapter aims to tackle the problem of lack of understanding and acceptance of quality cost concepts by providing a graphical tool to describe potential failure areas, possible consequences, and help in action planning.

The chapter starts by introducing the detailed objectives of the proposed model and its scope. This is followed by a discussion of the proposed methodology to be used and the presentation of a few real life examples that demonstrate the benefits of ‘Potential Failure Points’ identification and prevention. This is followed by an introduction of
the graphical approach of the model (the ‘customer need fulfilment’ value chain) and
the related definitions. Many possible scenarios could occur along this value chain,
and these are all discussed in further detail. Finally, conclusions are provided on how,
and where, to best use such a graphical model, potential benefits, and potential
limitations.

6.2 The Graphical Model

6.2.1 Model Objectives

The main objective of the model is to produce a graphical instrument to be used by
organisations to:

1. Demonstrate the importance of prevention and appraisal activities, and to
demonstrate the consequences of ignoring such activities.
2. Identify areas for potential failures in design and manufacturing operations and
help determine the required preventive activities.
3. Facilitate the decision-making process on how much to spend on prevention and
appraisal by providing a structured graphical tool that allows estimates of such
costs.

6.2.2 Model Scope

The proposed model can be applied in all organisations, irrespective of their business.
It deals with the generic activities of designing products and services based on
identified customer needs and consequently producing these designs into a final
deliverable to the customer. However, for the purpose of the study being presented, it
was decided to limit the scope of the discussion to manufacturing organisations, and
specifically the ‘design to manufacture’ process. This scope was chosen for several
reasons:

1. To keep the model simple and understandable – as with all new ideas, it would be
easier to present, and gain commitment to, if it was simple and clear.
2. Manufacturing organisations were selected due to the ease of identification of design and manufacturing activities, and the universal understanding of these activities (as opposed to service organisations).

3. The lack of resources (mainly time constraints) prevented from extending this pilot to cover service organisations or a wider section of the organisational value chain. Such expansion of the study is proposed as possible future work.

6.2.3 Methodology

The methodology for presenting and detailing the model ideas can be summarised as follows:

1. Process Mapping is to be used to plot the overall picture of the process under study and to highlight the Potential Failure Points (PFP) in that process.

2. The PFPs are to be discussed in further detail (presented in a tabular form) to present a list of actual failures that might occur, the consequences of these failures, and the preventative actions that could be installed to minimise/eliminate the failures.

3. Each PFP is assigned a risk probability for providing a satisfactory product to the customer, and each combination of PFP probabilities will result in its own specific risk probability of proving a satisfactory product for the end customer.

4. The ‘product failure scenarios’ are presented and discussed in further detail to clarify them and their consequences.

6.2.4 The Proposed Model

This section will present the proposed graphical model and its related definitions. The process mapping tool used to produce the model (Figure 6.1) is based on the IBM Process Mapping Methodology (Povey, 2000). However, in order to demonstrate the areas for potential failures, a modification has been introduced to the traditional process map in the form of Potential Failure Points (PFP).
Figure 6.1: 'Design to Manufacture' Generic Process Map

Of course it has long been known and widely documented that the quality of products and services in an organisation is strongly related to the profitability of that organisation. Poor quality results in high cost due to the generation of scrap, the need for rework or doing things over that were not done right the first time, the need for extra inventory, problem analysis, extra process steps, warranties, down time, etc. Clearly, an inability to control the engineering of product quality will be a major cause of unnecessary and unplanned design iterations, manufacturing rework, and rejected parts from outside suppliers. Moreover, design errors and rework slow down product development cycles and increase product costs. These costs reduce profits. Poor quality also leads to customer dissatisfaction and loss of market share and thus reduces future profits. The latter is obviously more costly in the long run. These are all costs of poor quality or costs of non-conformance of product or service to customer requirements. They can be measured and tracked.

The cost of these problems has a significant impact on bottom line profit. For example, in a survey of US Engineering companies, design errors were found to be
responsible for 45% of engineering change orders. The average cost of fixing one error has been estimated at $3,500 (Prescient Technologies, 2000). Companies typically make thousands of change orders during a product’s development cycle. The economic impact of these errors adds millions in development costs.

Controlling product quality needs to start where the product begins, and it begins in the engineering organisation. This is the new competitive advantage that companies in aerospace, automotive, electronics, and other discrete manufacturing industries are discovering.

As discussed in earlier chapters, there are three categories of quality costs that need to be considered (prevention, appraisal, and failure) at each PFP. These are often classified into Cost of Internal Failure (when the non-conformance is discovered before the product or service reaches the customer) and Cost of External Failure (when the non-conformance is discovered by the customer). These costs are a measure of how well an organisation is managing its quality, i.e. how well its quality system is functioning, and the measurement is in terms that management can understand and respond to, namely, money. To improve or maintain quality also involves cost. Product or service must be inspected to ensure bad output does not reach the customer. Control systems must be established and maintained. Workers must be trained. These are costs of conformance of product or service to customer requirements. They are costs of good quality. They are classified into Cost of Prevention and Cost of Appraisal. They can also be measured and tracked. The total Cost of Quality in an organisation is the sum of all these costs of failure, prevention and appraisal.

6.2.5 PFP in the Design to Manufacture Process

Table 6.1 shows the PFP determined earlier (Figure 6.1) and this is followed by a detailed definition.
Table 6.1: Potential failure points

<table>
<thead>
<tr>
<th>Potential Failure Points (PFP)</th>
<th>Potential Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internal Design Failure</td>
</tr>
<tr>
<td>2</td>
<td>Internal Manufacturing Failure</td>
</tr>
<tr>
<td>3</td>
<td>External Design Failure</td>
</tr>
<tr>
<td>4</td>
<td>External Manufacturing Process Failure</td>
</tr>
</tbody>
</table>

1. Internal Design Failure – a failure that will occur if the design concept or details are misconceived or fail to deliver the product requirements. This type of failure can be addressed by undertaking preventive action and using tools such as Quality Function Deployment. The cost for undertaking these preventive actions will be termed Design Failure Prevention Costs (see Table 6.2 for examples).

2. Internal Manufacturing Failure – a failure that will occur if the design of the manufacturing process is not capable of delivering the product design requirements. This type of failure may pass on to the final customer in the form of bad product quality, reliability, or both. This type of failure can be addressed by undertaking preventive action such as design for manufacturability techniques like concurrent engineering, cross-functional design teams (teams that bring together designers, process engineers, production managers, and even customers), and using Quality Function Deployment. The cost of undertaking these preventive actions will be termed Manufacturing Failure Prevention Costs (see Table 6.2 for examples).

3. External Design Failure – a failure that will occur if the final approved design fails to satisfy the customer requirements with a good quality product due to final design problems. This type of failure could be addressed by design appraisal actions and, in the event of not undertaking appraisal activities, customer compensation actions (which can prove extremely costly and damaging if failure occurs within safety of health issues). The costs related to appraising the design, and thus preventing its external failure, will be termed Design Appraisal Costs (see Table 6.2 for examples).

4. External Manufacturing Process Failure – a failure that will occur if the final manufactured product fails to satisfy the customer requirements with a good quality and reliable product due to a manufacturing fault. This type of failure could be addressed by manufacturing appraisal actions and, in the event of not
undertaking appraisal activities, customer compensation actions. The costs related
to appraising the manufactured product, and thus preventing its external failure,
will be termed Manufacturing Appraisal Costs (see Table 6.2 for examples).

Each of these Potential Failure Points (PFP) should be detailed further at each
individual organisation to demonstrate the actual actions, and thus costs, that will be
incurred in prevention and appraisal. Table 6.2 provides a generic list of prevention,
appraisal, and failure costs and actions. Organisations can use this table to determine
which of these actions are applicable to their work.

It should be noted that design review, drawing checking and quality auditing activities
may be considered as appraisal activities. However they are viewed here as pro-active
activities planned to give rise to prevention activities as it reveals weaknesses in the
system and equipment that need to be improvement to prevent failures from
occurring. Thus, they are viewed as failure prevention activities.
<table>
<thead>
<tr>
<th>Action (Cost Driver)</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prevention Costs</strong></td>
<td></td>
</tr>
<tr>
<td>Design reviews</td>
<td>Quality-related reviews to detect failures (i.e. FMCEA)</td>
</tr>
<tr>
<td>Product qualification</td>
<td>Product quality and capability measures</td>
</tr>
<tr>
<td>Drawing checking</td>
<td>Additional checking of drawing to detect latent quality deficiencies</td>
</tr>
<tr>
<td>Process quality</td>
<td>Process capability measures</td>
</tr>
<tr>
<td>Supplier evaluation</td>
<td>Endeavours on finding capable and suitable suppliers</td>
</tr>
<tr>
<td>Training personnel</td>
<td>Staff training to improve word performance</td>
</tr>
<tr>
<td>Quality auditing</td>
<td>Evaluation of quality system in order to assess the quality of processes, people and resources</td>
</tr>
<tr>
<td>Setting specifications</td>
<td>Endeavours on finding suitable specification to delight customer</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Preventive maintenance to reducing the incidence of emergency maintenance</td>
</tr>
<tr>
<td>Recruitment</td>
<td>Appropriate recruitment selection system to elicit suitable personnel</td>
</tr>
<tr>
<td><strong>Appraisal Costs</strong></td>
<td></td>
</tr>
<tr>
<td>Prototype inspection and test</td>
<td>Physical simulation</td>
</tr>
<tr>
<td>Process appraisal</td>
<td>Conformance check of processes with work or process standards</td>
</tr>
<tr>
<td>Supplier surveillance</td>
<td>-Regular audits of a supplier’s quality system</td>
</tr>
<tr>
<td></td>
<td>-Vendor rating</td>
</tr>
<tr>
<td>Incoming inspection</td>
<td>Sample or 100% test of incoming parts or materials</td>
</tr>
<tr>
<td>In-process-inspection</td>
<td>In-process-inspection of semi-finished products to determine its quality level</td>
</tr>
<tr>
<td>Material Control, Packaging inspection</td>
<td>-Receiving and checking materials, bought-out items</td>
</tr>
<tr>
<td></td>
<td>-Checking and dispatching finished products</td>
</tr>
<tr>
<td></td>
<td>-Checking stock levels</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Equipment reliability monitoring</td>
</tr>
<tr>
<td>Finance</td>
<td>-Auditing accounts</td>
</tr>
<tr>
<td></td>
<td>-Determination of quality-related costs</td>
</tr>
<tr>
<td><strong>Internal and External Failures</strong></td>
<td></td>
</tr>
<tr>
<td>Redesign</td>
<td>Redesign of products, processes or services</td>
</tr>
<tr>
<td>ECN/ECO</td>
<td>Engineering change notice and Engineering change order to change processes indices, product specifications</td>
</tr>
<tr>
<td>Purchasing change order</td>
<td>Modification of BOF (bill of material) or renewal of vendor selection</td>
</tr>
<tr>
<td>Corrective action</td>
<td>Efforts on rectifying discrepancies detected internally (i.e. quality improvement teams) or externally (customer complaints or customer recommendations)</td>
</tr>
<tr>
<td>Rework</td>
<td>Repeated acidity to generate a product or a service</td>
</tr>
<tr>
<td>Scrap</td>
<td>Costs of producing defective products, which are</td>
</tr>
<tr>
<td></td>
<td>-labour costs</td>
</tr>
<tr>
<td></td>
<td>-material cost</td>
</tr>
<tr>
<td></td>
<td>-equipment costs</td>
</tr>
<tr>
<td></td>
<td>-overhead costs</td>
</tr>
<tr>
<td></td>
<td>-disposal costs</td>
</tr>
<tr>
<td>Downgrading of products</td>
<td>Discounts, if compliance with quality level has not been achieved</td>
</tr>
<tr>
<td>Warranty</td>
<td>Financial compensation to be paid in case of non-delivery of products</td>
</tr>
<tr>
<td>Product liability</td>
<td>Legal consequence (courts costs or penalties)</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Repair costs of equipment including opportunity costs</td>
</tr>
<tr>
<td>Loss of business</td>
<td>Customer who stop purchasing the product due to non-satisfactory performance</td>
</tr>
</tbody>
</table>
Having identified the possible cost drivers (actions) at each PFP, the organisation must undertake a more in-depth analysis to try and eliminate the causes for failure. This is one of the main preventive and improvement activities. The proposed analysis technique for each PFP is adopted from the GE ‘Six Sigma’ methodology (Perks, 2000) as shown in Figure 6.2. Six Sigma is a performance improvement methodology that relies on using well known improvement tools such as reengineering, quality control and quality management tools. Six Sigma focuses the whole organisation on reducing variations in processes’ operations and outputs to within Six Sigma error levels, i.e. virtually defect free production. The proposed ‘Analysis methodology’ has been adopted from Six Sigma methodology due to the simple fact that it has proved very effective for many leading organisations, and thus considered a best practice in this regards (Perks, 2000)

**Figure 6.2 - Methodology for PFP analyses for prevention and improvement**
In addition to relying on the above methodology for analysing the failure causes, and thus providing potential solutions, organisations must realise that the earlier the fault is detected within a product's design, the less the overall failure costs (Campanella, 1999), as shown in Figure 6.3. Thus, organisations relying on the traditional 'final inspection' of products are losing a lot of value added and can clearly save costs by relying on the proposed model.

Figure 6.3: Failure costs as a function of detection point in a process (Campanella, 1999)

Measurements of these costs at many companies and organisations have shown that the cost of poor quality is often 25% or more of sales in companies and organisations that don't have a good quality system. The effect on profits is often several times more severe. Cost of Quality, especially if it is tracked over time, provides management and work groups with a focus on major causes on non-quality and provides the driver for continuous improvement efforts. Various 'costs of failure' can be compared with each other in Pareto fashion (plotting the different failures that occurred against the costs incurred from each failure, thus highlighting the core few failures that result in 80% of the overall failures costs), and the largest selected for
immediate action. Investing relatively small amounts of money in prevention can often produce savings in costs of failure. Both are tracked by a Quality Cost system. These savings are sometimes referred to as “low hanging fruit” since they can be gathered fast and easily. Companies that improve their management of quality often reduce their cost of poor quality to just a few percent of sales.

The final part of the proposed graphical model is presented in the next section where all the possible scenarios of undertaking preventive and/or appraisal actions for design and manufacturing, along the design of manufacture process, are discussed and their effects on final product performance and customer satisfaction are considered.

6.2.6 Internal and External Product Failure Scenarios

The overall ‘design to manufacture’ process map (Figure 6.1 and Table 6.1), identified four Potential Failure Points, and each can be addressed by undertaking either prevention or appraisal activities (as discussed earlier). If an organisation decides to ignore any of these activities, it will increase the probability of internal product failure leading to internal failure costs (as defined earlier) or external product failure, and thus customer dissatisfaction. The organisation could undertake several combinations of these prevention and appraisal activities as shown in Figure 6.4. Each of these combinations will have a certain impact on the internal failure costs, and the external failure cost, and in general, the less prevention and appraisal activities the organisation undertakes, the more the probability of internal and/or external failure (see Figure 6.3). Table 6.3 provides a comprehensive list of these possible combinations and probabilities of failure.
In Table 6.3, the probabilities range from 'very low', 'low', 'medium', 'high' to 'very high' in five increments. These indicative levels are deemed sufficient for the purposes of the proposed model and they support the graphical presentation with an assessment of the possible risk of failure. However, to be more convincing to organisations as a communication tool, and more useful as a process improvement tool, each organisation must calculate their specific probabilities. In the absence of absolute values, analysis based on linguistic variables of fuzzy methodology could be used (discussed in Chapter 10). This model is similar in various ways to Failure Mode and Effects Analysis (FMEA). Similarities include the fact that both approaches look at failure causes, possibilities of detection, risk potentials, and are tools for effectively ensuring preventive action is instilled (or for methodically approaching corrective actions). In a sense, the model here is a novel application of the FMEA methodology in relation to quality costs.

The only way to calculate the approximate values for these probabilities would depend on each organisation, their field of operations, nature of products, processes, etc. That is to say, these probabilities are very organisation specific, but the generic weights used in the table for the purposes of the study are still valid (based on earlier discussions of QOC theories). A proposed methodology for data collection to assess these probabilities is shown in Figure 6.5 (which is adopted from the GE Six Sigma methodology (Perks, 2000)), chosen for the reasons discussed earlier.
Figure 6.5: A best practice data collection methodology proposed for use in assessing failure probabilities in specific organisations

To support the best practice methodology shown in Figure 6.5 helps to follow a methodology proven successful by others. Quality-related costs are usually available from Accounting data but require some separation from normal operating costs. They can also be estimated by workgroups with help from Accounting. Organisations undertaking to measure and reduce Quality Costs have often found the following methodology effective (Carr and Poneman, 1994; Heagy, 1991; Ostrenga, 1991):

1. Obtain management support for a Cost of Quality assessment.
2. Select those parts of the organisation to be assessed. This may vary from the entire organisation to a small segment selected for a pilot study.
3. Establish the assessment team, ideally representing the affected work groups, management and accounting.
4. Define the various Cost of Quality components within each of the categories of Failure, Appraisal and Prevention, e.g. rework, inspection, training, customer complaints, etc.
5. Collect data on each of the Cost of Quality components for a given time period and convert into a financial measure. Compare with a base, e.g. total sales, cost of goods manufactured, or cost of service rendered.

6. Analyse the Cost of Quality data seeking to decompose each cost component into its drivers, symptoms and ultimately root causes.

7. Determine the financial impact of eliminating root causes of poor quality and the needed investment. Do a cost/benefit analysis.

8. Present to management the anticipated improvements in product or service quality, the associated savings, the required investment and the time period for realisation.

9. Based on a management decision to proceed, select and train the improvement team, develop an action plan and improvements.

10. Continually assess progress of the improvement projects and continually monitor and report Quality Costs.

Following on from the overall notion of simplicity, and to maintain the graphical display characteristics of the proposed tool, the options provided in the Table 6.3 have been reproduced in graphical format in Figure 6.6. This figure displays all the possible options, their consequences in terms of failure occurrence (internal or external), the probabilities of failure detection if it occurs at any point, and the effects on the internal and external customers that these failures have. Table 6.3 also provides a tabulated account of the effects that each possible combination of failures will have on the organisation’s internal customers (in our scope the internal customers to the design function are the manufacturing function) and the external customer (end user). It has to be noted that this table represents the view to today’s highly demanding customers, i.e. a ‘medium’ probability of failure will not ensure a satisfied customer, but will get a ‘low’ customer satisfaction rating. Similarly, a ‘very low’ probability of failure will get a ‘high’ satisfaction rating rather than ‘very high’ as good quality is the standard and not a bonus in the eyes of the customers. However, these values are indicative and are meant as a tool for communication (as specified in the model objectives) rather than exact values based on statistical analysis.
<table>
<thead>
<tr>
<th>#</th>
<th>Design Failure Prevention</th>
<th>Manufacturing Failure Prevention</th>
<th>Design Appraisal</th>
<th>Manufactured Product Appraisal</th>
<th>Activity</th>
<th>Failure type &amp; probability</th>
<th>Failure detection probability</th>
<th>Customer Satisfaction Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td>V. Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
<td>V. Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td></td>
<td>V. Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td></td>
<td>V. Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>5</td>
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<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td>V. Low</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>6</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td></td>
<td>V. Low</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>7</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
<td>V. Low</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>8</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td>V. Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>9</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>10</td>
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<td>Y</td>
<td>Y</td>
<td>N</td>
<td></td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>11</td>
<td>N</td>
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<td>N</td>
<td>Y</td>
<td></td>
<td>V. High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>12</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td></td>
<td>V. High</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>13</td>
<td>N</td>
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<td>Y</td>
<td>Y</td>
<td></td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>14</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
<td>High</td>
<td>V. High</td>
<td>Low</td>
</tr>
<tr>
<td>15</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td></td>
<td>V. High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>16</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td></td>
<td>V. High</td>
<td>Low</td>
<td>V. Low</td>
</tr>
</tbody>
</table>
KEY FOR FIGURE (6.6) QUALITY COST
SYSTEM GRAPHICAL MODEL

ACTIVITY

OUTPUT PROBABILITY

FAILURE COST

CUSTOMER SATISFACTION
As is shown in Table 6.3 and Figure 6.6, the possible outcomes displayed are wide ranging and it would be infeasible to discuss them all in detail. Thus, the scenarios that will be considered in the remainder of this section will be selected to provide a basis for understanding the scenarios for demonstration purposes only.

The scenarios chosen for discussion are as follows:

**Scenario #2 (see Table 6.3)**

In this scenario, the organisation undertakes design prevention activities, design appraisal activities, and manufacturing process preventive activities. In the design domain, undertaking preventative actions when designing the product means that the designers might use QFD to incorporate all the customer requirements in the design, they use FMECA to forecast and assess potential failures and thus change the design to minimise them. After the design is approved and the pilot is undertaken, the organisation also undertakes design appraisal activities to make sure the design does produce what it is supposed to. They undertake activities to test the designed product, for example, for its performance in the presence of excessive use (abuse), abrasive environments, etc. These activities so far will virtually eliminate all probability of internal design failures, and thus the probability for that was graded 'very low', and consequently if any failure were to occur, the chance of detecting that failure internally is 'very high'. This scenario so far ensures a 'high' internal customer satisfaction.

On the manufacturing side, in this scenario the organisation undertakes manufacturing prevention activities which could be using QFD to ensure manufacturability of the design (integrated within the design stage), or installing a system for Total Preventative Maintenance to ensure manufacturing failures will be minimised, and so on. However, the organisation does not undertake manufacturing appraisal activities (i.e. no activities are there to test the final products produced), and thus although the design errors have been minimised, and the manufacturing process errors also minimised (i.e. probability of manufacturing errors occurring should be very low, but the probability of detecting any when they occur is 'low'), any product errors will have a 'low' chance of being detected, and thus customer satisfaction will clearly be 'medium'.

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To further clarify this scenario, a hypothetical example of an auto parts manufacturer is presented (e.g. the manufacturer of water-pumps). The product, according to Scenario 2, will follow the following phases:

1. Design failure prevention activities are undertaken in the form of QFD to ensure customer requirements are met, tight product specifications, high quality training for designers, and design reviews. These should minimise the probability of internal design failure to very low rating (say 10%). Once the design is completed, design appraisal measures are put into place such as prototyping and process appraisal thus further minimising the probability of internal design failure to virtually nil. On the manufacturing side, prevention activities undertaken may include process capability studies to ensure the process delivers, total preventive maintenance system, and a systemised application of SPC. These would reduce the overall probability of final product failure to a ‘low’ rating (say 3% which might be there due to random manufacturing errors). Due to the nature of the final product, appraisal of the manufactured product (apart from checking dimensions) has to take the form of ‘destructive testing’, which is expensive and can only be done on a sampling basis. Thus, and according to Scenario 2, the company decides not to undertake manufacturing appraisal actions. The overall probability of this product failing to satisfy external customer requirements is a low 3%, which in the auto industry is unlikely to be an acceptable quality level.

It has to be noted that the numbers used in this example are purely hypothetical and only for demonstration purposes. It was presented to shed light on the applicability of the approach. However, the following chosen demonstrations of other scenarios will not include other hypothetical examples to avoid repetition.

Companies that will use this model must have their own specific numbers which can rely on historical data, detailed process analysis, detailed activity based costing analysis (see Chapter 8), or a combination of all these areas.

**Scenario #3** (see Table 6.3)
In this scenario the organisation undertakes design prevention activities (see Scenario # 2), but fails to undertake design appraisal activities. This will probably result in a 'very low' chance of internal design errors occurring due to prevention, but equally 'low' chance of detecting any failure if they occur. However, these are 'internal' errors, and although they add to the internal costs, will have a low chance of getting to the customer as a 'design error' since the design will be changed and modified as a result of errors identified in manufacturing. They will, however, result in only a 'medium' satisfaction rating for internal customers. On the manufacturing side, the organisation undertakes manufacturing process prevention activities and also manufacturing appraisal activities (sample testing, SPC controls, etc.), and, thus, the probability of product failure (not conforming to the design) with the end customer is 'very low', and if any occur, the chances of capturing it before it gets to the customer are 'very high', thus the end customer will have a 'high' satisfaction rating.

Scenario # 13 (see Table 6.3)

This is a scenario that could be found in many organisations operating today. It is one where the organisation undertakes only appraisal activities, both for design and manufacturing. Although appraisal, inspection and statistical quality control are important activities in a manufacturing organisation, it can be seen from the table that they are not enough on their own. Such organisations are running a high risk of internal design failures, resulting in highly dissatisfied internal customers, and a lot of internal failure costs. More alarmingly, these organisations run a medium risk in external failures (which in this day and age could be very costly in terms of customer retention, let alone recruiting). This scenario is seen to result in a 'low' external customer satisfaction rating. Thus, this is a very clear example that it is by no means sufficient to 'inspect quality in' after design or manufacturing, quality must be 'built in' through prevention activities.

Scenario # 15 (see Table 6.3)

In this final scenario being explored, an organisation only undertakes appraisal activities after manufacturing. Clearly due to ignoring design prevention and appraisal activities there is a very high probability of internal design failure, and all the costs associated with that. Moreover, with no prevention built in the manufacturing process, many internal product failures are highly probable, but with
manufacturing appraisal taking place, the probability of these failures getting to the customer is 'medium', but at the expense of very high internal design failure costs, very low satisfaction rating from the internal customers, high internal manufacturing failure costs, and a low external customer satisfaction rating.

6.3 Conclusions

Having explored some of the scenarios in details, it is clear now how the reasoning presented in Table 6.3 and Figure 6.1 can be used to achieve management acceptance of the need for prevention and appraisal for superior quality. As Table 6.3 and Table 6.4 reveal, the only scenario where there are low probabilities of internal failure and external failures is when all four PFP are dealt with through prevention and appraisal. Any organisation can undertake simple calculations, and these probabilities and costs can be accompanied by numbers to strengthen the case for prevention and appraisal (as discussed in the hypothetical scenarios). The main ethos behind quality management and continuous improvement is to shift the balance heavily towards prevention and minimise inspection and appraisal, i.e. build quality in rather than inspect quality in. In the classical PAF model, there is a balance that organisations aimed to achieve, termed optimal quality level, and presented in various sources in the quality literature (see Figure 6.7).

![Figure 6.7: Classic model of optimum quality costs (Campanella, 1999)](image-url)
However, the more organisations learn about quality and the importance of customer satisfaction and customer retention, the more this model is shifting, and the concept of acceptable failures is becoming less acceptable. World-class organisations are adopting new techniques in the 21st century to try and eliminate errors throughout the whole process, namely Six Sigma improvement methodologies. These organisations subscribe to the modified ‘optimal quality level’ as shown in Figure 6.8.

![Figure 6.8: New model of optimum quality costs (Campanella, 1999)](image)

Whatever the organisation’s inclination towards this debatable issue, the graphical model proposed in this chapter aims to facilitate the understanding of the importance of the design and manufacturing prevention and appraisal activities, and provides a simple-to-use, visual tool to get the message through strongly, and provide a systematic framework to look at the design to the manufacturing process and try to minimise the potential failures.
7.1 Introduction

The main concept proposed in this chapter relies on the ABC methodology. It is possible to tackle the issues faced by quality costing systems (as discussed in Chapters III and IV), and ABC will provide an ideal vehicle for facilitating the application of a quality costing system, and simultaneously, improving the benefits gained from it.

Finally, the relevance of ABC to Quality Costing systems is discussed, and a detailed look at the use of ABC for defining and managing costs of quality is provided.

7.2 Advantages of ABC in QCIS

A Quality Cost Information System (QCIS) is a cost structure that provides an enterprise with the ability to gauge and measure the efficiency and effectiveness of its management and processes. A fundamental management concern within any enterprise is the efficiency and effectiveness of the process by which the enterprise develops, produces, delivers, and provides both pre- and post-delivery customer services. Drucker (1963) defined effectiveness as the foundation of success. The goal of the quality cost information system is to identify, analyse, and assist in correcting the causes of inefficiency and ineffectiveness.

Although quality costs can be identified and collected within the framework of any financial accounting system, Activity Based Costing (ABC) is particularly compatible with quality cost methodology and objectives (discussed in Chapter 3). The following capabilities of the ABC system have been highlighted in the literature (Dale and
Plunkett, 1991; Letza and Gadd, 1994; Hester, 1993) as to why ABC is ideal for use in measuring and managing costs of quality:

1. Quality cost methodologies seek to assign quality related costs to specific activities, products, and processes or departments, so that these costs can be targeted for reduction. The use of ABC techniques makes it easier to find and assign these costs. The level of detail and the information content inherent in traditional accounting systems are often insufficient for adequate quality cost analysis and application to continuous improvement. ABC, on the other hand, because of its more detailed cost databases, is better suited to these needs. ABC will tell management the accurate cost of poor quality and indicate which activities are the most expensive through Pareto analysis. Accordingly, management can identify the direction and magnitude of the quality improvement opportunities.

2. The aspect of overhead allocation in calculating quality costs is seldom discussed in the literature. In practice, some companies add overheads to the direct cost of labour and material on rework and scrap, while other companies do not. If they do, “rework and scrap costs become grossly inflated compared with prevention and appraisal costs which are incurred via salaried and indirect workers” (Dale and Plunkett, 1991). ABC provides greater accuracy to the application of a firm’s overhead (by far the company’s major cost) directly to departments, processes, and products.

3. Most of quality costs measurement systems in use are not (there are some exceptions) intended to trace quality costs to their sources (O’Guin, 1991), such as parts, products, designs, processes, departments, vendors, distribution channels, territories, and so on. Accordingly, the quality costs information derived from these systems cannot be used to identify where the quality improvement opportunities exist. Within ABC, the process that identifies and quantifies the many cost drivers in an organisation provides a database that not only lets the organisation find the cost drivers but ultimately leads to the root causes. In theory, an organisation should be able to assign a quality cost to a root cause of a quality problem. This proves extremely valuable, since an organisation can then calculate the return on investment and the payback time for investing to fix a root
cause. Thus, by integrating the ABC system and the quality system, the cost of poor quality can be traced to its source and the integrated system can identify where the quality improvement opportunities exist whether it was a design, materials, supplier, or even customer problem. To allow effective tracing of quality costs to their sources, an organisation should find their root causes by using the cost driver analysis of ABC process view in order to direct improvement efforts to the cause of cost and avoid treating the symptom.

4. ABC can supply cost of quality information, but can also go further still. By describing costs as customer generated (using appropriate cost drivers), ABC can begin to look at quality costs from the customer information (in this case, non-conformance costs). If TQM is to be a truly organisation-wide discipline then a costing system built around processes will supply cost information (not only quality costs) at the level to which the management structure is operating. By identifying costs more accurately, ABC can highlight those processes where improvement is being made, and so tangible benefits will appear in bottom-line results. The benefits of TQM will be visible to senior management earlier on.

5. Since management establishes quality improvement targets for every unit of the organisation, management can then track actual performance to these targets after one period’s operation. Turney (1996) demonstrated how ABC was used for total quality control by utilising daily Quality Costs reporting in a Printed Circuit Board (PCB) plant. The ABC system was used to prepare a report on the cost of poor quality for each activity immediately after each of the three daily shifts and to show graphically the trend in physical defects and cost. The report allows management to focus immediately on the quality problems with the biggest cost impact. The ABC system also prepared a daily top ten offenders’ list that reports the ten products with the highest cost of poor quality on the previous day. It pinpointed the poor quality products and provided the greatest potential for redemption. When a product unit on this list was scrapped, a report, which showed the cause of the problem as well as the cost, was prepared and sent to the person most likely to correct the problem. This use of ABC made quality problems visible within a matter of hours, or even minutes. Turney suggested
linking ABC with Computer-Integrated Manufacturing (CIM) to prepare quality cost reports for real-time and cost-effective control.

6. ABC is geared to the medium term, and is flexible and customisable.

### 7.3 Comparison Between Quality Costs Approaches and ABC

In order to begin looking at how ABC can benefit the QCIS, Table 7.3 provides a detailed comparison between the quality costs approaches and ABC.

**Table 7.1: Comparison between quality costs approaches and ABC (Campanella, 1999; Tsai, 1997; Turney, 1996)**

<table>
<thead>
<tr>
<th>Comparison Criteria</th>
<th>Quality Costs Approach</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orientation</strong></td>
<td>Activity oriented</td>
<td>Activity oriented (cost assignment view)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Process oriented (process view)</td>
</tr>
<tr>
<td><strong>Activity/cost categories</strong></td>
<td>Prevention, Appraisal, Internal Failure, External Failure</td>
<td>Value added, Non-value added</td>
</tr>
<tr>
<td><strong>Treatment of overhead costs</strong></td>
<td>No consensus method to allocate overhead to quality cost elements under current quality costs measurement systems and traditional cost accounting</td>
<td>Assigning overhead costs to cost objects by using activity drivers in the second stage of ABC cost assignment view</td>
</tr>
<tr>
<td><strong>Tracing costs to their sources</strong></td>
<td>No adequate method to trace quality costs to their sources</td>
<td>Tracing activity costs to cost objects by using activity drivers in the second stage of ABC cost assignment view</td>
</tr>
<tr>
<td><strong>Improvement objectives</strong></td>
<td>Quality costs-related activities</td>
<td>Process/activities</td>
</tr>
<tr>
<td><strong>Tools for improvement</strong></td>
<td>Quality circles, Brainstorming, Group techniques, Cause and effect analysis, Fishbone diagram, Force-field analysis</td>
<td>Process/activity value analysis, Performance measurement, Benchmarking (measuring against best practice examples), Cost driver analysis</td>
</tr>
<tr>
<td><strong>Information outputs</strong></td>
<td>The cost elements of PAF categories, Total quality cost and costs of PAF categories/elements and their percentages of various bases</td>
<td>The costs of activities and processes, The costs of value-added and non-value added activities and their percentages of various bases, Accurate costs of various cost objects (e.g. product, department, customer), Activity based performance measures, Cost drivers of activities</td>
</tr>
<tr>
<td><strong>Related Management topic</strong></td>
<td>TQM</td>
<td>Activity Based Management</td>
</tr>
</tbody>
</table>
One of the most informative aspects of selecting an approach to use for QCIS is the information output. These outputs are what an organisation will use to set improvement targets, strategic goals, and make decisions. The fundamental cost information outputs achieved from the PAF approach are the costs of the PAF-related activity.

Therefore, we can see that there are many similarities in PAF perspective between the PAF cost approach and ABC. However, ABC can supply various costs and non-financial information to support quality costs programs. Moreover, ABC can provide more accurate costs of activities and processes than traditional cost accounting, which makes quality costs information more valuable for TQM. Hence, we can conclude that it is beneficial for organisations to integrate quality costs approaches with ABC. As for the QCIS model being discussed and suggested here, and based on the discussion presented in Chapter 3, it is seen as most beneficial if the organisation adopts the PAF model and integrates that with ABC to achieve the maximum benefits sought, with minimum complexity. Overhead costs are traced to activities by using resource drivers in the first stage of ABC cost assignment view. Then, activity costs are traced to their sources (i.e. cost objects) by using activity drivers in the second stage of ABC cost process view.

7.4 Quality Costs Management Using ABC

Quality costing, by providing a framework for identifying, collecting and compiling costs, ensures that a comprehensive picture of the costs of producing a product is obtained. ABC provides an accurate picture of the activities, which act as the cost drivers, thereby ensuring accuracy in the actual costs collected. Quality costing, as a tool of process improvement, must use the process cost model as a component of the framework for collecting and analysing the costs. When applying the ABC system to measure and report quality costs, the methodology outlined below can be used. To further illustrate this methodology, a hypothetical implementation example is presented in parallel. This example is for illustration purposes, and presents the case
of a ‘ready meals’ producing company. The company produces and delivers ready
meals to supermarkets and is a medium organisation that employs 400 people.

1. Define the activities – relying on the PAF approach, the activities of the ABC
model would be quality cost-related activities (prevention, appraisal, internal
failure, and external failure) and quality cost-unrelated activities (production,
marketing, etc). In the example presented, some of the quality costs-related
activities identified would be inspection of incoming raw material, production
machine cleaning, preventive maintenance, and final inspection.

2. Define the activity cost drivers – in the first stage of ABC cost assignment view,
resource costs (including overhead costs) of the company are traced to various
quality cost-unrelated and quality cost-related activities by using resource drivers.
The resources used by quality cost-related activities may be people, computers,
equipment, material (parts), supplies, facilities, energy, and so on. If a resource is
dedicated to a single quality cost-related activity, so the resource cost is directly
traced to that quality cost-related activity. If a resource supports several quality
cost-related and/or quality cost-unrelated activities, the resource cost must be
distributed among these activities by using an appropriate resource driver. In the
example presented, the cost drivers have been identified as per Table 7.4.

<table>
<thead>
<tr>
<th>Quality Activity</th>
<th>Cost Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incoming Inspection</td>
<td>Number of raw material deliveries</td>
</tr>
<tr>
<td>Machine cleaning</td>
<td>No of batches produced</td>
</tr>
<tr>
<td>Preventive maintenance</td>
<td>Machine hours</td>
</tr>
<tr>
<td>Final inspection</td>
<td>No of batches produced</td>
</tr>
</tbody>
</table>

3. Activity Costing – each of the four components of total quality costs can be
obtained respectively by accumulating the costs of all the activities related to that
quality cost component. Finally, total quality cost is the sum of the four
components’ cost. Accordingly, total quality cost, four quality cost components,
and the cost of detailed quality cost-related activities can be achieved from the
first stage of ABC cost assignment view. Activity costing is illustrated in Table 7.5 for the ‘incoming raw material inspection’ activity.

**Table 7.3 Activity costing for ‘incoming raw material inspection’**

<table>
<thead>
<tr>
<th>Incoming Raw Material Inspection Activity Costs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection Personnel Costs</td>
<td>Wages</td>
</tr>
<tr>
<td>Training Costs</td>
<td></td>
</tr>
<tr>
<td>Office overheads</td>
<td></td>
</tr>
<tr>
<td>Pension and other HR costs</td>
<td></td>
</tr>
<tr>
<td>Inspection Equipment</td>
<td>Capital and depreciation</td>
</tr>
<tr>
<td>Calibration</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
</tr>
<tr>
<td>Inspection reports</td>
<td>Preparation</td>
</tr>
<tr>
<td>Preparation</td>
<td></td>
</tr>
<tr>
<td>Circulation</td>
<td></td>
</tr>
<tr>
<td>Office supplies and overheads</td>
<td></td>
</tr>
</tbody>
</table>

4. Once the activity-based costs have been identified under the PAF, the organisation can utilise the information produced to create quality cost reports. These include quality cost reports associated with detailed quality cost-related activities for the whole company, quality cost reports associated with activities related to appraisal, internal failure, external failure costs by departments, products, or product lines, and quality cost reports associated with activities related to external failure costs by distribution channels or territories. At this point in the example, the organisation could tell how much, for example, inspection activities cost them, and they can calculate how much of these costs are attributed to each product.

5. Transform the data into knowledge - the quality cost reports usually provide monthly costs, year-to-date costs, variances to budgeted costs, and a comparison with the previous years’ cost data. These quality cost reports may include the quality cost percentage of various bases such as sales revenue, manufacturing cost, units of product, and so on. In addition, trend analysis can be used to compare present quality cost data with historical quality cost data in order to
know how quality costs change over time. In the example illustrated, the company can use the costs discussed, this would reveal the actual specific product cost structure, and this can then be reflected in product pricing and profitability calculations.

What ABC tells us is which activity absorbs which of our costs. What quality management (Quality Cost) does is point us in the right direction concerning which of these costs should be minimised with a documented financial reason from ABC, and then proceeds to help us do something about it.

7.5 Conclusions

Given the changes that have taken place in the manufacturing environment and the level of competition, the need for more accurate and informative cost accounting systems has become obvious. However, and although this chapter demonstrated the advantages of ABC, its applications in manufacturing companies have seldom been reported. Indeed, the survey results in Chapter 5 revealed a lack of spread of ABC applications. In this chapter, we presented the deficiencies of the traditional cost accounting system, especially as it affects the implementation of a Quality Cost Information System (QCIS). Traditional Cost Accounting (TCA) systems emphasise the external financial reporting requirements and tend not to provide relevant, timely and useful information for the managers who are faced with operational and strategic business decisions on a timely bases. TCA systems do not adequately trace the cost of overhead costs associated with activities such as the cost of quality, of machine idle, of set-up, or of parts waiting in a manufacturing area. As a consequence, managers can be led in the wrong direction to reduce manufacturing costs by paying little attention to overhead costs in an advance manufacturing system. Similarly, they allocate overhead costs to products based on production volume-related attributes such as direct labour cost, machine time or direct material cost in a manufacturing environment normally devoted to the manufacturing of a narrow range of products.

The chapter presented a discussion to show that an Activity Based Cost (ABC) accounting system will overcome these deficiencies when implemented in the right
manner, when incorporated into a QCIS. As discussed above, ABC systems have recently received much attention due to their ability to derive more useful cost information. With ABC systems, cost can be managed in the long-term by controlling the activities that drive them. In other words ABC systems focus on managing activities rather than costs directly. This makes it possible to quantify strategic long-term intangible benefits of QCIS more reliably. A comprehensive comparison of the traditional cost accounting system and the ABC accounting system was also discussed. The features of ABC that makes it more acceptable than the traditional cost accounting system were also discussed.

Today's general ledger and budgeted spending systems support departmental and stovepipe managerial philosophies, but not decision support; some standard costing systems are suspected for misallocating indirect costs. In contrast, ABC accounting/management information supports business process-based thinking and corrects for flaws in costing methods. It has been noted that quality managers are being denied their rightful access to meaningful and relevant cost measurement data to support their decisions. A significant portion of the accounting community is unaware that its general ledger accounting and reporting systems are structurally deficient to format cost data in a way that supports decision-making. An ABC system resolves this problem — it introduces new issues related to managers now being exposed to the truth.

ABC is not a replacement for the traditional general ledger accounting. Rather, it is a translator or overlay that lies between the cost account accumulators in the general ledger and the end-users, such as managers who apply cost data in decision making.

ABC translates costs into a language that people can understand and into elements of costs, namely the work activities, which can be more flexibly linked or assigned to business processes or cost objects based on demand-driven consumption patterns, not simplistic cost allocations. The reason ABC is more suitable than TCA is because the TCA general ledger is now recognised as being structurally deficient for delivering good business information for decision support. The general ledger is now a sound mechanism for collecting and accumulating transaction-intensive costs, but not for converting those costs into useful managerial information.
In contrast to traditional accounting, ABC focuses on the work activities associated with operating the business. ABC is very work-centric, whereas the general ledger is very transaction-centric. Both have their place, but the general ledger’s data is too raw to be considered business intelligence for decision support. ABC solves the general ledger’s flaw of unprocessed cost data. But ABC does much more. Just translating the ledger account expenses into their work activities is an incomplete story of ABC. The total ABC picture comes from linking the activities into networks to cost out items for analysis, determining trade-offs and decisions.

If TQM is to be a truly organisation-wide discipline then a costing system built around processes will supply cost information (not quality costs) at the level at which the management structure is operating. By identifying costs more accurately, ABC can highlight those processes where improvement is being made, and so tangible benefits will appear in bottom-line results. The benefits of TQM will be visible to senior management earlier on.
CHAPTER 8:
QUALITY COSTS INFORMATION SYSTEM (QCIS)

8.1 Introduction

The previous two chapters have discussed two of the proposed tools to allow manufacturing organisations to effectively understand, commit to, and benefit from, implementing a quality costing system. This chapter will describe the final part of the proposed package for quality costing, namely, the Quality Cost Information System (QCIS). The QCIS is a software programme developed as part of the overall research project discussed in this thesis.

This chapter will also discuss details of the QCIS by examining its scope and target audience, its concept and design criteria, and its operation and use. The chapter is accompanied by a QCIS User Guide, which is provided in Appendix 3. Finally, the chapter presents the potential benefits of using the QCIS, and indeed its limitations.

8.2 Quality Cost Information System (QCIS)

8.2.1 QCIS Scope and Target Users

Similar to the Graphical Model proposed in Chapter 5, the QCIS was designed with a specific scope in mind, namely manufacturing organisations and the 'design to manufacture' process. This scope was chosen for several reasons:

1. To keep the QCIS compatible with what has been proposed so far in previous discussions.
2. To keep the model simple and understandable. The QCIS so far developed is in its pilot stage and it is best to test it on a limited controllable scale before engaging the resources required to applying it more widely.
3. Manufacturing organisations were selected due to the ease of identification of design and manufacturing activities, and the universal understanding of these activities (as opposed to service organisations).

4. The lack of resources (mainly time constraints) prevented extending this pilot to cover service organisations or a wider scope of the organisational value chain.

However, the QCIS has been designed based on generic templates and generic quality and activity cost concepts thus is, in theory, expandable to application in other parts of the manufacturing organisation, or indeed in service organisations.

The QCIS was initially designed with a specific target audience, namely those engineers or quality professionals involved in product design and manufacturing activities. The QCIS was designed to be user friendly, it has several help options and a detailed user guide, thus it is, more or less, self-guiding and anyone with access to the required data from their own manufacturing operations can use it successfully. However, to achieve maximum benefits, it is recommended that users have a quality and/or manufacturing background, and more importantly a detailed knowledge of the process or product under study (including some information about the product failure, estimated failure costs, and estimated costs for prevention and appraisal activities).

8.2.2 QCIS Concept and Design

As discussed in earlier chapters, in most companies using traditional cost accounting systems, the costs of quality can be anywhere from 20% to 40% of the overall manufacturing costs, and in several cases have been as high as 50%. According to quality cost experts (Camapnella, 1999), these figures are similar for manufacturing and service organisations. The source of these alarming costs come from non-value adding activities like rework (of doing things two or three times before the "customer" gets what they ordered), delays (due to inspection, reworks, scrap, etc., which adds to the overall manufacturing cycle time), scrap (products that have no salvage potentials), extra overtime to meet deadlines, high inventories, and the like.
Evidence from previous chapters so far suggests that 'Quality and Continuous Improvement activities could be a Gold Mine for a company'. This statement has been the core of many quality management programmes and philosophies over the past few decades (Crosby, 1979; Campanella, 1999). Evidence to back these theories have also been accumulating over the years, so much so that we now have an abundance of case studies that claim cost reductions and overall financial gains by investing in quality and continuous improvement activities (Oakland, 1998). The sources for these financial gains that most manufacturing organisations noted include:

1. Costs decrease due to reduction in rework.
2. Inspection and repair costs drop due to fewer problems in the design and manufacturing of the product.
3. Cost reductions due to decrease in the volumes of scrap.
4. Cycle times are reduced.
5. Time saved on inspection and correction is usually spent on continuous improvement activities and at times lead to new innovations.
6. Productivity improvements.
7. Cost reductions may be passed on to consumers resulting in increasing sales volumes.
8. Reduction in warranty and contractual repair costs.

With such ample evidence, it is clear that the need for an information system that aims at reducing Quality Costs cannot be overemphasised. In the past few decades, quality and quality management have become more and more popular, and have started to be included in the 'way we do business' for most organisations. It is also worth mentioning here that TQM, unlike many other new organisational strategies such as BPR, has stood the test of time. From quality related, and induced, organisational visions and missions, to quality management systems like ISO 9000, quality has become paramount. However, much of the finer detail of implementing quality management, namely quality measurement via the most reliable, accurate and meaningful measure (the Cost of Quality), still poses a challenge for many. Measurement is at the heart of TQM success, but many authors avoid it altogether, while others state the results of TQM case studies without concluding how they arrived at them. The success of any change programme (including TQM) may be
measured on a number of dimensions such as business measures (increased market share, profits), customers (reduced complaints, increased satisfaction), output (less defects, claims, etc.), suppliers (better liaison, reduction of total cost of dealing), inputs (fewer defects), inside organisation (clearer leadership, internal process improvement), and people (morale, job satisfaction, teamwork). A common pitfall is measuring the ‘wrong’ indicators, such as the number of training hours per employee or number of suggestions made, and so on. While easy to measure, these indicators are ineffective and should be replaced by others such as percentage of individual training plan objectives met, number of suggestions implemented, etc., (Jarrar and Aspinwall, 1998). One of the most highly successful measures for quality efforts has been shown to be the cost of quality (Brown et al, 1995). Dale and Plunkett (1999) stressed the importance of measuring costs, as it allows quality-related activities to be expressed in the language of management. This in turn, allows quality to be treated as a business parameter along with, for example, marketing, research, and development, and production/operations.

As discussed in Chapter 6, an alternative accounting concept that could perhaps shed some light on the issue of Costs of Quality, and facilitating their understanding and calculation, is Activity Based Costing (ABC). ABC allocates costs to specific activities rather than departments or functions. These costs include labour costs, material costs, and overheads. Therefore, it is the activity that drives the cost and not the cost driving the activity. With this in mind, it is possible to further focus this study to deal with ‘activities’. In relation to their consumption of quality costs, design and manufacturing activities can be divided into three main categories:

1. Productive activities: making a product, designing a machine, writing a report, conducting financial analysis and selling a service. These can be called budgeted operating costs. The activities consume costs to produce the output that has value to the customer. Upon further inspection, these can be divided into value adding and non-value adding, which is the basis for many process improvement techniques.

2. Preventive activities: the activities that are undertaken to ensure that equipment, processes and procedures will lead to the desired results (conformance to

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requirements) every time without failure. These activities would include such
things as preventive maintenance, quality education and training, process proving,
procedure verification, customer-orientation training and design review. The
costs consumed by these activities are seen by most quality gurus (Oakland, 1998;
Crosby, 1979) as an investment that generates a very high return by minimising
internal and external failures.

3. Corrective activities: activities undertaken to find where the product or production
activity went wrong (inspection after the fact) and then correcting the non-
conformance (defect). This could include reworking or reprocessing a transaction,
or if not possible, scrapping the old product/service and redoing the whole
operation. Also, expediting the output to meet deadline requirements, computer
reruns, excess inventories, downtime, and repeated service, warranty activities and
obsolete material disposal. The costs consumed by these activities are by no
means value adding, and can be very expensive in some external failure cases.
These are the costs that Quality Management and Quality Assurance aim to
eliminate.

Obviously, the first category is nothing more than the “normal” operating activities in
a business organisation, complete with employee labour, material, and overhead costs.
This is the part of the business that reflects the level of business (if it is done right the
first time!). The only reduction that can be brought to this category without impairing
the business is through efficiencies from innovative designs of processes.

Next comes the category of prevention activities that are designed to help the
organisation perform the ‘production activities’ correctly. In the strict sense of the
word this is not a “productive” activity, but if neglected it could severely damage the
actual “productive” one. These are usually termed the ‘support’ processes/activities.
They are crucial and must be budgeted for. Eventually the organisation will want to
subject all these prevention activities to value analysis, as no matter how useful they
are, they are cost consuming activities. Clearly, the reduction of preventive activities
must not cause an increase in failures so they can only be reduced when an
organisation has reached a mature state of Total Quality Management where:
1. Processes operate within a Defect Free environment (one of the methodologies that world-class organisations are implanting to achieve this ideal goal is six sigma).

2. Improvement to the design of the process the establishment is operating, i.e. building quality in the process (and/or product) design.

3. Quality is an organisational mindset and not a programme. This could only be achieved with employee education, communication, and strong and visible leadership.

Thus, focusing on organisational ‘activities’ using the concepts of ABC will help an organisation focus on the actual ‘consumers’ of costs. Organisations can tell exactly where the bulk of their manufacturing costs are being consumed and thus focus on those areas for improvement. Consequently, this focus on activities will allow organisations to more readily identify Quality Costs, and thus manage them more efficiently.

So far, to facilitate the organisation’s ability to identify and manage quality costs, two major concepts have been recommended, namely the Graphical Model for Failure Identification, and the use of the structured activity focus in ABC methodologies. The Quality Cost Information System (QCIS) described in this chapter builds on both ideas and attempts to present a pilot for a software programme that will allow organisations to identify the Cost of Quality, and manage them to their benefit, with minimum effort on the organisation’s side.

8.2.3 QCIS Operation and Use

This section presents the detailed structure and operation of the QCIS programme it is also supplemented by a detailed ‘User Guide’ for QCIS (presented in Appendix 3). In planning the design of the QCIS, the following objectives were established:

1. To provide an information system that is simple to use.
2. To provide an information system that facilitates decision-making regarding quality activities (based on the current status and a cost/benefit analysis for future actions).

3. To provide an information system that does not require expert users, but rather can be operated by anyone involved in the manufacturing process (assuming basic quality background).

4. To provide an information system that can act as a pilot for the concept of Quality Cost Information Systems (the pilot was to initially cover the ‘design to manufacture’ process).

With these objectives in mind, the main features of the required QCIS were:

1. User-friendly interface – this was built-in by providing pre-prepared selections via drop-down menus, supported by a ‘Help’ function that explained most of the detailed ‘quality’ concepts.

2. As it was to support decision-making, the engine of the model had to have a software programme that operates on a set of pre-determined equations (based on the quality cost literatures discussed so far).

3. To allow the ease of use, the system had to allow maximum benefit with minimum information provided, thus the information to be inputted by the user are estimates (the more detailed the data the more accurate the output, but the system was still capable of producing valid results with estimates).

4. As a decision-making tool, part of the final output was required to be in the form of ‘advice’ or proposed future ‘action’. This feature was based on ‘generic’ best practices and ideas that have proved successful in other organisations and documented in the quality literature. However, it is by no means a prescriptive approach to action planning, as each organisation is different, and must tailor such practices and advice to their environment.

5. The system design had to be modular to allow changes and improvements to be easily integrated and thus can be easily transferred to a sector, or organisation’s specific Quality Cost Information System.
The final design parameter was selecting the programming language to be used to design the QCIS. The choice was made to use Visual basic as it provided the following advantages:

1. Simple to use, and thus allowed easy additions and improvements to the programme.
2. An advanced programming language that allowed the inclusion of various features, and did not present any limitation on the final requirements.
3. Relatively easy to learn which was beneficial as it placed minimal time constraints on the available resources for the research project and will provide the same advantages to organisations wishing to tailor the software to their use.

8.2.3.1 QCIS Installation and Main User Interface

The programme installation is a simple ‘install’ operation in a Windows environment and can then be run following the ‘start’ menu, or double clicking its corresponding icon. This was in line with the ‘ease-of-use’ strategy to allow use of the QCIS virtually anywhere with a stand-alone PC. Once started, the main interface between the user and the system is a screen that informs the user what the system is designed for, as well as some background information about Quality Costs. This helps in restating the importance of proper quality cost isolation to the user’s company, and reminds the user of the main goals of the programme, mainly the need to focus on failure prevention. Upon pressing any key on the keyboard, the system proceeds to display the Fault Selection Interface.

8.2.3.2 The Fault Selection Interface

The next interface displayed to the user is the failure category selection menu. This menu is displayed in Figure 8.1.
This interface provides a means of selecting a specific failure category, which is either an Internal or External Failure. If the User is unsure what these categories are, a context-sensitive help, that explains what each option is and how to proceed from the current interface, is provided.

Irrespective of the selected option, each category has further sub-categories in a drop-down menu. In the Internal Failure category, further sub-categories are:

- Design Failure
- Manufacture Failure
- Supplier Failure

Similarly, the External failure category, further sub-categories are:

- In-Warranty
- Out-Of-Warranty
- Recalls

If, for instance, the user selects an Internal Failure category and Design Failure sub-category, the next piece of data the QCIS requests would then be the name of the failure (to be selected from the list of ‘standard failures’ supplied in a further drop-down menu). The selection of these ‘standard failures’ to be included in the menu, was based on the literature survey and the consensus views of their significance. In
the few cases where there were differences of opinions pertaining to some factors the decision was based on the findings of the Industrial Survey (Chapter 4) and personal observations and experience (a detailed listing and definitions of the factors included in each of these menus is provided in Appendix 3).

Upon selecting a specific failure and clicking the ‘Next’ button, the Estimated Failure Cost dialog pops up, to enable the user to enter the estimated total costs for that specific failure (as shown in Figure 8.2).

![Figure 8.2: Estimated Total Failure Cost Dialog Window](image)

As is shown in Figure 8.2, the estimated cost of the specific failure can be selected from: very low (approx. £100), low (approx. £1,000), medium (approx. £10,000), high (approx. £100,000), very high (approx. £1,000,000) or other values specified by the user. The classifications selected for these values were given a wide range to allow the user to easily select the category their failure falls in, i.e. they are approximate and aim to facilitate data entry. Moreover, they do assume a large organisation’s perspective, i.e. a failure costing £10,000 is termed medium, while this could be a detrimental amount for an SME (Small to Medium Enterprise). However, the focus here is on the amount rather than its description, and the supply of this value is important, as the computation of the expected cost is dependent on it.

Organisations that apply ABC accounting principles will be able to clearly specify this value. However, organisations with traditional cost accounting activities will not have a clear estimate, and might have to use approximate data based on experience. This, in turn, stresses the importance of applying ABC for the clear and successful identification of quality costs, and can readily be seen as one of its benefits.
It has to be stressed here again that the whole aim of the QCIS is to provide a decision-making aid and highlight areas for improvement, and not to give detailed calculations and exact action plans. It is firmly believed that a detailed prescription of an action plan would be damaging to organisations, as each organisation is unique and only its people (those who design and produce the products) can decide what is a suitable action plan. Alternatively, the QCIS model is based on providing a generic advice list of possible practices to be followed (condensed from the quality literature and the experiences of successful organisations), and supports these practices with initial cost/benefit analysis.

Upon giving a specific value and pressing ‘next’, a tabbed dialog screen is displayed (Figures 8.3a and 8.3b), whereby the user is presented with a set of standard activities that could address the specified failure. If the failure initially input by the user is ‘Internal Failure’, then the options presented on the screen will be Design Prevention Costs (DPC) and manufacturing Prevention Costs (MPC). Each screen will contain a set of activities that, when performed, will help minimise or eliminate the failure reported. The DPC screen is as shown in Figure 8.4a and the MPC in Figure 8.4b. It should be noted here that design appraisal activities are considered to be prevention activities preventing internal failure (as discussed in Chapter 5).
If the failure initially inputted by the user is, say, ‘External Failure’, then a similar procedure is followed and the options presented on the screen will be Appraisal Design Costs (ADC), and Appraisal Manufacturing Costs (AMC). Each screen will contain a set of activities that, when performed, will help minimise, or eliminate, the
failure reported. The ADC screen is shown in the Figure 8.5a and the AMC in Figure 8.5b.

**Figure 8.5a:** Failure Cost Elements Dialog Window (ADC)

**Figure 8.5b:** Failure Cost Elements Dialog Window (AMC)
The user is requested to select the activities that are currently not performed within the organisation, or may be under-performing. The idea is to give the user a set of best practices to deal with the problem on hand, and allow the user to input their knowledge of the business and select the activities that might produce the benefits. If the user is not familiar with all or any of the proposed activities, a comprehensive ‘Help’ option is available to explain certain areas in further detail, as shown in the example in Figure 8.6.

![Figure 8.6: Further Information on QFD](image)

Once the activities have been selected, the user is requested to enter an estimated cost. For example, if the user thought that one of the activities that will help eliminate that specific failure was developing a system of Internal Audits, then the costs related to such audits must be estimated, e.g. employee time to perform the Audit, training required, facilities, etc. Again, this would be much more accurate if the organisation had an ABC system in place. In any case, these numbers have to be estimated and entered to enable the system to compare the Failure costs with Prevention and Appraisal costs.

Once the costs have been estimated, and the user clicks the ‘Calculate total activity costs’ button, the QCIS will perform a summation and compare the outcome with the original cost of failure. If the total activity cost is less than the original failure cost, these activities are accepted and the user is advised to pursue them (with an output report similar to Figure 8.7a).
However, if the total suggested activities’ costs prove to be larger than the original failure cost, it would clearly be unfeasible to pursue all of them. The user is then prompted to provide the estimated ‘effectiveness’ of the selected element (see Figure 8.6b). ‘Effectiveness’ here has a future outlook and requests the user to estimate the returns expected on the investment made in each activity. For example, if the organisation believed that ‘Internal Audits’ will cost £1,000 to administer, they have to estimate how much will this investment be worth when it actually produces its results. This value can range from 10% to 500% of the initial investment. This is designed in such a manner such that comparing the costs of failures with the costs of quality activities is not based on abstract monetary values, but to include the estimated gains from the improvements being put in place. The accuracy of the ‘effectiveness’ entered will clearly depend on the user’s understanding of the quality technique or tool to be used (the comprehensive Help function will be of benefit here), and more importantly, the user’s understanding of their own business processes and activities. Thus it was recommended earlier that the user of the proposed QCIS should be a ‘quality engineer’ or production engineer’ or some one at that level.
Based on values and information entered, the system traces back and identifies the activities that should be carried out in order to achieve improved performance. An improved performance level is that in which the company does not spend more on overcoming a failure cost than on the failure cost itself.

The system then carries out a straightforward summation of the individual costs entered, as follows:

$$\text{Total Activity Cost} = \sum \text{DPC} + \text{ADC} + \text{MPC} + \text{AMC}$$

The overall logic used within the system to select the prevention activities is the reduction of overall quality costs, and maximising the effectiveness. Thus the prioritisation will be based on the activity costs, and if similar, then the system relies on the activity ‘effectiveness’.

Next, the system performs a comparison of this calculated value (Total Activity Cost) with the initial ‘Failure Cost’ entered by the user (Figure 8.2). Depending on which
value is higher, the system should advise the user accordingly. For example, if Failure Cost is greater than Total Activity Cost, then the system advises the user to carry out the activities in order to rectify the problems.

On the other hand, if the opposite is the case, that is, if the Failure Cost is less than Total Activity Cost, then the System informs the user of this outcome, as shown in Figure 8.8

![QCIS Information](image)

**Figure 8.8:** Information about the Imbalance between FC and TAC

Upon clicking the OK button, the system re-displays the related activities, but this time with additional check boxes beside each activity, as shown in Figure 8.9. In this step, the QCIS would have assigned a ‘priority level’ to each of the suggested activities. This prioritisation process is based on the conclusion that performing all the suggested activities in Figures 8.4a and 8.4b is clearly not economically beneficial and not the most feasible way to minimise the specific failure under study. This prioritisation process is subjective, and based on the need to provide the organisation with a cost-effective solution to allow for minimising (or eliminating) the current failure with least expenditure on corrective or preventive activities.
After the prioritisation process is complete and the user clicks the 'Go to final results' button, the system re-computes the Total Activity Cost, and advises accordingly, as shown in Figure 8.10.

From this dialog, the user can terminate the interaction or re-start the computation of another failure cost, if they experience more than one failure sub-category.
8.3 A Practical Example (QCIS simulation)

In order to demonstrate the applicability of the QCIS, and its effectiveness, it was decided to select two organisations from the manufacturing and engineering literature that have faced a design and/or manufacturing product failure. The information provided about these failures was fed into the QCIS programme, and this section presents the details entered and the outputs achieved from the QCIS.

8.3.1 Sample Case – Acme Widget Company (Taylor, 1998)

Acme Widget Company is a manufacturing organisation in the USA. They are involved in several manufacturing operations, of which a large part is machining various alloy materials. The company relied heavily on the metallurgical quality and consistency of a certain purchased alloy material. This alloy was machined and formed to make an integral component in all of Acme’s finished products. To a fault, Acme trusted its raw material suppliers to provide conforming and consistent material chemistry and like any other ‘wise’ purchaser, Acme required the supplier to provide certificates of analysis with each shipment. These certificates identified quantities of important metals in the alloy and contained a statement of conformance. The supplier nearly always provided acceptable materials, each ingredient being within specification limits.

Acme had a wealth of quality information at hand – the certificates from the suppliers, test lab analysis, etc. – at its fingertips. This was an ideal preventive action stage: the use of quality data to detect, analyse and prevent potential causes of non-conformance. However, they did not use the data. The organisation witnessed the rejection of one lot (100 pieces) of semi-finished alloy components per day due to cracks detected following machining (costing $8,300, i.e. £5,500) per day (the period under study in this example is one working day).

To simulate this case in the QCIS, the following steps have been taken:

1. The Failure Type selected was ‘Internal Failure’
2. On the next screen, the failure details entered were for 'Manufacture', and the failure name was selected as 'scrap', since all the cracks that appeared in the components rendered them unusable.

3. The total failure cost entered was 'Other, £5,500' per day.

4. Given that the problems were occurring due to material failures, it was obvious that the main solution choice would be 'Incoming Inspection' within the 'AMC'. The cost for these activities were calculated as follows: given that the organisation already has a very good vendor certification system and lab test certification all that was needed in extra costs was a person to analyse this data, and assuming a full time supervisor for one shift, the overall costs per day (period under study) is £155 (based on £30,000 assumed annual salary plus £1,000 annual training costs, and 200 working days a year). The second solutions chosen was 'Vendor Certification' within the 'MPC'. However, given that the information is readily available and assuming that the one person that was recruited for the first solution can oversee this, the overall expected cost for this activity was considered to be £155 per day, as above, and administrative support expenses of £100 per shift for an assistant (based on £15,000 annual salary and £5,000 per year administrative overheads and 200 working days a year).

5. In the first iteration, the QCIS advised on undertaking the proposed activities as they were seen as cost effective and promised a massive cost reduction. There was no need to enter the estimated 'effectiveness'.

8.3.2 Sample Case – AFG Industries, Inc. (Little, 1998)

AFG Industries is a vertically and forwardly integrated producer, fabricator and distributor of flat glass products. It is now the second largest flat glass producer in North America.

As a manufacturer, AFG is a quality conscious firm. It is committed to the continuous quality improvements of raw material, products, processes and services. AFG's management team has established quality goals for each of these manufacturing related activities. The standards for these goals are based on research, experience and customer needs. The main quality goals related to manufacturing
process goals (which are seen to be the key for AFG's quality) are identified as 'quality elements' and cover products, processes, and services. For the case study example on hand, it was decided to look at the 'process quality element'. The main measure that AFG chose to reflect the process quality element is 'breakage'. AFG set their goal in this area as 'the loss must be less than, or equal, to 2 percent'. In 1998, the actual measure was 3.1%, with a variance of 1.1%. Internal calculations revealed that the costs of this non-conformance were £1,850 per day.

Having identified the problem and its costs, we can now input this information into the QCIS to test its operation, and the relevance of its outcomes.

1. The Failure Type selected was 'Internal Failure'.
2. On the next screen, failure details entered were for 'Manufacture', and the failure name was selected as 'rework' since the process breakage can result in products that can be re-worked. The Total costs per day were £1,850. The costs to be used for this case are calculated per day.
3. The proposed solutions include a full time maintenance engineer (£30,000 annual salary, plus £1,000 annual training costs, plus £500,000 per year for advanced maintenance equipment and materials), at a cost of £2,655 per day (calculated as above). In addition, another solution would be an internal auditor (50% of their time) at a cost of £310 per day (£30,000 annual salary, £1,000 annual training costs).
4. Upon initial calculation, the system concluded that the total solution costs exceeded the failure costs, and thus the user is promoted to enter the estimated 'effectiveness' for the quality activities proposed. As discussed in the previous example, the proposed effectiveness of the internal quality auditor would be 200%. As for the maintenance engineer and equipment, and since the solution includes advanced machinery and highly skilled and capable engineer, the effectiveness has been estimated at 400%.
5. Once this data was entered, and upon re-calculation, the system reported that the quality activities' costs still exceeded the failure costs and assigned 'priorities' to the proposed activities as follows: Internal auditor (high priority) and maintenance engineer and equipment (low priority).
6. Thus, given this isolated failure, the solution proposed by the QCIS is to deploy the internal auditor only.

8.4 QCIS Potential Benefits and Limitations

8.4.1 QCIS Benefits

The Quality Cost Information System (QCIS) design aims at helping manufacturing organisations trace the root cause of problems arising from internal or external failures (design or manufacturing). The QCIS was designed as a pilot based on sound quality management techniques and best practices. Its practical benefits and implementation pitfalls can only be fully determined upon full-scale implementation. However, based on its design concepts, its targeted benefits include:

1. Providing a structured analysis once an organisation discovers a failure. The analysis tool will facilitate the determination of the likely cause of the failure and thus will provide clear information for the organisation to build a preventive measure. While not sufficient on its own as a quality management planning tool; the QCIS provides a very well structured approach, based on sound quality management techniques, for failure cost and cause analysis.

2. Providing a learning tool for the organisation to train its designers and manufacturing employees on the importance of preventive actions, and allow them to study all the potential failures throughout the ‘design to manufacture’ process. The inclusion of the failure cost and quality activities cost analysis provides an ideal simulation tool for employees to see and understand the effects of quality management on the ‘bottom line’.

3. Providing a fact-based communication tool for initiating quality improvement programmes. As opposed to expensive research and process analysis, the QCIS can be used to quickly and easily demonstrate the potential upside of initiating a quality management system based on the cost of current quality failures.
8.4.2 QCIS Potential Limitations

Again, as the system is still in its pilot stage, the limitations presented here are only potential limitations and mainly based on the system design limitations rather than practical implementation pitfalls. The potential limitations include:

1. The system is generic, and attempted to cover as many scenarios as possible. However, by definition, a generic system would usually overlook some organisation specific issues and possibly some sector specific issues. That said, the system is valid in any industry that employs a ‘design to manufacture’ process, and can be easily refined to be sector, or even organisation, specific.

2. The QCIS operates with estimated values for Quality Costs, which provide a very good ‘snap shot’ of the status quo, and for possible future actions. However, due to this ‘approximate’ nature, it should be only used as a first step in the Quality Cost Management process to highlight areas for improvement and possible actions, and never as a planning tool on its own.

3. Although the system was designed to be user friendly and self guiding, it is a very technical programme and its maximum benefits can only be achieved by someone with the right data, and a background in quality management concepts or tools. To help most users to get the maximum benefits, the User Guide (Appendix 3) and the ‘Help’ option in the QCIS provide a comprehensive array of definitions and explanations.

4. The system can only provide approximate information and is highly dependent on the user’s knowledge of the organisation and a background in quality management tools. A less educated user might result in less practical results.
CHAPTER 9:
DISCUSSION AND CONCLUSIONS

9.1 Introduction

This chapter presents the overall conclusions arrived at from the study undertaken. These are presented in three main sections, which discuss the following:

1. How the overall study objectives were met;
2. The effectiveness of the research methodology and survey undertaken;
3. A summary discussion of the research results, which present the overall conclusions from the study undertaken, comments on the possible value of the work, and the lessons learned.

This Chapter is structured in a way to provide a summary of the work and discussion of the findings. The main conclusions that were drawn out of the work are presented.

9.2 Research Objectives

Overall, it was felt that the main research objectives and specific questions set out in Chapter 1 have been successfully met and tackled as follows:

1. The theory of quality cost, and its application to manufacturing industries, has been thoroughly investigated both through an extensive review of the literature (Chapters 2 and 3) and through conducting the industrial survey on quality costing in the manufacturing industry (Chapters 4 and 5). These investigations allowed the identification of areas for improvement in the application of quality costing, and indeed the proposals for these improvements. These findings are summarised in section 5.8.
2. The adequacy of traditional cost account systems in providing relevant and useful quality cost information has been assessed, and an alternative approach has been proposed and discussed. The potential of activity-based costing systems as an alternative to traditional cost accounting systems (TCA) in meeting the challenges presented by today's competitive environment, giving particular attention to the manufacturing sector and the measurement and allocation of quality cost, has been assessed. Consequently, an approach for the deployment of ABC within Quality Cost Information Systems has been proposed.

3. A set of tools for improved quality costing and to facilitate the concept's adoption and implementation in manufacturing organisations has been proposed; namely the 'graphical quality costing system' tool, integrating quality costing with Activity Based Costing approaches, and the Quality Costing Information System software programme.

9.3 Effectiveness of Research Methodology

Overall, it was felt that the research methodology proposed and followed was successful, as it allowed the above-mentioned achievements. The literature survey undertaken highlighted the historic and current thinking research in the areas under study, and allowed the basis to be properly set for the industrial survey. It is based on the outcome of the literature review that the survey objectives and instrument were designed.

As for the industrial survey, it achieved its objectives as it allowed conclusions to be drawn regarding:

1. The quality cost measures currently used in manufacturing organisations.
2. The quality costing activities currently undertaken by manufacturing organisations.
3. Levels of quality costs within industry.
4. Approaches used by organisations for their costing systems (traditional accounting, ABC, etc.).
5. The current understanding and awareness of Activity Based Costing principles.
The current satisfaction with costing methods and major areas for improvement.

Furthermore, the survey provided evidence that justified the need for a new approach to quality costing (as detailed in Section 9.4).

Finally, and regarding the survey instrument and methodology used, it was concluded that these were successful and efficient for achieving the objectives. The response rate for the survey undertaken was 20%, which is typical of such mail-based surveys. It provided the ability to sample a large group with a wide geographical coverage (UK, Germany, and Kingdom of Saudi Arabia), while keeping the cost and time resource requirements to a minimum. Moreover, although some of the returned questionnaires were not satisfactorily completed, it was felt that these reflected the lack of experience of participants with the topic rather than any issues with the instrument design.

9.4 Discussion and Conclusions

9.4.1 TQM and Quality Costing

This study began in 1996 with a focus on studying quality cost systems and their ability to bring about performance improvement for organisations. A wide and analytical review of the literature has been undertaken. The review looked at the concept of Total Quality Management (TQM), and where ‘quality costing’ systems fell within that framework. What the review revealed was that the implementation of TQM can have a profound effect on quality cost. On the other hand, the analysis of quality cost can lead to the setting of realistic goals for the TQM programme, and their identification and management is in fact crucial for TQM success.

As far as ‘quality cost systems’ in specific were concerned, it was demonstrated that they were management tools for securing quality improvements that contribute to profits. They can also be used as a planning tool for budgeting, as it will help to show the full expected costs.

Thus, it was concluded that for successful implementation of TQM, and for a system of continuous improvement, organisations need a structured management information
system to manage quality costs. This system must measure, monitor, manage, and continuously improve quality cost to allow for effective cost reductions and product and/or process continuous improvement. To do this successfully, organisations need an integrated system for quality cost.

From an accounting point of view, a review of the traditional cost accounting techniques revealed that they are not capable of providing the required information to successfully implement such a system. Quality costs are activity related, and the traditional accounting techniques do not monitor nor measure such costs. Thus, another conclusion was that there was a need for a new way of measuring and recording costs within the organisation to allow successfully implementation of quality cost concepts.

9.4.2 Literature Review

1. From the study undertaken, it is possible to summarise the major Traditional Cost Accounting (TCA) systems drawbacks, and thus the justifications for a new costing system, as follows:

   a) The nature of overhead cost has changed from costs, which were predominantly influenced by the output volume to a composition determined largely by the complexity and diversity of production (Kaplan, 1984). In today’s manufacturing with advanced manufacturing systems, the diversity of production does not allow the application of TCA systems, since such systems cannot keep pace with changes in manufacturing technology.

   b) TCA is deficient as an operational/managerial control tool. TCA systems do not provide non-financial information such as cycle-time, and turnover rate in a company. They provide little useful information about what matters to customers (which is the main requirement of any world-class company).

   c) Traditional performance measurement systems associated with TCA are obstacles to adopting TCA in Quality Costs Information Systems as they are
designed to measure the performance of production volume-related attributes. Although the measurements are still considered valuable criteria for judging the efficiency of a manufacturing system, they can lead to several problems.

d) The relevance of ABC to Quality Costing systems has been discussed, and a detailed look at the use of ABC for defining and managing cost of quality is provided. ABC was concluded to be the most suitable accounting method for quality costing. Specifically, it was concluded to be most beneficial if the organisation adopts the PAF model and integrates that with ABC to achieve the maximum benefits sought, with minimum complexity. Overhead costs are traced to activities by using resource drivers in the first stage of ABC cost assignment view. Then, activity costs are traced to their sources (i.e. cost objects) by using activity drivers in the second stage of ABC cost process view.

e) If TQM is to be a truly organisation-wide discipline then a costing system built around processes will supply cost information (not only quality costs) at the level at which the management structure is operating. By identifying costs more accurately, ABC can highlight those processes where improvement is being made, and so tangible benefits will appear in bottom-line results. The benefits of TQM will be visible to senior management earlier on.

9.4.3 Industrial Survey

The industrial survey undertaken involved organisations from the UK, Germany, and Saudi Arabia. The survey initially targeted around 750 organisations, out of which 87 satisfactory completed and returned the survey instrument. 95% of the participating organisations were manufacturing organisations, and they included a wide cross-section in terms of product mixes, competitive environments, and turnover. Thus, the sample was unbiased and was deemed capable of providing an objective view of current practices in manufacturing organisations regarding costing methodologies and quality cost related activities.
The results have indicated there is a major gap in organisational systems. Many organisations perform quality related activities (prevention and appraisal) but do not measure the outcomes (thus it is virtually impossible to know if they were a success or a failure). More importantly, organisations acknowledge that they have a high percentage of internal and external failures, but again fail to measure them (although they all estimated high costs). Clearly, a quality cost information system is needed to measure and manage these issues.

Finally, the survey provided empirical evidence that a relationship exists between failure prevention and internal and external failures, which indicates that if companies spend more in prevention, this will result in a reduction or even a total elimination of failure costs. Moreover, it was also seen that a relationship exists between failure prevention and quality appraisal, which suggested that organisations that reveal quality awareness by undertaking prevention activities were by in large the same organisation that undertook appraisal activities, thus stressing their focus on total quality.

Specifically, the major survey findings were:

1. There is a need to improve traditional cost accounting methods - Over 35% of respondents indicated their dissatisfaction with their existing costing methods, and 63% highlighted the overhead allocation method as the main area for improvement.

2. The results revealed low take-up levels of both prevention and appraisal activities. On the other hand, both were reported to have low cost levels. Thus it can be concluded here that prevention and appraisal activities do not seem to cost much. However, organisations still need much more education and persuasion to undertake them. In other words, they need tools to show them the possible benefits of the activities.

3. In terms of experiencing internal failures, most companies experience these costs, and some failures were experienced by as much as 100% of respondents. A similar scenario was revealed for external failures. Thus, failures do seem abundant, and
this is a clear opportunity for improvement for organisations to take. Moreover, this finding stressed that the low take-up of prevention and failure activities was not due to lack of problems rather than lack of knowledge and initiative.

4. A more alarming result was the consistent failure of organisations to measure the levels of costs associated with activities and failures. This lack of measurement seems endemic in manufacturing organisations, and an area that would require immediate attention to achieve any benefits. It was also noted that organisations that used ABC were only marginally better at measurement, thus, even when the tools do exist, measurement still does not seem entrained in organisational culture, and most of the cost seem to be lumped into overheads.

5. It was seen that a relationship exists between failure prevention and internal and external failures, a relationship that indicated that if companies spend more on prevention, this would result in a reduction or even a total elimination of failure costs.

6. It was also seen that a relationship exists between failure prevention and quality appraisal, which indicated that if companies spend more on prevention, there would be less need for appraisal.

7. Similarly, a relationship was seen to exist between quality appraisal and internal and external failures, which indicated that a substantial spending in appraisal leads to a substantial increase in internal failure costs but only a slight decrease in external failure costs.

These findings, coupled with the conclusions of the literature review, have substantiated the original research hypothesis. They provided further evidence for the need for a quality cost information system, and more importantly, have highlighted areas that such a system must tackle to achieve its desired benefits (namely lack of current organisational measurement, inadequacy of traditional cost accounting systems, and the need to educate organisations about quality costs). These findings formed the basis for the proposed approaches, as discussed in the following section.
9.4.4 Proposed Approaches for a Quality Costing Information System

The following three main approaches were proposed to tackle the issues raised and were summarised in the previous section, to allow for successful implementation of quality cost management:

9.4.4.1 Graphical Tool for a Quality Costs System

A comprehensive and simple to use graphical tool was designed to demonstrate the importance of quality costs, the benefits of managing them, and the consequences of ignoring them. This tool was designed to be simple to use so that it could be utilised as a communication tool to convince and gain support from managers and engineers. This need to 'convince' organisations of the benefits of failure identification and prevention, and thus achieve organisation-wide commitment to minimising cost of quality, was the main driver behind designing this tool. The graphical tool was aimed to allow design and manufacturing personnel (and indeed everyone in the organisation) to identify the Potential Failure Points (PFP) in the 'design to manufacturing', and to demonstrate the consequences of these failures in order to set prevention and appraisal points. Its main objectives can be summarised as:

- Demonstrate the importance of prevention and appraisal activities, and to demonstrate the consequences of ignoring such activities.
- Identify areas for potential failure in design and manufacturing operations and help determine the required preventive activities.
- Facilitate the decision-making process on how much to spend on prevention and appraisal by providing a structured graphical tool that allows estimates of such costs.

The methodology for presenting and detailing the graphical tool can be summarised as follows:

1. Process Mapping was used to plot the overall picture of the process under study and to highlight the Potential Failure Points (PFP) in that process.
2. The PFP were discussed in detail to present a list of actual failures that might occur, the consequences of these failures, and the preventive actions that could be installed to minimise/eliminate the failures.

3. The combinations of possible failure points’ occurrences along the ‘design to manufacture’ process (product failure scenarios) was presented and each assigned a risk factor (according to the probability of delivering an unsatisfactory product to the customer).

4. The ‘product failure scenarios’ were presented and discussed in further detail to clarify them and their consequences.

5. The whole set of possible scenarios and different paths were presented in one graphical presentation.

9.4.4.2 Use of Activity Based Costing as a Basis for Quality Costing

The aim was to put forward a system that would integrate the concepts of activity based costing within a quality cost information management system. This would tackle many of the problems posed by traditional cost accounting.

Several researchers and organisations have pointed to the inadequacy and irrelevance of traditional cost accounting in the present competitive environment (Hunt et al, 1985; Jeans and Morrow, 1989; Letza and Gadd, 1994). The majority of these sources have identified the use of inaccurate data to allocate indirect costs as the most serious problem of the traditional cost accounting systems. The main solution proposed here was the use of activity-based costing.

The ABC system is based on the premise that products consume activities, activities consume resources and resources consume costs. It provides relevant and accurate information for strategic decisions concerning product pricing, customer and product profitability analysis, and process improvement. The main concept proposed was that by relying on the ABC methodology, it was possible to tackle the issues faced by quality costing systems (as discussed in Chapters 3 and 4), and that ABC would provide an ideal vehicle to facilitate the application of a quality costing system, and simultaneously, improving the benefits gained from it.
With ABC systems, cost can be managed in the long-term by controlling the activities which drive them. In other words ABC systems focus on managing activities rather than cost directly. This made it possible to quantify strategic long-term intangible benefits of a QCIS more reliably. A comprehensive comparison of the traditional cost accounting system and the ABC accounting system was also discussed. The features of ABC that makes it more acceptable than the traditional cost accounting system were also discussed.

9.4.4.3 Quality Costs Information System (QCIS) Programme

A software programme was designed to facilitate the implementation of quality cost information systems by providing a system that allows the user to tackle their quality problems, decide on improvement actions, and assess the possible benefits of their decisions.

In planning the design of the QCIS, the following objectives were set:

1. An information system that is simple to use.
2. An information system that facilitates decision-making regarding quality activities.
3. An information system that does not require expert users, but can be operated by anyone involved in the manufacturing process (assuming basic quality background).
4. An information system that can act as a pilot for the concept of a Quality Cost Information System (the pilot was to initially cover the ‘design to manufacture’ process).

With these objectives in mind, the main features of the required QCIS are:

2. A decision support system based on the quality cost methodologies.
3. To allow the ease of use, the system had to allow maximum benefit with minimum information provided, thus the information to be inputted by the user is
kept as estimates (the more detailed the data, the more accurate the output, but the
system is still capable of producing valid results with estimates).

4. As a decision-making tool, part of the final output is in the form of ‘advice’ or
proposed future ‘action’. This feature is based on ‘generic’ best practices and
ideas that have proved successful in other organisations and documented in the
quality literature.

5. The system is designed to be modular to allow changes to be included, and thus
can be easily transferred to a sector, or even individual organisation.

There will always be a need to continuously improve and develop. It is hoped that
this report has provided a platform to allow manufacturing organisations to tackle
their quality costs in a facilitated manner. Organisations are always advised to
develop, question, and improve any approach, and everything they do, as it is clear
that in the 21st Century, the only constant is change.
CHAPTER 10:
RECOMMENDATIONS FOR FURTHER WORK

10.1 Introduction

This chapter is the final part of this report and provides:

1. Recommendations for further work to be carried out in certain areas to further advance the findings.
2. Proposals for future research potential.

10.2 Recommendations for Future Work and Research

Based on the research presented in this report, from the literature review and industrial survey undertaken, it is felt that the following areas would be valuable potential for future work and research:

1. A company-based pilot application of the proposed graphical model and QCIS in organisations to test its effectiveness as:

   1.1 A communication tool – to demonstrate the importance of quality costing.
   1.2 A training tool – to educate staff about potential failure points, preventive actions, and consequences of ignoring quality.

Ideally, the pilot should be undertaken in an organisation that has not been exposed to quality costing techniques. It is proposed that the graphical model is handed to the quality manager or quality function head allowing them to own it and use it in their training and communication. In parallel, it would be useful to monitor and measure employee understanding and attitude towards quality costing techniques before and after using the model to assess its effectiveness. This pilot should
highlight any practical modifications required for full-scale implementation of the tool.

2. Once the graphical model is validated, it would be useful to expand its scope from the current ‘design to manufacture’ boundaries to cover the whole supply chain from raw material to final product delivery. Quality starts with receiving the raw material and ends with a customer happily paying for the product. Thus it would be useful for organisations to expand the scope as such to have one comprehensive and integrated organisational-wide quality costs information system including purchasing, marketing, customer relationship management, etc. This expansion of the tool’s scope should follow the same process used in this report to develop the model, starting with mapping the process under study, defining the activities (production and support) and evaluating the probabilities of potential failures along the chain.

3. Regarding the QCIS software programme, there are several opportunities to expand and improve on it in future work and research. These areas include:

3.1 The QCIS software is clearly at an embryo stage. One of the main areas for potential improvement lies in proposals for integrating ideas on how to rely on more objective information rather than the user’s inherent knowledge and experience. Some of the these proposals are:

a. Inclusion of a facility to allow the user to provide more detailed material and process costs (e.g. how much does scrapping some material cost, how much does setting up a testing machine cost, etc.). This type of information will provide a more valid basis for prioritising quality activities rather than relying on the user’s ability to assemble and calculate these costs.

b. Integrate the QCIS with more educational material. The quality of the QCIS output relies to a large degree on the user’s knowledge and background of quality management and quality tools. At the moment the QCIS provides a comprehensive ‘help’ facility to allow the user to understand the basic concepts of the proposed tools. However, to make the QCIS useable by a wider cross-section of employees, it would be useful to integrate the programme with some form of multimedia based training.
(short and concise sessions based on the user’s need) to cover aspects like quality improvement tools and product failures.

c. Incorporate a ‘real’ knowledge based expert system (KBES) for decision making. This KBES should be based on expert opinions, documented evidence, and clear decision making rules.

3.2 Company based full-scale pilots: pilot the QCIS in several organisations and assess the practical implications, challenges, and benefits of its application. A wide-scale pilot study would be useful to highlight issues such as user-interaction, validity and practicality of output, and the overall acceptance of engineers and quality professional of such a tool. Most of these issues have been taken into consideration when designing the QCIS, and all attempts were made to build quality in its design. However, as with many new ideas, only practical implementation can reveal its implications. User testing feedback is probably the only approach to software development and improvement and the QCIS must be tested in several organisations, preferably with different products/sectors (e.g. a chemical process industry, auto parts industry, and a packaged food producer) before it is ready for full-scale application.

3.3 Customise the QCIS for specific industry sectors – to maximise the benefits of applying the QCIS, it could be tailored to specific industries. As it stands, the QCIS is a generic software that deals with quality costs. However, some organisations might find the generic quality activities do not specifically apply to them, and might be able to provide more detailed information, and thus receive more meaningful outputs, if the activities and terminology were directly tailored to their industry. It would also be useful to customise the QCIS for certain industries (e.g. automotive, packaging, etc.). Such a customisation would require some research on the quality issues that face these specific organisations by using the generic process map (Chapter 6) and running through each sector’s processes to identify their potential failure points. Then, sector specific solutions could be integrated within the software, along with sector and industry best practices. Such a customised Quality Costs Information System would prove very useful to many organisations, and
might prove financially feasible to produce, run, continuously update, and retail.

4. A detailed pilot design of ABC system in a company – the ABC system proposed for application to quality costs (as proposed in Chapter 7) will benefit from a detailed pilot in several organisations. Similar to the proposed QCIS pilot, this also should take place within different sectors (e.g. a chemical process industry, auto parts industry, and a packaged food producer). These pilot applications of the system will:

1. Provide feedback for improving the system.
2. Provide valuable information for detailing the system and providing more user-friendly guidelines.
3. Provide sector specific information to facilitate tailoring the system to certain sectors.
4. Provide solid data and success stories on its ability to perform and improve organisational quality costing systems, which can be used as a communication tool to educate organisations about using ABC for quality costing.

5. Use fuzzy logic mathematical analysis to analyse the 'graphical model' probabilities provided in Chapter 6: the probabilities associated with the graphical model presented in Chapter 6 are linguistic variables and are potentially suitable for fuzzy mathematical analysis. Fuzzy methods could provide more meaningful results and are proposed as a possible future research project.
REFERENCES


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APPENDIX 1:

ABC Quality Costing

Section 1 General information about your business unit.

1) Classification of your business unit.
   A) Manufacturing
   B) Service
   C) Other (please specify)

2) The value of assets employed.
   A) Under £1M
   B) £1M-£30 M
   C) Over £30 M

3) Number of employees
   A) Less than 100 employees
   B) 100-1000 employees
   C) Over 1000 employees

4) What is your annual turnover
   A) Less than £5M
   B) £5M-£50M
   C) Over £50M

5) Product environment of your business unit.
   A) Single (homogeneous) product environment
   B) Multi-product (heterogeneous) product environment

6) What is your production environment
   A) Design and make to order
   B) Make to order
   C) Design/Make to stock

7) What is the degree of automation in your current production facilities?
   A) Mostly automated
   B) Moderately automated
   C) Slightly automated
   D) Not automated at all
8) Rate the degree of competition you face in the market.
   A) Low (Few Competitors)
   B) Moderate
   C) High (Many competitors)

9) What costing method do you use?
   A) Traditional Cost Accounting (TCA)
   B) Activity Based Costing (ABC)

10) As a % of Total Production Cost what approximately is your:
    Direct labour cost
    Overhead cost
    Material cost

    100%

11) Indicate your degree of satisfaction with the current costing method.
    A) Very satisfied
    B) Satisfied
    C) Not satisfied

12) Which one of the following, do you think would improve your costing system?
    a) An alternative basis for overhead allocation/recovery
    b) An alternative inventory evaluation method
**Section 2 Quality Costs**

For each of the following elements of quality cost in the categories of Prevention, Appraisal, Failure, please indicate if you perform the activity, if you measure it and the level of cost associated with the activity.

### Failure Prevention

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<th>Cost In...</th>
<th>Do you do the Activity</th>
<th>Do you Measure the Cost</th>
<th>Level of Cost (5 is high, 1 is Nil)</th>
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<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
| a) Product Design  
(e.g. QFD, FMEA, etc.) | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| b) Quality Review and Verification of Design | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| c) Process Planning | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| d) Quality Planning | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| e) Design and development  
of quality Measurement,  
Test and Control Equipment | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| f) Purchasing / Procurement | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| g) Supplier Assurance | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| h) Vendor Certification | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| i) Quality Training | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| j) Quality Audits Internal | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| k) Quality Audits External | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| l) Quality Related Maintenance | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| m) Quality Administration | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |
| Other (please state) | ☐ | ☐ | ☐ | ☐ | 5 4 3 2 1 |

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<td>Yes  No</td>
<td></td>
</tr>
<tr>
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<td>□  □</td>
<td>□  □</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>b) Incoming Inspection</td>
<td>□  □</td>
<td>□  □</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>c) Material/Parts In-Process Inspection and Test</td>
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<td>□  □</td>
<td>5 4 3 2 1</td>
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<tr>
<td>d) Material/Parts Final Inspection and Test</td>
<td>□  □</td>
<td>□  □</td>
<td>5 4 3 2 1</td>
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<tr>
<td>e) Assembly/End-Item Final Inspection and Test</td>
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<td>□  □</td>
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<tr>
<td>f) Repair Test and Inspection</td>
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<td>□  □</td>
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<td>5 4 3 2 1</td>
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<td>Activity</td>
<td>Do you do the Activity</td>
<td>Do you Measure the Cost</td>
<td>Level of Cost (5 is high, 1 is Nil)</td>
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<tr>
<td>a) Design Failure</td>
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<td>□ □</td>
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<tr>
<td>b) Failure analysis</td>
<td>□ □</td>
<td>□ □</td>
<td>5 4 3 2 1</td>
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<tr>
<td>c) Supplier Reviews</td>
<td>□ □</td>
<td>□ □</td>
<td>5 4 3 2 1</td>
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<td>d) Material Review and Action</td>
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<td>5 4 3 2 1</td>
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<td>e) Rework</td>
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<td>f) Repair</td>
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<td>g) Re-inspection</td>
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<td>h) Reclassification</td>
<td>□ □</td>
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<td>5 4 3 2 1</td>
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<td>i) Scrap</td>
<td>□ □</td>
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<td>5 4 3 2 1</td>
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<td>j) Replacement</td>
<td>□ □</td>
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<td>5 4 3 2 1</td>
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<td>Other (please state)</td>
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<td>Do you Measure the Cost</td>
<td>Level of Cost (5 is high, 1 is Nil)</td>
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<tr>
<td>a) In-Warranty Repair/Parts</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
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<tr>
<td>b) Out-of-Warranty Repair/Parts</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
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<td>c) Field Service</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
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<td>d) Returns</td>
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<td>Yes ☐ No ☐</td>
<td>5 4 3 2 1</td>
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<tr>
<td>e) Reclassification</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
<td>5 4 3 2 1</td>
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<tr>
<td>f) Recalls</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>g) Product Liability Reserve</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>h) Administration</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
<td>5 4 3 2 1</td>
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<tr>
<td>Other (please state)</td>
<td>Yes ☐ No ☐</td>
<td>Yes ☐ No ☐</td>
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</tbody>
</table>

13) What is your Quality Cost as % of manufacturing cost
   A) 10% ☐
   B) 10%-15% ☐
   C) Greater than 15% ☐
   D) Do not know ☐
Section 3 Your Costing Method

14) Are the main Manufacturing costs in your process caused by
   A) Activities in the processes
   B) The product being produced

15) Do you allocate overhead to each individual product from a production process?
   A) Yes
   B) No
   C) Do not know

16) Which of the following do you use to reduce costs: (tick all that apply)

   16-A) Reduce the budget available
   16-B) Identify and minimise activities which add least value.
   16-C) Ask production worker for ideas on reducing costs
   16-D) Empower production workers to implement their ideas on reducing costs
   16-E) Provide incentives for production workers to reduce costs
   16-F) Consult the product Design Department
   16-G) Consult the Production Engineering Department
   16-H) Consult the Warranty Repair Department
   16-I) Consult the Quality Assurance Department
   16-J) Consult the Field Service Department

We would now like to know your familiarity with Activity Based Costing.

17) How familiar are you with Activity Based Costing?
   A) Very familiar
   B) Familiar
   C) Unfamiliar
18) Do you believe that ABC is or would be beneficial to your company?
   A) Yes
   B) No
   C) Not sure

19) How much do you believe ABC has or would improve your costing system?
   A) No improvement
   B) No change
   C) Big improvement
   D) Not sure

20) Do you need more information on ABC?
   A) Yes
   B) No

21) Please add any comments, that you believe important to the control of quality cost

If you want to receive detail of the results of the research, please tick the box and add your name and address or attach your business card.

Name
Address
Post code
Tel. No
Fax
E-mail
APPENDIX 2:
QUALITY COSTS INFORMATION
SYSTEM USER MANUAL

1. System Requirements

- The system is designed to operate on Windows 95, 98, or NT.
- To install the QCIS, double click setup.exe. This will take two minutes and the system is ready to run.
- No specific knowledge is required in quality costs theory, but the system can only produce maximum benefits if used by the product designer/manufacturer.

2. System Objectives

The Quality Costs Information System (QCIS) design aims at helping manufacturing organisations trace the root cause of problems arising from internal or external failures (design or manufacturing).

It can be used as:

1. An analysis tool once an organisation discovers a failure. The analysis will help determine the root cause of the failure and thus will provide clear information for the organisation to build a preventive measure. Preventive measures based on root case analysis have been proved to be the optimal way to build quality in the products and reduce the quality and failure costs.

2. As a learning tool for the organisation to teach the designers and manufacturing employees on the importance of preventive actions, and allow them to study all the potential failures throughout the ‘design to manufacture’ process.
3. How to Use the QCIS

The QCIS is designed to be user-friendly and to allow the user to be self-guided. To allow for maximum benefits, the user is advised to familiarise themselves with the definitions in Section 3.1, and then follow the step-by-step guide provided in Section 3.2. The following list provides detailed accounts and definitions for all the terms used within the QCIS. Some of these definitions are also provided with a brief implementation or planning guide. The information provided is all sourced from documented best practices or the ISO 9000 quality standards series.

3.1 Definitions

External failure
A product failure that occurs after it has left the manufacturing facility, either with the distributor or the final customer.

Internal Failure
A failure that occurs before the product leaves the manufacturing facility, either during design, manufacturing, storage, or distribution.

Design Failure - Internal Failure
A failure that occurs internally due to design errors, e.g. difficulties in manufacturing the design recommended resulting in redesign, etc.

Manufacture Failure - Internal Failure
A failure that occurs internally due to manufacturing error, necessitating rework, scrapping the product, etc.

Supplier Failure - Internal Failure
A failure that occurs internally due to supplier problems, e.g. delivered material not to specification, delivery failures, etc.
In Warranty - External Failure
A failure that occurs externally due to design/manufacturing errors while the product sold is still under warranty and guarantees of the producer.

Out of Warranty - External Failure
A failure that occurs externally due to design/manufacturing errors after the product sold has survived the warranty and guarantee periods of the producer.

Recalls - External Failure
A failure that occurs externally due to design/manufacturing errors while the product sold is still under warranty and guarantees of the producer and has severe effects (e.g. health or safety) that the producer has to recall all the products in that category.

Redesign
Undertaking the product design activities again, after the initial design has been finalised, usually due to products design failures or difficulty in manufacturing.

Failure Analysis and Development
A technique used to analyse the reasons and root causes for the occurred failure to install corrective and preventive features to minimise its future occurrence.

Scrap
Activities undertaken to terminate a failed product that cannot be fixed in any feasible way, thus is disposed of as scrap (some material might be reusable, but at a small fraction of the scrapped product value).

Rework
Activities undertaken to fix failed products that might be salvaged by some rework to make it a saleable product again.

Repair
Activities undertaken to fix product failures. Usually less demanding than rework and might include changing some defective components.
Re-inspection
Activities undertaken to test the product functionality and reliability after some form of corrective action has been undertaken as a result of the product failing the initial test (inspection).

Retooling
Activities undertaken to re-adjust or replace the tool and tool machine heads after product failures have been occurring due to the traceable problem of machine tool wear or lack of fitness for purpose.

Maintenance
Activities undertaken to fix the manufacturing machines, both on a reactive basis to fix problems (corrective maintenance) and on a proactive basis to prevent possible problems from occurring (preventive maintenance).

Supplier Quality Assurance
Refers to the accuracy, capability, and reliability of the Quality Assurance system used by the supplier to provide information on the supplied material and components, and subsequently the reliability of this information.

Receiving Inspection
Activities undertaken to inspect the incoming materials and components from the suppliers.

Purchasing / Procurement
Activities undertaken to source the suppliers for raw materials and components. These should include research on price and quality data (delivery time, reliability, supplier quality assurance system, etc.).

Failure Analysis
Activities undertaken to analyse the failures of the product, both on a reactive basis to fix problems (corrective) and on a proactive basis to prevent possible problems from occurring (preventive).
Quality Planning
Activities undertaken to ensure product and process quality. These might include (but are not restricted to) QFD, SPC, Quality Assurance Systems (ISO 9000), etc.

Design and Development of Quality Measurement
Activities undertaken to set the appropriate quality measures throughout the design and manufacturing process aiming for quality assurance. Measures might be technical like stress and strain test, or could be cycle time, MTBF, etc.

Product Liability Claim
A claim for the customer (product user) due to the product failure after purchase. This might be requesting a replacement, or might be legal action due to safety problems.

Loss of Customer Good Will
A problem that occurs when the products fail while with the customer. Customer might lose faith in the producer, and thus do not attempt repeat purchases or spread bad publicity.

Repair (In-House)
Activities undertaken to fix product failures in-house (in the manufacturing facility). Usually only done for products that are under warranty and the degree of failure is so severe that they cannot be fixed in the field.

Repair (Field)
Activities undertaken to fix product failures in the field (i.e. customer's normal place of use). Usually less demanding than in-house repair and might include changing some defective components.

Administration
Activities involved in processing customer claims, requests, and complaints.

Loss of customer
The customer decides to return the purchased product for a refund, or cancel the buying decision, normally due to price issues, quality issue, or a combination of both.
Replacement
Providing the customer with a new product after the one they purchased was found faulty.

Design Review
According to the ISO 9000 quality management standard, this involves the planning and conduction of formal documentation reviews of the design results. Participants at each design review shall include representatives of all functions concerned with the design stage being review, as well as other specialist personnel, as required. Records of reviews shall be maintained. The first requirement therefore for design review is for the division manager to establish a policy whereby all of the division's design projects will be subjected to a design review, and to give enough personal regard to the process to ensure that it happens. This applies irrespective of the type of product to be sold to the customer – whether it is a hardware product, a design to which such a product could be manufactured, or a software product such as a computer program.

There are two different approaches to design review. For the first, the design review is conducted by independent experts who have similar skills to the members of the design team. The approach is practicable for large design-development organisations with several teams working simultaneously on different design projects. Members of one or more design teams can participate in the design review of another team's project. This approach is often applied to development projects for major computer-software products. For large companies, members of the company-level research and development staff may conduct design reviews of divisional projects. In smaller companies, external consultants may be used.

For the second, the design review is conducted by functional specialists representing marketing, purchasing, manufacturing engineering, test engineering, and quality. The controller may be represented to review cost issues. In large organisations, reliability, safety, and other experts may participate. In practice, design reviews following the second approach are of major value for virtually all significant design projects, while those following the first approach may have a less universal application. The design manager is not a formal member of the design review committee but it is important for him or her and other appropriate members of the design team to participate in the
A design review plan must be prepared by the design team as part of its overall planning for the design project, and, for a long duration project, the plan should be extended periodically as the project proceeds. The plan is approved by the design manager, the project manager, and the design review committee chairperson. It includes the design review meeting schedule related to key project milestones, the budget allocation, the names of the chairperson, secretary, and other committee members, the data requirements for each meeting, and the extent, if any, of participation by customer representatives.

The primary objective of the design review committee at each of its meetings is to identify defects present in the design at that time which might cause the design, or product manufactured according to the design, to fail to meet any of its quality, cost or schedule requirements. Secondary objectives are to recommend design changes to eliminate such defects or to improve quality, cost or schedule beyond the existing requirements, to evaluate alternative designs, and to resolve open issues by assigning actions.

**Design Aspects for Evaluation by a Design Review Committee:**

1. Conformance of the product requirement specification to all aspects of the customer's need.
2. Completeness of the product requirement specification with regard to requirements for reliability, maintainability, safety, environmental resistance, quality assurance, government regulations, and so on.
3. Conformance of the design to all requirements of the product requirement specification.
4. Conformance of the design to all relevant divisional engineering standards.
5. For a manufactured product, the expected cost of a product manufactured in conformance to the design.
6. The manufacturability, testability, and inspectability of the design.
7. Achievability of design tolerances by existing manufacturing processes of known capability.
8. The purchasability of items needed to manufacture the design.

9. The schedule for the design project.

10. The schedule for manufacture of a manufactured product.

11. The plans for and results of appropriate analyses (reliability, thermal stress, mechanical stress, safety, etc.).

12. The plans for and results of appropriate tests (design, qualification, field application, etc.).

13. The allocation of product requirement specification features and characteristics to subsystems, assemblies, and components.

14. Synthetic models of the design approach. Engineering documentation (product requirement specification, design specifications, drawings, component specifications, process specifications, etc.).

15. Applicability of experience on previous designs.

Re-Design

A process whereby the designer go back to the drawing board, with some feedback on the initial design with an effort to remove sources of potential problems, or even change the whole design concept. The review is usually taken based on the outcomes of the pilot studies, however some reviews may be based on consumer complaints.

Calculation Check

A design appraisal step that relies on collecting certain data about the design (when in prototype, pilot, or use) and performing some calculations to re-evaluate the design.

Prototype (Field Testing)

A simulation process for testing a product’s design. The design is transformed into a small number of products to be tested in real life scenarios. The prototype might test the design’s manufactrability, the final customer use, the service and repairs required, the health and safety aspects, and so on.

Drawing Checks

A process whereby the designers (based on some feedback form the prototype or final use) perform a mini design review, i.e. they review the design drawings and blueprints.
without having to review the whole concept. This activity may result in some dimensional changes, etc.

**FMCEA**

Failure Modes and Criticality Analysis (FMECA) is a technique which identifies the potential problem areas of a product and initiates early corrective actions to reduce their impact. It gives capabilities for identifying and prioritising areas of risk and promotes corrective action, and encouraging early design changes to improve performance. FMECA describes the logical and instinctive process that we use when designing a product or service and their associated parts or processes. It provides a disciplined and rigorous team based method for establishing desired function, brainstorming potential failure modes and prioritising elimination actions.

When considering a complicated part or process, many subtle forms of failure must be considered and where possible avoided. The FMECA process documents this consideration of risk by establishing potential causes of failure, the severity of the effects of failure and our ability to detect failure. Even before a detailed design exists, it should be possible to discuss overall purpose (function) and brainstorm potential problems. Steps can then be taken early in the development process to control or eliminate them.

FMECA is therefore initiated at the earliest opportunity, during the planning stages of a product or process - not as a retrospective review of what went wrong, but to reduce customer dissatisfaction through avoidance of failure.

In summary, the purpose of FMECA is

- to identify and evaluate potential failure modes
- to review their corresponding effects
- to rank order potential design deficiencies
- to prioritise elimination actions
**Purchasing / procurement**

An important area to consider when planning Design and/or manufacturing prevention activities. Purchasing should be planning systematically to provide the highest quality raw material and information at the lowest price, but should never be based on price considerations alone. The design and manufacturing quality starts with ensuring quality inputs, and that is where the purchasing role is crucial.

**Vendor Certification**

A process whereby the quality of the incoming material and information is assured via ensuring the vendors comply with a quality system standard (e.g. ISO 9000). The vendor audit and certification can be done by third parties (Third Party Audit as is involved with ISO9000 certification) or by the organisation itself (Second party audit whereby organisations audit and certify their vendors and suppliers). The best practice criteria to be followed for certifying Vendor are as follows:

1. Financial Stability and Solvency: Each vendor who makes application for vendor certification must submit tax, insurance, revenue, budget and sales information. All financial information submitted is then subject to background checks and certification. Solvency determinations are based upon information at the time of certification. Subsequent checks and verification during the certification period will only be made upon request.

2. Quality and Support of Product or Service: The quality of products and services provided by each vendor who makes application for vendor certification are subject to verification at the time of certification. Customers' satisfaction and product supply are measured by interview or site visit. Product quality in most cases is determined by use of the product. Subsequent checks and verification during the certification period will only be made upon request.

3. Expertise and Qualifications of Personnel: Each vendor who makes application for vendor certification must submit resumes on all key personnel. All information received from vendors pertaining to key personnel is subject to background checks and verification. Subsequent checks and verification during the certification period will only be made upon request.
Quality Training

Training on quality concepts for all organisational staff, and technology quality tools for those involved in improvement teams and activities is one of the crucial preventive activities an organisation can plan and implement. Quality training can cover wide areas such as Customer Relationship Management, Quality Audit techniques, Statistical Quality Control tools, problem-solving techniques, etc.

This includes activities as attending, developing, implementing, operating and maintaining formal quality training programmes. Training must be provided and documented for all personnel whose activities affect quality. Personnel must be trained in the specific tasks assigned, qualified to perform to perform these tasks, and supported with documentation and records of training. These records must be maintained to reflect the current task.

The organisation’s quality plan must outline the procedures for identifying the tasks that require training. Training can be based on formal education, supervised training on the job, or past experience. In any case, a formal record must be maintained and approved by an authorised individual as defined in the procedures.

If a generic job description exists, procedures should require the integration of both the job description and any additional requirements. Requirements that are not included in the job description should be added to a department-specific record.

Therefore, three documents should exist:
- A procedure on how to develop the training requirement.
- The generic job description.
- The specific training record that incorporates the additional requirements and references the generic job description, complete with the supervisor's and employee's signature validating the successful training.

The ISO 9000 standard requires that:
1. The organisation shall have and maintain training records for all employees whose workmanship affects quality.
2. The organisation will have a documented procedure for identifying training needs.
3. Only trained personnel are qualified to perform tasks affecting quality.

Training records shall identify appropriate education, training and/or work experience.

**Material/Parts In-Process Inspection**

Inspection activities that are undertaken to test the components while they are being used. Examples here include testing electrical components before assembling them to the final product, testing dimensional aspects of a component before fitting, or even visual testing for colours or information on a component before installation or assembling.

**Repair, Test and Inspection**

Activities that are undertaken when a failure is identified. The severity of the failure will determine which activity needs to be done. If none are feasible the failed product would be scrapped.

**Quality function deployment**

Quality Function Deployment (QFD) is a means by which companies are lead towards designing products and processes around the real customer and market demands. QFD uses customer as the focus and through a series of matrices helps the team of QFD engineers to translate customer requirements into clear specifications at every stage of the product design, manufacture and launch process. It can provide a means of:

- Forcing traditionalists and specialist functions to listen to the real ‘voice of the customer’
- Bringing teams together to gain a common view of the issues
- Getting rid of misconceptions and eliminating unproductive and speculative debates within the team
- Forcing on real requirements through the consideration of all relevant information
- Revealing flaws in functional design judgements early in the process and giving the opportunity to develop better potential concepts
- Prioritising efforts and using resources for best effect.
Quality Review and Verification of Design
Quality organisation monitoring activity during the product's design and development phase to assure the required inherent design quality. Its involvement with design review activities and in verification activity during the various phases of the product development test programme including design approval tests and other tests to demonstrate reliability and maintainability.

Design and Development of Quality Measurement, Test and Control Equipment
This involves activities as the cost of designing, developing and documenting any necessary inspection, testing or proving equipment (but not the capital cost of the equipment in question).

Supplier Quality Assurance
This involves the initial assessment, subsequent audit and surveillance of suppliers to ensure they are able to meet and maintain the requisite product quality. This also includes the quality organisation's review and control of technical data in relation to purchase orders.

Quality Administration
This takes various forms (according to the ISO9000 Quality Management Standard), among which are:

1. Quality policy
Management must define and document its quality policy and objectives to ensure its commitment to quality and to the minimum requirements of ISO 9000. Management must see that this policy is understood and implemented throughout the organisation and ensure that:

1. The quality policy is defined and documented.
2. The quality policy is relevant to the customer's needs.
3. The quality policy is known by everyone in the organisation.
4. The quality policy is maintained and implemented at all levels in the organisation.
2 Organisation

This subsection requires the organisation to be able to prove that the template for the organisation’s quality approach is effective and defines responsibility. The standard calls the organisation to address problems systematically and solve them by attacking the root causes.

Specifically, the organisation must be certain that:

1. The organisation have defined and documented who has responsibility to stop the processing or delivery when a deficiency is detected
2. The organisation have clearly defined who has the authority to identify and record deficiencies, recommend solutions, and verify their correction
3. The organisation have allocated trained resources to conduct verification (audits) of the organisation quality policy
4. A senior member of the organisation has been assigned responsibility for the ISO 9000 standard and the organisation’s compliance, as well reporting its status to the organisation

3 Management representative

A senior management representative must be designated to ensure that the requirements of ISO 9000 and all other defined standards are established and maintained.

People who are designated as the quality contacts can have multiple functions within the organisation; therefore, it is not necessary that they have a strictly quality-related title. However, the organisation needs to be careful of the fox-in-the-hen-house syndrome. It is quite possible that the organisation’s senior production manager within the organisation is responsible for total quality in his organisation, including the verification and inspection aspects. If so, there needs to be a very strong case made, supported by documented evidence, that this individual is acting impartially and meeting the full intent of the standard. An easy way to define the quality responsibility is to designate quality responsibilities from the president to the assembly line person on the organisation’s corporate organisation chart.
Process Planning and Tooling

Process planning refers to the entire process of producing a product and the method by which the organisation control and ensure that the organisation’s processes are followed - it is not limited to some form of statistical process control. The standard frequently uses the term "procedures" when referring to process planning.

The organisation must provide a controlled work environment that ensures that the quality of the product is adequate and in conformance with the documentation and record requirements of ISO 9000. This requires the organisation to provide adequate and controlled written instructions (procedures) or representative samples that ensure proper assembly and workmanship standards. These standards should define the criteria for acceptable workmanship. The process should define the equipment, environment, reference standards, and quality plans, and must include regular monitoring during production. The equipment used by the employees must have appropriate operating instructions and maintenance plans.

Work instructions must reviewed by authorised personnel. These instructions are required whenever their absence could adversely affect the quality of the output. The instructions should be reviewed periodically to ensure adequacy and proper alignment with other procedures. The work instructions must clearly define the acceptance criteria so the operator can differentiate the good from the bad.

A "special process" is any process that cannot be fully confirmed through immediate testing or inspection so a defect may only surface when the product is being used by the customer. Typical examples are welding, paint applications, and heat treatment of materials. These processes require identification as special processes, clearly defined process parameters, operation by appropriately trained personnel using qualified equipment, and/or continuous monitoring with supporting records. Special processes must also meet the full requirements of this section.

To satisfy the requirements of Process Planning in the ISO 9000 quality management system -
1. The organisation will have a documented and controlled system of procedures and instructions in place that ensures all processes affecting customer requirements are carried out in a controlled manner.

2. Documented procedures are required where the lack of which could adversely affect the quality of the product or service being provided.

3. A controlled process will include the approval of suitable production, installation, and servicing equipment by an authorised individual.

4. A monitoring of appropriate process and product requirements shall occur during the processing of the customer's requirements.

5. A suitable working environment and maintenance of equipment shall be provided for.

6. Clear accept/reject decision criteria shall be documented and made available, as related to workmanship or material conformance.

When the organisation cannot immediately verify acceptability of the material/workmanship (termed special processes, such as painting, welding, and heat-treating) the organisation must identify pre-qualified process parameters, provide fully trained personnel and authorised equipment. The documentation will also include a full identification of the special processes, and will ensure continual process parameter monitoring of those processes.

Quality Planning

The activity of planning quality systems and translating product design and customer quality requirements into measures that will ensure the fulfilment of the requisite product quality. It includes that broad array of activities that collectively create the overall quality plan, the inspection plan, the reliability plan and other specialised plans as appropriate. It also includes the preparation and vetting of manuals and procedures needed to communicate these plans to all concerned. Such quality planning may involve departments other than the quality organisation.

Quality planning shall be consistent with all other requirements of supplier's quality system and shall be documented in a format to suit the supplier's method of operation.
The supplier shall give consideration to the following activities, as appropriate, in meeting the specified requirements for products, projects or contracts:

1. the preparation of quality plans
2. the identification and acquisition of any controls, processes, equipment fixtures, resources and skills that may be needed to achieve the required quality
3. ensuring the compatibility of the design, the production process, installation, servicing, inspection and testing techniques, including the development of new instrumentation
4. the upgrading, as necessary, of quality control, inspection and testing techniques, including the development of new instrumentation
5. the identification of any measurement requirement involving the capability that exceeds the known state of the art, in sufficient time for the needed capability to be developed
6. the identification of suitable verification at appropriate stages in the realisation of product
7. the clarification of standards of acceptability for all features and requirements, including those which contain subjective element
8. the identification and preparation of quality records

Supplier Quality Assurance (SQA)
This involves the initial assessment, subsequent audit and surveillance of suppliers to ensure they are able to meet and maintain the requisite product quality. This also includes the quality organisation's review and control of technical data in relation to purchase orders.

Quality Audits - Internal
This involves the internal activity of appraising the entire system of quality control or specific elements of the system used by the organisation. This involves the internal activity of appraising the entire system of quality control or specific elements of the system used by the organisation.

The organisation must carry out a comprehensive review of the organisation to verify the effectiveness of the quality system and compliance with the ISO 9000 standard. This review should take the form of scheduled audits of the various areas, based on
the relative importance of the operations and activities. Audits are to be conducted in accordance with the documented procedures by trained individuals. The results of the audits must be documented and presented to management personnel for timely corrective action of any non-conformances cited, and tracked to ensure follow-through. Follow-up audits must be conducted to confirm the corrective action.

Audit frequency will be determined based on experience as well as the importance to the products being produced. Generally, no more than one year should be allowed to pass between audits of the same area to maintain compliance.

Audits are carried out according to a documented plan that will specify not only locations and time, but also the qualifications of the auditors, the output required, the method for conducting the audit, and who will receive the results. Audits shall be conducted by personnel independent of the operation being audited and trained in ISO 9000 requirements.

For internal quality audits:
1. The organisation will have procedures for conducting internal audits.
2. The organisation will conduct audits according to a planned schedule based on the order of activity importance.
3. The audits will be conducted by trained personnel independent from the area they are auditing.
4. The audits will be recorded and reviewed by management as part of the management review.
5. The audit results will be brought to those responsible for the audited areas. The management of these areas will take timely corrective action to remedy the non-conformance.
6. Recorded follow-up audits shall be conducted to ensure the corrective action has been taken.

**Quality Audits - External**

This involves the external activity of appraising the entire system of quality control or specific elements of the system used by the organisation.
The organisation must carry out a comprehensive review of the organisation to verify the effectiveness of the organisation’s quality system and compliance with the ISO 9000 standard. This review should take the form of scheduled audits of the various areas, based on the relative importance of the operations and activities. Audits are to be conducted in accordance with the organisation’s documented procedures by trained individuals. The results of the audits must be documented and presented to management personnel for timely corrective action of any non-conformances cited, and tracked to ensure follow-through. Follow-up audits must be conducted to confirm the corrective action.

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For external quality audits:
1. The organisation will have procedures for conducting internal audits.
2. The organisation will conduct audits according to a planned schedule based on the order of activity importance.
3. The audits will be conducted by trained personnel independent from the organisation.
4. The audits will be recorded and reviewed by management as part of the management review.
5. The audit results will be brought to those responsible for the audited areas. The management of these areas will take timely corrective action to remedy the non-conformance.
6. Recorded follow-up audits shall be conducted to ensure the corrective action has been taken.
Training

Training must be provided and documented for all personnel whose activities affect quality. Personnel must be trained in the specific tasks assigned, qualified to perform these tasks, and supported with documentation and records of training. These records must be maintained to reflect the current task.

The organisation's quality plan must outline the procedures for identifying the tasks that require training. Training can be based on formal education, supervised training on the job, or past experience. In any case, a formal record must be maintained and approved by an authorised individual as defined in the procedures.

If a generic job description exists, procedures should require the integration of both the job description and any additional requirements. Requirements that are not included in the job description should be added to a department-specific record.

Therefore, three documents should exist:
- A procedure on how to develop the training requirement.
- The generic job description.
- The specific training record that incorporates the additional requirements and references the generic job description, complete with the supervisor's and employee's signature validating the successful training.

The ISO 9000 standard requires that:
1. The organisation shall have and maintain training records for all employees whose workmanship affects quality.
2. The organisation will have a documented procedure for identifying training needs.
3. Only trained personnel are qualified to perform tasks affecting quality.
4. Training records shall identify appropriate education, training and/or work experience.
Process Development

Process control refers to the entire process of producing a product and the method by which the organisation control and ensure that the organisation's processes are followed - it is not limited to some form of statistical process control. The standard frequently uses the term "procedures" when referring to process control.

The organisation must provide a controlled work environment that ensures that the quality of the product is adequate and in conformance with the documentation and record requirements of ISO 9000. This requires the organisation to provide adequate and controlled written instructions (procedures) or representative samples that ensure proper assembly and workmanship standards. These standards should define the criteria for acceptable workmanship.

The process should define the equipment, environment, reference standards, and quality plans, and must include regular monitoring during production. The equipment used by the employees must have appropriate operating instructions and maintenance plans.

Work instructions must reviewed by authorised personnel. These instructions are required whenever their absence could adversely affect the quality of the output. The instructions should be reviewed periodically to ensure adequacy and proper alignment with other procedures. The work instructions must clearly define the acceptance criteria so the operator can differentiate the good from the bad.

A "special process" is any process that cannot be fully confirmed through immediate testing or inspection so a defect may only surface when the product is being used by the customer. Typical examples are welding, paint applications (Zyglow inspection), and heat treatment of materials. These processes require identification as special processes, clearly defined process parameters, operation by appropriately trained personnel using qualified equipment, and/or continuous monitoring with supporting records. Special processes must also meet the full requirements of this section.
To satisfy the requirements of Process Development:

1. The organisation will have a documented and controlled system of procedures and instructions in place that ensures all processes affecting customer requirements are carried out in a controlled manner.

2. Documented procedures are required where the lack of which could adversely affect the quality of the product or service being provided.

3. A controlled process will include the approval of suitable production, installation, and servicing equipment by an authorised individual.

4. A monitoring of appropriate process and product requirements shall occur during the processing of the customer's requirements.

5. A suitable working environment and maintenance of equipment shall be provided for.

6. Clear accept/reject decision criteria shall be documented and made available, as related to workmanship or material conformance.

7. When the organisation cannot immediately verify acceptability of the material/workmanship (termed special processes, such as painting, welding, and heat-treating) the organisation must identify pre-qualified process parameters, provide fully trained personnel and authorised equipment. The documentation will also include a full identification of the special processes, and will ensure continual process parameter monitoring of those processes.

**Product Qualification Test**

Of all quality assurance systems, product qualification is the most cost effective. The most expensive quality problems are usually caused by design deficiencies. If the design of a product is right, blunders or ill luck in purchasing or manufacturing can cause serious problems but they can usually be resolved by a single-stage correction process. However, if a new product is launched with serious design defects the consequences are horrendous. The customers are complaining bitterly and the product is being returned. The design-development people are frantically searching for a solution. They launch an inadequately tested correction into production. As often as not it does not work and a further correction is introduced. Now production has three different versions to cope with erroneous original design and two different corrections. The majority of the world's biggest quality problems-those that are
headlined in the newspapers and discussed in courts and parliaments-have this kind of genesis. Product qualification is a key means of preventing such problems.

All new products are subjected to tests and inspections during the design-development phase. In the early stages of design, tests are part of an iterative process for achieving the product's requirements. In later stages the purpose of the tests is increasingly to confirm that features of the product work and that characteristics have their required quantitative values. Testing and inspection is also carried out in manufacturing as means of identifying and correcting defects. It is possible for the informal testing of the development phase to merge into the routine testing of the manufacturing phase with no particular test event separating the two. Engineering, on the basis of its own information, "releases the product" to manufacturing, production starts, and a little while later product is delivered to customers. Unfortunately, because development testing is informal it is not possible for its adequacy to be appraised as a whole. Because of time and money pressures on the design engineers and their confidence in the quality of their design, it is unlikely to be complete. Because manufacturing testing objectives is to check conformance to the design and, because it has cost and schedule constraints, it is also inadequate for proving a newly designed product.

As mentioned previously, major institutional customers may require that a development is not declared complete until they have "qualified" the product. Such customers usually base their decision to qualify or not on the results of formal tests performed by themselves, or the producer, or an independent laboratory. The tests are called "qualification tests" and their definition and performance are part of the contract between the vendor and the customer.

For products where there is no customer requirement to perform qualification tests, it is still extremely useful for the development of a new product to conclude with formal qualification testing. In the absence of contractual requirements, as with design review, for a division to impose on itself the discipline of product qualification requires strong leadership from the division general.

In essence, qualification testing is a particularly thorough phase of testing carried out on the product when development is complete to give assurance that the design is
correct. One approach is to have an "open-ended" investigation of the product. This is possible only when a group of experts are available (e.g., from an external laboratory). A different approach, applicable to virtually any new product, is to examine conformance of the product to its product requirement specification.

The purpose of product qualification is to give assurance by the formal performance of a series of specified qualification tests that the product (manufactured in conformance to its design) conforms to all of the requirements defined in its product requirement specification.

The product requirement specification, which defines exactly what the product must be able to do—its performance, appearance, external dimensions, environmental resistance, reliability, safety, and so on—should be issued before the start of design, and revised and made more precise as development proceeds.

Before submitting samples of a product for qualification testing the development team should be confident (from what they know of the design and results of development tests) that the samples will pass the qualification tests. Qualification testing should not be limited to aspects of the product about which the development team has doubts; on the contrary, significant doubt of a product's ability to pass the tests probably indicates that the product is not ready for qualification testing. Experience indicates that, however confident the development team is in a product, usually the product fails one or more qualification tests and corrective action is required. Development team confidence is not a good reason for omitting particular tests.

The following is a summary of the tests to be included in a Product Qualification Test Specification:

1. Check of configuration.
2. Check of conformance of samples to design.
3. Visual and mechanical inspection of dimensions and workmanship.
4. Complete functional testing under normal operating conditions.
5. Functional testing under specified marginal conditions.
6. Tests of ability to function correctly in specified environments.
7. Tests of ability to withstand without damage specified transport and storage environments.
8. Reliability tests for life and failure rate.

Incoming Inspection
No material should be incorporated into the product without verification to the product specifications. This does not mean all the organisation’s material must undergo a full specification inspection. "Partials" are legitimate as long as they meet the organisation’s inspection plans. If, due to emergency, the incoming material is used without verification, it will require designated authorisation, full documentation, and tracking (positive recall procedure). All pre-verified materials should be maintained in a segregated area according to a documented process.

The verification of the incoming product must conform to the organisation’s quality plan and documented procedures. Verification can take many acceptable forms and is not necessarily delegated to the receiving inspection organisation. However, records must be maintained to meet the defined inspection requirements specified in the organisation’s procedures. When establishing inspection schemes the organisation should consider recorded evidence of receipt histories as well as the process capability of the organisation’s supplier.

To verify incoming product:
1. The organisation shall establish a documented system that ensures that no incoming material is used until its fitness has been verified to the organisation’s defined quality.
2. When establishing an inspection and testing consideration, the organisation should consider recorded evidence of process compliance, as well as historic evidence of compliance.

Material/Parts In-Process Inspection and Test
The organisation must document the organisation’s in-process inspection procedures and test points and carry out the defined inspections. The level of in-process
inspection is determined by the organisation's own operations, and, with the exception of special process inspections, there is no additional requirement.

If in-process inspection is required, the organisation will need to provide holding points for non-conforming materials. The ISO 9000 standard encourages the use of in-process inspection as a method for minimising defects and allows in-process inspections and test if appropriate.

To satisfy this requirement in the ISO 9000 standard:
1. The organisation must perform in-process test and inspection of the product according to the documented product specification requirements or to the organisation's own quality plan.
2. The organisation must not allow materials to proceed through the process until they have met the test requirements.

Assembly/End-Item Final Inspection and Test

The organisation is required to perform a full inspection and test of the organisation's final product as specified in the organisation's quality plan and documented procedures. This full inspection and test must verify that the inspection data fully meet the specifications of the product, as defined in the organisation's quality plan. Final inspection should incorporate the results of previous inspections and their successful satisfaction of requirements. The organisation are required to hold the product and defer its shipment or release until all inspections have been completed and the product has met all the specifications. The organisation's inspection record should indicate who authorised the release of the product (of course, this person must be authorised to do so).

To satisfy this requirement:
1. The organisation must perform final inspection and test of the product according to the documented product specification requirements or to the organisation's own quality plan to ensure the product meets the customer's specified requirements.
2. The final inspection shall include verification of satisfactory in-process inspections.
3. No products or materials shall pass final inspection until all requirements have been satisfied and records completed and released by authorised individuals.

4. Step-by-Step Guide to operating QCIS

To install the QCIS form the Diskettes provided, please follow the following instructions:

(1) Insert Disk 2 and using Explorer select "31/2 Floppy Drive"
(2) Select Setup.exe
(3) You will be prompted to Insert Disk 1
(4) Insert disk 1 THEN press OK
(5) Installation will commence
(6) If you are requested to restart then do select OK then from Step 1
(7) Next you will be prompted to Insert disk 2
(8) Insert disk 2 THEN press OK
(9) Once this is all done a blue screen titled "Quality Cost Information System" will appear with a blue box containing a big Computer icon
(10) Select the icon, the application will now install
(11) Select Start > Programs > Quality Cost Information System > Quality Cost Information System and then run the application, or, double click the icon ‘quality.exe’ shown below.

![Quality.exe](image-url)
The main user interface window will pop up (shown below). Click any key to continue.

The ‘Failure Type’ window (shown below) will pop up. Select either ‘Internal Failure’ or ‘External Failure’. See Definitions in Section 3.1 to ensure accuracy.

Once selected, another window will appear which requires another selection. If the initial selection was ‘Internal Failure’, the selection would be:

- Design Failure
- Manufacture Failure
- Supplier Failure
If the initial selection was 'External Failure', the selection would be:

- In-Warranty
- Out-Of-Warranty
- Recalls

See Definitions in Section 3.1 to ensure accuracy.

Once selected, the organisation will be prompted to enter 'Failure Name', which describes the details of the activities to be undertaken due to the failure. If, for instance, the organisation selected 'Internal Failure' and then selected 'Design Failure' sub-category, the organisation have to next select the name of the failure from a list of standard activities which include: Redesign, Failure Analysis and Development, Scrap, Rework, Repair, Re-inspection, Retooling, etc (other). Upon selecting a specific failure click the 'Next' button. Before selecting the 'Failure Name' see Definitions in Section 3.1 for accuracy.

Next, the 'Failure Cost' window pops up (shown below), to enable the organisation to enter the total (estimated) failure cost for that specific failure. Organisations that apply the ABC accounting principles will be able to clearly specify this value. However, organisations with traditional cost accounting activities will not have a clear estimate, and might have to take an educated guess.

Upon giving a specific value, click 'Next' and the organisation will be presented with the dialog screen shown below.
This screen provides a list of standard quality cost activities. To help understand some of the elements and activities in this screen, a user-friendly ‘Help’ Facility is provided, as shown in the screen below.

The organisation are requested to identify which of the activities (currently not being performed by the organisation’s organisation) has the potential to minimise, or eliminate the failure in question, when applied.
For each activity selected, estimate the total cost for applying this activity or system (e.g. machine hours, employee time, training, etc.). Enter that amount on the screen as shown below.

Upon assigning a cost to any of the elements, estimate the ‘effectiveness’ of the selected element (range from 0% to 500%). This value is the expected rate of return on the investment made in the quality activities chosen (after they are applied). This is a subjective measure and relies on the organisation’s understanding of the organisation’s business and the Quality Activity / System being discussed. It could be a good idea to consult others in the process to reach this value.

Based on what is entered, the system traces back and identifies the activities that should be carried out in order to achieve optimal performance.

If the Failure Cost > Total Activity Cost, the organisation will be advised to carry out the activities in order to rectify the problems. On the other hand, if Failure Cost < Total Activity Cost, then the System informs the organisation of this, as shown below.
Upon clicking the OK button, the system re-displays the related activities, but this time with additional check boxes beside each activity as shown in the figure below, to enable the organisation to define which activities are of high priority and which are of less priority (based on the organisation specific organisational situation and again the organisation’s knowledge of the organisation’s business).

After the prioritisation process is complete, click the ‘Calculate Total Activity Cost’ button. The system re-computes the Total Activity Cost, and advises accordingly, as shown in the figure below.
From this dialog, the organisation now has advice regarding the organisation’s reported fault. The organisation can terminate the interaction or re-start the computation of another failure cost.