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A FRAMEWORK FOR IMPROVING THE QUALITY OF MANAGEMENT INFORMATION

by

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Dissertation
Submitted in fulfilment of the requirements
for the degree of
MAGISTER COMMERCII (ACCOUNTING SCIENCES)
in the faculty of
ECONOMIC AND MANAGEMENT SCIENCES
at the
UNIVERSITY OF PRETORIA

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PRETORIA DECEMBER 1994

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ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my study leader Dr. Steve du Randt who, despite his very busy schedule, made time to officiate as my study leader, read and discuss relevant material and make constructive input. The research is dedicated to my wife Elmien, and my three children, Elbrie, Johan and Gawie whose patience and support carried me through. All the honour and glory for both the preparation and successful completion of this work goes to my Lord and Saviour Jesus Christ who gave me the wisdom, understanding and endurance.

SANDTON

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SUMMARY

A FRAMEWORK FOR IMPROVING THE QUALITY OF MANAGEMENT INFORMATION

by

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Good management information is critical to the success of any organisation. Without proper information, the organisation will starve and management will steer it towards its own destruction. Although management usually receives a constant flow of information every day, it does not necessarily serve its purpose. The information could be useful and contribute to good decision making. It could also be wrong, which could contribute to poor decisions and failure. Finally it could be available but inappropriate to the management of the organisation.

Computer systems produce most of the management information in organisations. There are a variety of types of computer equipment and applications that could make a significant contribution to improve the quality of the information produced in an organisation. Improving the quality of the information could enhance the decisions and actions of management and therefore improve the results of the organisation.

The objective of this study is to develop a framework for enabling managers to understand the attributes of quality information, and to identify appropriate computer equipment and applications to enhance the quality of information.

The hypothesis is as follows:

> "Quality information is that information that can have a decisive impact on the decisions and action of the decision maker. It is feasible to identify the attributes of quality information. This research clarifies the main and supportive attributes of quality information.

> Computer equipment and applications, collectively known as computer tools, used and managed in an organisation contribute to enhance or impair quality information. These tools, and the role they can play to produce quality information, will be explained in this study."

To support the hypothesis the study is conducted in three phases. Phase 1 will establish the attributes of quality information. It commences by considering the historical development of computers and information. It explores the different driving forces that produced the technology of today and tomorrow. It then explores the nature and characteristics of information to develop an appreciation for the complexity and intricacies of information. This phase concludes by identifying the attributes of quality information: relevancy, accuracy, timeliness and comprehensibility.

Phase 2 will assess the contribution of computer tools to produce quality information. The contribution that the computer equipment and applications make to enhance the attributes of quality information is described and evaluated. Computer tools are defined, and a method of assessing their contribution to enhance quality is designed and applied. The phase concludes with a summary of the contribution that the tools could make to enhance specific information components.

The final phase produces a framework to evaluate the production of quality information. With a clear understanding on the one hand of the attributes of quality information, and, on the other hand of the contribution that different computer equipment and applications can make to improve the quality of information, a framework is developed to help managers to identify appropriate technology to improve the information on which they base their decisions. This framework could be used by information managers to improve the effectiveness of management's actions and decisions.

The results of the study, it is submitted, support the stated hypothesis and add benefit to the practical application of information management.

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OPSOMMING

'n RAAMWERK OM DIE KWALITEIT VAN BESTUURSINLIGTING TE VERBETER

deur

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'n Suksesvolle organisasie is afhanklik van goeie bestuursinligting. Sonder behoorlike inligting sal enige organisie kwyn en bestuur loop die gevaar om die onderneming die afgrond in te lei. Alhoewel bestuur gewoonlik inligting voordurend ontvang, dien dit nie noodwendig sy doel nie. Die inligting mag moontlik baie bruikbaar wees en 'n bydrae maak tot goeie besluitneming. Dit kan egter ook foutief wees, wat sal bydrae tot swak besluitneming en mislukking. Die inligting mag beskikbaar wees, maar waardeloos en ongeskik, met geen effek op die organisasie nie.

Die meerderheid bestuursinligting in organisasies word deur rekenaarstelsels geproduseer. Daar is verskillende soorte rekenaartoerusting en toepassings wat 'n wesentlike bydrae kan maak tot die verbetering van die kwaliteit van inligting in 'n organisasie. Die opgradering van die kwaliteit van inligting behoort die besluitneming en aksies van bestuur te verbeter met die gepaartgaande verbetering van resultate in die onderneming.

Hierdie studie het ten doel om ‘n raamwerk te ontwikkeling vir gebruik deur bestuurders om 'n beter begrip te hê van inligting, en wyses waarop die kwaliteit daarvan verbeter kan word deur toepaslike rekenaartoerusting en toepassings te gebruik.

Die hipotese vir hierdie studie word as volg gestel:

> "Kwaliteit inligting is daardie inligting wat 'n deurslaggewende invloed het op die besluite en aksies van besluitnemers. Dit is moontlik om die eienskappe van kwaliteit inligting te

identifiseer. Hierdie studie sal die primêre en sekondêre eienskappe van kwaliteit inligting toelig.

Rekenaartoerusting en toepassings wat gebruik en bestuur word in 'n organisasie kan die kwaliteit van inligting verbeter of verswak. Die rol wat rekenaartoerusting speel in die produksie van inligting sal in die studie ondersoek word."

'n Studie, in drie fases, is onderneem om die hipotese te ondersteun. Die eerste fase vestig die eienskappe van kwaliteit inligting. Aanvanklik is daar 'n geskiedkundige oorsig van die ontwikkeling van rekenaars en inligting. Die dryfvere in die ontwikkeling van rekenaars word ondersoek. Daarna word die aard en eienskappe van inligting bespreek. Dit verbeter waardering vir die kompleksiteit en interafhanlikhede van inligting. Hierdie fase word afgesluit deur die identifikasie van die eienskappe van kwaliteit inligting. Die volgende primêre eienskappe word bevestig: toepaslikheid, akuraatheid, tydigheid, en verstaanbaarheid.

Fase twee het ten doel om die bydrae wat rekenaars maak vir die produksie van kwaliteit inligting te ondersoek. Hierdie bydrae word beskryf en ontleed. Die verskillende tipe rekenaars word geklassifiseer. 'n Metode word ontwerp en toegepas om die bydrae van verskillende rekenaarhulpmiddels tot kwaliteit te meet. Die fase word afgesluit met 'n opsomming van die bydrae wat die verskillende groeperinge van rekenaars maak om die kwaliteit van onderafdelings van inligting te verbeter.

'n Raamwerk vir die evaluering van kwaliteit inligting word in die derde en finale fase saamgestel. Met 'n goeie begrip van wat inligting is, en watter rekenaars 'n bydrae maak tot die verbetering van die kwaliteit van inligting, is dit moontlik om a praktiese raamwerk daar te stel wat deur bestuur gebruik kan word om die kwaliteit van inligting te ondersoek en te verbeter. Dit sal 'n positiewe bydrae maak tot beter besluitneming.

Daar word gevoel dat die gevolgtrekkings en resultate van die studie die gestelde hipotese ondersteun, en 'n praktiese toepassing lewer vir doeltreffende inligtingsbestuur.

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CHAPTER 1

FRAMEWORK FOR THE RESEARCH

1.1 BACKGROUND

Computing in business has developed from the mechanical processing of limited sets of data some ninety years ago to a highly sophisticated electronic tool to manage business processes from the very small too the extremely large. Organisations find themselves today in the sixth major generation of computers in forty-three years. (Edmunds 1987: 109). Computers have become an integral part of success in business. In order for business to survive industry competition in the 1980's and into the 21st Century the use of computers must be part of business strategy. (Griffiths 1986: 184).

It has become commonplace to talk about modern Western societies as operating in a post industrial age. The economies and business enterprises in the post industrial age are characterised by information related activities. This age, which some depict as the information age, was born in the 1950's when computers reached the commercial market for the first time. (Hussain 1981: 5).

The expanded scope and diversity of information systems and the infiltration of information technology into every facet of business mean that information management cannot be confined to the data processing arena - it is a corporate-wide affair. Hammer, chairman of one of the largest banks in the United States, regards the corporation's three fundamental assets as people, capital, and information systems. (Griffiths 1986: 185). As a resource, information is unique. Unlike most resources, information is not exhausted by use, rather its value can be increased by its circulation. (Longley 1982: 165). The price-performance ratio of technology has also improved many times over and is still improving. The use of information warrants more attention as many more people in the wider community outside data processing departments began to make use of technology. (Griffiths 1986: 186).

Initially the focus of computers was on the processing of data. In the 1970's the awareness of the significance and value of information became more evident. The mere processing of data shifted to the compilation of information for management. Growth in the size of organisations and an increase in the number of managers demanded a wider distribution of information within shorter periods. This caused information to expand rapidly. According to Murdock, 75% of all information available was produced in the last two decades. (Murdock 1980: 4). Users are finding it difficult to cope with the overload of information. Adams said that "computer-created information is rapidly becoming too great for executives and others to absorb." (Adams 1977: 7). The apparent overload caused by the vast volumes of information demanded in turn the development of new technology to improve the capabilities of handling this information.

The growth in the computer industry has been phenomenal. Forty years ago there were virtually no computers, now the computer industry is the fourth largest industry in the world, with over three thousand firms. (Awad 1988: 55). Computers offer an ever increasing variety and complexity of products, technologies and developments. The technological development emphasises the production and manipulation of ever increasing volumes of data and the presentation of acceptable information for management decision making. More recent developments include database management systems, advanced and more user-friendly programming capabilities, hypermedia, powerful processors and expert systems. A major technological trend is the convergence of computer and communication technologies. All these developments enhanced the users' ability to obtain better information for decision making.

Complex alternatives such as the choice between processors, software development platforms, and networking topologies are available to management to select suitable equipment, applications and the appropriate technological environment to produce acceptable results. Because of the complex relationship between different alternatives and the impact it could have on the production of information, it is no simple task to produce the information required at the right place, and at the right time. This wide variety of tools available to collect, manipulate and produce information, presents a potential problem to management. Selection of alternatives is often made for reasons other than the production of good quality information, such as price or processing power. The contribution that specific equipment and computer applications could make to improve the quality of information should be considered to help management with the appropriate selection and application of computer technology.

1.2 PROBLEM DEFINITION

There is an abundant supply of literature on information systems and information technology. More than 250 books and articles were studied during the research. This literature includes subjects such as the production of information in various systems and industries, information systems planning, and various elements of information systems. A substantial amount of literature also deals with information management.

Although the literature refers to types and categories of information, it seldom stresses those attributes of information that are more valuable than others. This research did not uncover any literature that focuses on various computer tools, or their contribution to improve the production of quality information. No real emphasis is placed on the need to monitor the creation of quality information and to assess and classify the abilities of available computer tools to contribute to the creation of quality information.

When selecting and using computer equipment and applications, management should understand the contribution that different tools can make to improve the production of better quality information.

The study therefore has as its final objective the development of a framework that will help with the evaluation of the contribution that computer tools make to produce quality information in a business environment. This framework will strengthen management's ability to control the production of the information with the desired quality.

Improving the quality of information will enhance the effectiveness of management decision making.

1.3 SCOPE

This study has two main focus areas: computer tools and quality information. It aims at bringing the interrelationship of these focus areas together.

The first focus area of this study is information. Information has not yet fully been established as a separate scientific discipline in its own right, although some might differ with this observation. From the literature it was evident that considerable emphasis is placed on a better understanding of this product of the computer revolution. The study of information is contained in several scientific disciplines including: Information Management, Psychology and other human behavioural sciences, Computer Science, and Business Science. This study will approach information from a very specific angle. It will focus on the attributes of information in a business environment. It will consider the background, nature, and features of electronic information in business produced by formal electronic information systems. However, it will not focus on information typically found in other disciplines such as informal information, scientific research results and mass media.

The second focus area is the computer equipment, applications and technology environment which produce information. Computers and related technologies are very wide subjects. They are covered by Computer Science, Electronic Engineering, and Management Science. This study will not elaborate on all aspects of computer equipment, types of applications and technologies in the computer environment. It will concentrate on those aspects that relate to the processing of data and the production of information.

Finally, the study will consider the impact that the components of computer systems have on the value of information. Many other factors, beside computers could affect the value of information. For example, the ability of the information user to define, interpret and react appropriately on the information could greatly affect the value of information. When a user produces and interprets data, many hindrances such as computer knowledge, and interpretative skills could affect the value of the information. These obstacles cannot be solved by computer tools only. Although the user may use different tools to convert data into information, poor quality information could still be produced with the same tools. The information user could therefore greatly affect the perceived value of the information. This study will not consider the human factors of processing and interpreting information such as skills, human preferences and intellectual ability, but concentrate on the abilities of computer tools. Another factor determining the value of information, is the source data. Data is the raw material to produce information. The quality of the source data will have a direct impact on the quality of information. This study assumes that the source data is of adequate quality and only considers the process of converting that data into information. It will not consider the process of ensuring the adequacy of source data. Notwithstanding the impact that other factors might have on the value of information, this study will concentrate on the impact that computer equipment and applications have to produce quality information.

1.4 HYPOTHESIS

Quality information is that information that can have a decisive impact on the decisions and actions of the decision maker. This study submits that it is feasible to identify the attributes of quality information. It will clarify the main and supportive attributes of quality information.

Computer equipment and applications, collectively known as computer tools, used and managed in an organisation contribute to enhance or impair quality information. This study will consider these tools and the role they play to support the production of quality information.

Therefore the hypothesis can be defined as follows: using the most appropriate computer equipment and applications, and managing the optimisation of the features of these tools would lead to the improvement of information quality.

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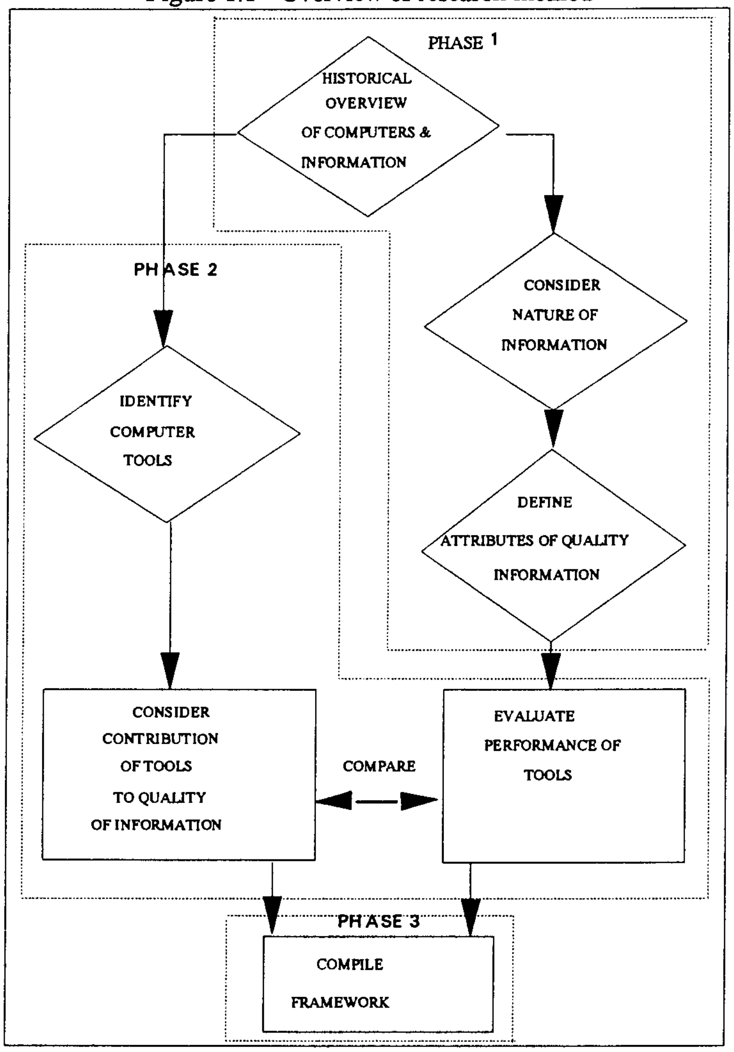
1.5 RESEARCH METHOD

The research method unfolding the hypothesis, is illustrated in Figure 1.1.

Figure 1.1 - Overview of research method



The research method includes the following steps:

a) A comprehensive literature study and synopsis of the historical development and trends of computing. The synopsis will end with a summary of the main driving forces behind computer development. This overview will put the developments of information producing machinery in their historical perspective.

b) An overview of the nature and characteristics of business information. This overview will explain the question: "The quality of whát is being considered?". It will also improve the understanding of the concepts of information.

c) An identification and compilation of the attributes of quality information. The preliminary literature study suggested a very haphazard coverage of the attributes of quality information. The study will isolate the main attributes and give assurance that the attributes identified are comprehensive. This step concludes the first phase of the study.

e) A classification of the computer equipment and applications, collectively called tools, into logical groups. To ensure that a comprehensive review is done of all applicable tools that might influence the production of information, an extensive survey off computing topics is done in the literature.

f) Assessment of the potential contribution that each group of tools identified in the step above could make to improve the attributes of quality information. The characteristics of the tools and the attributes are analysed to deduce an acceptable method of assessing each tool's contribution to the production of quality information. This step concludes the second phase of the study.

g) The refinement of the elements of information into measurable components to evaluate the significance of the attributes for individual information components and comparing this evaluation with tools that could improve the quality of the information. A practical method is developed to evaluate the attributes that are not optimised for improvement. The evaluation of the contribution of tools to individual elements of information will be illustrated using an illustrative company.

h) The compilation of a framework to be used by managers to analyse information components and to identify areas of improvement to produce better quality information.

1.6 SUMMARY

The steps followed to support the research method are arranged in several chapters. The arrangement of the chapters, and a brief overview of their contents is outlined in Table 1.1 below.

Table 1.1 Chapter overview

CHAPTER	SUBJECT	CONTENT
1	Framework for research	. Background . problem definition . scope . hypothesis . research method
	PHASE 1 - Establish the attributes of quality information	
2	Synopsis of computing and information development	. historical development . driving forces behind this development
3	Nature of information	. defining information . processing information . using information . classification of information
4	Attributes of quality information	. value of information . surveys and discussions of quality information . the key attributes
	PHASE 2 - Assess contribution of tools to produce quality information	
5	Defining computer tools	. identifying all the tools . classifying the tools . grouping tools
6	Designing an assessment method	. defining assessment levels . determine assessment criteria . describing assessment method
7-12	Assessment of computer tools	. discussion of characteristics of each tool group . assessing each tool group
13	Evaluation of assessment	. evaluating the assessments of individual tool groups jointly
14	Evaluation of tool performance	. outline of illustrative company . information components to be measured . evaluation of attributes . identify tools' contribution to improve quality
	PHASE 3 - Produce framework to evaluate the production of quality information	
15	Framework to evaluate quality information	. identify responsibility . outline framework . conclusion

PHASE 1

ESTABLISH THE ATTRIBUTES OF QUALITY INFORMATION

Phase 1 will establish the attributes of quality information. It begins with a synopsis of the development of computing and information production in Chapter 2; Chapter 3 defines information and review its nature and characteristics; Chapter 4 examines the quality attributes of information and ends with the identification of key attributes of quality information.

This phase will be based mainly on a review of applicable literature and a deduction of the significance of the quality of information from it.

CHAPTER 2

COMPUTING AND INFORMATION PRODUCTION - AN HISTORICAL OVERVIEW

2.1. INTRODUCTION

An historical overview of the development of computing and information is provided as a first step to understand the impact that computers have on the production of information. The computer age changed business operations dramatically. As recently as eighty years ago, almost all data in the business environment was gathered and recorded by hand. Any information had to be withdrawn by tedious reworking of the recorded data. Business and other needs to process more functions much faster with increasing accuracy, led to the evolvement of computers. A synopsis of the development of computers, from the early decades of the nineteenth century, until now, and even beyond, will give a clear picture of what brought them into existence.

Information was not an initial driving force behind the development of computers. The emergence of the need for information, and the use of it, followed later. The rising need for information was nevertheless interwoven with the development of computers.

This chapter reviews the main stages in the development of computers. Although the developments did not strictly take place in specific periods, the computer industry does identify several computer generations and relates important development stages with them. This chapter will review the early years of development before 1950 and the six generations of technological development after that.

Major developments in computer technology emerged from various driving forces. These driving forces were a combination of the needs of users and available technology. This chapter closes with an overview of those forces that worked together to advance computer development.

2.2. PRE - 1950'S

Before the eighteenth century there were two primary reasons for processing data. First, there was the natural desire by individuals to provide an account of their possessions and wealth. Babylonian merchants were keeping records as far back as 3500 B.C. As trade and commerce increased, people needed more aids to help keep track of more and more details. (Burch 1979: 41).

The second reason for processing data before the eighteenth century was governmental requirements. As tribes grew into nations, the authorities of these nations - Egypt, Israel, Greece, etc. - conducted administrative surveys to raise taxes and conscript soldiers.

In the eighteenth century more pressures developed for formal processing of data. The increased size and complexity of organisations such as factories, mining and service industries demanded more sophisticated methods for collecting and distributing the information needed by management. (Burch 1979: 41).

At the same time there was a complex network of creative forces and social pressures to produce machines to perform calculating tasks. The outcome of this era is personified in the creators of instruments of computation, and their machines or tables; the inventors of mathematical or logical ideas and their applications; and the fabrications of practical devices to serve the immediate needs of government, commerce, engineering and science. Blaise Pascal designed and built a small simple machine in 1642 at the age of about twenty years. His machine performed fundamental operations of addition and subtraction. (Goldstine 1972: 7). When Charles Babbage designed his "Difference Machine" and later the "Analytic Machine", there was a single clear glimpse of the computer idea. Although he never finished any of these developments, they combined the essential parts of the computer idea, and he is widely regarded as the initiator of computer development. (Goldstine 1972: 14). Adding machines and arithmometers were common toward the close of the nineteenth century. The procedures for multiplication and division were slow and indirect, so lengthy computations were generally done with logarithmic tables. The machines of Thomas de Colmar were the most popular with several thousands being built, starting about 1830. (Fleck 1973: 14). In its early stages the computer was conceived by its developers as a mechanical brain or mechanised intelligence, replacing the mundane functions done by human beings. (Fleck 1973: 6).

Large scale data processing was first used by Herman Hollerith in 1896 to speed up the processing of American 1890 census data. Hollerith developed a card on which data could be represented by holes, known as the Hollerith card, which was read by electric machines doing primary accounting operations. (Hussain 1981: 17). Insurance companies used his machines for actuarial work; Marshall Field's store in Chicago used them for sales analysis. (Weiss 1969: 31). Hollerith's work at the Census Bureau was supplemented by the work of James Powers who developed punched card machines used in the 1910 census. Both men left the Census Bureau to start business firms to produce their own machines. The International Business Machines Corporation (IBM) is a descendant of Hollerith's Tabulating Machine Company, while the UNIVAC division of the Sperry Rand Corporation is descended from the Powers Accounting Machine Company founded by James Powers. (O'Brien 1982: 13).

The business machine industry got under way with two American machines marketed in the 1890's: the Comptometer, invented by Dorr E Felt, and the Burroughs Adding and Listing Machine, invented by William S. Burroughs. They became the most popular accounting machines in the world. (Fleck 1973: 38).

By 1913 mass production was becoming a reality, as manufacturers set up the first moving assembly lines. Simultaneously the Spanish inventor Leonardo Torres y Quevendo was demonstrating a theory of automata that looked beyond assembly lines to the industrial use of programmed machines. To prove that machines could do the jobs that required mental ability, he combined electro-mechanical calculating techniques with his principles of automata, and showed how a machine could be assembled to perform any desired sequence of arithmetic operations. (Fleck 1973: 66).

In 1938, IBM president Thomas J Watson Sr. assigned engineer Clair D. Lake to supervise the designing and building of a large machine for Harvard University. It was completed in 1944. Named the "Automatic Sequence Controlled Calculator," it became known at Harvard as the "Mark I". It was the first automatic, general purpose, digital calculator. (Fleck 1973: 123).

It is quite evident that the priorities at this time were to handle large volumes of data, and to do calculations. These can be regarded as the initial driving force behind the first developments.

World war II created a new impetus. The age of systems was entered during this period. The production of hundreds of thousands of war planes by an economy that had produced only a few hundred, was a revolution in management. National systems of airlines, roads, defence, and social security came into being. The later decades of the twentieth century saw the rise of world systems, such as the World Bank and multinational corporations. (Murdock 1980: 5). Many war projects cried out for faster and faster computations. Relay computers were the first computers to give answers to these military needs. During the years 1944 to 1947, four types of relay computers were put into operation to solve scientific problems. One of them was the Bell Telephone Laboratories' Relay Computers. (Weiss 1969: 32). The pressing needs to solve war problems, and the realisation that the relay computers were not fast enough, resulted in the development, in 1946, of a machine using electronic tubes. The first computer, the ENIAC (Electronic Numerical Integrator and Calculator), did calculations in milliseconds. This speed could be compared to doing 300 days of manual computations in one day. However, the ENIAC was not a "stored program" computer and utilised the decimal system. Its processing was controlled externally by switches and control panels that had to be changed for each new series of computations. (O'Brien 1982:16). It weighed more than 30 tons and occupied a space 30 by 50 feet. But it had taken a giant step and started a revolution - a technological revolution based on the development of the electronic computer. (Weiss 1969: 38).

The stored program, conceived by John von Neumann in the 1940's gave the computer the capability of treating its regulatory instructions in the same fashion as the numerical data of the input, so that the computer could alter its program and make such logical decisions as might be required from moment to moment during its operations. (Fleck 1973: 7). Von Neumann gave a "blueprint" for the modern computer. Almost immediately, the building of several machines was started in Britain and the United states. Most of the new machines were named in the acronymic style of the ENIAC - EDVAC, EDSAC, MADM, UNIVAC, SEAC, SWAC, MANIAC, NORC; perhaps fifteen in all were in progress or completed by 1950. (Fleck 1973: 154).

Appropriately enough, the first of the modern computers completed was built in England, where Babbage had described his "Analytic Engine" in 1833. EDSAC, a computer built at Cambridge University by Maurice V. Wilkes, was the first stored program computer, complete with input and output facilities, to be placed in operation in May 1949. (Weiss 1969: 43). The EDSAC also included one of the first developments in automatic programming. The conversion from symbolic form to machine form was done by the computer itself. (Goldstine 1972: 335).

Advances in computers have served to bolster the recognition of the importance of information and knowledge in the management of organisations and institutions at large. Frequently information scientists were sought to develop, design and set up information systems to aid organisations in the planning, operating and controlling functions. (Yovits 1990: 326).

The development of expert systems technology draws on a wide background. The early developments that contributed to this technology started in 1943 with the definition of the "post production rules" by McCulloch and the Pitts' "neuron model". (Giarratano 1989: 12). It is noticeable that at the beginning of the first generation of electronic computing the importance of powerful processors, productive programming facilities, realisation of the importance of information, and the relation between human thinking patterns and the computer, were already present. Perhaps the first person to see beyond the basic uses and conceive the computer as a fundamental tool for transforming human thought and human creative activity was Vannevar Bush. (Preece 1990: 1). In Bush's classic paper of 1945 'As we may think', he foresaw the application of the computer for information storage and retrieval, the value of associative indexing in that activity, and correctly anticipated the multimedia nature of computer use in the future. (Preece 1990: 5).

Computer development originated from a natural desire to account for wealth and possessions resulting from government requirements. Very soon demands changed with increased sizes of organisations and a desire to build calculating machines to improve manual calculation productivity. World war II had a massive impact on the thinking of computer scientists of the day, resulting in great emphasis on research and development. The computers before 1950 were very big with limited programming capabilities. It is interesting that there was no evidence of computers communicating with each other, or networking at this stage. The various computers developed during this period served to expand and to improve the scope for what was lying ahead.

2.3. FIRST GENERATION: 1951-1958

Reviewing the historical development of computers after 1950 becomes difficult. Scientists in virtually every highly civilised country realised the need for these instruments, which resulted in a great awareness of the scientific importance of computers to university and government communities. The earliest and boldest developments during this time were generally in universities and not in the industrial world. (Goldstine 1972: 251).

The Institute for Advanced Study, at Princeton University, started in mid-1946. The so-called "Electronic Computer Project" of the Institute was undoubtedly the most influential single undertaking in computing during this period. (Goldstine 1972: 255). The project consisted of engineering, logical design and programming, mathematical and meteorological groups.

The UNIVAC I (Universal Automatic Computer) was the first general-purpose electronic digital computer to be commercially available. Remington Rand eventually built 48 UNIVAC I computers. (Weiss 1969: 48). This computer marked the beginning of the first generation of electronic computers in 1951. (O'Brien 1982: 17). The first impetus of the information age was felt when these electronic computers reached the market. (Hussain 1981: 5). These first generation computers were bulky and inflexible, used vacuum tubes for memory, required air conditioning, and handled only one program at a time. Programming was done in machine language. (Awad 1988: 55).

On 7 April 1953 the famous IBM type 701 computer was formally dedicated. The machine used electrostatic storage tubes, a magnetic drum, and magnetic tapes. It was developed in two years to meet the challenge of competition. In all, 19 of these systems were built and installed. With these, IBM was launched into a new world of electronic computers. (Goldstine 1972: 328).

Early information processors did not use operating systems because there was no apparent need to do so. Computer hardware was originally of limited capability, with no ability to multi-program or multi-process, even if software had existed to support those features. More important, early computers were not usually operated in what would today be considered a production environment. Often the programs run were one-time jobs, created to solve a specific, non-recurring problem. (Booth 1973: 8).

Heinz Rutishauser, with excellent work both in programming and numerical analysis, invented the first compiler and problem-solving language in 1952. (Goldstine 1972: 337). Unfortunately he was ahead of his time, as it was only several years later that his work was used in writing the algorithmic language ALGOL. (Goldstine 1972: 338).

The development of FORTRAN, Formula Translator System, began in the summer of 1954. It soon became the most widely used higher level programming language. A program of 47 FORTRAN statements could be written in four hours. When it was compiled, it produced about 1 000 machine instructions, and took about six minutes to do this compilation. (Goldstine 1972: 235).

The development of between-job monitors, spooling and interrupts, commenced the process of multi-programming. In the late 1950's and early 1960's, experiments with interactive systems began. Interactive systems are those that provide direct contact between the computer and the individual operating a terminal. Interactive timesharing systems began the evolution towards remotely oriented or geographically-distributed systems. Early transaction-processing systems also developed at roughly the same time. (Booth 1973: 11).

During the first generation of computers, several development projects made a significant contribution to the advancement of artificial intelligence. Markov developed an algorithm for controlling rule execution in 1954. In the late 1950 and 1960's, many programs were written with the goal of solving general problems. The most famous of these was the "General Problem Solver" created by Newell and Simon. (Giarratano 1989: 11). Although the university community was deeply involved in the initial stages of the development of the electronic computer, industrial needs and business developments surpassed university efforts by 1956. Of 44 manufacturers of electronic systems in use in the United States by 1956, only 17 were from the university community, the balance of 27 was from industrial companies. (Goldstine 1972: 326).

By the end of the first generation, major advances had been made to put more power into programming and to move towards systems operating remotely.

Advances in processor technology had a significant impact on the first generation of computers. This generation was also characterised by the increased awareness of the scientific importance of computers to universities. More power was put into programming and systems started to operate remotely. All these drives resulted in the birth of the information age. Parker said that "Since 1950 the United States has been an information society in which more of the labour force has been in information occupations - those occupations dealing with symbols - than in the traditional occupations dealing with materials, energy, and physical services." (Parker 1981: 73). The computers of the first generation were nevertheless still bulky and inflexible, required air-conditioning and had other physical constraints, and could only handle one program at a time. There as also very little communication between computers.

2.4. SECOND GENERATION: 1959-1964

The second generation of computers heralded the arrival of the data processing professionals. It marked the development of high level languages such as COBOL and FORTRAN and the emergence of programmers and analysts. These computers used disk storage for some on-line processing, and symbolic rather than machine language, for programming. During this time transistors replaced vacuum tubes, and magnetic core became standard memory. IBM 1401 was the most popular computer of this era. (Awad 1988: 56).

The need to use data communications to expand information processing capabilities was now generally recognised, but two different approaches were taken in merging communications and information processing. One approach was to attach two communications lines directly to the information processor. The attachment generally consisted of a multi-line controller in what was termed the multi-controller approach. The other approach was to attach the communications line to a separate computer, specially structured for data communication functions, and then to interface that computer with the information processor. The data communications computer was called a front-end processor or network processor, in what was termed the network processor approach.

The multi-computer information processor developed in two different ways. Two separate computer systems, usually of different types, connected via a hardware link, had software that caused the two computer systems to co-operate to achieve common goals. Usually less than that of a particular communication channel, messages from the source can be so encoded that they can be sent over the channel with an error rate less that any prescribed value, however small. (Inose 1984: 28).

Shannon and others have also developed powerful models of information to measure such concepts as signal and noise meaningfully. Without a formal model of information and its associated measures of information, it is difficult to estimate with accuracy the characteristics of transmitting information.(Losee 1990: 1).

3.2.2 Defining data

'Data' and 'information' are often used interchangeably. An assessment should be made of these terms to avoid ambiguity.

O'Brien defines data as "any representation of facts, observations, or occurrences." (O'Brien 1982: 44). Data, in the business environment, can have many forms of representation. The facts, observations or occurrences usually take the form of numbers, words, images, or codes composed of numerical or alphabetical characters or special symbols. (Burch 1979: 4).

Data sources could be either internal, or external to the organisation. External data originates outside the boundaries of the organisation and flow through visual, audio or electronic channels into the organisation. Humans play a major part in converting the external data into a format that would be accepted by the information system of the organisation. The elimination of human intervention with developments similar to electronic data interchange, is becoming more prevalent.

Internal data comprises those elements of facts, observations, or occurrences derived or produced within the organisation that are captured into the information system for further processing. The data can be represented in such forms as lines on a graph or other types of graphic representation, visual, audio or electronic. Data in visual form could be a screen display, or printed data; audio data is represented by sound. Most of the data in the computer environment is represented only in electronic form in the computer.

there was a master/slave relationship with a strong element of specialisation of the function of each computer. The second type of multi-computer consisted of two or more computers linked via some type of hardware interface. Each ran under its own operating system, which might, or might not be identical to the operating systems of the other computer. The computers operated independently, but they co-operated to do whatever processing was required. (Booth 1973: 12).

On the artificial intelligence front the LISP artificial intelligence language was developed in 1959 by McCarthy. Expert systems were further developed by Rosenblatt's "Principles of Neurodynamics" on perceptions. (Giarratano 1989: 12).

The need for data communication was an important driving force in this generation. The front-end processors with connectivity of different processors, combined with improved processing power and memory capacity, made computers more suitable for business applications.

Several accounting applications such as payroll, accounts receivable, and accounts payable were developed. Despite the development of programming during the first and second generation of computers, few realised the potential of software. Each program was unique, and built for specific purposes. There was still no software industry. (Capron 1987: 74). The end of the second generation stood at the brink of a major boom in the programming industry.

2.5. THIRD GENERATION: 1965-1970

At the beginning of 1968 there were more than 50 000 computers, with a total value of 13.6 billion dollars, installed in the United States. (Weiss 1969: 51).

In 1968 the management consultants "McKinseys" reported that of 36 large US and European companies, 30 had already converted, or were about to complete the conversion of, routine administration and accounting operations to computer systems. In a survey in 1969 of 100 UK-based companies claiming to be interested in management information systems and committed to substantial expenditure on computers, it was reported that "most of the systems are predominantly concerned with record keeping and data processing of relatively mundane character." (Whitehouse 1971: 60). Management information was still not a common feature of these systems and the general approach tended to be descriptive e.g., of the 40 manufacturing companies in the survey, 32 cited purchasing and inventory recording, and only 10 order processing, as their main focus.

Third generation computers replaced transistorised circuitry with integrated circuits, which allowed several individual transistors and other components to be mounted on boards. It also featured improvements in the speed, capacity, and types of computer input/output and storage devices, including widespread use of magnetic disk units. Time sharing, data communications, operating systems, high-level programming languages, and minicomputers were other developments in the third generation. Experimental timesharing and networking systems were built in the early 1960s by Bolt Beranek and Neumann Inc. and others. (Preece 1990: 9). In the mid 1960's the development of wide area computer networks, linking machines and users located in geographically remote sites, took place.

During this generation the amount of information expanded rapidly for several reasons. High on the list was the growth and complexity of the economy and the enterprises within it. As companies expanded, merged and diversified, there was a greater need for formal information to keep staff adequately informed. During the period 1900-1965, with the industrial growth of the United States the personnel numbers engaged in manufacturing, occupations increased from 6 million to 17.8 million, and the number engaged in service industries surged from 4 million to nearly 17 million. (Terry 1970: 8).

A second factor influencing the growth in the amount of information was growth in the number of organisational executives that occurred along with the exponential growth in the size of organisations. This increase required the wider spread of information within relatively short periods, and as the managers become more sophisticated in the use of information, they demand more of it. Probably the most conclusive evidence of the growth in the amount of information was the increase in the number of people performing this type of work. In 1870 the percentage of clerical workers to the total workforce in the United States was 2.4%, in 1900 it was 3.7%, in 1940 10.2% and in 1968 16.8%. (Terry 1970: 9). The need to produce the necessary information became a matter of survival rather than just a desirable goal to improve efficiency. (Burch 1979: 42).

There are those who believe that the increasing emphasis upon quantitative techniques of management, the design of systems, and the increase in the number of computers are the basic cause for the growth of information. (Terry 1970: 10).

Developments in the third generation were characterised by increased demand for information. The improvement in speed, capacity, types of input/output and storage devices made it possible to meet this demand. The processors and programming languages developed in the previous generations became better utilised. The need for business applications in all functional areas forced the establishment of major software houses. However, this generation was mainly concerned with record keeping and data processing applications. The maintenance and development cost of systems was very high, and there was a major demand for programmers.

2.6. FOURTH GENERATION: 1970-1980

In the first three computer generations there were major step changes between the different generations. The change-over from the third to the fourth generation computers did not come about because of any significant breakthrough in technology. The development of fourth generation computers was gradual. In total it amounted to significant improvements in design and performance. (Edmunds 1987: 108).

Development began in the early 1970's with the introduction of computers that utilised such developments as large scale integrated circuits with densities of 100 000 components per chip (Awad 1988: 56), micro programming, virtual memory, and the replacement of

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magnetic cores with integrated circuitry for main memory. The speed of processing information by computer was increased by a factor of one million. (Hussain 1981: 5). Distributed processing, data base management systems and the microcomputer were other fourth generation developments. This meant more direct and immediate access to records. Increased availability of minicomputers made it possible to decentralise computer power to the user level rather than centralise it in the traditional computer centre. (Awad 1988: 56).

Software development by software houses was expanding. In a publication of Higgens (Higgens 1976: 207) the author says that "there has been considerable development in the last five years or so in the field of computer packages for corporate, financial and investment planning."

From the mid 1970's a strong movement towards more formal ways of tackling software development emerged. New ways to align programming with accepted scientific methodologies and engineering techniques were developed. Oman quoted Barry Boehm's practical definition of software engineering as: "The practical application of scientific knowledge in the design and construction of computer programs and the associated documentation required to develop, operate, and maintain them." (Oman 1990: 33).

An IBM survey in 1971 of 15 UK companies covering some 20 computer packages, came up with some interesting results. These included frequent requests for flexible reporting in a form readily comprehensible to top management, e.g., graphical output, for interactive modelling, and for user-orientated and relatively simple language to avert the need for the user to spend time learning programming. The needs of the user became a dominant driving force. (Higgens 1976: 212).

An invention of the 1950's called the "direct view storage tube" made low-cost graphics possible in the early 1970's. This provided a tremendous stimulus to the industry. (Preece 1990: 10). The development of the hardware and software supporting graphic applications led to flourishing new applications in mathematics, science, engineering and art. (Preece 1990: 11).

The rate of progress in database management systems was phenomenal. As a result of the significant improvements on both hardware and software, and of an increasing sophistication on the part of the users, there was an increase in the number of USA users of the data base approach from about 100 in 1970 to around 2000 in mid 1975. (Infotech state of the art report 1975: 541).

The development of data preparation equipment lagged behind some other more phenomenal advances made in computing. In 1975, 85% of data preparation equipment in the United States was still based on cards. (Bates 1975: 18). It was in this generation that serious attention was given to the development of key-to-tape in a single and multi station arrangement. There was also a move toward key-to-disk and direct on-line data entry using visual displays. (Bates 1975: 18).

The Xerox Palo Alto Research Centre (PARC), formed in 1971, made several major contributions. A new kind of computer called the 'personal workstation' was developed. This computer was intended for use by one individual. It had local processing power and memory, high-resolution bit-mapping display, a keyboard and a pointing and drawing device called a mouse. The centre also pioneered methods for the local area networking of these workstations to enable users to have both the advantages of personal machines and of sharing resources with other users. (Preece 1990: 17). The Apple Macintosh was the first commercially successful personal computer of the Xerox style human interface. (Preece 1990: 21).

Research in the field of decision support systems began in the early 1970's, first under the term "management decision systems" and subsequently under the title "decision support systems." (Holsapple 1987: 160).

Information processing in the 1970's had gone through an explosion in the use of communications-based systems. This, far more than new "generations" of computer hardware, caused fundamental changes in the way information was processed. Information processing as a whole moved rapidly toward ever greater tiers of complexity. The average computer installation moved toward remotely orientated network-based systems. (Booth 1973: 257). Distributed data processing systems provide the advantages of enhanced performance, reliability, availability, and modularity to an organisation. (Yovits 1988: 122).

Booth summarised the key traits distinguishing the information processing systems of the 1970's and thereafter as follows:

- "they are heavily network orientated
- they have high requirements for integrity, availability, and reliability
- they must support a wide range of users, including many without programming or other computing background ." (Booth 1973: 257).

During the fourth generation of computer development, the development of artificial intelligence also made major progress. With the acceptance of the knowledge-based paradigm in the 1970's, several successful prototype expert systems were created. (Giarratano 1989: 15). In 1970 work began on PROLOG. Other developments included speech recognition, medical diagnosis, and intelligent tutoring. The first artificial intelligence shell, "EMYCIN", was developed in 1973 by Van Melle, Shortliffe and Buchanan. In 1979 the commercialisation of artificial intelligence began. (Giarratano 1989: 12).

Fourth generation computers brought computer power to the end users. Technology improvements such as large scale integrated circuits, data base management systems, packaged application software, graphical user interface, and networking capabilities boosted the use of computers and the proliferation of the production of information. The production of information was no longer exclusively in the hands of the EDP department but moved to the desks of the end users.

2.7. FIFTH GENERATION

The term 'fifth generation' was coined by Japan to describe its goal to create powerful, intelligent computers by the mid-1990's. This revelation of the Japanese when introducing the fifth generation, left the industry scrambling to define what the fourth generation was. (Alter 1990: 67). The developments attached to the fifth generation did not preclude that the fourth generation developments discussed in the previous chapter were not to continue. The result was a merging of the developments of different generations to such an extent that the different generations could hardly be distinguished from each other.

The technologies identified by the Japanese for the "Fifth Generation Computer System" were identified as very large scale integration (VLSI) architecture, parallel processing such as data flow control, logic programming, knowledge-base systems based on relational databases, and applied artificial intelligence and pattern processing. (State or the art report 11:1 1983: 3).

Although the Japanese have identified the fifth generation computers with their super computer project, it has become an umbrella term encompassing many research fields in the computer industry. Key areas of ongoing research are artificial intelligence, micro-computing, decision support systems and office automation. (Awad 1988: 56).

The current age is experiencing an "information explosion". Naisbitt coined a useful expression to describe the dangers that a surfeit of information can bring: "we are drowning in information but starved for knowledge". (Griffiths 1986: 185). The information explosion is evidenced within social and economic organisations. Besides many professional development seminars that are offered, there exist hundreds of periodicals that contain information for every type of skill and profession. There are tons of daily, weekly, and monthly computer reports that reflect all aspects of organisations' internal operations. And there are seemingly an un-ending number of meetings that must be attended in order for the individuals to obtain the information necessary to do their jobs. (Burch 1979: 3).

The most universally obvious sign that the information age is fast growing into maturity is the changing distribution of work across the whole economy. If profiles of the working population are examined, they show that the largest proportion of workers in the developed countries are engaged in some form of information-handling work. Over 70 percent of the workforce of the United States is involved in organisations directly producing information-based services. (Griffiths 1986: 183).

One of the key benefits of micro computing was the focus on development of the man machine interface. The man machine interface is the contact point at which the computer system provides information to managers or at which managers provide data to the computer system. In the early days of computing, human beings had to adapt their way of thinking and operation to suit the requirements of the machine. There has been a considerable shift to greater human-orientation of input/output devices. (Bates 1975: 17). Most experts believe that there were two primary causes of the lack of user friendliness. The first was that the systems analyst and data processing specialist did not have an intimate understanding of the management processes of organisations and therefore was unable to tailor information systems to an organisation's need. Secondly, there was an inability to understand the way the human mind processes information, so that computer programmes did not process the data as users do, and therefore were unable to communicate effectively with users. (Scott 1986: 89).

User-computer interface (UCI) technology developed from the field of cognitive science. In the early 1980's, UCI models were built and tested. UCI progress has had a profound impact upon the design, development and use of information and decision systems. (Advances in computers Vol. 31 1990: 69). Some key developments in the ergonomical aspects of human computer interaction in this era were the start of the journal "Behaviour and information technology" in 1982; seven major conferences held in USA, UK and Europe with attendance ranging from 180 to 1000 with an average of 485 during 1982 to 1984; and the start of the journal "human-computer interaction' in 1985. A landmark event in the consolidation and popularisation of human-machine interface issues was the publication of a book entitled "design of man-computer dialogues" by James Martin. (Martin 1973).

Another major development of the fifth-generation is the field of artificial intelligence. (Edmunds 1987: 109). The news that

PROSPECTOR, an expert system to diagnose minerals, had discovered a mineral deposit worth $100 million, and that XCON/R1, an expert system to configure computer systems, was saving Digital Equipment Corporation millions of dollars a year, triggered a sensational interest in the new expert system technology by 1980. (Giarratano 1989: 15).

The fifth generation had a major influence on the improvement of the user machine interface, the ability of computers to communicate with each other, and the wide distribution of the use of computers. Businesses could no longer survive without information and the effective use of it.

2.8. SIXTH GENERATION

The most specific approach to sixth-generation technology is suggested in a report by Japan's Council for Aeronautics, Electronics, and Other Advanced Technologies, which indicated the need for basic research in such areas as physiology, psychology, linguistics, logic, computer science and other fields, the object being "... to develop expert systems, machine translation systems, and intelligent robots." (Edmunds 1987: 109).

The further development of the user-computer interface dominated much of the sixth generation developments. The use of interactive graphical displays of all kinds will expand, and speech input and output should also emerge as a viable user computer interface technology. (Yovits 1990: 71). Speaker-independent Automatic Speech Recognition by computers of large or difficult vocabularies is still unsolved, especially if words are pronounced connectedly. Several areas of human perception of voice have yet to be explored, and the findings of this research must be exploited for building listening machines. What has been done so far is based mostly on analytical methods, and only very recently have researchers incorporated detailed speech knowledge in their recognition models. (Yovits 1990: 100).

It is safe to say video will become integral to future information and decision support. Information, concepts, and many ideas can be communicated much more effectively via graphic, symbolic, and iconic displays. Systems that do not have these and related capabilities will fail. (Yovits 1990: 73).

Vision is computationally intensive; conventional computers are too slow to perform complex visual tasks in real time. Computer vision systems have a long way to go before they can match the performance of the human visual system, which can recognise objects in a fraction of a second. (Yovits 1988: 307).

Hypermedia is a technique of linking information as text, graphics, sound and video on a personal computer. It allows a more natural way of getting to information through association of ideas. The birth of the hypermedia technology was due to the substantial increase in information, coupled with the inadequate systems for its storage and retrieval. The growth of the hypermedia market in the US is projected to leap to nearly $2 billion by 1997 - up from $155 million in 1989. (Information management report 1991: 9). Several related markets are adding to the expansion of hypermedia, including the rise in multimedia - the use of audio and video with computers - and the increase in the availability of CD-ROM disk drives and players.

Research has already commenced to extend the database concept into the normbase concept. According to Stamper (Stamper 1991: 68) the normbase structures will complete the separation of data management from applications programming, extend the distributed systems concept, and also divide applications programming into a part that focus exclusively on knowledge of the organisation and another upon knowledge of how to exploit the technology. This concept differs from database systems which allowed the unexpectedly difficult task of data structuring to be solved and managed separately from applications programming.

Next generation systems will communicate with systems in other organisations in other parts of the world. Falling costs of satellite communications will permit global linkages and contact with databases, expert systems, inventories, and the like, thereby multiplying the capabilities of in-house systems significantly. (Yovits 1990: 75).

Although computer development has made extraordinary progress in the last forty years there is still much room to improve the capabilities of systems. Although many functions of the "human computer" can already be duplicated or imitated, such as complex calculations and storage of large volumes of data, computers still have major limitations. Currently the limitation of computers is in human skills like intuitive reasoning, associative recall, creativity, recognition of all patterns in written and spoken words, and in the human senses of hearing, smelling, feeling, and tasting. (Hussain 1981: 8). Although computers can produce information, and have come a long way in selecting and acting on appropriate information, society is still suffering from an overload of inappropriate and ineffective information.

2.9. COMPUTER DEVELOPMENT DRIVING FORCES

Change in the computer world was caused by a combination of key forces. Research and development opened up new possibilities. The immediate needs of society at a particular point in time, consumed the ideas of the scientists and inventors to create viable products. Research also created new opportunities to solve new problems. Factors which increased the pressures on researchers to produce better results included changes in the scales of economy, developments in areas like communication, human behavioural research, and electronics and many other disciplines.

During the last forty years, the main forces behind the direction in which computers developed can be summarised as follows:

- The profit motive of a major industry in the world;
- increased processing power of smaller and smaller "engines";
- the widespread use of computers in all areas of life;
- the connectivity of computers throughout the world;
- the storage capacity of data and information for many uses.

The driving forces behind the developments in the six generations discussed, with the major benefits and shortcomings of each phase, are summarised in Table 2.1.

Table 2.1 - DRIVING FORCES

PHASE	DRIVING FORCE	PRODUCTS & BENEFITS	SHORTCOMINGS
Early days 1800 - 1950	- natural desire to account for wealth and possessions - government requirements - increased size of businesses - creative forces to build calculating machines - World war 2 demand for faster computations - research	- replacing mundane tasks performed by humans - adding machines - arithmometers - mass production of data - building of powerful processors - productive programming - relation between human thinking and computer achieved	- limited stored programs - enormous computers - no communication between computers - no networking - limited reliability
First Generation 1951 - 1958	- advances in processor technology - awareness of scientific importance of computers to universities - putting more power into programming - systems to operate remotely	- birth of information age - faster processors - first digital commercial computer - FORTRAN developed - commencement of multiprogramming - experimentation with interactive systems and timesharing	- bulky and inflexible - used vacuum tubes for memory - required air-conditioning - handled one program at a time - programming performed in machine language
Second Generation 1959 - 1964	- cost reduction in accounting applications - need to use data communication - multi processing - transistors replacing vacuum tubes - magnetic core memory - upcoming data processing professionals	- front-end processors and remote communications - symbolic programming languages - development of COBOL - EDP managers move up in organisation - typical applications: payroll, accounts receivable, accounts payable, billing	- little realisation of potential of software - no software industry - management lax in full utilisation of EDP resources - no charge back of EDP costs to users - lack of flexibility
Third Generation 1965 - 1970	- applications in all functional areas - exponential demand for computer use - appearance of software houses - growth in size of organisations and economy	- integrated circuits - improvements in speed, capacity, types of input/output, storage devices - mini computers - Typical applications: general ledger, forecasting, budgeting, inventory control	- primarily concerned with record keeping and data processing - management information not common - high maintenance and development costs - poor documentation - high demand for programmers
Fourth Generation 1970 - 1980	- expansion of information production and needs - complexity of economy and enterprises increased - further growth in number of managers and other users - emphasis on quantitative techniques in management - controlled application development - EDP funds tightened - emphasis on user needs - explosion in use of communication based systems - requirements for integrity, availability and reliability	- significant improvement in design and performance - large scale integrated circuits - micro computers - Database management systems - move towards centralised computing - controls and standards enforced - restructuring of application portfolios - surge of application software packages - greater involvement of users - databases and distributed computing appear - user base expansion	- little inter-organisational communication - dependence on user programming - limited use of micro computers

PHASE	DRIVING FORCE	BENEFITS	SHORT COMINGS
Fifth Generation	- user machine interface - expert systems - networking - distributed processing - client-server technology - communication - wide range user support - graphical developments - human computer interaction	- VLSI architecture - parallel processing - office automation - micro computing for single users and networks - user-friendly packages - decision support systems - experimental work in expert systems - end user computing - graphics	- explosion of information - expectation gap between users and DP departments - technology explosion - user machine interface under developed - expert systems not commonly used - use of advanced technology limited - pressure on capabilities
Sixth Generation	- expert systems - machine translation systems - intelligent robots - cross disciplinary research e.g. physiology, psychology, linguistics, logic etc. - speech handling - vision - world wide communication	- total integration of computers - comprehensive information provider	- intuitive reasoning - associative recall - creativity - hearing - smelling - feeling - tasting - emotion - gestures

2.10. SUMMARY

Computers are making a profound impact on all areas of life. They changed the face of almost all business organisations, irrespective of size. Every business, whether service or manufacturing, traditional or emerging, large or small, must provide for the transition from doing business in an industrial economy to doing business in an information economy. The structural changes that occurred in the economies of the United States and other advanced societies have major implications that affect every business organisation. These include changes in the composition of the work force, productivity, competitive battlefields, and business management philosophies. (Marchand 1986: 1).

Chapter 2 gave a short summary of how the change in the computer industry came about, and what forces caused the change. The historical overview pointed out that the growth in computer technology had been exponential. The impact that computers had on business and the information capabilities of business changed dramatically. It is evident that the process of change has not ended.

An improved understanding of the progress of development of computers and the forces behind the developments leads to an appreciation of the importance of searching for ways to ensure quality information. An overload of information in a society that has not yet come to grips with the use of the most appropriate information suggests a problem to be analysed.

CHAPTER 3

THE NATURE OF INFORMATION

3.1. INTRODUCTION

Chapter 2 discussed the emergence of the information age, and the driving forces behind it. The production of information, although it existed before the 1960's, became a major industry in the past three decades. An increasing number of employees are directly involved in the information service industry. In the 1980's an explosion of information took place. A recent study suggested that the existing volume of data will double 19 times before the year 2000. (Freibrun 1991: 22). This explosion became a major driving force in developing computer technology to improve the management of information. The development of computers over the past four decades gave new meaning to information as a strategic resource for modern business.

The term information is often used to describe a wide variety of activities. This is evident from the meaning of the word "information" according to the American Heritage Dictionary (1987):

- "The act of informing or the condition of being informed; communication of knowledge.
- Knowledge derived from study, experience, or instruction.
- Knowledge of a specific event or situation; news.
- A formal accusation of a crime made by a public officer rather than by indictment by a grand jury.
- A non-accidental signal used as an input to a computer or communications system.
- A numerical measure of the uncertainty of an experimental outcome."

It is necessary to understand more about the nature, use and classification of information before considering what quality information is all about. This chapter will commence by considering the definition of information in a business context and its relationship to data. It will examine the business environment in which information is processed.

After that the use, and users of information will be discussed. Finally the different types and classifications of information will be considered.

After thinking through the nature, use and classification of information, the qualities of it will be considered in Chapter 4.

3.2. INFORMATION THEORY AND DEFINITIONS

3.2.1 Information theory

There have been several attempts at defining information and related terminology. Information theory is important because it illustrates what can and cannot be done, it gives insight into the process of communication, and it gives clues as to how to build better communication systems.

In 1949, an objective model of information was suggested by Shannon, whose work remains the basis for much of the current theory of information. Several researchers based their work on the foundations laid by Shannon. It is not the intention of this study to consider the mathematical theories of Shannon and others, nor to research information theory in any depth, but merely to note the development of information theory. The following is a brief summary of some of the key focus areas of information theory.

Value of information

Shannon relates the value of information carried by a message that a specific event has occurred inversely to the probability of an event. The more information an event carries, the rarer the event will be, and vice versa. Losee used the following example to illustrate this point: "If I tell a friend that I ate breakfast this morning, I am proving little information if my friend knows that I usually eat breakfast. If, however, I inform my friend that I just purchased a car, my friend will find this very informative, because it happens so seldom." (Losee 1990: 3).

Entropy of an information system

The average information or uncertainty contained in a system is called the system's 'entropy'. Entropy has a low value if there is little information in the system. High average information would be characterised by an entropy approaching a situation where all system probabilities are equivalent. (Losee 1990: 10). In the example above, the entropy of the communication system between the two friends will be higher in informing his friend on the car purchase than on having breakfast. The uncertainty has been reduced to a far greater extent with information regarding the car purchase than the breakfast. This resulted in higher average information, and therefore a higher value entropy.

Communication channels

For information to be of use, it must be 'moved' from one point in space or time to another point in space or time, preferably without the information being distorted. Distortion and noise are unfortunate realities. Shannon and others developed formal models describing information travelling through time and space, to allow the making of predictions about what could be expected to happen with the information. This travel through time or space is called a channel. The message originates at the source and is then passed on to the transmitter. The transmitter changes the message into a signal with the capability of being intercepted by the receiver. The receiver's function is to intercept the signal and convert it back into the original message, or something as close to it as possible. The surrogate for the original message then passes to the destination. There is always an element of noise in the communication channel. The relationship between noise and the channel may be formalised based on the probabilities that particular messages are received as transmitted. (Losee 1990: 11).

Measuring the amount of information

Shannon described the amount of information as the amount of choice the sender exercises in generating a message, or the amount of uncertainty by the recipient about what message he may receive. Shannon's elementary measure of amount of information is the bit, a binary choice, such as the uncertainty about whether a flipped coin will land heads or tails. The information rate of a message source, such as speech or text, is measured in bits per message or bits per second. The capacity of a communication channel - even an imperfect channel that sometimes gives errors - can be measured in bits per second. Shannon shows that if the information rate of a particular information source is

Data may be regarded as low-level, elemental, relatively unprocessed information. (Higgins 1976: 1). It could be viewed as the raw material that is processed into the finished product of information.

3.2.3 Defining information

In 1970, the American National Standard Vocabulary for Information Processing of the American National Standards Institute was adopted by the International Standards Organisation (ISO). This organisation defined information as "the meaning that a human assigns to data by means of the human conventions used in their presentation." (Yovits 1990: 328).

Information can also be defined "as data that had been transformed into a meaningful and useful form for specific human beings." (O'Brien 1982: 44). Only when data is in a form that could affect behaviour, does it become information. Information is therefore the result of modelling, formatting, organising, or converting data as raw material into a format that increases the level of knowledge for its recipient. (Burch 1979: 4).

The same set of facts could be insignificant data for one user, and valuable information for another. Information for one user could be the data for conversion into information for another user. The distinction between 'data' and 'information' is not generic to the contents of the elements, but closely related to the interrelationship between the elements and the user.

The definition of information is therefore not absolute, but about the usage and recipient of it. It should increase the knowledge of the recipient to qualify it as information. (Burch 1979: 6).

3.3. PROCESSING INFORMATION

3.3.1 Information as a product

Data is the raw material from which information is created. Invoices are captured at the sales counter of a building contractor by the sales clerk. Various fields are entered, for example customer number, stock item number, and quantity. The computer adds to this data by inserting data such as the discount applicable, the price, description of goods and invoice total. From this data various forms of information are produced such as the customer invoice, debtors ledger, and sales statistics.

Information is the product of a production process to convert the data into a format that improves the ability of the user to act upon it. The invoice, collated by the computer by adding the data collected from the sales clerk and data in its own memory, will assist the customer to evaluate the purchase he has just made. The invoice will produce the data for making financial entries in the ledgers. This data will be added to other data to produce sales statistics, customer accounts, marketing information, and a host of other information that is valuable for various other users amongst whom may be the sales clerk, sales manager, credit controller, business manager, auditor and the financial manager.

The process of converting data into information may be very simple or very complex. An example of a simple process will be to take a list of sales for the day and to calculate the average sales from it. Complex processes are associated with multiple steps of collecting and manipulating data into different types of information. In the example above, where the inputted sales data is converted into information such as accounting, marketing, and other statistics, a complex conversion process would be involved. Where the processing appears to be complex, the complexity can be reduced by further processing into several simpler components. (Burch 1972: 7).

Information produced by one set of data could easily be the raw material or data necessary to produce other information. This adds to the complexity of the processing cycle. An example would be where the average sales of the day are fed into a graphics presentation tool which presents the trend for the month in graphical form.

Information is therefore always a product of a conversion process using data or other information as input into the process.

3.3.2 Stages of production

Several logical processing steps have been identified in the literature to convert data into information. These steps and the processes associated with them are depicted in Table 3.1.

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Table 3.1 - Stages of processing information

PROCESSING STAGES	EXAMPLES OF PROCESSES
input	create, capture, collect, record, retrieve
process	read, classify, write, calculate, compare, verify, summarise, filter, inferencing
output	communicate, transmit, compress, report, reproduce, write, disseminate

(Source: combination of Burch 1979: 8; Avison 1988: 8; Duffy 1989: 7)

All of the data operations identified in Table 3.1 could be performed by individuals using basic tools such as pen and paper. However, advances in technology have resulted in a variety of devices or tools that can be used to perform these operations much more efficiently and effectively. (Burch 1979: 8).

Burch, in his discussion of data processing technologies states that "since a computer executes only the instructions given it, the results of its activities depend entirely upon how good or bad the program is, and on the accuracy and validity of the input data." (Burch 1979: 10). This study will, however, show that the choice between different computer tools, and the specific use of these tools could dramatically affect the quality of the results of processing data, and the product of its "information".

These computer tools will be identified and linked to their characteristics to illustrate their contribution to the enhancement of the production of quality information in Chapter 5.

3.3.3 The information system

Information does not exist automatically. Information can only come into existence after the raw material data elements have been converted into a format acceptable to the recipient. This conversion process takes place in an information system.

According to Murdock, a system of which an information system is an example, is "essentially a group of things that functions together to achieve common objectives." (Murdock 1980: 5).

A system may also be defined as "a set of connected things or parts" or "an assemblage of objects united by some form of regular interaction or interdependencies." (Higgins 1976: 1). Some authorities go further and attribute goal-seeking behaviour to a system. For example, Churchman (Churchman 1968: 5) defines a system as "a set of parts co-ordinated to accomplish a set of goals."

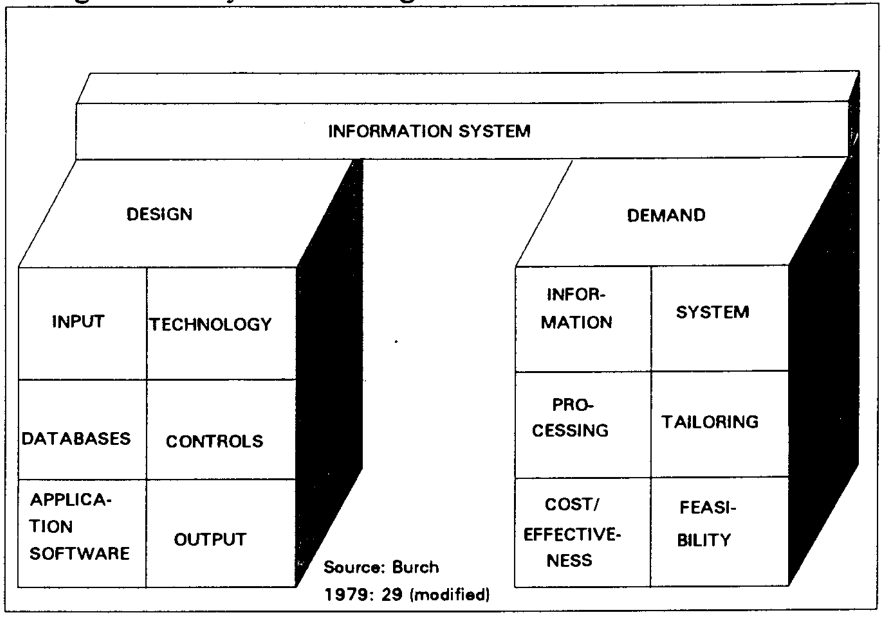
Mallen (Lansdown 1982: 230) summarised an information system as follows:

> "Firstly, an information system must be able to find facts from a range of sources and databases; secondly, it must be able to facilitate the task of putting data together to inform and illuminate different aspects of the situation; thirdly, it must facilitate the tasks of combining data in models or sets of calculations to make projections or answer 'what if...?' type of questions. Fourthly, it must facilitate the communications of data, models, and deductions between users; and fifthly, it should be able to accumulate some record of the uses made of the system so that it might be adapted and refined in the light of experience."

An information system is therefore an organised set of components designed to produce intelligence required for decision making from the captured and stored data. (Hussain 1981: 16).

The total information system in a company is composed of sub systems designed to carry out activities in support of company objectives. The information system strives to serve all departments or operating groups equally and all levels of management equally, as well as external users. (Burch 1979: 27). These information systems must be so designed that they capture and store needed data to be converted into information that is useful to managers. (Murdock 1980: 15). The information system is a formal entity composed of a variety of physical resources divided into various production stages. The production stages could collectively be seen as all of the data processing tools and technologies. It is portrayed by Burch (Burch 1979: 7) as a logical structure in terms of a series of building blocks. According to him the elements of input, processing and output give purpose and meaning to an information system. Burch illustrated that any information system building is constructed with two main sections, the design and demand building blocks. This structure is summarised in Figure 3.1.

Figure 3.1 - System Building Blocks



The data processing tools and technologies are a subset of the design building blocks: input, technology, databases, controls, application software and output. The demand building blocks are derived from the nature and operations of the organisation, its management policy, and the needs of the users. (Burch 1979: 30).

The design building blocks are the components that go into developing, selecting and operating the information system. Before the system can be developed, the organisation must define its requirements. The demands of the organisation stem not only from the information processing domain, but also from fundamental business principles such as cost justification and contractual requirements.

The requirements for information are an important building block in specifying an information system. They will have a major influence on the selection of alternative design building blocks. Burch signified the importance of the different qualities of information, which will be considered in the following chapter, by placing them as the key criteria in the 'information' demand building block. Other demand building blocks include requirements that are related to the characteristics of the system, processing features, abilities to tailor the information system, the cost effectiveness of the solution, and finally, different aspects of the feasibility of the system solution. The detailed components of the demand blocks, as portrayed by Burch, is set out in Figure 3.2.

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Figure 3.2 - Demand Building Blocks

DEMAND BUILDING BLOCKS

INFORMATION	SYSTEM	PROCESSING
Quantifiability Accessibility Comprehensiveness Accuracy Appropriateness Timeliness Clarity Flexibility Verifiability Freedom from bias	Reliability Cost Installation schedule Flexibility Life expectancy Growth potential Maintainability	Volume Complexity Time Computational
TAILORING	**COST EFFECTIVENESS**	**FEASIBILITY**
Filtering Monitoring Interrogative Key variable Modelling Strategic decision centre	Direct cost Indirect cost Direct benefits Indirect benefits	Technical Economic Legal Operational Schedule

(Source: Burch 1979: 30)

The components of the design building blocks as summarised in Figure 3.1 represent the information system based on the criteria of the demand building blocks. Following is a short discussion of the design building blocks.

- The input block represents the data fed into the processing system to be converted into information outputs. Data can move through several conversion processes, and various methods can be identified to move data from its original source into its final stage before information creation.
- The technology block is composed of the processors, its peripheral equipment, communications and the operating software to control the computer. This is the kernel of the information system.
- The data base block is a repository for all data of interest and value to the users of the information system. This could represent a logical or physical grouping of files.
- The controls block represents a very important component of the information system. Several types of controls can be identified: input, processing, data base, procedural, output, documentation and security controls.
- The application software block represents all the application programs, modelling systems, and other software that make the information system functional to the user.
- The output block directly relates to the production of the information results to the user.

When making a judgement whether a system is good or bad, effective or ineffective, efficient or inefficient, the components of the design blocks are evaluated against the requirements of the users. These requirements are formulated and designed on the basis of the demand blocks. (Burch 1979: 29).

The information system is the factory producing information. This study aims at concentrating on the impact that the information system has on the quality of the information it produces. The components of the information system as represented by Burch, will be used as the departure point for scoping the computer tools and equipment involved in producing information. This focus will be taken further in Chapter 5.

3.3.4 Organisational influences

There are several factors that affect the nature of information in a specific organisation. These factors will affect the approach to information management, information requirements, types and complexities of information, and processing requirements. The five main factors identified by Burch are summarised in Table 3.2.

Table 3.2 - Factors affecting nature of information

FACTORS	EXAMPLES
External pressures	• government regulations • competition • advances in technology • changes in nature of information
Purpose	• airline/manufacturing/real estate
Size	• large organisations require more formal information requirements • segmented business requirements • dissemination of information
Structure	• degree of centralisation • organisation • divisionalisation
Management philosophy	• budgeting • cost management

(Source: Burch 1979: 42)

Each of the above factors in an organisation could affect various aspects of the nature of information. A combination of these factors could further complicate the information requirements. Although organisational influences could affect the perceived quality of information, this study does not intend to concentrate further on this aspect. It will concentrate mainly on the information system.

3.4 INFORMATION USERS

The sole purpose of producing information, is to use it. Without users, information has no meaning or purpose. To understand the nature of information it is necessary to consider the users and the influence it may have on the information content. In the following paragraphs the style of usage, different types of users, their preferences and some typical user responses will be considered.

3.4.1 Styles of usage

Decision makers rarely use all the information available. Instead, they search through the available information and pick out those messages (i.e., bits of information) that are of interest to them. Individuals use different patterns in making this search. For example, when the task is to judge the performance of a responsibility centre, some individuals habitually compare information about that responsibility centre with performance information from another, presumably a comparable responsibility centre, whereas other individuals compare performance with information stored in their own memory as to what constitutes acceptable performance.

Individuals differ in the way they use information. These are differences in decision making style. Some view the problem in its totality; others divide it into pieces and reach a conclusion on each piece. Individuals also differ as to the amount of quantitative information that they habitually use. Some people like to work with numbers, others prefer non-numerical statements. Even for heavily "numbers-orientated" people there is an upper limit to the amount of information they can absorb. If confronted with a mass of information that exceeds this limit, they may be unable or unwilling to use any of it. This condition is called information overload.

Individuals sometimes tend to request more information than they need. This is because the real state of the environment is unknown and the real validity of the information is uncertain. The information processor often does not know what information is relevant.

Individuals also differ in respect to the amount of time they spend using information to solve a given problem. In part these differences reflect differences in the quantity of available information and the complexity of the problem that is being addressed. In part, however, they depend on the individual's own preferences, developed from experience. These preferences can change in time as an individual learns better information processing methods. (Anthony 1980: 128).

3.4.2 The users

There is a wide variety of information users in any organisation. Traditionally management is represented as being separated into a number of levels depending on the significance of the decisions in the organisation. The quality of managerial decisions is related directly to the information available for decision making. (Burch 1979: 49). Decision making can range from making very routine kind of decisions to complex ones that have a significant impact on the system.

Managers are both vital consumers and producers of information. As producers of information, managers are an integral part of the information system. As consumers of information, managers are key users of the information system. Managers have personal characteristics that influence their attitudes toward information systems, their information needs, and the way in which they interact with systems.

(Scott 1986: 25). The use of information is viewed as the key ingredient of the power and authority associated with a manager in performing job functions. (Burch 1979: 47).

Management styles and approaches have a direct impact on the depletion of information during the production thereof. Typically the levels of management are associated with the complexity of decision making. Different information requirements are also associated with these levels. The following management levels use information:

- Senior Managers and Planners, who represent the organisation's leaders and long term planners, are responsible for the strategic decisions in the organisation. Strategic decisions are characterised by a great deal of uncertainty and are future-orientated.
- Middle Management, which is made up of all those leaders responsible for yearly planning and leadership, is usually responsible for tactical decision making related to short-term activities and the allocation of resources for the attainment of the objectives.
- Operational management, which represents all those responsible for the month-by-month planning and leadership, and the supervisors who are concerned with the day-to-day leadership, are involved in technical decision making.

The different levels of management and decision making, have different information requirements. These requirements are summarised in Table 3.3.

Table 3.3 - Levels of decision making

DECISION MAKING LEVEL	INFORMATION REQUIREMENTS
Senior managers & planners: Strategic information	• special requests • substantiation for decisions • trends • highly summarised reports • external information
Middle management: Tactical information	• feedback on operational performance • control of cost, quantity, inventory • plans to be followed • reports on operations
Operational management: Technical information	• performance • measurements • statistics • schedules • transactions • work instructions

(Source: combination of Terry 1970: 6; Burch 1979: 53; Dyer 1988: 7)

3.4.3 Information format preferences

The format in which information is presented to a manager can greatly affect how efficiently the manager uses information. It has been established that financial information presented in graphic form is more readily assimilated and understood by most managers than the same information presented in the form of tabular financial statements. According to Scott, graphics is an aspect of information systems that is now receiving extensive attention. (Scott 1986: 24).

Different types of managers react better at arriving at conclusions when they are presented with different types of information stimuli. Table 3.4 summarises the information formats preferred by different managerial groups.

Table 3.4 - Information format preferred

MANAGERIAL GROUP	PREFERRED INFORMATION FORMAT
Accountants	financial tabulations and statements
Financial managers	charts and financial tabulations
Engineers	graphs
General managers	narrative descriptions
Attorneys	narrative briefs in case form
Management scientists	mathematical problem formulations and models

(Source: Scott 1986: 24)

3.4.4 Typical user responses

The reaction of users to the information received is a barometer of the value of that information, and of the success of the information system. If the information is well received and fully used for decision making, it is an indication that the information system was successful in providing appropriate information to the user. On the other hand, an inadequate information system will evoke negative responses from the user.

A summarisation of some typical user responses to inadequate information systems as portrayed by Shackel is detailed in table 3.5

Table 3.5 - Typical user responses to inadequate information systems

RESPONSE	MEANING	COMMENTS
Disuse	Reliance on and 100 per cent use of other information	Needs other sources
Misuse	"Bending the rules" to shortcut difficulties	Needs "know-how". May damage system integrity
Partial use	Use of limited subset of system capabilities	Users may not learn to use the most relevant facilities
Distant use	Use delegated to an operator	Typical response of managers to bad usability
Task modification	Changing the task to match the capabilities of the system	Typical for rigid tools and unstructured problems
Compensatory user activity	Compensation for system inadequacies by additional user actions	Typical with users of low discretion, such as clerks
Direct programming	Programming by user, to make system suit needs	Computer-sophisticated user, e.g. scientist or engineer
Frustration and apathy	Response of users when above actions are inadequate or unsatisfactory	Involves lack of user acceptance, high error rates, poor performance

(Source: Heaton 1988: 102)

3.4.5 Conclusion on role of users

There is no doubt that users have a major impact on the nature of information. Users are involved in the definition, collection, recording, processing and interpretation of information. It can be argued that quality information has two main components - the production system on the one hand, and the recipient on the other hand. In formulating the focus of this study serious consideration was given to analysing the role that users have in processing quality information in depth. This would have entailed researching aspects such as those briefly discussed in the previous paragraphs, in depth. It would also have had to focus on other disciplines such as psychology and other human behavioural sciences. It was decided not to include any further research on the effect of users on information in this study. Studying the effect of information systems is a self contained unit, and the results of the study will achieve its aim without branching out into the user area. In addition, the overview discussion of information users in the previous paragraphs is sufficient to appreciate that another dimension of information exists.

3.5 CLASSIFICATION OF INFORMATION

Many classes of information are found in an organisation. The information could be written or verbal, from within the organisation or from external sources. It could also be accounting, operational, statistical, numerical or text information. The various classes of information can be grouped together to enable a better understanding thereof. Burch submitted that no universally accepted classification scheme of information suitable for all situations exists. (Burch 1979: 43).

A classification of information was compiled from the literature, and a discussion of the different classes of information is included as Annexure A. Such a classification of information facilitates a better understanding of the nature of information in business. Each category of information identified relates to a particular view or relationship of information. Depending on the perspective from which information is being viewed, different characteristics and categories can be identified. Table 3.6 summarises the different types of information detailed in Annexure A.

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Table 3.6 - Classification of information

RELATION	TYPE	CHARACTERISTICS	CONTRA TYPE	CHARACTERISTICS
relation to organisation	internal	• flows from within organisation • most important for business • format determined by organisation • used by operational management	external	• flows from economic, political and environmental arena • written, visual, verbal, and electronic • used by top management
relation to system	systematic (also known as formal)	• flows through formal system • source of all reports • only valid output of formal information system • used by operational and middle management	non-systematic (also known as informal)	• verbal transmission • personal observation • personal experience • used by top management
relation to objectives	action (also known as active)	• directed to induce user to act • either immediate or postponed action • e.g. order from customer	non-action (also known as passive)	• indicates that some action has been carried out • e.g. acknowledgement of dispatch of goods
relation to frequency	recurring	• regular interval reports • used by operational control	non-recurring	• occasional, special reports • used by senior management and strategic planners
relation to content	quantitative	• common in business • all accounting information is quantitative	non-quantitative	• verbal • descriptive • impressions
relation to perception	audio	• based upon hearing senses • not yet widely used in business environment • much potential for future development	visual	• based upon visual senses • paper • display
relation to timing	historic (also known as past)	• drawn from past events • used to develop standard of performance • basis for future projections • used by financial accountants	projected (also known as future)	• forecasts, planning, budgets, and projections • represents expectations of organisation • used by senior managers and planners

3.6 SUMMARY

Although exact definitions and classifications of information are somewhat illusive, it is clear that information is a key resource in any business, and is critical for the success thereof. Knowledge of the business and its environment is totally dependant upon the information produced by the information system. Without information the management of an organisation will not be able to make sound decisions. The organisation, and its personnel, will determine its own view of what data in their environment must be processed into information to add to understanding and provide the basis for decision making for management.

There is a wide variety of information types and characteristics, each highlighting different perspectives of the organisational and user needs. Information has different formats and uses, and elicits many responses from its users. The information is sometimes appropriate and sometimes not. The mere production of information will not deliver the required results if it does not comply with the requirements of the users and their expectations. It is therefore necessary to confirm, when information is valuable, how to ensure the production of quality information.

This chapter aimed at forming an appreciation of the nature, use and classification of information. With a clear understanding now of what information in business is all about, the study can continue to consider what constitutes quality information.

CHAPTER 4

DEFINING ATTRIBUTES OF QUALITY INFORMATION

4.1 INTRODUCTION

Chapter 3 discussed the nature of information, the environment in which it is produced, and presented different classifications of it. It was made clear that information aims at increasing the level of knowledge of the decision maker, at improving his understanding of specific situations, and of enhancing his ability to act appropriately. The bid to define information was met with observations of the elusiveness of information. Mention was made of the many facets of information. Scientists are yet to refine the description of information.

Information is nevertheless very real. It does exist; it does make a difference in decision making; it does have value; an ever increasing part of the economy of the world is being spent on producing and controlling it.

Throughout the preceding chapters reference was made to the quality of information without considering its significance. This chapter will consider information as usable or non usable, valuable or not valuable and come to agreement on what is quality information. To illustrate the value of information, take the example of the manager of a bakery, who might observe one morning that no customers are coming into his shop. By obtaining information, either from the customers, his own observations, or from his employees, he could improve his understanding of his problem, and react appropriately. He could ask one customer, obtain information from him, and react to it; or he could obtain several pieces of information from other varied sources, and therefore improve the relative quality of the information that he could rely on to improve his understanding.

This chapter aims at identifying those attributes of information that make them more valuable to the recipient. The chapter will commence with a discussion on the value of information and how to measure it; it will then consider the perspective of several authors on the attributes of quality information; finally it will reduce those attributes identified to main and contributory attributes. The main attributes of quality information will be those that users seek most in evaluating an improvement in information quality.

4.2 VALUE OF INFORMATION

4.2.1. Information as a resource

The lifeblood of any organisation is the flow of intelligence, information and data. This "plasma" moves along channels from point to point through the interrelated network of the operating elements of the organisation. This flow of data is a continuous record of the status of all the pertinent elements that affect the survival and growth of the organisation. In the 1970's 'Information Resource Management' originated in the United States. The importance of managing information in essentially the same way as other resources is stressed in this focus. (Eaton 1991: 159)

This focus should be seen against the backdrop that quality information is a scarce resource although it sometimes appears that information is in abundant supply in this era of surplus information. According to Terry information "is not only man's greatest tool, but also one of his greatest needs." (Terry 1970: 3) Traditionally it was believed that the cornerstones of an economy were land, labour, and capital. Capron, in his book "Computers: tools for an information age," believes that these three key elements have expanded to four: land, labour, capital, and information. (Capron 1987: 4)

According to Olaisen "the growing awareness that information behaves as an active economic resource like capital, plant, or human resources have focused attention on how to manage information as a strategic resource." (Olaisen 1990: 194) Eaton, on the other hand differs from the advocates of "information as a resource." (Eaton 1991: 156).

According to him the idea that information is a resource, and should be managed like other resources (land, labour, etc.), could lead to the adoption of inappropriate, and potentially harmful, resource management models for managing information. Eaton stresses that information has properties that clearly distinguish it from other resources. These properties include the differences in the nature of the exchange of information from other commodities. Information is not lost by transmitting or parting with it. The usual means of control of resources such as legal protection, secrecy, and monopoly are inapplicable to information. The very use of information is bound to reveal it, at least in part.

Cleaveland gives a clear account of the unique, indeed paradoxical, qualities of information that are summarised below:

- Information is expandable, it increases with use;
- Information is compressible, able to be summarised, integrated, etc.;
- Information can substitute for other resources, e.g., replacing physical facilities;
- Information is transportable virtually instantaneously;
- Information is diffusive, tending to leak from the straight jacket of secrecy and control, and the more it leaks the more there is;
- Information is sharable, not exchangeable, it can be given away and be retained simultaneously. (Cleveland 1982: 39).

Connel (Connel 1981: 78) attempted to demolish the ideas of information resource planning with the argument that although information may be regarded as a resource, an asset, or a commodity, it cannot be managed in the same way as other resources. According to him: "If information is not a resource on its own, then, what is information? It is brain food. It is the feed stock used in the intellectual effort of managing other resources. How it is used depends on the user. How it is defined must also depend on the user, if it is to have value in his own eyes."

Eaton continues by identifying five key distinctions between information and traditional, tangible resources. (Eaton 1991: 163).

"1. The value of information can not easily be calculated. Its value depends on its contents and its use by particular users.

2. Consumption of information reacts differently from other resources. It is not lost when it is given to others, nor does it diminish when used.

3. Information cannot be regarded as a static resource to be accumulated and stored within the confines of a static system.

4. Information can have multiple life-cycles as ideas come into, move out of, and finally come back into fashion. Demand for information can be extremely variable, which sometimes makes forward planning and marketing a difficult exercise.

5. Information comes in many different forms and is expressed in many different ways. It takes on any value in the individual situation."

Eaton closes by saying "We can agree, then, that information is a resource, in the sense that is very important to organisations, by virtue of its importance to the individuals within them. But it is a resource qualitatively different from others: Much more distinct from tangible resources listed earlier, that any of them is from each other. If any parallel can be drawn, it is perhaps between the information resource and the intangible aspects of human resources: enthusiasm, commitment, openness to change, etc." (Eaton 1991: 165). On the other hand Burk concludes with "too much is sometimes made of the need for something to be a tangible 'thing' for it to be recognised as a resource." (Burk 1988: 21).

Information can thus be regarded as an intangible resource similar to a process, trademark, patent, or skill-level of a work-force, with all the difficulty in expressing its value in monetary terms. (Burch 1979: 13). It is a resource to be protected and cherished for the survival of a business.

4.2.2. Value of information

There are different views on the value of information. Information can have a value, because of the cost of producing it. Its value may lie in the contribution it makes to arrive at sound decisions. Value can also be linked to the savings or return on investment achieved because of the information. (Burch 1979: 13). As discussed in Chapter 3 information theory had as one of its goals, the development of models to evaluate information. In this section information value theory will be taken a step further.

Chapter 3 pointed out that information has value in decision making. If information has value, it suggests that information is a phenomenon that results in an increase in economic benefit to the decision maker. Decision theory suggests that the action with the maximum benefit should be taken, or, more simply, that one should do what will be of greatest benefit to oneself. The expected benefit of a decision may be computed as the average benefit of the possible choices. For example, It one takes an umbrella and it rains, taking the umbrella might be judged to have been worth R5, while if it does not rain, the burden of carrying the umbrella might be considered to have been -R1. Given a 40% chance that it might rain, the expected benefit of taking an umbrella as one travels outside is computed as the sum of the probability that it will rain, times the benefit of having the umbrella and the probability that it will not rain, times the cost of carrying the umbrella.

EB(umbrella) = Sum Pr(rain)B(umbrella,rain)
= R5 x 0.4 + (-R1) x 6
= R1.40

Because there is a positive expected benefit associated with carrying an umbrella in these circumstances, the umbrella should be taken. (Shannon 1949: 41).

According to Shannon information about the expected weather conditions could have some economic value for a decision maker who had to make a choice of taking the umbrella. In the case of the example, the economic value was R1.40.

In a paper "Decision making and the value of information" by Ahituv (Galliers 1987: 28) the author says: "any attempt to assess the value of information should be closely tied to the decision supported by the information. In other words, information does not have an absolute universal value. Its value is related to who uses it, when it is used, and in what situation it is used." Although the author attempts to arrive at different approaches to the valuation of information, he concludes with: "We could not arrive at clear-cut conclusions, definitions, terms, and practices regarding the value of information." (Galliers 1987: 3). According to Hall, in "The economic nature of information," simple, reliable, general accepted measures of the value of information simply do not exist. (Hall 1981: 161).

The question of value becomes dynamic, involving a fluid interaction between many variables: it becomes not merely the result of any given stage of the information cycle, but the product of an accumulation of decisions involving the entire range of the information flow process. In such a situation, value takes on a dynamic quality of it own. (Black 1981: 198). The value of information, which is used to reduce variety or decrease uncertainty for a decision making process, is often decided in an arbitrary but rational manner that considers the cost of the resources to be affected by the decision. The value could be considered equal to the cost saving in performing a specific task, due to the actions taken by the recipient, following the reception of the information. On the other hand Burk writes that values of information relate closely to information (quality of information, utility of information holdings) and to the impact of information resources on particular organisational attributes (productivity, effectiveness and financial position). (Burk 1988: 92).

The value of information can often be decided by answering the question: How much is the information worth to the recipient? The value of the information is measured in terms of the additional knowledge it gives the recipient. When information does not add any value for any recipient, it does not imply that it has no value, because the same information can add value for another recipient. It could even add value for the same recipient in other circumstances when combined with other information.

Although the exact value of information is illusive and uncertain, it is sufficient for the purposes of this study to conclude that information has value, and that the value of different pieces of information might differ.

4.2.3. Information cost

No information exists without a cost associated with its production. The cost might not be incurred by the organisation, or the recipient using it, such as information produced externally to the organisation. The preparation of formal information requires a considerable investment in other resources such as people, machines and supplies. Many traditional staff functions such as accounting, market research, and various other analytic and clerical groups exist within an organisation for the sole purpose of producing information.

As a percentage of total organisational expenses, the cost of producing information ranges from less than 1 percent, to more than 50 percent. (Burch 1979: 13). Technological developments continue to improve the price/performance ratio of computers, while wage rates continue to escalate.

Usually there is a relationship between cost and price. The price of most goods is decided by the interaction of supply and demand. Supply reflects the cost of production and demand reflects the relative subjective value of the goods. Although the cost of the information might be calculated, it does not reflect its price. The price of many kinds of information may only reflect the value of searching and distribution costs, and not the cost of the process of producing it. Price is also not an accurate reflection of the relative value of information. (Hall 1981: 161).

When formal information is identified as required or necessary, its value is sometimes equal to the sum of the costs incurred in producing it. (Burch 1979: 16). Optimising the value of this type of information is equal to minimising the cost of production. Even if information may cost a considerable amount to be produced, it may have no value, either to the corporation as a whole or to an individual recipient.

The same set of information may have opposite values for different recipients. An expensive in-house system that produces information on the sales trends in the motor industry will have very little value for an organisation that has nothing to do with motorcars. Although the cost of this information could be considerable, its value is negligible for this organisation. On the other hand, information on the sales trends in the motor industry could have value for the manager in control of the vehicle fleet of the organisation, but no value for the production manager in the chemical plant.

Attributes of information that have no relevance to the cost of production may cause a set of information to be very valuable in a particular set of circumstances, and in other circumstances to have no value. The cost of producing timely information to a stockbroker, might make the information very valuable to him. The same cost incurred might has very little benefit to the share trend analyst only interested in the historical movement of shares.

Therefore, there is not necessarily a direct relation between the cost and value of information, nor between cost and price.

4.2.4. Quality and value

Information has been defined in the previous chapter as "data made meaningful." Quality information can thus be regarded as a set of information that has more value to one recipient than another set to another user because of the attributes of that particular set of information. According to Davis, "quality" is not an absolute concept; it is always defined within a context. Information will only have quality if it is of value to its primary and secondary users. (Davis 1985: 604).

For information to have any value, it must have a certain quality. By improving the quality, value may increase, or decrease. If the value of the information is measured in terms of the cost of producing it, improving the quality could result in additional investment and therefore increase the cost of producing the information. This will result in a decrease of the value of that particular set of information, although the quality might improve dramatically.

When value is measured in terms of the contribution that the information makes to better decision making or improved savings, an improvement in the quality of the information will usually increase the value of the information.

The value and quality of information are therefore not synonymous. It depends on the method of deciding the value of information.

Information can be produced in a such a way that it can increase the level of knowledge more than if it were produced in a different way. The quality of information therefore depends on the measure of impact that the information will have on the knowledge levels of the decision maker.

4.3 SURVEYS AND DISCUSSIONS OF QUALITY INFORMATION

It was evident from the literature reviewed that several authors considered that information has different attributes of quality. The term "quality" is used abundantly. The lack of consensus of what these qualities are is however, significant. Not less that sixty-one different adjectives were found in the literature used by authors to describe qualities of information. The adjectives are listed in Annexure B.

The remainder of this section summarises the views of different authors on quality.

4.3.1 Burch (Burch 1979, 1986, 1988, 1989)

Burch developed some aspects of the quality of information. His work has gone through five editions, which have changed from one to the other.

Burch identified various functions of information. The first function he identified was "to reduce the variety of choices and the uncertainty related to these choices" (Burch 1979: 6). Information can provide probabilities and possibly a series of choices at different levels. Information does not direct the decision maker in what to do. However, it should reduce the number of alternatives and revise the probabilities attached to the alternatives.

In Burch's endeavour to quantify the value of formal information, he identified the following nine attributes in the second and third editions of his book:

- Accessibility. This attribute refers to the ease and speed with which information can be obtained.
- Comprehensiveness. This attribute refers to the completeness of the information.
- Accuracy. This attribute pertains to the degree of freedom from error of the information. The errors referred to are errors of transcription and errors of computation.
- Appropriateness. This attribute refers to how well the information relates to a user's request.
- Timeliness. This attribute relates to the elapsed time of the cycle, input, processing, and reprinting of output to the users.
- Clarity. This attribute refers to the degree to which information is free form ambiguity.
- Verifiability. This attribute is a relative concept. It refers to the degree of consensus arrived at among various users examining the same information.
- Freedom from bias. This attribute means the absence of intent to alter or modify information to influence recipients toward reaching a particular conclusion.
- Quantifiability. This attribute refers to the nature of formal information produced from a formal information system. (Burch 1979: 17; 1983: 6).

Although Burch identified "flexibility" (is the information adaptable for use by more than one user?) in the second edition, this attribute was replaced by "precision" (the measurement detail used in providing information) in the third edition.

Burch changed his approach to quality information in the fourth and fifth editions. He reduced the list of attributes and depicted quality information to rest solidly on three pillars - accuracy, timeliness, and relevancy. (Burch 1986: 5; 1989: 6).

4.3.2 Davis (Davis 1985)

Davis defines quality as "excellence or fitness." (Davis 1985: 604).

Davis identified the characteristics of quality in information systems as listed below.

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Table 4.1 - C

QUALITY CHARACTERISTIC	IMPLEMENTATION OF QUALITY CONCEPTS
Complete data	All data items are captured and stored for use. Data items are properly identified with time periods.
Accurate data	The correct data values are recorded
Precise data	Measurement of variables meets user needs for precision
Understandable output	The output of the system is understandable to the users.
Timely output	The output of the application is available in time for actions and decisions.
Relevant output	The outputs are relevant to the actions and decisions to be taken
Meaningful output	The format, labelling, data provided, and context in which data is presented makes the output meaningful for actions and decision making.
User friendly operation	The system provides user interfaces that are understandable and designed to conform to human capabilities
Authorised use	Suitable error prevention and detection procedures are in place. There are procedures for reporting and correcting errors. Various audit procedures are applied.
Protected system and operations	Only authorised personnel have access to facilities, applications, and data. The system and its operations are protected from various environmental and operational risks. There are provisions for recovery in the event of failure or destruction of part or all of the system.

(Source: Davis 1985: 605).

Davis considered the above characteristics as a selection of some items to be included in the concept of quality in information systems. He did not consider the attributes of quality information.

4.3.3 Dew (Dew 1973)

In a research study done by Dew in 1973 to assess the use of control information by middle management in manufacturing companies, it was found that as much as 46 percent of the control information produced was not used. (Dew 1973: 43). This information was regarded by the line managers as irrelevant, or at best as simply background information, sometimes but not necessarily, of any interest.

The reasons for non-use were found to be:

- Obsolescence.
- The subjects on which the information was provided were outside the control of the managers.
- The information that was provided was insufficiently detailed to be helpful.
- The information was considered inaccurate.
- The information was not presented in a form that could be readily understood. (Dew 1973: 48).

Dew came to the conclusion that information for middle management was largely wasted where there was no firm grasp of essentials by higher management. At top management level, the successful management was not necessarily the one that was equipped with the most sophisticated apparatus and the most advanced management techniques, but the one that succeeded in retaining a clear view and a firm grasp of fundamentals.(Dew 1973: 87).

4.3.4 Duffy (Duffy 1989)

Duffy refers to an ongoing poll of some 1695 managers and equivalents at all levels to perceive the quality of the information they receive. Table 4.2 reflect the results of this study:

Table 4.2 - Perceived quality of information

The information received is:	frequency %
too much	10.2
too little	22.7
of dubious accuracy	20.2
too late	23.9
not relevant	9.0
poorly presented	10.2
inaccessible	0.6
subject to some deficiency	1.1
just right	2.3

(Source: Duffy 1989: 5).

The major deficiencies perceived in this study were that the information received was too late, too little or of dubious accuracy. Virtually none of the managers was satisfied with the information received.

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4.3.5 Black and I

In their article "Assessing value of information in organisations" (Black 1981), Black and Marchland identified some attributes associated with the quality of information.

Errors in the transmission process could be due to bias or variability. Systematic bias in the transmission channel, i.e., the manipulation of information for ideological viewpoints, might severely skew both the frequency and contents of information signals. Unintentional errors in data gathering and analysis are examples of variable errors in information systems.

Other attributes identified include 'decision-relevance': information is relevant if it changes a decision; 'timeliness and accuracy'; its 'diffusion or scarcity'; its 'applicability and its contents'. (Black 1981: 213).

4.3.6 Anthony (Anthony 1980)

Anthony (Anthony 1980) considered those aspects that should be controlled in providing information. He identified "improving the clarity of the message, filtering out non-relevant information, and improving the precision of the information as key criteria." (Anthony 1980: 127).

4.3.7 Robinson (Robinson (1991)

In a very interesting research study and article by Robinson "Measuring the bottom line impact of decision support systems", the author examined the factors that decide the performance of a knowledge worker.

His hypothesis was "that the performance of a knowledge worker can be enhanced by support systems which increase his value by increasing the value of the outputs he produces." (Robinson 1991: 24).

Robinson considered the knowledge worker's performance by measuring his efficiency and effectiveness. The worker's efficiency was directly related to the ability to deliver on schedule and on priority. On the other hand, effectiveness was dependant upon reliability, available information, timely information, the degree of integration, the acceptance of support systems and quality of output. (Robinson 1991: 30).

Robinson arrived at seven value-added factors related to the Decision Support Systems (DSS) needs analysis cycle that enhance the knowledge worker's performance. The findings are shown in Table 4.3.

Table 4.3 - Value-added factors related to DSS needs' analysis.

VALUE-ADDED FACTOR	VALUE ENHANCEMENT TASK	DEVELOPMENT PHASE
on schedule	. identify system requirements . automatic time-sensitive functions . determine optimal schedule . graphics user interface . maximise information content	needs analysis decision analysis decision analysis rapid prototyping rapid prototyping
on priority	determine highest priority task concerns	decision analysis
judgement reliability	provide access to key data	data analysis
information availability	support decisions	decision analysis
degree of integration	integrate with existing applications	technical analysis
acceptance	system acceptance	operational analysis
output quality	make the right decisions	decision analysis

(Source: Robinson 1991: 32).

Although Robinson does not make the link between the value-added factors related in the needs analysis of a decision support system and quality information, it is evident that these factors strongly relate to the quality of the information that will be produced from the Decision Support System developed.

4.3.8 Nichols (Galliers 1987)

Nichols, in a paper "On the nature of management information," (Galliers 1987) summarises the attributes of information as follows: (Galliers 1987: 12).

"A partial list of desirable business information attributes is: Relevance, availability, timeliness, objectivity, sensitivity, comparability and quality . . . information must possess the first three attributes - relevance, availability, and timeliness - to have value and thus to qualify as information. Objectivity, sensitivity, comparability, conciseness, and completeness are desirable, but they are present and necessary only in varying degrees . . . The last attribute, quality, refers to the presence or absence of ambiguities in information. All information should possess 'quality'. Measures of quality are validity, accuracy, and precision."

4.4 IDENTIFYING THE MAIN ATTRIBUTES

The attributes of quality information identified in the literature review have been considered in the previous section. Most of the authors referred to 'relevancy', 'accuracy', and 'timeliness' being important. Several other adjectives relate to these. The adjectives associated with these are listed in Table 4.4.

Several adjectives relate to the ability of the user to understand and work with the information. Although the ability to comprehend the information is closely associated with 'relevancy', there is a distinct difference between the two. 'Relevancy' has to do with the content of the information. 'Comprehension' has to do with the interface between the user and the information. No single concept was defined in the literature as the dominant collective term for the attributes referring to these two aspects. For the purposes of grouping all these adjectives together, "comprehensibility" is used.

The four main attributes: relevancy, accuracy, timeliness and comprehensibility, and the other adjectives associated with them are summarised in Table 4.4.

Table 4.4 - Attributes of quality information

MAIN ATTRIBUTE	SUB ATTRIBUTES	
relevancy	sufficient detail not too much not too little comprehensive appropriate closeness to problem flexible support decisions authorised degree of integration complete	ability to manipulate acceptable accessible available adaptable ease of access pertinence meaningful fitness selective
accuracy	limited noise verifiable precise freedom from bias	credible reliable valid
timeliness	at the right time not too late on priority	current on schedule out of time
comprehensibility	readily understood adequately presented clarity reproducible understandable output	ease of use output quality quantifiable simplicity user friendly

The significance of the main attributes will be discussed in the following paragraphs.

4.4.1 Relevancy

Information is constantly accumulating, having reference made to it and being stored. It can be a Frankenstein monster if not controlled. Too much in store can be self-defeating, but too little causes the decision makers and problem solvers to operate without true knowledge of what they are doing. To be kept under control, information must first be analysed and categorised to ensure useful benefit to all potential users. According to Whitehouse information is knowledge; rapid and easy access to the right knowledge is intelligence. (Whitehouse 1971: 2). It must be available in sufficient detail to meet the needs of the user.

All information progresses from new to old and will be lost if not consciously preserved. Too much information gives retrieval problems, so information must not only consciously be preserved but must be consciously destroyed. (Whitehouse 1971: 3). The information retained must be appropriate for the users, and sufficiently close to the problem to be pertinent.

Vast quantities of information are produced, more than any person can possibly need or use. A person's brain filters most of the data, and is consciously aware of it, but acts upon only a tiny fraction of it. The objective is for a management information system to be so constructed as to filter out unneeded information, and to convey only the information that supports the needs of the decision maker. The difficulty is that designers of information systems cannot know exactly what information will be relevant to an organisation. The challenge is to assess the relevancy, and to provide appropriate access to it.

To be relevant, the information must apply to the action or decision to be considered. It must be close to the problem, not over-presented information but have sufficient detail and be flexible enough to provide for all the alternatives to be considered.

Two users facing the same decision might use completely different information to arrive at an acceptable conclusion. For example two managers face a decision to increase production volumes. The one will primarily use production statistics and sales volume information; the other will largely base his decision on market trends, the age of the plant and equipment and make his final decision because it will please his boss. Appropriate relevancy is therefore primarily dependant on user preferences.

Only when the information is available in a required form or place, can it become relevant. Non-existing information cannot be relevant. Information however, can be incomplete and have a low quality. The degree of fit in a particular situation is largely dependant on the process of filtering irrelevant information, and providing easy access to that which is relevant.

Because of the developments in information technology, there will be a marked increase in the quantity of rapidly accessible information and the ability to manipulate it. (Longley 1982: 165). This will not necessarily improve the relevancy of the information. Facilities must be provided to get the right information at the right time.

4.4.2 Accuracy

Any communication channel contains some background activity, which is called noise. Information can only be recognised on the channel if it transmits signals stronger than the noise. The theory of noise in a communication channel and methods to minimise it, is well established in natural sciences. It is more difficult to determine noise in management systems. However it does exist and because it can never be eliminated, measures to improve the clarity of the messages in a management system are worthwhile to be considered.

With each message the relevant question is whether the information is a close enough approximation to reality for the intended purpose.

Deciding the accuracy of information depends on the nature of it. Usually accuracy is associated with quantitative information. There are two types of quantitative information: counts and measurements. Counts can be precise. A count of twelve stock items is exact, in the sense that it is not twelve and a fraction. A measurement is never precise. Measurements are always approximations. Modern technology has made many measurements very accurate, but a margin of error always remains. Most messages in a management information system are measurements, rather that counts. Inventory quantities may be obtained by counts, but the monetary amount of inventory is a measurement. Measurements of such items as the expenses of an accounting period are likely to be a fairly rough approximation.

Many accounting measurements are also not precise because they are surrogates. (Anthony 1980: 127). A surrogate is a substitute measure of some phenomenon that is used because it is not feasible to measure the phenomenon directly. Profit, as defined according to certain rules, is often used as a general measure of a division's performance.

Accuracy can also be associated with non quantitative information. For example, a report on the attitudes of staff in the organisation. The accuracy of the information cannot be measured or counted. It could however be judged by comparing it with other data, for instance, general knowledge about the staff, or the result of a comparable report.

Mostly, precise measurement is not only impossible, it is also undesirable. The more precise the measuring instrument, the more it costs. There is no point in spending money to increase the precision of measurement beyond the degree of approximation that is needed to make sound decisions.

For information to be accurate, it must be verifiable. To be verifiable, it should be related to other information from the same system, or to information from another system, or even to information such as verbal confirmation, prior knowledge, or 'gut feel'. Although it might not necessarily be precise, it must be credible for the needs of the user. This credibility could be supported by the process of validation, or even beliefs or perceptions. For the information to be valid the user should be able to rely on it.

Some inaccuracy of information is attributable to incorrect data producing unacceptable results. To improve the accuracy of the information, the source data must be improved. Inaccuracy could be caused by noise in the communication channel. This is particularly true when the user is biased towards an expected result and therefore judge the accuracy of the information inappropriately or incorrectly. Noise in the communication channel could also result from a lack of interpretative skills, cultural background, or emotion of the user. Finally information could get lost in a channel during the process of transferring information, for example, from one person to another.

There is a trade-off between precision and timeliness. Often it will take more time to produce more accurate information. Approximate information might be more useful to the decision maker than late, accurate information. Quality information must be accurate, however. The desired accuracy to form quality information is completely dependant on the user and could vary from situation to situation and user to user.

4.4.3 Timeliness

Timeliness simply means that the recipient can get the information when he needs it. When information is not timely, it is usually because it is late. The same piece of information might be too late for one decision maker, and just in time for the other, depending on the priorities.

Information can also be received too early. Receiving it too early might result in the storage of the information until it is used, or even the loss of it when it is eventually required.

An important angle of timely information is related to the time that it takes to produce the information. Preece quotes a study that Licklider had done in 1960 (Preece 1990: 7), with the following results: "about 85% of my 'thinking' time was spent getting into a position to think, to make a decision, to learn something I know. Much more time went into finding or obtaining information than into digesting it. Hours went into the plotting of graphs and other hours into instructing an assistant how to plot. When the graphs were finished, the relations were obvious at once, but the plotting had to be done in order to make them so." Although this study of Licklider is somewhat old, the problem is still very real.

No information can be regarded to be timeless, a situation where there is no necessity for information to be available at a particular point in time. Every decision has a beginning and an end. The beginning commences when the need for the decision arises, the end when the decision has been made, Every piece of information used for a decision is received within a time frame, which either suits, or does not suit the time frame of the decision. The information is on schedule when it is received or available within the boundaries of the time frame of the decision.

Because of the difficulty of figuring out the exact timing of when the information must be available, and the different needs of users, some information providers lean towards having the information always available on request. For instance, the accumulation of large databases of information which can be queried at any time. This trend is noticeable in document imaging, CD ROM and inter-continental information networks. These trends are indicative that the cost of information storage is less that the cost of not having the information available on time.

Information that is not on time is worthless and make no contribution to add to the relevant knowledge of the user. For information to have any quality at all, it must be on time. The degree of on time will decide the degree of quality of the information.

4.4.4 Comprehensibility

The presentation of information is vital for the actual grasping of it. It must be presented in a format that could be understood by the recipient. Recipients have preferences, some prefer graphics, some tables, and other numerical data. When information is retrieved it must be presented in a way that will enhance its meaning and ensure rapid assimilation. (Whitehouse 1971: 3).

The presentation must be free from ambiguity, and should contain a clear picture for the actual purposes of the information. The output must be understandable. Today much is done to make computers more user friendly. This implies that as the interaction between the computer and the user improves, the presentation of information by computer is more comprehensible. Major computer development trends focus on the need for better presentation such as multimedia, graphics, high resolution screens, and Windows.

The information must not only be presented, but perceived and readily understood. Without understanding, information would not be converted into knowledge by the user. Understanding is dependant on the quality of the information and the abilities of the user.

Despite the availability of information, or its accuracy, or even its timeliness, without comprehending the information, information will loose the benefit of all other attributes.

4.5 AFFECT OF QUALITY

When information has no quality it is useless, non-significant, and has no impact on the decision making of a user. In these circumstances, it could be argued that this "information" loses its character of being information, reducing it to data. It must increase the knowledge of the recipient to qualify as information. (Burch 1979: 6).

The question is therefore not whether information affects the decision making of a user, but to what degree it does. The absence, or presence of, or the particular interaction between different attributes of quality will improve or decrease the abilities of the decision maker. For information to be of value, the right mix of attributes of quality must be present to suit the needs of the particular user.

What is important is that the requirements of the user of the information, and not the information itself will decide which attributes should be present at what level to have an impact on the decision. Attributes can never be considered in isolation. They influence each other, either positively or negatively.

Information might be relevant, but not timeous, and therefore loses its value in total. For example, a stockbroker might receive the notification of a major disaster in a company too late. Although the news of the disaster is used for deciding to sell the shares of the company, receiving the information late will render the stockbroker helpless.

Information might be very accurate, does not require to be timeous, but is not presented in an understandable way. This lack of comprehensibility will reduce the value of accuracy.

All four attributes must be present in one or other form for information to have quality. Information with no relevancy cannot add knowledge. Completely inaccurate information is misleading and can be dangerous. If the information's timing is out, it will have no impact on the user. And if it cannot be understood it is rendered worthless.

Quality information is therefore relevant, accurate, on time and comprehensible. Only when these attributes are present can information be of benefit to the user.

4.6 SUMMARY

This chapter aimed at identifying those attributes of information that distinguish them as making information valuable to the recipient. The accurate valuation of information has proved to be very difficult and illusive. That information has value is beyond doubt and that its value can be improved was strongly substantiated. The chapter concluded by isolating those attributes that users expect in valuable information. These attributes were grouped to represent those factors that contribute to quality information.

The first element of the hypothesis of this study was that quality information can have a decisive impact on the decisions and reactions of the decision maker. The chapter considered the value that information could have for the decision maker and those attributes that would improve the ability of the user to derive the expected value from that information. It is the presence of these attributes of quality information that manifests the degree of impact, and the ability of that information to influence a decision.

The second element of the hypothesis of this study was that attributes of quality information can be identified. The chapter illustrated that these attributes are distinguishable and can be defined. The four attributes, relevancy, accuracy, timeliness and comprehensibility, will be used in the remainder of this study to highlight the production of quality information.

The chapter concludes with the support for the first and second element of the hypothesis. It concludes the results of the first focus area defined in chapter 1 i.e. to concentrate on information. Chapter 2 gave background on the historic development of computers and the driving forces behind the production of information. Chapter 3 discussed the nature and classification of information, and chapter 4 concluded with isolating the four attributes of quality information. It is the objective of this study to develop a framework for managers to enable them to understand the effect that different computer tools have on the production of quality information. With a thorough understanding of information and what contributes to its quality, it is now appropriate to continue to focus on the computer tools responsible for producing information.

PHASE 2

ASSESS CONTRIBUTION OF COMPUTER TOOLS TO PRODUCE QUALITY INFORMATION

Phase 2 will assess the contribution that computer tools make to the production of quality information. It will commence with defining an appropriate classification for the computer tools in Chapter 5. Chapter 6 will develop a method of assessing the contribution that computer tools make. This method is applied in Chapter 7 to 13 to evaluate the complete range of computer tools responsible for production of information. Chapter 14 will illustrate the assessment for an illustrative company by applying the assessment criteria to various sets of information.

The review of the computer tools and their characteristics will be based on a literature study. The assessment of the contribution of the tools and the evaluation of the quality information will be based on deductions against pre-defined guidelines.

INTRODUCTION TO PHASE 2

Computers have a multitude of purposes and functions as highlighted in chapter 2. A key objective of computers identified earlier is to produce information from the available data. Chapters 5 to 14 will concentrate on computers and their components that produce information. Depending on the size and complexity of the computer installation, there could either be few computer components involved, or in large installations, a vast and intricate association of many different parts.

Chapter 2 outlined the development of computer technology and information management. The development of computer technology was characterised by an exponential growth in all aspects of computers. The growth in computer technology closely followed the outcome of research and development. Not only did a greater selection of alternative solutions for the same problems become available, but new solutions for problems unsolved in the passed, emerged. It is against the background of this growing number of computer solutions available that this study will consider their effect on producing better quality information.

The unique relationship between data and information, the diversity of information and its users, and a classification of different types of information, was analysed in chapter 3. The information system, producing information from data, was also considered. The development of an information system was separated into several building blocks. The building blocks identified were input, technology, databases, controls, application software and output. This chapter will relate the different computer tools and components with these building blocks.

The mere production of information adds little value. Information that meets the requirements of the user has more value. In chapter 4 special emphasis was placed on understanding the attributes of quality information. Increasing the quality, and therefore the usability of the information, differentiates the value of one set of information from another. The ability to distinguish between good and better information challenges the user to find ways to produce information according to the defined needs.

In a recent report (Information Management Report 1991: 9) it was stated "As information gathering grows so does the need for refining and delivery." Although this report specifically refers to the role of hypermedia to refine information, computers are predominantly responsible for the process of improving information. Computers make it possible for users to produce information of different qualities. This phase will therefore consider those facets of computers mainly responsible for producing information. It will commence with explaining the research method used to identify the different components of computers and classifying them as tools responsible for producing information. It will then develop criteria to evaluate the potential contribution that these tools could make in producing quality information. In a summarised analysis of the potential contribution that all the tools could make to improve the attributes of quality information, the validity of individual assessments will be tested. This phase will conclude with an illustration of an evaluation of individual information sets and tools that could improve the quality of the sets in an illustrative company.

CHAPTER 5

SCOPING OF COMPUTER TOOLS

5.1 INTRODUCTION

The first objective of phase 2 is to collect and gather an understanding of a representative selection of all the tools in the information production process. The preliminary literature review revealed a variety of tools, with few literature sources dealing comprehensively with all aspects. The historical overview of the development of computing in Chapter 2 emphasised the magnitude of aspects covered by computing. Furthermore the review for this phase dealt with an extensive range of available literature with complex and specialised deliberations of each technical area. The risk of becoming overwhelmed by non-related facts was recognised. It was necessary to develop a research method that ensured adequate coverage of all related computer topics, without going into unnecessary detail.

This chapter will define the method used to ensure that all appropriate computer tools have been taken into account with a structured and logical approach. It will commence by defining what computer tools are, then continue with a statement on the method used to analyse the literature, and close with a suggested summarised classification of computer tools which would be appropriate for this study.

5.2 DEFINING COMPUTER TOOLS

Computer tools are regarded as all the components of an information system that fit together to make a computer installation operational. Kirakowski identified three conceptual components of every tool. (Kirakowski 1988: 8). He summarised them as follows: "One is the thing that the human holds, or the control surface. Another is what makes things happen, or the effector surface." The third element identified is the transducer. A tool is described by Kirakowski as a control surface, manipulated by a human being, with the effector surface transducing energy or information at the other end. He applied it to computers: "As a tool, a computer can be thought of as a number of control and effector surfaces." (Kirakowski 1988: 9). Each section of the information system that controls certain functions, and effect certain results could therefore be regarded as a tool. This chapter will identify the computer tools used for producing information.

5.3 RESEARCH METHOD TO IDENTIFY COMPUTER TOOLS

The method used in phase 2 to structure and organise all computer tools has two major steps: To identify an appropriately broad classification of tools of the complete information production process and to ensure that an adequate representation of all appropriate computer tools has been taken into account. This is done by identifying nomenclatures that relate to each section of the production process. The process is concluded with a discussion of the characteristics of each group of tools in relation to the production of information.

5.4 CLASSIFICATION OF THE TOOLS

The study considered an appropriate method of grouping the computer tools to provide an analysis in relation to the production of information.

Scott (Scott 1986: 104) identified several groupings of the capabilities of computer systems that, according to him, entirely disproves the often heard assertion that "a computer is only a high-capacity adding machine or calculator: it cannot do anything different; it can only do it faster." According to him these capabilities have revolutionised the nature of information systems and are revolutionising the management processes utilising the information that these systems provide. He identified the following main groupings of data processing:

- "Batch transaction processing.
- Single transaction processing.
- On-line, real time transactions processing.
- Data communications and message switching.
- Remote data entry and file update.

- Record search and analysis.
- File enquiry.
- Decision algorithms and models.
- Office automation." (Scott 1986: 104).

Kirakowski summarised the computer tools under the headings "the computer and its accessories," "the software story - programming languages," "operating systems," and "the software story - packages." (Kirakowski 1988: 1). He dealt with the information user and knowledge-based systems in separate sections. He also approached aspects such as networks and communications purely from a software point of view.

As discussed in detail in Chapter 3, Burch summarised the design of a computer system, with the objective to produce information, in the section on design building blocks. The groupings of Scott and Kirakowski are not comprehensive, and somewhat confusing. For example, "File enquiry" could be considered a particular type of "record search." From the review in Chapter 3, it was concluded that the building blocks of Burch are more appropriate, and complete. They cover the total data processing cycle logically. No computer tool was found in the literature review that could not be associated with the building blocks of Burch.

The six main design building blocks of an information system defined by Burch and discussed in chapter 3 of this study (input, application software, database, controls, technology and output) form the broad classification of the information production process used in phase 2.

5.5 COMPUTER TOOL COMPLETENESS CHECK

The research covered a comprehensive review of nomenclatures that apply to computers, information management, computer technology, and related subjects. A nomenclature is "a system of names used in an art or science." (The American Heritage Dictionary 1987). The review made special reference to the indexes of the literature covered in the review. It was further substantiated by referring to computer dictionaries and encyclopaedia. The review was done by noting down all nomenclatures. More than 4000 nomenclatures were listed. The literature sources used to identify the nomenclatures are listed in Annexure C.

The nomenclatures were grouped into the six main building blocks noted by Burch. Mostly it was possible to distinguish the connection of nomenclatures between the different building blocks. However, sometimes there were overlaps, for instance "input" and "output" overlap. An example is a workstation, which captures data, and produces output for the user. In other cases the same nomenclature could be associated with more than one building block. An example would be "access" that could relate both to "storage" as part of technology, and "data" as part of databases. Some nomenclatures and their associated classes affect most of the building blocks, such as the user interface. In the these cases the nomenclatures are grouped in the most appropriate building block. The grouping of nomenclatures into the building blocks is based on the following criteria:

- General complexity of the building block.
- Association of the nomenclatures with each other.
- Uniformity of the characteristics of the nomenclatures.
- Contribution that the nomenclatures have as a group on the production of information.

Identifying and classifying the nomenclatures ensured that an adequate representation of the appropriate tools was taken into account in the research. The study will not explain all the nomenclatures in detail.

5.6 SUMMARY OF COMPUTER TOOL GROUPS

The groups of the nomenclatures based on the classification of tools previously defined are summarised with a short description and examples in Table 5.1. These groups will be discussed in more detail in the rest of phase 2.

Table 5.1 - Summary of computer tools.

BUILDING BLOCK	TOOL GROUP	SHORT DESCRIPTION	NOMENCLATURE EXAMPLES
Input	Data capture	The acquisition of data by capturing non-electronic data by a user	Keyboards, speech recognition, scanners, bar code readers
	Data transfer	The acquisition of data by electronic transfer from external sources	Electronic data interchange, electronic mail, file transfer
Technology	computer architectures, devices and processors	The different elements of the computer to construct a processor	Central processing unit, array processors, multiprocessors
	Computer processing	Processing of data and instructions to produce information	Distributed data processing, parallel processing, pipe lining
	Memory and storage	Custody of data in electronic form	Cache memory, optical media, direct access storage devices
	Communications	Data links between processors, peripheral equipment, and users	Satellites, fibre optics, local area networks, common carriers
	Software	Instruction sets enabling command of the computer to perform tasks	Operating systems, application programs, computer languages
Databases	Physical	Physical organisation of data in records, files, and other relationships.	Linked files, hierarchical database, data integrity
	Logical	Access to, and management of data.	Database management system, direct access
Controls	Data controls	Safeguarding data	Pre-input controls, input controls, output controls
	Processing controls	Safeguarding the processing of data and instructions	Logging records, communication controls, programming controls
	System controls	Safeguarding the computer systems environment	File security, recovery procedures, standards and procedures
Models	Application software	Models to provide functional use of the computer	Business applications, payment systems, operations systems
	Decision support models	Models focusing on decision making	decision support system, expert system, analytic modelling
	User interaction models	Computer tools to enhance the human-computer interaction.	Graphics, speech recognition, light pen editing
Output	Presentation	Method of communication of information with the user	graphs, tabular, colour
	Monitors and terminals	Displaying computer responses to the user	Cathode ray tubes, flat panel displays
	Hard-copy equipment	Printed form of computer response to the user	Plotters, printers, copiers, fax machines

CHAPTER 6

DEVELOPMENT OF AN ASSESSMENT METHOD

6.1 INTRODUCTION

The second objective of phase 2 is to assess the contribution that the tools make to deliver quality information. Although most of the tools identified are in some or other way involved with data processing, they do not necessarily contribute equally to all attributes of quality information. Each tool has some potential to make a contribution. This contribution can be expressed in terms of the tool's 'larger' or 'smaller' effectiveness than other tools to affect a particular attribute. Effectiveness in contributing to a specific attribute is related to the appropriate functionality and technical ability of the tool to affect, or change, a specific attribute of quality information. As an example, a computer processor has a larger potential to be effective in improving the production of timeous information than a data capturing device.

This chapter will present a method to assess the contribution that computer tools make to enhance the quality of information. It will commence by considering different assessment levels; continue by formulating criteria to rate the assessment; then consider the requirements of tools to improve quality attributes and conclude with a method to assess the tools.

6.2 ASSESSMENT LEVELS

The contribution each tool makes can be gauged by assessing the effectiveness of the tool to improve a quality attribute. This study will assess the tools in various levels of effectiveness. The assessment will be based on deductions made against the levels of assessment criteria explained in section 6.3. In categorising the assessment of effectiveness, the relative ranges between the assessments have been made sufficiently broad to limit the negative impact of error of judgement between the levels. Levels of assessment such as 'high', 'low' or 'moderate' will be used rather than exact measures such as 10% or 35%.

Sub-components of tools can make a vast difference in the effectiveness of that tool. For example, a computer processor, with different characteristics, e.g. different micro processors, could be significantly more or less effective. Different combinations of tools could also significantly affect the effectiveness of tools. For example, an excellent graphics monitor combined with a slow processor will perform much worse than a monitor combined with a fast processor. The study recognises the importance of considering alternative sub sets of tools, and the interrelationship that tools have with each other. However, the study does not aim to differentiate the effectiveness of tools to a great level of detail. By focusing at a level with too much detail and permutation, the identification of the potential contribution that a group of tools could make would be lost. Effectiveness will therefore be considered for tool groups as listed in Table 5.1, instead of individual tools.

6.3 ASSESSMENT CRITERIA

The following assessment criteria have been developed to rate the effectiveness of the tools in producing the different qualities of information. The criteria were derived from a study done by Burk to rate the effect of computers on the value of information. (Burk 1988: 99).

- Highly effective: The tool is designed, and has as a primary objective to affect the particular attribute of quality. It has the appropriate functionality, and is technically adequate to make a major contribution to improve the particular quality.
- Supportive: The tool does not perform a primary role to improve the particular attribute of quality, but has appropriate functionality and technical ability to operate with others tools to greatly affect the quality of a particular attribute of quality.
- Limited: The tools have a secondary and limited potential capability to change the particular attribute of quality.
- No contribution: The tool does not have any impact on the attribute.

To each of the above assessment criteria a ranking is assigned to help the evaluation of the combined contribution of tools. The ranking assigned is similar to those used by Burk. (Burk 1988: 99). The rankings assigned are detailed in Table 6.1.

Table 6.1 - Ranking of assessment criteria.

ASSESSMENT CRITERIA	RANKING
Highly effective	10
Supportive	5
Limited	1
No contribution	0

6.4 REQUIREMENTS OF TOOLS TO IMPROVE QUALITY ATTRIBUTES

To simplify the assessment of the potential effectiveness of tools in contributing to the production of quality information, the attributes identified in chapter 4 are discussed to identify the requirements of tools that can support the information quality attributes.

6.4.1 Tools that affect the relevancy attribute

To improve the relevancy of information, the tool must ensure that the information is provided in sufficient detail. It must not be too much, nor too little. It must be comprehensive enough, and appropriate enough for the user to derive the knowledge necessary in a particular situation from the information presented.

Information presented will not be relevant when it does not apply to the situation, or because the appropriate information is not presented, or accessible.

Tools that will improve the relevancy of information must focus on deciding what is relevant, get to the appropriate data, select it, and filter unnecessary information.

6.4.2 Tools that affect the accuracy attribute

For information to be accurate, it must be verifiable. The degree of accuracy required in a particular situation will vary. The information must be reliable and credible for the situation. It must be free from bias. The distortion of accuracy, because of interference or noise in the communication channel, must be limited as far as possible.

If the information does not agree with other appropriate and verified information, it will be rejected as dubious. If the information does not suite the acceptance level of accuracy by the user, it will also be rejected. The same information set could be regarded as accurate for one decision maker, and inaccurate for another. Similarly, the same information set could be accurate for one type of decision, but unacceptable for another.

To ensure that the information is sufficiently accurate, the tools that produce the information should capture it accurately, retain it so that it is not mixed with other data or lose its character, and reproduce it when required in such a form that in can be verified.

6.4.3 Tools that affect the timeous attribute

For information to be timeous, it must be with the decision maker at the right time. The information must therefore be accessible to the user, exactly when it must be used. Time cannot be expressed in a fixed number of hours nor at a fixed date. The timing may vary from user to user, and decision to decision.

Information is not on time when the user has to make a decision, or take action, without access to the appropriate information.

For the computer to produce timeous information, the data must be captured in time, the information processed in time, and reproduced in time.

6.4.4 Tools that affect the comprehensibility attribute

Information is comprehensible if it can be readily understood by the user. It must therefore be presented with sufficient clarity and be free from any distractions. The information must convey the message effectively and adequately.

When the user does not perceive the message of the information, or when the user has difficulties in arriving at perception, the information is not sufficiently comprehensible.

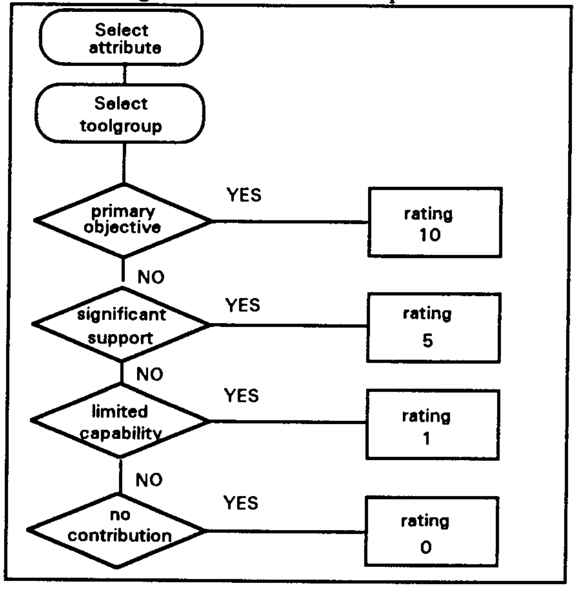
For the computer to produce comprehensible information, the tools must have the functionality and ability to present the information to the user in an optimal format. The user must understand the communication from the computer, free from distractions.

6.5 ASSESSMENT OF TOOLS

Section 6.4 focused on what type of tools would enhance each quality attribute. To assess the effectiveness of the tools to affect each quality attribute, criteria were developed in section 6.3. In Chapters 7 to 12 the characteristics of the group of tools and their significance in producing information will be discussed. Each Chapter will conclude with an assessment of the affect that the specific group could have on the quality attributes of information. To do this assessment, the relationship between each group of tools and each quality attribute will be considered. The assessment criteria will be used to determine this relationship.

The departure point for the assessment will be the four quality attributes. From the discussion of the characteristics of each tool group, the primary objective of the tool group will be identified. If the primary objective of the tool group is to support the quality attribute, the assessment rating will be ten. If the tool group does not fulfil a primary role to support the quality attribute, it will be determined if the tool group significantly supports other tools to affect the quality attribute. Should it fulfil this support function, the assessment rating will be five. If the tool group has only a limited capability to support other tools to affect the attribute, the assessment rating would be one. Sometimes tools cannot affect a specific attribute. An assessment rating of zero will then be assigned. This process is summarised in Figure 6.1.

Figure 6.1 - Assessment process



This assessment process is followed for each group of tools discussed in the following Chapters. The Chapter 13 will conclude with a summary of all the assessments.

6.5 SUMMARY

Chapter 6 formulated the method of assessing the contribution that computer tools make to improve quality information. The assessment will be done for tool groups within the information system building blocks. These tools groups and building blocks were summarised in table 5.1. The characteristics of the tool groups will be evaluated against the criteria set in paragraph 6.3. This evaluation will follow the process defined in paragraph 6.4. An assessment rating will be assigned to each tool group according to the ratings in Table 6.1.

Chapter 7 to 12 will perform the above assessment for each building block.

CHAPTER 7

ASSESSMENT OF INPUT BUILDING BLOCK

7.1 INTRODUCTION TO INPUT BUILDING BLOCK

The first building block in the information processing system identified by Burch is "input". Input encompasses the processes of acquiring data from sources external to the information system. Without the input building block, the information system will have no raw material from which to process information.

Computer tools responsible for acquiring the data could also be involved in producing output and communicating with the user. An example is a touch screen monitor, which accepts input, and produces output. Depending on the dominant information processing characteristics of such tools, it will be considered either as input, or alternatively, as output building blocks.

The input building block is divided into two groups:

- Data capture - focusing on acquiring non-electronic data.
- Data transfer - focusing on acquiring electronic data from external sources.

7.2 DATA CAPTURE

Nomenclatures that are associated with the recording of data from non-electronic data sources, have been grouped together as "data capture" as part of the input building block. Some data capturing devices operate also as output devices such as touch screens. Data capture is therefore closely related to the output building block.

Although data capture is not a primary information producing tool, it has a large impact on the ultimate information produced. Without data capturing tools data will not exist, and therefore no information could be produced.

These tools have changed dramatically since the inception of the computer. Data capture moved through the following major stages: data captured on card and paper; data preparation through off-line data capture and batch processing by specialised data capturing staff; data capture as a subset of the day to day activity of users.

The era of punch cards and paper tape is something of the past. Gardiner noted "Punch cards for data input are now almost obsolete (just ten years ago they were quite common)." (Gardiner 1987: 281).

Data capture by specialised staff in data preparation departments still takes place, although this is a somewhat diminishing phenomena. The alphanumeric keyboard is still the predominant data capturing device, be it by on-line or off-line methods. It is dependant on the skills of the user, is slow and error prone.

The stages of data preparation can be summarised as:

Data capture
data conveyance
data control
transcription
verification
conversion
validation
production of invalid input lists
return of data to point of origin.
(Central Computer Agency Guide 8: 1979: 8).

The aim of any data capturing development is to shorten the above cycle as much as possible by combining actions, and automating the process. "Any data capture method which simplifies or eliminates the stages in the data entry process should be considered during selection." (Central Computer Agency Guide 8: 1979: 8).

There is a movement away from the data preparation concept to a situation where the user of the data does the actual capturing of it. Examples are the invoice clerk capturing the invoices; the bank customer entering his own withdrawal into the automated teller machine, and the ordering clerk entering his own orders. Gardiner said "Powerful functionality is continually migrating towards the individual user workstation . . . there has been continual innovation in the kinds of input and output techniques employed." (Gardiner 1987: 281). The movement away from specialist data capture clerks to ordinary users accessing the computer, placed enormous pressure on the development of the user interface to perform direct data entry. The principal arguments for direct data entry were summarised by Benwell (1976: 199):

- "Elimination of data transcription requirement via a variety of keyboard entry methods.
- Reducing of errors in data entry.
- The responsibility of error checking in entered data remains with the originator of it.
- Immediacy of data entry.
- Reduction of cost in data entry."

Gardiner classified input techniques as follows:

- "Natural: hand print, speech, vision.
- Keying: keyboards, punch cards.
- Direct pointing: light pen, touch screen.
- Indirect pointing: mouse, touch pad, tablets, pressure pad.
- Controlled pointing: roller ball, joystick.
- Others: tactile(prosthetics), psycho physiological, thought".
  (Gardiner 1987: 282).

The key characteristics of data capturing for the production of information were deducted from the literature. These characteristics are:

- Ease of use to minimise errors.

- Capturing speed.
- Accuracy of capturing.
- Versatility to capture different data sources.
- Cost effectiveness of acquisition of data.

These characteristics correlate with the main objective for data entry defined in Central computer Agency Guide 8 (1979: 9).: "To convert data into machine readable form with the minimum delay, minimum introduction of errors and at minimum cost" Sutcliffe summarised the general objectives for data entry as: "To save the user work, and to make entry error rates as low as possible. This is achieved by keeping the users' memory loads as low as possible, making the interface predictable and consistent, protecting the user from making mistakes, and automating as much of the data entry as possible." (Sutcliffe 1988: 119).

Some capturing tools that concentrate on the ease of use are digitising pad, light pen, mouse, trackballs, touch screens and joysticks. Capturing tools that specialise in capturing speed and accuracy are scanners, bar code readers, optical character readers, magnetic ink readers, electronic data interchange, and tag readers. Capturing tools geared for different types of data are: voice recognisers, computer or machine vision, page readers, optical scanners, handwriting scanners, and digital pads.

Data capturing is still not mature. Some areas are still in development and are not generally available. These areas include voice recognition, handwriting and computer vision. What Benwell said in 1976 still holds true today "if we had overcome the problem of digitising speech, man's most natural and universal means of communication would have become the computer's natural means of accepting its instructions and data preparation would become an empty phrase." (Benwell 1976: 171). Preece believes "managing input is so complex that it is unlikely that we will ever totally understand it." (Preece 1990: 123). He pointed out that there are still major shortcomings in our ability to enter information manually into a computer. He stressed the importance of looking outward from the devices themselves to how they fit into a more global, or holistic, view of the user interface. (Preece 1990: 137). There is no doubt that there is still a long way to go to develop the ultimate data capturing device.

If we take the key characteristics of data capturing into consideration it is evident that data capturing tools contribute significantly towards enhancing information accuracy and timeliness.

7.3 DATA TRANSFER

Nomenclatures that are associated with the recording of data from electronic data sources have been grouped together as "data transfer" as part of the input building block. This group is closely related to communications and networking, dealt with as part of the technology building block. It is also related to the software and applications that control the transferring of data, dealt with as part of the application software building block.

The input features of data transfer focuses specifically on electronic data sources external to the organisation. This type of data transfer includes:

- Electronic data interchange.
- Electronic funds transfer.
- Electronic mail.
- File transfer.
- Value added networks.

The development of data transfer is primarily aimed at improving the accuracy and speed of data capture. There is a significant difference in both the accuracy and speed of data transfer, in comparison to other methods of data capturing.

7.4 CONCLUSION OF ASSESSMENT

Input determines the acquisition of data into the information system. The main features associated with this process can be summarised as:

- Many data sources of which a large portion remains non-electronic.
- The human element.
- A variety of data acquisition methods.

The primary objective of input, including both data capture and data transfer, is to capture data accurately. Input is therefore designed and has the appropriate functionality to make a major contribution to improve the accuracy attribute.

Although it is an objective of data capture to record data timeously, it lacks the appropriate functionality to achieve this objective. A key reason why there is a move from data capture to data transfer, is to ensure improved timeliness of data acquisition. Data transfer is therefore highly effective. Data capture, on the other hand is only supportive due to the large impact that users and the lack of functionality of the tools have on the timeous capturing of data. Improved methods of capturing data such as images, voice and vision will enhance the effectiveness of data capture.

Data capture is still very dependant on the user's ability to assess and capture the relevant data. With the development of new technologies to acquire original forms of data such as voice and vision, data capture could become more effective to enhance relevancy. Data transfer is slightly more effective in acquiring appropriate data, but is still not highly effective to improve relevancy of information. A move towards intelligent data acquisition facilities with the capability of fetching the data required and filtering out unnecessary data will put input into a position to be highly effective to affect the relevancy attribute. Currently data capture and data transfer are only supporting the improvement of relevancy of information.

Input does not affect the comprehensibility of information as this attribute is output related.

The assessment ratings of the input block are summarised in Table 7.1

Table 7.1 - Input building block assessment ratings

SUMMARY OF INPUT BUILDING BLOCK		
	Data Capture	Data Transfer
Relevancy	5	5
Accuracy	10	10
Timeliness	5	10
Comprehensibility	0	0

CHAPTER 8

ASSESSMENT OF TECHNOLOGY BUILDING BLOCK

8.1 INTRODUCTION TO TECHNOLOGY BUILDING BLOCK

Burch collectively tags the computer tools that process the input, drive the application programs, store and access the data, produce and transmit output and help to control the whole system as the "technology building block". (Burch 1979: 42). There is certainly a number of terms for this collection of tools, and also various approaches to group them.

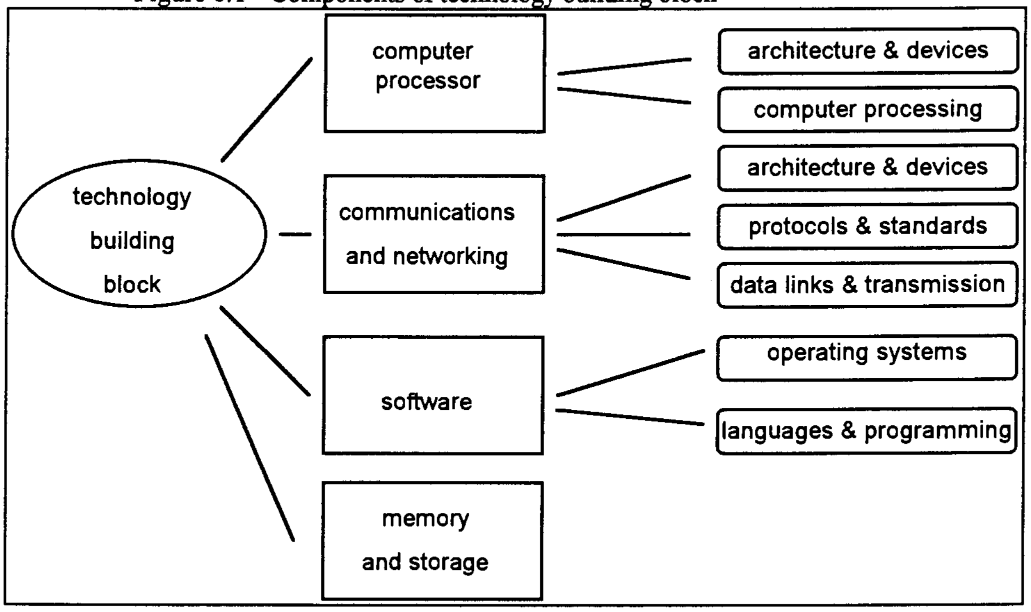
A comprehensive review of related nomenclatures was done. This was done to ensure that the relevant tools and their characteristics have been taken into account. Technology in itself is a very wide subject. It encompasses a range of disciplines. It is largely governed by computer science and electronic engineering. Each element of technology is highly technical and very complex. Technology represents the heart of the computer operation. However, in itself, it does not represent information. It is responsible for processing the input data, and producing output as information.

Input and output operations are reasonably transparent to the information user. Technology is more like a black box, with the user having very limited contact with its actual operations.

This study focuses on the data processing characteristics of technology, with the objective to produce information. It is not within the scope of this study to consider all the elements of technology in detail.

The following main groups of technology are identified: computer processing, memory and storage, communications & networking, and software. Each of these main groups is further divided. The computer and its peripherals is the main processor of data. It can further be divided into computer architectures, devices, and processors; and computer processing. Memory and storage retain the data and make it available for processing. The telecommunications component of technology provides the communication between users and computers, as well as between computers themselves. This group can be divided into communication architectures and structures; protocols, topologies and standards, data links, communication devices, transmission and switching, and communication software and applications. The software component of technology provides the basis for instructing the computer. This component can be divided into operating systems and control programs, languages and programming. The components of the technology building block is illustrated in Figure 8.1.

Figure 8.1 - Components of technology building block



A brief summary of the key information production related characteristics of these groups follow.

8.2 COMPUTER PROCESSOR

8.2.1 Computer architectures, devices and processors

Computer architecture represents the design of the different elements of the computer to construct a processor. Huck said that "the combination of instruction set and storage objects define the architecture of a machine." (Huck 1989: 3).

The central processing unit (CPU) is the heart of the computer system. It consists of three major sections: main memory, the control section, and the arithmetic logic unit (ALU). The entire CPU is composed of electronic circuitry. Included in this circuitry are registers that are used to hold data and instructions to the computer, similarly to the way data is held in registers of a calculator. Differences in all three sections of the CPU will distinguish one computer from another, and allow for different types and sizes of systems. Different architectures construct different types of computers with distinctive processors.

In terms of data processing, the main objective of processors and the development of new architectures is computer power. The processor determines the time it takes and the accuracy with which it performs the task in the production of information. Computer power is the rating of the amount of work a computer system can complete in a given period. Computer power is tied to several different indicators of processing speed and efficiency, no one of which, by itself, accurately measures computer power. In summary these indicators are:

- The number of CPU's in a computer system.
- The size of the computer's instruction set.
- The processing speed of the computer's instruction set.
- Main memory size.
- Cycle time.
- "Word size."
- Throughput.

Computer power is the number of CPU's a computer system possesses. Some computer systems have one CPU, others have two, three or four. The latter is called a multiprocessor computer system.

An instruction set allows the ALU to perform unique, individual tasks as one ALU processing step. For example, if a computer had no DIVIDE instruction, it would have to accomplish arithmetic division by repeatedly processing the SUBTRACT instruction. Reducing the size of the instruction set will reduce the time it takes to process the set. RISC ("reduced instruction set") computers are new technology aimed at reducing the complexity of the instruction set.

The speed at which the computer processes its instruction set is measured in "million instruction sets per second" or MIPS. Some of today's largest computers are approaching 100 MIPS. (Andriole 1985: 6).

The size of the main memory will influence the size of data sets that the computer can handle simultaneously. All else being equal, the larger the main memory, the more capable the computer because it can contain and process larger programs and data sets.

There are different types of cycle time in a computer. The time it takes for data to move from main memory to the ALU and back to main memory is one type of cycle time. Another is the amount of time needed to transfer data from channel devices to main memory. And a third type is the amount of time it takes to transfer data from secondary memory to main memory and return it to secondary memory.

The "word size" is the number of bits that are manipulated together during processing. The larger the word size, the faster the rate of processing, all else being equal. Most computers word sizes are 8, 16, 32 or 64 bits. (Scott 1986: 184).

The ultimate test for computer power is the amount of throughput. This is the actual number of work units accomplished in a given period. Throughput depends on the type of the transactions, and the particular configuration of the computer system. (Scott 1986: 184).

The improvement of computer power has been predominant throughout the development life of the computer. Enslow commented on the goals of computer system development as follows:

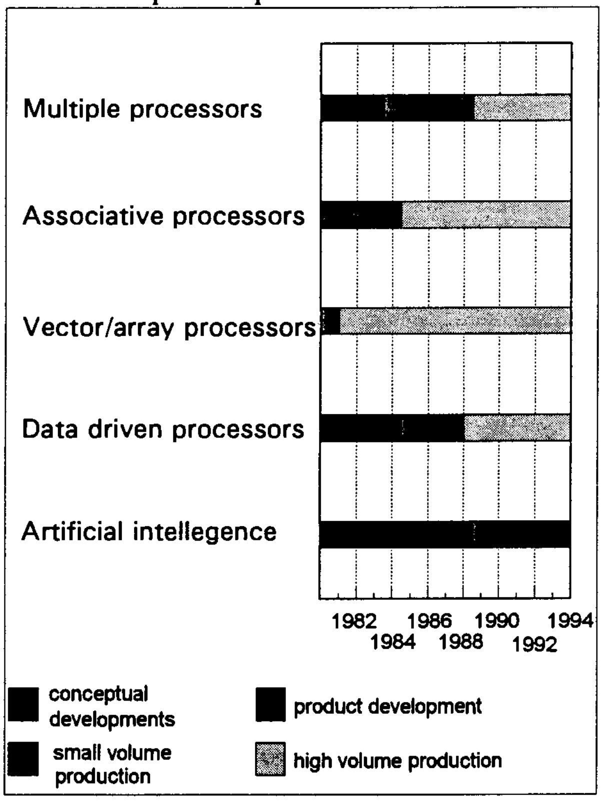
> "It is somewhat remarkable that the goals motivating most computer system development projects have remained unchanged since the earliest days of digital computers. Perhaps the most important of these long-sought-after improvements are the following:

- Increased system productivity (greater capacity, shorter response time, increased throughput).
- Improved reliability and availability.

- Ease of expansion.
- Graceful growth and degradation.
- Improved ability to share system resources." (Evans (1982: 43).

The development of predominant processor architectures over the last ten years is illustrated in Figure 8.2

Figure 8.2 - Development of processor architectures



Source (Scott 1986: 118).

There are still several limitations to current processors. These include intelligent information retrieval, the size of circuitry, instruction set structure, cost of components, limited throughput and the usage of different power sources.

The computer, as the main tool in the toolbox, will continue to be fundamental for the production of information and contribute significantly to the effectiveness of the quality of information.

8.2.2 Computer processing

In considering computer processing, several aspects will be considered. There are different methods of processing data, e.g. batch, on line etc.;

there are different approaches to processing, e.g. stand alone, integrated, distributed, etc.; and there are various operational processing techniques, e.g. pipe lining, interrupt handling, background processing, etc.

Most organisations use a combination of processing methods to accomplish their information goals. The decision to use one method of data processing over another is based on economic considerations, the processing requirements for producing the needed information, and the performance factors related to each data processing method. (Burch 1979:10).

The different processing methods will determine the speed and availability of the data for information, according to circumstances. Burch states "that as the volume of data units grows, as complexity of processing increases, as time constraints become more severe, and as computational demands escalate, an increasing level of automation is warranted." (Burch 1979: 11).

An efficient way to process large volumes and variety of transactions is to collect all transactions of the same type for a period and process them as one "batch' of transactions. This approach enables data processing personnel to control the entire processing cycle better for that type of transaction, and it improves efficient scheduling of computer processing. Payroll transactions are an example of a transaction type that is usually processed in batches. (Scott 1986: 105). An alternative to batch processing is single-transaction processing, where each transaction is entered by itself into the computer system. While the efficiencies of batch processing are lost, there is usually no delay while waiting to accumulate a batch of transactions for processing, and therefore records are updated on a more timely basis. Single-transaction processing is usually used where accelerating the speed of processing provides significant advantages, such as earlier delivery of merchandise sold. If the transaction is processed not only singularly but also as it occurs, it is said to be processed on an on-line, real time mode. On-line real time means that the record files for the transaction types are kept on line. The method of data processing, be it batch, single-transaction, or on line will directly impact on the availability of data at the right time.

It is often necessary for data to flow between systems. Data flows between systems are commonly encountered where multiple systems need to access the same data elements from a prime source or where the output of one system must be the input of another, such as when the information from a transaction processing system is input to a managerial information system. (Scott 1986: 84). The major benefit of integration is better flow of information within the organisation. Reports are likely to be more timely, and more information needs for a managerial activity would be available.

Distributed data processing systems are another data processing approach that could provide the advantages of enhancing performance, reliability, availability and modularity to an organisation. A great deal of research has taken place over the last fifteen years to find effective and efficient methods for designing, controlling, using and managing distributed data processing systems. (Yovits 1988: 122). User transparency is a primary objective of distributed systems. The processing details of a user transaction could be invisible to a user. The user is unaware of whether the transaction requires distributed processing or not. Achieving user transparency is a challenge not yet met by most distributed systems.

The data processing approach, whether it is stand alone, non-integrated, integrated or distributed, will be an important consideration to improve the consistency of data in various systems, and to a lesser degree the availability of data when it is required.

There are many complex operational processing techniques. These techniques determine the way in which the computer performs. It is dependant upon the type of processor and specific architecture. These techniques such as pipe lining, interrupt handling, and background processing, to name but a few aim at improving the reliability, throughput and capability of the computer. Although not always transparent to the users, these techniques could make a fundamental difference in the production capabilities of different computers.

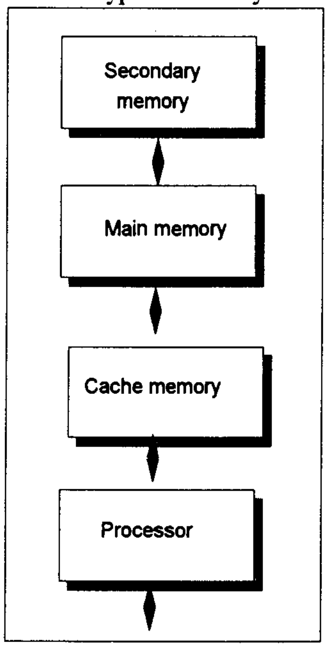
8.3 MEMORY AND STORAGE

The next major component of the technology building block is memory and storage. The objective of memory and storage for information purposes is to keep the data for as long as it is required, and to have it available in the most efficient way when required.

> "An essential element of a computing system, memory simply facilitates the storage and access of data. There are two fundamental classes of memory: sequential access and random access." (Desrochers 1987: 13).

A typical memory hierarchy is illustrated in Figure 8.3.

Figure 8.3 - Typical memory hierarchy



Source (Desrochers 1987: 61).

From a data processing point of view, the main objectives of memory and storage are to optimise the address ability of the data, and to decrease the access time. Riley commented "memory performance and cost are the twin keys to computer technology. Although new electronic devices, processor organisations, and software systems have contributed to enormous advances in computer technology, they would have been worthless without the faster and cheaper memories that were developed with them." (Riley 1971: vii). Stone summarised the most important parameters for any storage system as "the capacity of the given module, the access time to find any piece of stored information, the data rate at which the stored information can be read out, the cycle time, and the cost to implement all these functions." (Stone 1980: 211).

There are a variety of storage media and technologies. Some older ones are magnetic ink, magnetic tape, and magnetic disk. New storage technology is being introduced. Optical storage and laser storage are becoming more common place. As an alternative to magnetic media, optical disks offer on-line access to large quantities of information, low storage costs, and a durable medium that is easily handled and is less susceptible to environmental contamination than magnetic storage materials. Capacity on these discs varies from 100 MB to 4 GB with transfer rates of up to 5.4 MB per second. A massive growth in the use of this technology is expected. (Saffady 1984: 55).

Average access time of storage technologies is illustrated in Figure 8.4.

Figure 8.4 - Average access time of storage technologies

AVERAGE ACCESS TIMES
OF STORAGE TECHNOLOGIES

	1982	1987	1992	1997
random access				
fast speed RAM	12 nsec	8 nsec	5 nsec	4 nsec
medium speed RAM	60 nsec	40 nsec	25 nsec	15 nsec
slow speed RAM	250 nsec	150 nsec	80 nsec	60 nsec
fixed non-volatile RAM	350 nsec	150 nsec	80 nsec	80 nsec
fixed non-volatile ROM	70 nsec	50 nsec	30 nsec	20 nsec
rewritable non-volatile	250 nsec	150 nsec	80 nsec	80 nsec
serial access				
serial semiconductor	0.4 msec	0.25 msec	0.15 msec	0.1 msec
bubble	2 msec	1 msec	0.7 msec	0.5 msec
magnetic	25 msec	20 msec	15 msec	10 msec
video disk		0.1-3 sec	0.05-3 sec	0.02-2 sec

Source (Andriole 1985: 60).

Memory and storage significantly contribute to accessibility of information, as well as the on time availability of it.

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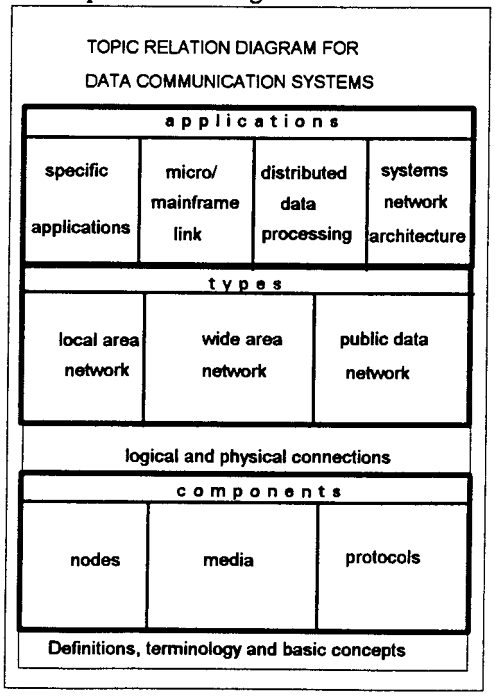
8.4 COMMUNICATIONS & NETWORKING

Communications and networking represent the next major component of the technology building block. This component includes data links between different parts of the same computer installation, e.g. terminals, printers, front-end processors and processors, data links between remote computers, and data links between remote users through various channels to various computers. (Chou 1985: 1). In the words of Umbaugh: "It is a means for providing connectivity between users and applications, a very complicated undertaking." (Umbaugh 1988: 349). The literature review revealed a very wide range of related subjects and issues. McGovern summarised the various topics for data communication systems very effectively in a diagram, illustrated in Figure 8.5. The diagram illustrates, as building blocks, a framework for communication. The different components of communication, linked by logical and physical connectors, are built into various types of networks that could be used for a wide variety of applications. These subjects could be summarised in three main groups: Communication and networking architectures, principles and devices; standards and protocols; and, data links and transmission. These three groups will be considered separately in the following sections.

Figure 8.5 - Topic relation diagram for data communications



Source (McGovern 1988: 12).

8.4.1 Architectures, principles, and devices

The rate of growth and change in the computer industry has been matched only by the rates of growth and change in communications industry. (Umbaugh 1988: 349).

A network describes the architecture of connecting several components of a single computer installation, or of multiple computer installations. Networks have a major impact on the availability of information. Whether it is in a local area network, across the borders of buildings, cities or countries, information is brought much closer to the user of it. A wide area network can be defined as inter-city data communications. All but the largest users rely entirely on services available from communication providers for their wide area network requirements. The most frequently used services are provided by common carriers such as AT & T or Telcom in South Africa. The types of services they offer are generally grouped into the categories of switching and dedicated circuits.

Dedicated circuits are established permanently and are available twenty-four hours a day, seven days a week for a flat fee. Switched circuits are most often used for intermittent transmission or for applications requiring users to log onto several hosts from a single device. The most frequently used switched circuits are analogue circuits in which a matched pair of modems communicates by means of a phone call. A newer type of switched circuit is digital switched service.

Message switching is a communication service to store-and-forward transfer formal messages. Message switching often involves an electronic mail system, by which an organisation's managers send letters, or messages to managers at other locations instead of using the postal system. Facsimile, another communication based service, enables users to transfer image reproductions of documents.

Specialised common carriers, or a value added network, offer a cost-effective alternative to traditional common carrier services. Value added networks are large networks constructed of leased lines and packet switching. Value added network services range from simple data transport to such sophisticated services as protocol conversion and electronic mail.

Satellite transport has had a controversial past. The unique advantage of satellites over cable for point to point telecommunications is that any station can communicate with any other without an in-place terrestrial cable and switching network. (Cawkell 1986: 85). Satellites, however, did not grow in popularity as expected, largely because of advances in fibre optics. Nevertheless, the possibilities of communication by satellite, and in particular potentially universal connectivity, are receiving much attention. Some most lucrative new services targeted by research and development in both industrial and private use sectors include personal portable communications, large scale data transfer, and tracking systems. (Chou 1983: 249). In considering the examples of integrated network applications offered by Chou it is quite evident that in itself, this type of network will increase the availability of information enormously. These examples are summarised in Table 8.1 below.

Table 8.1 - Examples of integrated network applications

GENERAL COMMUNICATION	electronic mail, messages teleconferencing speech encrypted speech still pictures moving pictures
ELECTRONIC OFFICE AND WORK ASSISTANCE	remote work via telecommunication terminals computer-enhanced output quality computer-assisted task management and co-ordination remote meter reading
MANAGEMENT	farm management services data collection computer-assisted problem solving and decision making modelling
COMMERCE	electronic markets and auctions computerised commerce employment service electronic funds transfer; banking services remote shopping
PROFESSIONAL	monitoring patients and population groups remote medical consultation and diagnoses medical records and other knowledge databases
GOVERNMENT	command, control, and communications logistics national crime information centre social security
PROTECTION	home and business security

EDUCATION INFORMATION, AND ENTERTAINMENT	computer-assisted education customised news selection on-request television programs video games remote instruction and interactive training teletex services

Source (Chou 1983: 268).

Local area networks consist almost exclusively of point to point connections. To the one extreme of the local area network is a system designed to connect microcomputers, to the other extreme is one designed for use in a computer room containing large, expensive mainframe computers. Stallings ascribes the phenomenal growth of local area networks to the need for sharing expensive resources, and the exchanging of data between systems. These needs were caused by the proliferation of small, single function systems and general function microcomputers. (Stallings 1985: 4).

There is a move away from analogue communication systems, which forms the backbone of our current telephone networks, to digital networks. World-wide activities in planning Integrated Services Digital Networks (ISDN) have intensified. Penetration to half the USA may be realised between 1995 and 2010. World-wide distribution is not expected to be complete before 2020. (Chou 1983: 342).

There is a strong move towards the integration of a variety of devices and data traffic types in the office environment, including copier, fax and telephone, with data types such as image, data, audio and video. Until recently, private branch exchanges (PBX's) were installed exclusively to provide a voice telephone service at a company's location. With advanced digital voice and switching technology, PBX's have become attractive alternatives for transporting data.

The different types of communication links and networking are the most significant tools to bring data sources closer together.

8.4.2 Protocols and standards

Protocols and standards plays a very important part in the development and maintenance of good communications. Under the auspices of the International Standards Organisation (ISO), Comite Consultatif

Internationale de Telegraphie et Telephone (CCITT) and the Institute of Electrical and Electronics Engineers (IEEE) a seven layered protocol was developed. These layers define the common elements of the communication spectrum, from the physical and electrical connections to the user functions.

The purposes of a protocol can be:

- To make the system convenient to use.
- To use communication resources in an efficient and orderly manner.
- To control congestion and traffic flow.
- To route and switch traffic.
- To maintain message integrity. (Chou 1983: 29).

8.4.3 Data links and transmission

Many factors influence how data is best transmitted between users and applications. These factors include the physical geography, the amount of data to be transmitted, response time requirements, cost, whether the transmissions are batch or interactive, and the period the user needs to stay linked each day. (Umbaugh 1988: 349).

Transmission speed and reliability are key characteristics of communication. These could vary extensively depending on the type of equipment used, from 200 bits per second (bps) to 560 million bits per second (Mbps) in fibre optic transmission. Transmission speed and reliability are very dependant upon the selection of the logical and physical connections used. These could relate either to the transmission media including a variety of cabling options; microwave, radio wave, or light wave; satellite channels or the telephone plant facilities (e.g. analogue or digital); or the suppliers of data communication. These could include common carriers (e.g. Telcom), special common carriers, satellite companies or private networks. (Chou 1983: 28).

Fibre optics is a recent entrant into the wide area networking market. It is the combination of lower cost, easier installation, and the added bonus of larger bandwidth that is the primary motivation behind the intense activity in the field of fibre optics. (Chou 1983: 275). Several companies in America have built inter-city networks of fibre optic cabling and are now offering high speed circuits for lease at competitive prices. There are many attributes of transmission via optical fibre cables. These include:

- Small size.
- Light weight.
- Very wide bandwidth.
- Low cost potential.
- Interference and noise immunity.
- Complete electrical isolation.
- No spark or fire hazard.
- Security. (Chou 1983: 276).

Each type of network adds another dimension to the availability of information, and connectivity allows for the bridging of different technologies and proprietorships. It is particularly in this area that open systems interconnection protocols (OSI) play an important part.

The main characteristic of communication as a whole in terms of processing information, is to make it more available.

8.5 SOFTWARE

Software is the final component in the technology building block.

Throughout the history of computer technology, software has lagged behind hardware in terms of sophistication, performance capabilities and reliability. Current trends in software technology centre around efforts to improve higher order programming languages, and tools to make computers easier to use and to increase programmer productivity. (Andriole 1985: 6).

Software consists of total programs and routines that are used to make the hardware perform its data processing functions. Included in software are manuals, documentation, and administrative procedures.

(Burch 1979: 8). Marcotty (1987: 6) summarised programming as follows:

> "A programming language is a set of conventions for communicating algorithms. An algorithm expressed in a programming language is a program."

For the purposes of this study, software is divided into two main groups: operating software and control programs, and languages and programming. Software, as a technology building block, is closely linked to the tools of other building blocks. All the applications and other models, included in the application software building block, are developed with the software building block. The distinction between software in this building block, and the software building block is the focus on the end user. The software building block forms the language platform and the development tool for the software in other building blocks. The operations managing the databases in the database building block are also developed by the software building block. Similarly the operations of the input, output, and controls building block are heavily interrelated with the programs developed with the software building block. The software and programs in the different building blocks are all very closely related, and sometimes difficult to distinguish.

8.5.1 Operating software and control programs

The operating system drives the computer's internal operations interface. An operating system attempts to maximise the utilisation of the hardware by performing many functions that were formally the responsibility of the computer operator. Operating systems are responsible for processor management, memory management, input/output device management and file management. This is collectively known as resource management. (Desrochers 1987: 90).

A large variety of operating systems and control programs can be identified:

- Batch systems for large computers (e.g. DOS/VS, MVS, MCP).
- Timesharing systems (e.g. TSM, VAX/VMS).

- Minicomputer operating systems (e.g. BOS, DMS, SUN).
- Microcomputer operating systems (e.g. CP/M, DOS, OS/2, Windows NT).
- Workstation operating systems (e.g. Mac OS, PILOT, MS Windows).
- Highly reliable and secure systems (e.g. GUARDIAN, PSOS).
- Unix and its derivatives (e.g. Unix, Xenix, Aix).
- Virtual machine systems (e.g. CMS, CP).
- Real-time executives (e.g. CCP, RTE).
- Distributed operating systems (e.g. CP/NET, DPPX). (Lane 1989: 676).

The efficiency with which any computer operation works is directly related to the selection of the appropriate software to instruct the computer to perform its operations. This efficiency will impact on all attributes of quality information.

8.5.2 Languages and programming

All instructions and programs in a computer are written in any one of a very wide variety of computer languages. Although programming languages share most common principles, they can be classified according to the area of application or mode of use. The following classifications have been identified:

- Commercial language - concerned with the manipulation of files of alphanumeric data and with production of reports.
- Scientific language - used for manipulation of numeric data.
- System programming language - used to write operating systems.
- Command language - the interface between the computer and the operating system.
- Interactive language - designed to allow changes and corrections to files interactively.
- Procedural language - allows the user to specify a set of imperative statements to be performed in a particular sequence.
- Non-procedural language - not specifying the sequence of operations, but defining the problem and its outcome.
- Applicative language - consists of the evaluation of a function that uses the input data as arguments whose value is the result of the computation.

- Data-flow language - permits the flow of data between the statements of a program to be examined so that the inherent parallelism is exposed.
- Object-oriented language - data elements are active, having some characteristics normally associated with programs. (Marcotty 1987: 7).

There are also types of languages that can make a significant difference in processing efficiency and programmer productivity. Machine languages are written in binary code that the computer can interpret directly. It is efficient for the computer, but very inefficient for the programmer. (Burch 1979: 78). Assembler languages were developed in the early 1950's. These languages were made up of mnemonic operation codes and symbolic addresses that the human being could remember more easily than the machine codes and addresses. However, the instructions had to be translated into a language that the computer understood. The translation was performed by an assembler program that converted the mnemonic operation codes and symbolic addresses (the source program) into machine processible form (the object program). Compiler languages are also known as high level languages because the instructions resemble the English language or mathematical expressions used by humans. Pratt summarised the reasons why programmers prefer one language over another as follows:

- Clarity, simplicity, and unity of language concept.
- Clarity of program syntax.
- Naturalness of the application.
- Support for abstraction.
- Ease of program verification.
- Appropriate programming environment e.g. documentation.
- Portability of programs.
- Cost of use for both development and maintenance. (Pratt 1984: 12).

Each language has its own programming techniques and rules. It is these techniques and rules that distinguish to a large extent one language from another. In choosing between languages several practical considerations should be considered. Harold identified the following considerations:

- Size of installation.
- Type and variety of applications and the language facilities required.
- Language efficiency in execution, compilation, and core store usage.
- Skill and training of present staff.
- Standards of the organisation.
- Manufacturer's support for the language and machine constraints.
- Software and liveware problems of switch over.
- The problem of mixed applications.

(Infotech state of the art report 1974: 234).

There are many languages, some for very specific uses, others for more general use. The choice of language, and the specific application of the language, will decide the effectiveness of the programs developed. The efficiency of programs has a direct impact on all attributes of information quality.

8.6 CONCLUSION OF ASSESSMENT

The technology building block can be regarded as the heart of data processing. Without the technology building block no electronic information production will take place. For the purposes of assessing the technology building block it will be grouped as processing, memory and storage, communications and software. The process described in section 5.3.4 will be followed to assess this building block.

The primary objectives of the components of the technology building block are identified from the characteristics of the tools in the previous sections. Table 8.2 summarises these objective and their translation into the quality attributes.

Table 8.2 - Summary of main objectives of technology building block

TECHNOLOGY BUILDING BLOCK COMPONENT	MAIN OBJECTIVES	RELATED QUALITY ATTRIBUTE
processing	processing speed	timeliness
memory and storage	data availability	relevancy timeliness
communication	access to data	relevancy timeliness
software	accurate and reliable data processing	accuracy

The supportive roles of the technology building block components are so strong that they might sometimes seem like the main objectives. It is important to evaluate the difference between main objectives and these strong supportive roles for this assessment. The following paragraphs will argue the validity of the main objectives listed in Table 8.2.

The accuracy of processing is, in the first place, dependant on the effectiveness of the programs instructing the hardware to perform and the quality of the data it processes. Malfunction of the hardware will negatively affect the accuracy. The processor, therefore, has a very important supportive role which is to ensure accuracy, but it is not its main objective to produce accurate information. The processor is responsible for receiving data from capturing, performing the programs to process the data into acceptable format and then to perform the instructions of the programs to produce the results. It therefore has a very important role to ensure that the information is accessible and appropriate for the user. Its contribution to the relevancy attribute is significant, However, it is not the main objective of the processor to ensure the relevancy of information, but to perform its main functions so that relevant data will automatically flow from it. Finally, the processor is only limitedly responsible to affect the comprehensibility of information. Its real involvement is in performing the programs responsible for producing the output and managing the hardware resources related to it. The main objective of the processor is to make a major contribution towards the speed and throughput of processing. The conclusion is that its effectiveness to influence accuracy and relevancy is supportive, and comprehensibility only limited.

Memory and storage is the custodian of data and makes it available to the rest of the system. Both timeliness and relevancy are significantly dependant on the availability of the appropriate data when required. The accuracy of the information is not greatly dependant on the storage of it, though malfunctioning could decrease the reliability of the information. Its assessment is somewhere between supportive and limited. For the purposes of this study it will be regarded as supportive.

Finally, memory and storage has no contribution to make to the comprehensibility of data. It does not affect presentation or output.

Communications are highly effective and make a major contribution to improving the relevancy of information through availability and accessibility. They are also designed to obtain information timeously, and are highly effective in this. Bad communication could cause significant breakdowns in the accuracy of information. Because of the lack of technological advancement, the elimination of corrupted or incomplete data transmission is an important focus area for communication. However, the main aim of communications is not just to ensure the accuracy of data. Provision of reliable data transmission is one of the fundamentals for an effective communication system. Communication is therefore only supportive of the accuracy attribute. Without effective communication channels, users will find it difficult to understand the information presented. The capabilities of communication enhance the availability of more effective forms of presentation, such as video and graphics. It is therefore supportive in improving the comprehensibility of the information through closing the gap between the information and the users.

In assessing the software building block, the distinction between the software and applications software building blocks must be re-emphasised. The software building block is used to create the applications and models. The software building block plays a distinctive, although not dominant role in improving information. It supports all attributes of quality information as the development platform for the creation of the programs and models responsible for the actual production of information. Incorrect use, or inappropriate software for a specific use, will inadvertently decrease the effectiveness of programs and therefore the accuracy, relevancy, timeliness and comprehensibility of information.

The assessment ratings for the technology building block are deducted from the motivations above and summarised in Table 8.3.

Table 8.3 - Assessment rating summary of technology building block

	RELEVANCY	ACCURACY	TIMELINESS	COMPREHEN-SIBILITY
processing	5	5	10	1
memory and storage	10	5	10	0
communications	10	5	10	5
software	5	5	5	5

CHAPTER 9

ASSESSMENT OF DATABASES BUILDING BLOCK

9.1 INTRODUCTION TO DATABASES BUILDING BLOCK

Databases are considered as the third main building block in the data processing cycle. Databases can be regarded as the entire accumulation of data to meet the data processing and information requirements of an organisation. (Burch 1979: 80). It is a highly integrated but flexible collection of computer files, each consisting of several records. For the databases to be useful, the files should be cross references to each other in a meaningful way. (Bradley 1983: 2). The data in the databases is normally shared among users in many parts of an organisation and at many different organisational levels.(Burch 1979: 80).

The distinction between data structures and storage structures has been recognised for some time. They are also called physical and logical structures. (Bradley 1983: 49). The physical data is the data that the database manager stores, or retrieves from some medium. The logical data would represent the data that the application program presents to or receives from, the database manager. In considering the characteristics of databases for the purposes of information processing, this study will distinguish between the physical and logical characteristics of databases.

9.2 PHYSICAL DATABASES

Physical databases include the physical structures and storage devices of data and files. The physical structures of data and files will be considered in this paragraph. Storage devices have already been discussed in the section on memory and storage.

Databases consist of a collection of files. Files consist of a collection of records. Each record could have different fields. Each field may have unique attributes. These attributes will decide the length of the field and the characteristics of the contents of the field. The data dictionary contains the information on the structure of the files, the types of data and the uses of it. (Davis 1985: 505).

The physical design of databases concentrates on the interrelationship of files, records and fields with each other. There are several ways in which a database can be designed. Aspects that impact on the complexity of the physical design of databases include the number of links that must be made between data components, the number of data units, and the complexity of the relationships. (Infotech state of the art report 1975: 64). The objectives of the physical organisation and storage of data records are to promote, share ability, evolve ability, and establish the integrity of the data. (Davis 1985: 502).

A description of these objectives is summarised in Table 9.1.

Table 9.1 - Objectives of physical organisation of databases

DATABASE OBJECTIVES	DESCRIPTION
Availability	Data should be available for use by applications (both current and future) and by queries
Share ability	Data items prepared by one application are available to all applications or queries. No data items are 'owned' by an application
Evolve ability	The database can evolve as application usage and query needs evolve
Data independence	The users of the database establish their view of the data and its structure without regard to the actual storage of the data.
Data integrity	The database establishes a uniform high level of accuracy and consistency. Validation rules are applied by the database management system

Source (Davis 1985: 504).

There are various methods of relating data components to each other, including pointers and sequential connections. The use of pointers to chain one record to another provides for a plausible method of getting from one record to another. Files can be linked in different ways, including: linked files, inverted files, hierarchies, relations, nets and networks. These methods are often used in combination. There are also different approaches to designing the relationship between files.

Choices between different approaches to design databases are closely linked to the hardware associated with it. Some key components are the processor, memory and storage that were dealt with in previous paragraphs. The speed limitation and storage capacity of the external storage devices have a great impact on the design and effectiveness of database management systems. There are many trade-offs to be made in selecting the physical design of databases such as storage utilisation, speed of access, ease of maintenance, and availability of data for a variety of uses. (Davis 1985: 505). The targeted application programs for the databases will also have a major impact on the selection of the appropriate database design. Applications with large quantities of data will demand designs that optimise the links between data components.

Much research and development are directed towards effective physical relationships between data and files. Duplication of the types of relationships between data components in the human brain and the "database design" of it has not yet been achieved. While databases are still largely dependant on file structures and the relationship between files, data in the human brain is not structured in any "file" format. Constant development in this area could ensure that data could be accessed more effectively. The types of designs currently available have already improved the accessibility of data tremendously.

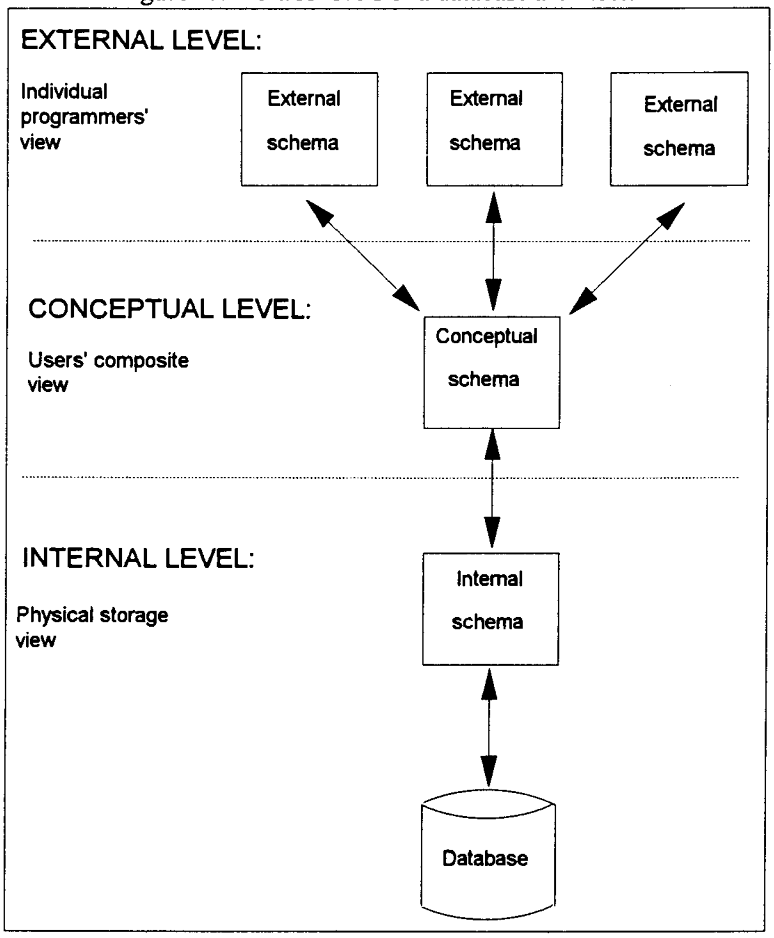
9.3 LOGICAL DATABASES

The logical aspects of database design include:

- Data independence.
- Data reliability.
- Data integrity.
- Security.
- Elimination or reduction of redundancy.
- Multiple search strategies.
- Centralised control of data and its use.
- Concurrent access.
- Ad hoc enquiry. (Infotech state of the art report 1975: 14).

A database architecture has three levels: internal, conceptual and external. This architecture and the different views of a database are illustrated in Figure 9.1.

Figure 9.1 - Three levels of a database architecture



Source (Infotech state of the art report 1975: 12).

This architecture is managed by the database management system (DBMS). This system will relate the data in an integrated file of information, and control it in such a way that it could be shared by, and be developed for, a community of users. The DBMS uses various types of database languages. The data description languages are used for creating schema and sub-schema directories. The data manipulation languages control the I/O statements to access the database. The query languages are more user-friendly English-like languages to help with the retrieval of information without writing detailed programs. (Tsai 1989: 198). The benefits that database management offers are manifold. Rullo (Rullo 1980) featured the key benefits:

- "Integration of systems offering the benefit for sharing timely and accurate information among end users.
- Minimal data redundancy reducing the cost of storage and improving data integrity that increased performance and overall operational efficiency.
- Data integrity, not only from reducing data redundancy, but also from automatic validations. This improved the reliability and correctness of information substantially.
- The on-line nature of database systems increase the usefulness of information. DBMS's provide quick and timely information for decision making.
- Data independence decreased the cost and time to change the size or type of data item, offering much more flexibility in the user's logical view of the physical database.
- Sophisticated backup and recovery procedures and controls had to be built in to prevent database corruption and other errors that could be disastrous.
- Security with centralised databases is easier to develop and maintain than with multiple files and application systems.
- Database systems increase the complexity of physical storage structures, access methods and search logic. They require much more powerful processors. Tuning and performance are therefore of utmost importance with trade-offs between fast response time and throughput." (Rullo 1980: 70).

There are various methods by which data can be accessed in a file. The main considerations of the different methods are:

- Ability to handle large volumes of data.
- The time it takes to access a specific data item.
- The complexity to operate the specific access method.

The most important methods of file accessing is sequential, indexed sequential, relative, and direct. (Tsai 1989: 32). Large files are often created by batch processing. The processing can be small, or it can be quite complex, including the editing or checking of the validity of the data against data stored in other files. (Bradley 1983: 33). Batch processing of sequential files is a relatively efficient process, although it usually means that every record must be read. Programs for the generation of reports from these files usually take some time to develop. For example, a manager could not phone the data processing department with a request for regular reports with a complicated calculation method and have the report immediately available.

The main problem with sequential files is that the records always have to be accessed sequentially. It is possible to retrieve a record from a particular address which is based on the value of the primary key field of the record. This can be done in an index sequential file. Index sequential files have their records stored in ascending primary key order, but besides that, they also have an index for each record. The main disadvantage of index sequential files is the need to access the index during processing by direct access, so that about three disc accesses are typically needed for each record retrieved. This means that an index sequential file that is part of a nation wide on-line system is bound to have bottlenecks. (Bradley 1983: 76).

The hashing technique with direct access can also be used to access database records. The disadvantage of hash files is that they are not convenient for sequential batch processing. However, for the types of on-line application for which they are commonly used, this is not an important consideration. Hash files are commonly used as database storage files. The most important aspect for the efficiency of a hash file is the average search link, which is the average number of disc accesses required to retrieve a record. (Bradley 1983: 71).

9.4 CONCLUSION OF ASSESSMENT

Physical database structures support the logical database structures. For the purposes of assessing the contribution that the database building block makes to the attributes of quality information, no differentiation can be made between these two components.

The primary objective of databases is to ensure efficient access to data and information. It is highly effective in contributing to the relevancy attribute of quality information.

Databases are not primarily responsible for the accuracy of the information, although they support other tools in maintaining the integrity of data, and eliminating conflicting data elements. Badly designed databases can greatly affect the reliability of information. They therefore strongly support the accuracy attribute.

A primary objective of database design is to decrease the time it takes to access the data in the databases. It has the potential to be highly effective in improving the timeliness of information. However, further research and development would increase the efficiency of databases and their architectures to reduce access time of databases.

Databases are supportive in making information more comprehensible by improving the understanding of the data that produces the information. It is easier to understand the information and the process of producing it, if the data is more transparent and properly normalised.

The assessment ratings of the database building block derived from the discussion above are summarised in Table 9.2.

Table 9.2 - Database building block assessment ratings

SUMMARY OF DATABASE BUILDING BLOCK	
Relevancy	10
Accuracy	5
Timeliness	10
Comprehensibility	5

CHAPTER 10

ASSESSMENT OF THE CONTROLS BUILDING BLOCK

10.1 INTRODUCTION TO CONTROLS BUILDING BLOCK

The fourth main building block in the data processing cycle is the controls surrounding all the operations. These controls are not only to be found in a particular area, such as the input process, but cover the information generation process from start to finish.

Controls are a requirement for a business as a whole and for its subsystems. Without controls in the subsystems, resources may be wasted and objectives never achieved. Internal accounting controls will produce valid, accurate, complete and authorised accounting data in a system. This data is the raw material for the production of information.

The controls that are available to manage information will ensure that the system receives reasonable data. However, without accurate data, all the measures taken to control the information will be superficial. Incorrect information could be due to human errors or machine errors.

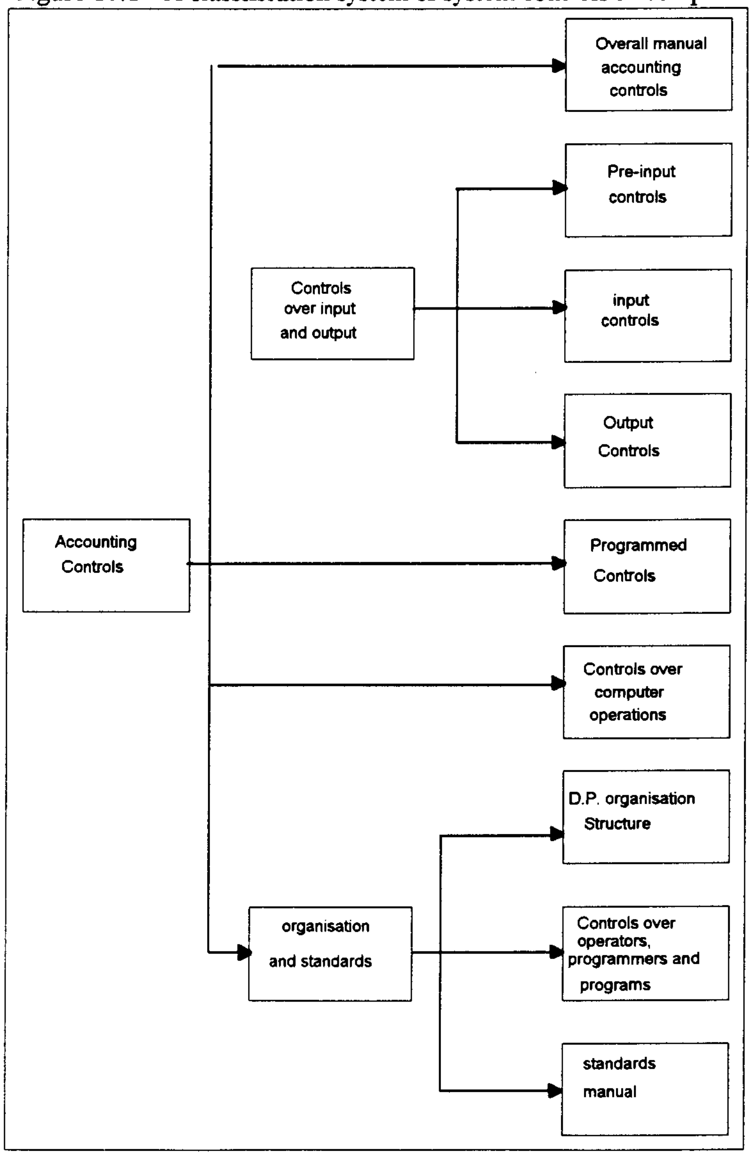
Seven major areas of control in an information technology environment were identified by Murphy. (Murphy 1989) These are:

- Implementation controls. Designed to ensure that programmed procedures for new systems are appropriate and are implemented effectively.
- Maintenance controls: Designed to ensure that changes to programming procedures are designed, tested, approved and implemented appropriately.
- Computer operations controls: Designed to ensure that authorised programmed procedures are applied consistently and that correct versions of data files are used.
- Program security controls: designed to ensure that unauthorised changes cannot be made to programmed procedures.

- Data file security controls: designed to ensure that unauthorised changes cannot be made to data files.
- System software controls: designed to ensure that suitable system software is implemented and protected effectively against unauthorised changes.
- File conversion controls: designed to ensure that data is converted from an old to a new system completely and accurately. (Murphy 1989: 13-3).

Chambers summarised the controls somewhat differently. All the elements identified by Murphy can be associated with the classification of Chambers. The classification of controls by Chambers is illustrated in Figure 10.1.

Figure 10.1 - A classification system of system controls in computer systems



Source (Clark 1991: 17).

According to Murdock control means bringing or maintaining:

- "The performance of an individual, group, machine, or facility, or
- the characteristics of an individual, group, machine, or facility, or
- the characteristics or value of a variable within prescribed limits." (Murdock 1980: 172).

The control of information will therefore ensure the continued availability of the information systems (performance), and the continued retention of integrity or accuracy (characteristics) of the elements of information.

For the purposes of producing information, the control building block will be considered as those controls aiming to ensure the integrity or accuracy of the data and eventual information; those controls affecting the processing of data; and finally the remainder of the controls affecting the systems environment.

10.2 CONTROLS AFFECTING DATA AND INFORMATION

These are the controls that have direct contact with data and information, and input and output processes. According to Umbaugh "input controls ensure that the data centre processes only authorised, properly formatted input that conforms to control procedures for batch control documents, control totals and document counts. A data control function is a common means of verifying input acceptability." (Umbaugh 1988: 554). These controls include pre-input controls such as division of duties, input forms design, pre-numbered documents, tidiness and direct entry, and input controls such as check digit control, batch control, authentication and authorisation.

Output controls ensure the integrity of information after processing (i.e., information is complete, accurate, and distributed only to authorised personnel). (Umbaugh 1988: 563). These controls include control totals, distribution of output, computer output operations control and output message control.

10.3 CONTROLS AFFECTING PROCESSING

The next layer of information-related controls is involved in the processing or converting of data into information. These controls ensure that the captured data is not corrupted, changed, or lost, and that the information produced is not incorrect, incomplete, or invalid.

Implementation controls ensure that new systems operate as expected and produce the desired results, as for instance, file conversion controls. Maintenance controls include testing of programs, documentation and change management. Logging records the activity of a computer. It lists all the requests made by a user, or all the transactions performed by the computer. Recording these activities provides a trail to check for misuse, or to be used for recovery. (Chambers 1975: 35). Programmed controls include validation checks, posting checks, run-to-run controls, and control totals.

Communications control the flow of data between users and computers. With the increased dependence on computer communication technology, a widespread awareness of the need for security and privacy in public communication systems emerged. (Chou 1983: 369). The growing recognition of the need for computer and communications security has stimulated the design, development, and installation of "patches", packages, and even new operating systems intended to provide higher degrees of data and system protection.

10.4 CONTROLS AFFECTING THE SYSTEMS ENVIRONMENT

There are many other traditional systems controls that ensure a stable and secure operational computer environment. Computer operations controls such as file security, recovery procedures, operating instructions, job submission and authorisation, ensure the smooth running of operations.

It also includes: system software controls, program security controls, organisational controls and standards and procedures.

Physical security of computer and communication installations such as area access control, hazard protection, personnel practices, backup, recovery and disaster planning, and backup for power and cooling, mainly protects the computer tools.

10.5 CONCLUSION OF ASSESSMENT

The control building block is not isolated to a particular tool, or to a specific process of producing information. The controls span, the total spectrum of all the tools, and enhance the capability of each to accomplish its objectives. Without controls, all data processing will, most probably, result in chaos.

Controls improve the effectiveness of tools such as databases, and of communications that improve the relevancy of information. This support is not the primary focus of controls as the contribution of controls to relevancy is limited.

Controls assist tools such as programs, models, data capturing equipment, communications and output devices thus ensuring that the information produced is accurate. Also, controls are designed to improve integrity and accuracy of data. They make a significant contribution towards the accuracy attribute of information.

Certain controls, such as scheduling and operators controls, aim to ensure that information is produced at the right time. On the other hand, controls sometimes prolong the time it takes to produce information, as when additional steps are added to the process. The contribution of controls to timeliness should thus be regarded as limited.

Controls such as programming controls and output controls, support tools such as programming, applications and output devices, are responsible for improving the understanding of information.

Controls, by design, aim at supporting other functions and do not have any primary objective to contribute to the attributes of quality information. The assessment rating of the controls building block is summarised in Table 10.1.

Table 10.1 - Controls building block assessment rating

SUMMARY OF CONTROLS BUILDING BLOCK	
Relevancy	5
Accuracy	10
Timeliness	1
Comprehensibility	5

CHAPTER 11

ASSESSMENT OF THE APPLICATIONS SOFTWARE BUILDING BLOCK

11.1 INTRODUCTION TO THE APPLICATIONS SOFTWARE BUILDING BLOCK

The applications software building block can be regarded as holding all the software that transforms the requirements of the users into results. Application software can be defined as all programs developed to perform specific functions. Software for a single application can consist of multiple programs, files and databases. It could also perform many functions. The applications software building block is the user's point of contact with the technology and databases building blocks. With the applications software building block, assisted by the technology and database tools, the users transform data into information.

All programs in the applications software building block are developed by the software component of the technology building block. The technology building block provides the languages, development platforms, and control programs to develop applications software. Occasionally the application programs and models will require specialised computers and other devices, such as neural computers, or large storage capacity. It could also require special types of databases, such as relational databases. The application software links the functionality of all the other building blocks to produce the results required by the users.

For the purposes of this study, the applications software building block will be divided into three groups. First the vast selection of applications or functionality offered by different programs will be considered, then specialised models that support managerial decision making will be discussed. Finally those programs that improve the interaction between the user and the computer will be considered.

11.2 APPLICATIONS SOFTWARE

An ever increasing number of computer applications are being developed. The development of new applications is driven by the needs of users to computerise more of the processes they are involved in. New developments in programming languages, computer technology and the other data processing building blocks also stimulate new applications development.

At the Cebit 1992 International Technology Fair in Germany, 515 (Cebit international technology fair 1992) different product groups of applications were on sale. These applications covered all walks of life. Business applications have been grouped by Gessford as follows:

Personnel administration data systems.
Payment systems.
Financial control systems.
Operations systems.
Systems for planning.
Strategic information systems. (Gessford 1980).

The satisfaction of the users with the software is the measurement of effectiveness of applications. The same application might satisfy one user, and fall short in producing the desired results for another. As users become more computer literate and sophisticated, their needs change, and the level of expectations increases.

Applications are not static, but are constantly being changed, upgraded and sometimes replaced with improved software to meet the changing needs of users, and to make full use of new developments in technology.

Applications development and implementation should be managed properly to achieve the desired results. Different application development processes are used, depending on the types of applications to be developed. Unstructured applications such as decision support systems, could be developed using an experimental process such as prototyping. Structured application systems are usually developed through the systems development life cycle model in which each stage of development is well defined and has straightforward requirements for deliverables, feedback and sign-off. (Davis 1985: 572).

Application programs are subject to the limitations of the other building blocks. For example, a program cannot exceed the speed of the processor when executing functions. It is limited by the database structure and capabilities when optimising the management of data; and the quality of a graphics display is limited by the capabilities of the display technology.

On the other hand, the functionality of all the other building blocks is completely dependant on the efficiency of the applications software. For example, input equipment must have application programs to run the processes of data collection. The data in storage on disk requires applications software to access it, use it, browse it or perform any other functions with storage devices; and application software is required to format the reports produced on screen or printed.

11.3 DECISION SUPPORT MODELS

A separate discussion of decision support models is warranted because of the significant contribution that these applications make to the enhancement of quality information.

During recent years, several application software models that focus on improving the decision making of management, have become popular. These products include decision support systems (DSS), expert systems, executive information systems (EIS) and analytic modelling. Only a few decision support systems were implemented before the 1970's. (Scott 1986: 81).

11.3.1 Decision support systems

A decision support system is an interactive system that provides the user with easy access to decision models and data to support semi-structured decision making tasks. It may be easier, however, to define DSS's by describing their characteristics. These characteristics are:

- Focus on the less structured, unspecified problems that senior managers face.
- Combining the use of models or analytic techniques with traditional data access and retrieval functions.
- Focus on features that simplify their use, interactively, by non-management information systems personnel.
- Emphasis on flexibility and adaptability to changes in the environment and the decision making approach of the user.

Rather than attempting to provide systems that give management whatever information it needs to manage the company, developers are designing DSS's with a specific decision, or a well-defined class of decision, in mind. Consequently, such commercial software packages as planning languages (IFPS, Empire, Simplan) and spreadsheet systems (Lotus 1-2-3, Excel, Visicalc) are not examples of a DSS. They are DSS generators that can create a specific DSS to support a specific decision in a specific organisation. Examples of specialised DSS software packages are the IBM DATA Interpretation System (Watkins 1991: 20), and IMS (interactive marketing system). (Sprague 1986: 49).

The future of decision support systems will be marked by three main trends: first, the gradual improvement and sharpening of skills in the development and implementation of traditional DSS's; second, advances in database and graphics capabilities for micro computers; and finally, exploratory work in such fields as expert systems, DSS's to support group decision making and visual interactive modelling. (Symposium on information retrieval 1976: 704).

DSS is particularly suitable for organisations with the following scenarios:

- The organisation needs to make high value decisions in short time frames using data intensive ad hoc analysis. These decisions will have a direct impact on profitability.
- The business professionals spend time on data gathering tasks such as downloading data from a mainframe to a PC, or re-keying data from printed reports into spreadsheets.
- It takes a programmer with knowledge of SQL or a 4GL language to access and analyse the databases. As a result, the information user is dependant on the information services department or outside consultants.
- The organisation needs to access databases easily that range in size from 100 Mbytes to several Gigabytes.
- The business professionals may want to analyse data from different computers or different data sources. (Watkins 1991: 21).

Some main characteristics of decision support systems are:

- It is a general purpose set of facilities to help people in making decisions.
- The user, who is usually a senior or middle manager, has control over the "models" and performs his own adjustments.
- Altering the model or its data input slightly, which is easily accomplished, offers alternative solutions to a managerial problem, each of which can then be evaluated.

The elements of a decision support system include the model, a specialised data file in the nature of a database, and a manager who interacts directly with the model through a terminal to test possible solutions to a managerial problem. The data in the database is typically a combination of data extracted from the organisation's transactions or master files, and data from external sources, although all the data may come from only one of these sources. Often a rudimentary decision support system to deal with a special problem of management is assembled in just a few hours of analysis and programming and is then discarded when the crisis is over.

Several special-purpose software packages are available to help non-data processing personnel develop a decision support system quickly. These language packages usually include several pre-written analysis routines such as interest calculation formulas, discounted cash flow calculation routines, internal rates of return, and time-series analysis routines. Pre-written report preparation routines also greatly ease the programming burden.

In a research project, highlighted by Sprague, company officials were asked what motivated the development of the DSS. The most frequently cited factor was a need for more accurate information. This factor was mentioned in 67 percent of the cases. (Sprague 1986: 40).

11.3.2 Expert systems

There are many situations in which people could make use of a high level reasoning tool to help them store knowledge and enable others to access it. Knowledge is a sophisticated form of information, and expert systems are sophisticated information systems. (Hart 1988: 15). It is almost impossible to provide a definition of "expert system". It may mean different things to different people. Certainly the use of the word "expert" is misleading. Heart said: "Indeed I hope that the term "expert system" will soon disappear and that we shall start to talk about different types of knowledge base systems." (Hart 1988: 23).

An expert system assists the decision maker with certain types of problems and can provide solutions if the user can supply answers to the questions. An expert system is designed for specific fields of problems, not as a general tool. One of the features that distinguishes between a decision support process and an expert system, is the ability of asking the computer "why?". An expert system will have the relevant knowledge stored in a way that is accessible to the user of the program and will allow the user to be aware off what the system is doing, and why.

An expert system needs knowledge, some means of using the knowledge, and the capability to communicate with a user. These features are often called a "knowledge base" or an "inference mechanism," or a "man machine interface." The knowledge base is where the knowledge is stored. This knowledge consists of facts and rules. The distinction between the knowledge base and the inference mechanism is not always clear. Part of the inference mechanism may be represented in the knowledge base rules. The knowledge base and inference mechanism do not exist without each other, but most designers try to keep rules associated with knowledge separate from those associated with the inference.

It is estimated that there are some 1500 expert systems in operation. According to Grupe these systems save the companies using them about $100 million annually. (Grupe 1991: 36).

Knowledge engineering is the term that is used to describe the process of building expert systems. (Hart 1988: 28). The person who carries out the task is sometimes called the knowledge engineer. Almost all the authorities agree that expert systems should be built by using prototyping, normally by using a shell. Expert system shells are artificial intelligence programming environments that simplify the creation of expert systems. An advantage ascribed to the use of expert systems shells is their ability to deal with uncertainty. (Grupe 1991: 36). A shell is like an empty expert system, because it has predefined forms of knowledge representation and inferences, but no knowledge about the application. An inference network is used to describe the rules by which knowledge is entered and related so that inferences can be made. Representing and handling knowledge is not simply a matter of storing and approving numbers.

According to Hart "expert systems are aimed to use a system to make people better on what they are good at, by exploring the things that computers are good at." (Hart 1988: 25). It is expected that expert systems will make a major contribution towards improved qualities of information in the future.

11.3.3 Executive information systems

Executive information systems (EIS) are developed specifically for senior management and therefore attempt to broaden the horizon and to look at the organisation as a whole over a long period. EIS information can have a very broad range of sources. An imaginatively-designed EIS might include internal data on finance, personnel, marketing, customer satisfaction and production quality. External data might cover competitors, their products, their publicity, foreign currency exchange rates, a model of economic trends and data on statutes and regulations. (Black 1991: 2).

EIS can be used to:

- Select and store information from external databases, e.g., new services and stock prices, also internal company databases.
- Compare and contrast different sources of information and identify changes and anomalies. Data can be compared with predetermined norms or targets, with other data sources or with historical information.
- Present information in an easy-to-understand, colour-graphic form, without the need for keyboard skills.
- Probe into several different layers of information, to focus on detailed operational figures. (Bird 1991: 11).

EIS differs from DSS in several significant aspects:

- EIS typically covers a wider breath of information sources, both internally and externally and allows rapid adaptation to changing requirements.
- DSS is often functionally specialised, meeting the needs of specific business groups.
- DSS relies on the computer knowledge of the user whereas EIS is designed for people with no time or inclination to operate complex interfaces.
- DSS is typically based on large databases whereas EIS is designed for rapid response. (Bird 1991: 18).

EIS is still an immature technology. Putting an EIS together is a major undertaking that is likely to be time-consuming for most people within the organisation, and may require bringing in outside consultants.

11.3.4 Analytic models

The rapid development of computer technology has made it feasible to develop, adapt, and implement quantitative methods as an aid to management. Decision analysis has become an important technique in the solution of business problems. It is most useful for making long-range decisions such as capital investment, product selection, plant expansion, mergers and acquisitions, and many other problems. (Brosh 1985: 88). The speed and data storage capacity of the computer makes it possible to process large quantities of data. Perhaps more important, it provides the capability to solve and validate mathematical models that would take too much time to calculate manually or which could not be solved by any other method.

Several mathematical methods for decision making can be identified:

- Linear equations and inequalities.
- Curve fitting with either freehand, semi-average, moving-average, or least-squares methods.
- Complex linear problems with the simplex method.
- Probability solutions.
- Goal programming.
- Sensitivity analysis.
- Assignment models.
- Critical path method.
- Program evaluation and review technique (PERT).
- Queuing models.
- Simulation.
- Markov chain models.

(Brosh 1985: 311,253,525; Kim 1989: 422, 492; Baltz 1970: 274).

These models represent powerful tools to analyse information and derive solutions. Through this process the quality of information is enhanced.

11.4 USER INTERACTION PROGRAMS

11.4.1 Graphics

Graphics applications are designed to enhance the ability of the user to understand the information presented to him.

Producing graphics requires hardware and software. The hardware tools will be discussed in a following chapter. The hardware is of little value if it is not accomplished by appropriate application software. Business graphics software takes one of three forms:

- Stand-alone graphics packages.
- Graphics subroutine packages.
- Purpose-made programs. (Lansdown 1982: 43).

The range of business graphics applications is wide and has already produced unexpected payoffs by providing in new ways of looking at business data and of putting new pressures on data gathering. Lansdown said that "graphics as an aid to decision making are seen by some as the most useful application." (Lansdown 1982: 69).

The following are the most commonly used application areas for graphics:

- Simulation - interfacing graphics with simulation models.
- Representing different data - representing data with abstract images such as bars, lines, circles and other pictographic symbols.
- Animation - dynamic presentation of information.
- Financial information - communicating financial data.
- Business planning - representing long-range planning pictures.
- Statistical graphics - statistical data presentation and analysis.

Developments that are likely to improve the usability of systems and also add to more widespread penetration of graphics in the business market include:

- Executive workstations.
- Videotex.
- Improved hard copy devices.
- Videodisk.
- Voice input.
- Picture input.
- Application software packages.

The power of graphics in business applications is enormous. Lansdown is realistic in commenting that "it will certainly take some time and some familiarity before users are able to exploit the power of business graphics fully." (Lansdown 1982: 87. It will, nevertheless, make a large contribution to the improvement of quality information.

11.4.2 User interface

Kirakowski formulated the applied goal of the human-computer interface development as: 'to create usable computer systems' (Kirakowski 1988: 5).

The user interface cannot be seen as a tool in itself, but as a focus on the redefinition of a whole range of tools which improve effective interaction with the computer. It is a science to reconsider the strategy for, and the building of, all the tools that influence human interaction with the computer. It dominates the current development of data capture, programming, applications and output. The enhancement of the characteristics of the tools in all these areas is very closely linked to development of the theory and practice of the user interface science.

Four types of user interfaces can be identified:

- Developing computer programs.
- Dialogue, or browsing through files.
- Accessing data.
- Providing input. (Scott 1986: 89).

The research and development in the area of the user interface was initiated by an increase in focus on the human elements of computing. It found its roots clearly in cognitive psychology. As stated in the scope of this study, it is not primarily concerned with the human element in the information processing cycle, but with the tools available to the human for its information processing functions. This study will only focus on the elements of the user interface that enhance other tools to improve the ultimate quality of information.

Preece considered the user interface and saw it as synergistic coupling of human and machine capabilities that is labelled 'man-computer symbiosis'. (Preece 1990:8). Ten problems, the solutions of which prerequisites for true man-computer symbiosis, were listed by him. These ten problems give insight into the extent of what the user interface is all about:

- "Time-sharing of computers among many users.
- An electronic input-output surface for the display and communication of correlated symbolic and pictorial information.
- An interactive, real time system for information processing and programming.
- The facilitation of human co-operation in the design and programming of large systems.
- Combining computer speech recognition, hard-printed character recognition and light pen editing.
- Natural language understanding, including syntactic, semantic and pragmatic aspects.
- Recognition of the speech of arbitrary computer users
- The theory of algorithms - discovery, development and simplification.
- Heuristic programming." (Preece 1990: 8).

The objective of a study done by NCR Corporation at Dayton, Ohio, (Preece 1990: 37) was to show the benefits of improved human interface design. A reasonably successful NCR package was taken and improved upon in the categories of: screen formatting, screen content, elimination of abbreviations, consistency; data entry/change procedures, error correction and feedback and on-line assistance. The comparative experiments confirmed an improvement of 25% in the average transaction time, and a reduction of 25% in the error rate. 75% fewer transactions were cancelled and restarted. This operation clearly proved that benefits could flow from improved human computer interface design.

According to Preece the quality of an interaction design is found by some combination of the following primary criteria:

- "The time any user must spend accomplishing a particular project that the system is intended to support.
- The accuracy with which the user can accomplish the project.
- The pleasure the user derives from the process." (Preece 1990: 76).

These user interfaces plays a significant part in the enhancement of the process of producing information and improving the quality of it. The main focus of the user interface is to improve the general ability of the user to work with the underlying tools. For example, the processor provides the ability to do multi tasking. However, it is the enhanced capability of the user interface to switch between tasks and to the view of several tasks performed on the same screen with windows, which improves the capability of the user to relate and manage multi tasking.

11.5 CONCLUSION OF ASSESSMENT

The applications software building block is the link between the needs of the users and the use of computers to perform operations, take actions and make decisions. It is the prime contact of the users with all of computer technology. It is the channel through which the computer interacts with the user. It performs the operations that the users demand. Through the applications software building block the computer tools process the data into information and prepare it for use by the users. Quality information is largely dependant upon the applications that produce it.

The components of the applications software building block are designed to effectively improve all four attributes of quality significantly. The contribution that applications will make to the improvement of the attributes will largely depend on the design, or the selection of the programs for a specific situation.

The assessment rating of the applications software building block is summarised in Table 11.1.

Table 11.1 - Applications software building block assessment rating

SUMMARY OF APPLICATIONS SOFTWARE BUILDING BLOCK	
Relevancy	10
Accuracy	10
Timeliness	10
Comprehensibility	10

CHAPTER 12

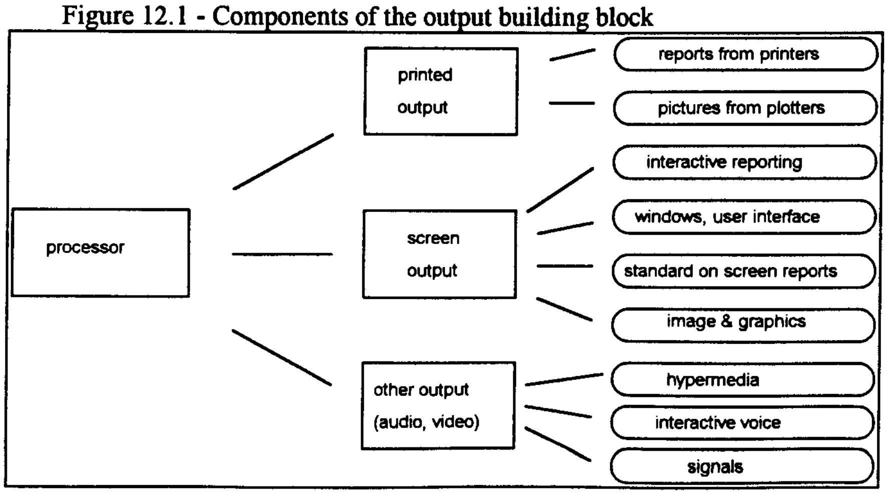
ASSESSMENT OF OUTPUT BUILDING BLOCK

12.1 INTRODUCTION TO THE OUTPUT BUILDING BLOCK

Output is the final information system building block. This building block is the communication mechanism of the computer with the user. Users receive thousands of messages every day. These messages are received through their main senses: sight, sound, smell, taste and touch. However, only sight and sound are used to receive information from computers. (Adams 1977: 7).

Communication with users takes place in an environment filled with distractions that can distort and affect the meaning and content of a message. This chapter will consider the characteristics of output of the building block in the information production process. From the nomenclatures the building block has been grouped into printed output, screen output and other output. These three methods of output will be discussed. As reports are not dependant on the output method, they will be discussed separately. A graphical picture of the output building block is illustrated in Figure 12.1.

Figure 12.1 - Components of the output building block



12.2 PRINTED OUTPUT

Hard copy is still in today's business environment, the most important output media. This might change in future as technologies such as imaging, hypermedia, graphical user interface and the application software supporting these technologies mature.

There are three major types of hard copy equipment: plotters, printers, and copiers. Among these types there are a wide ranges of equipment available to produce hard copy results. This equipment varies in production speed, print quality, graphics capability, colour and price.

Printers and plotters employ seven basic technologies:

- Electromechanical.
- Electro photographical.
- Electrostatic.
- Thermal.
- Dot-matrix impact.
- Ink jet.
- Electro-optical.

Each of these technologies has its own characteristics, particularly in its ability to produce colour at a reasonable cost. (Grupe 1991: 34). To make a sensible choice between the possible options for hard copy equipment, consideration should be given to four characteristics: resolution; speed of production; cost of device; and cost per copy.

Colour enhances the presentability of information. Colour applications in business grew by 20 percent in 1989 and 50 percent in 1990. (Grupe 1991: 15). Simkin is very optimistic about the growth of colour. He said: (Simkin 1991: 15).

> "It is difficult to overestimate the importance of output printed in colour. Today, almost all magazines, mail-order catalogues and Sunday paper advertisement inserts are printed in colour, as are most television outputs, camera slides and book jackets. This is no accident . . . With the exception of purposeful artistic ones, black and white output is fast becoming a relic of the past."

12.3 SCREEN OUTPUT

Screen output is produced by computer monitors and terminals. Most computer monitors and terminals are used for both on-site and remote-site data input and output. The prime function of these devices is to accept instructions, capture data, and display the response of the computer to the user. Various types of video displays are available including full page displays, colour displays, and non-colour displays. Displays could either be Cathode Ray Tube (CRT), or flat panel displays. Now, CRT types dominate the scene and will continue to do so in the future. (Lansdown 1982: 23).

Flat panel display technologies are much more diverse than CRT's and have become very popular in business applications, from cash registers to notebooks, over the last ten to fifteen years. The major advantages of flat panel displays over CRT displays include:

- Less depth in critical operator work area.
- Better linearity accuracy.
- Ability to superimpose maps, drawings, forms, and text.
- Matrix addressing (may be a disadvantage occasionally).
- Lower voltage requirements.
- Better contrast in high ambient light for some technologies.
- Potential higher resolution. (Lansdown 1982: 29).

The resolution of the pixels in the display decides the quality of the picture. There has been a constant increase in the resolution of displays. Although business applications of computer graphics are thought of as unsophisticated - requiring use of simple pie and bar charts to represent data - this situation is changing rapidly. Business users' needs for graphics are becoming more sophisticated, which makes it more desirable to have higher resolution. Advancement of display technology was largely driven by user needs for more sophisticated graphical presentation on screen. Graphical abilities of monitors have made a significant contribution to improve the comprehension of information.

New developments in information presentation have put more focus on the quality of the monitors required. Hypermedia is an emerging technology that relies heavily on high quality graphical presentation equipment. There is also a greater emphasis on moving away from re-producing everything on paper. Electronic document storage and imaging will also put further demands on the screen as a primary output media to the user.

12.4 OTHER OUTPUT

There is an increased focus on non visual forms of output technology development. These include audio and vision. Audio output includes the use of sound effects to signal a specific action to the user, hi-fi quality music, special sound effects, and voice animation. Vision includes graphical displays, animation and videos.

The hypermedia market is making full use of the latest developments in output technology. Hypermedia is an approach to combine text, graphics, sound, animation and video in one presentation of information.

Although the use of other output formats are developing very fast, their use in practical day to day business affairs is still limited.

12.5 REPORTS

According to Lansdown "computers have greatly opened our capacity for capturing, storing and manipulating information. However, our ability to use this information - particularly in a decision-making sense - has been very much inhibited by our ability to extract the pertinent data and present it clearly at the time and point of decision." (Lansdown 1982: 7).

The largest form of presentation by the computer to the user is done with non-verbal reports. Non-verbal reports can be produced both in printing and on screen. Scott identifies the following forms of non-verbal reports:

- Written narrative form.
- Tabular form.
- Financial statement form.
- Picture form.
- Graphic form. (Scott 1986: 113).

Since so much of managers' access to information involves extracts and reports, it is essential to find effective methods of presenting information in reports. Often words or numbers are not effective enough. The reader of a report may understand its explicit contents, but may have difficulty conceptualising its implicit contents, such as trends in relations to previous reports, and comparisons between different numerical items.

Reports should have the following general characteristics:

- They should highlight the important information.
- They should be as simple as possible.
- Appropriate detail should be included.
- They should recognise that managerial reports often evolve and change.
- Some reports should be decision-formatted.

Most reports contain summarised information. There are several types of summarisation.

- *Aggregation:* This takes place when the information is combined in uniform categories, for example, within departments and across departments. Aggregation could cause the loss of information at higher levels of summarisation, although this information should be available at lower levels. Alternatively this backup detail may be kept available and provided only when requested.
- *Compaction:* With compaction, data that is not considered important for a particular purpose is deleted. The use of short descriptions, abbreviations, coded information and similar ways to reduce the record length, are examples of compaction.

- *Statistics:* Averages, percentages or percentile distributions, ratios, and standard deviations are all statistical indicators that provide information about a set of transactions or other detailed data.
- *Written or verbal narratives:* Narrative descriptions can also summarise information. This type of approach suffers from a lack of precision and completeness. Often narrative descriptions include only the highlights of more detailed information or the conclusions that were derived from deliberations.

Reports should be clear, to the point, and goal oriented.

Graphic reporting is becoming recognised as more efficient than either descriptive or numeric reporting for some purposes. Graphics can express an entire pattern of information quickly, increasing a manager's ability to absorb the information presented. Placing numeric data in graph form is a process of data interpretation. Thus data in graphic form is pre-interpreted before the manager receives it. Lansdown said:

> "Computer graphics systems are now beginning to liberate the manager to do what he is paid to do - analyse situations and take action. This liberation is coming about because of two distinct realisations:
>
> - Not all managers are accountants with a preoccupation for detail. Rather, they prefer a broad overview with an effective means of communicating trends and relationships.
> - The mere existence of data does not guarantee its usefulness. In order for data to become information, it must be accessible enough to provide the manager with a sufficient reward for his invested time." (Lansdown 1982: - 9).

Although there have been significant developments to improve the format of presenting information Wright said that "there is no single correct way of presenting information." (Infotech state of the art report 1981: 120). Selecting the correct presentation format of information remains a difficult task.

12.6 CONCLUSION OF ASSESSMENT

Understanding can only be secured if the information is successfully communicated to the user. Lansdown summarised the impact of an inadequate output building block as follows:

> "We often found that the information was already captured in large computer systems, but the delays or difficulties involved in extracting, understanding and manipulating such information rendered it useless to the manager." (Lansdown 1982: 8).

The communication from the computer to the user is managed with the output building block. The contribution that the output building block makes to the attributes of quality information could be assessed as follows:

As the main communication mechanism with the user the primary objective of the output building block is to enhance the understanding of the user. Without the output building block the user will not have any comprehension of what has happened in the computer, and the information in the computer will be valueless.

The output building block is not responsible for deciding the relevancy of information. Output could support the presentation of the information that the models have produced to assess and identify the information about the situation. By using presentation techniques the relevancy of information could become more appropriate.

When it comes to accuracy, the output building block merely reproduces the information provided by the models. It cannot make significant changes to the validity of the information. It will only marginally affect the ability of the models to present information accurately.

In the past, output technology was a bottleneck in the production of timeous information. The process of preparation and production of data, graphics and information that made sense often took a considerable time. But new developments in output technology have enhanced the ability of output to improve timeous production of information significantly. Technologies such as faster printers, on screen presentation of information, and imaging, will improve the timeliness of information. To a large extent it is the application software behind the production of information, and not the output technology, that makes the most significant contribution to the improvement of timeliness. The output building block does have the potential, as a primary objective, to produce timeous information.

The assessment ratings for the output building block are summarised in Table 12.1.

Table 12.1 - Output building block assessment rating

SUMMARY OF OUTPUT BUILDING BLOCK	
Relevancy	5
Accuracy	1
Timeliness	10
Comprehensibility	10

CHAPTER 13

EVALUATION OF ASSESSMENT

13.1 INTRODUCTION

The six main building blocks of data processing were considered in Chapters 7 to 12. Every Chapter concluded with a summary of the assessment of the contribution that the building block makes to the attributes of quality information.

The assessment of each building block was based on a review of the main characteristics of the building block and the rating of these characteristics against the criteria set in Chapter 6. In this chapter, if a tool group makes a significant contribution towards a quality attribute and this contribution can be regarded as a primary objective of the tool group, a rating of 10 will be assigned. When a tool group supports other tools in achieving a major contribution towards a quality attribute, a rating of 5 will be assigned. If a tool group has only a limited contribution to make, a rating of 1 will be assigned. And finally if a the tool group makes no contribution to a quality attribute, a rating of 0 will be assigned.

Chapter 13 will combine all the assessments of the previous chapters and evaluate these assessments in relation to each other. The evaluation will be based on assessing the general acceptance of the results after the information system as a whole has been considered. It will consider the relationship between the tool groups and ensure that the individual ratings have a sound balance. To help the above evaluation, a cumulative analysis of the assessment will be done. This analysis will illustrate the relative weightings of the individual assessments. The aim of this evaluation is to validate the individual assessments.

When the individual assessments have been validated, the study can continue to illustrate the evaluation of the performance of tools for specific sets of information. This will be done in the following chapter.

13.2 SUMMARY OF ALL ASSESSMENTS

A summary of all these assessments from Chapters 7 to 12 is presented in Table 13.1.

Table 13.1 - Summary of assessment of all building blocks

BUILDING BLOCK GROUP	RELEVANCY	ACCURACY	TIMELINESS	COMPREHEN-SIBILITY
input building block	5	10	7.5	0
data transfer	5	10	10	0
data capture	5	10	5	0
technology building block	7.5	5	8.75	2.75
processing	5	5	10	1
memory and storage	10	5	10	0
communications	10	5	10	5
software	5	5	5	5
databases building block	10	5	10	5
controls building block	5	10	1	5
applications software building block	10	10	10	10
output building block	5	1	10	10

These assessments represent the potential of each building block to improve the attributes of quality information. These results were deduced from an analysis of the characteristics of each group of tools, the identification of the primary objective of the tool group, and the supportive role it played to enhance the quality attributes of information. The reasoning behind each assessment rating was stated in the discussion of each tool group.

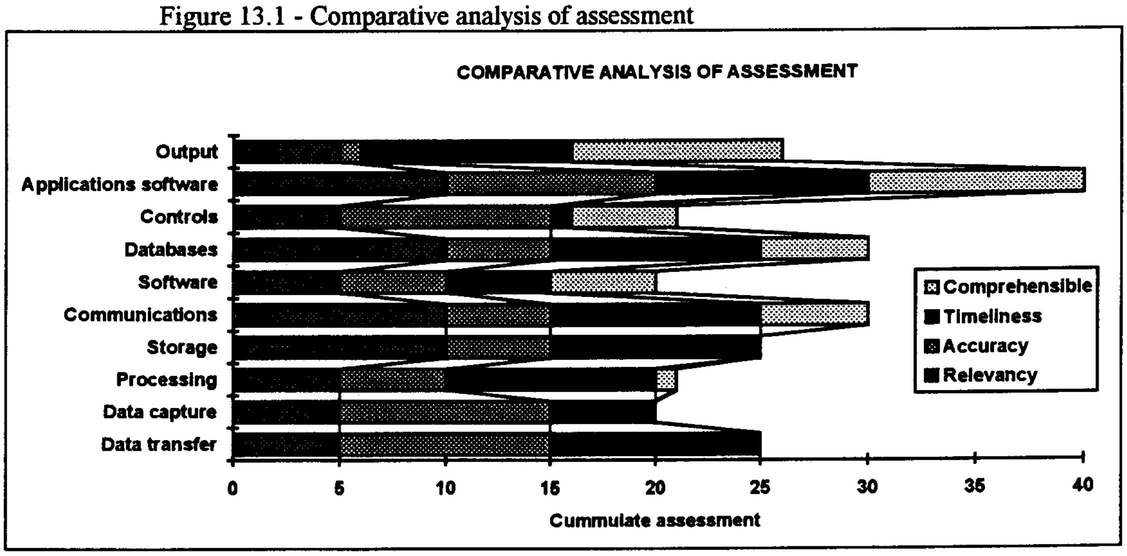
Now that all the tool groups have been assessed, the general assessment of all the tools together and the evaluation of the individual assessment can take place. It is important to stress again that the purpose of the study is not to make an accurate assessment of each individual tool. The objective is to create a framework from which the potential contribution of tool groups can be assessed. It will highlight those tools that concentrate on the achievement of specific quality attributes. The assessment will point readers in the direction to find tools that will make the most significant contribution to a specific quality attribute. If the assessment achieves this objective, it can be regarded as a valid and successful assessment.

To help the evaluation, a table of comparative analysis is presented in the next paragraph.

13.3 COMPARATIVE ANALYSIS OF ASSESSMENTS

Table 13.1 highlights the concentration points of the tools' contribution. A comparative analysis of the tool assessment reveals those tools that focus more on specific qualities. It also highlights which tools will make the most significant contribution to specific quality attributes. This comparative analysis is illustrated in Figure 13.1.

Figure 13.1 - Comparative analysis of assessment



The following general observations are made from the analysis:

- All tools do not contribute equally to each attribute of quality information.
- The two lowest scorers, controls and software, are both very supportive tools that do not perform primary information production roles.

- All the tools make a good to an excellent contribution to the relevancy of information.
- When considering quality information, the model tools are by far the most significant. It is application programs that make the biggest contribution to enhance all the attributes of quality information.
- In relation to other computer technology development, the technology that enhances the understanding and comprehension of data is relatively immature. It is only in recent years that a major focus has been placed on this deficiency. The analysis illustrates this immaturity and the lack of support of the tools for comprehensibility in relation to the support for other attributes.

The reasonability of the assessment will also be validated by comparing the above assessment with the requirements of tools to improve quality attributes detailed in paragraph 6.4. Each quality attribute will be considered separately.

Relevancy

In paragraph 6.4.1 it was stated "tools that will improve the relevancy of information, must focus on deciding what is relevant, getting to the appropriate data, selecting it, and filtering the unnecessary information." According to the analysis, application software, databases, communications and storage make significant contributions to improve relevancy. The applications software contributes to deciding what is relevant, selecting the data, and filtering unnecessary information. Communications provide the channel to the data, storage has custody of the data, and the databases make it available.

Software tools support the development of the application programs performing the evaluation of relevancy. Output produces the relevant information based on results of the application software. Processing performs all the functions specified by the application software.

Accuracy

Paragraph 6.4.2 stated "to ensure that information is sufficiently accurate, the tools that produce the information should capture it accurately, retain it so that it is not mixed with other data, or lose its character, and reproduce it when required in such a form that it can be verified."

According to the above analysis data capture and data transfer ensure the accurate recording of data, with controls making a significant contribution to ensure the maintenance of the accuracy of data and information. The applications software contains all the algorithms and functions to ensure the accurate manipulation of data into information.

The databases, operating software, storage and communications support the functions of the applications software, controls and input to ensure that data is processed accurately.

Output has a limited contribution to make by supporting the applications software in reflecting the results of processing accurately.

Timeliness

Paragraph 6.4.3 states "for the computer to produce timeous information the data must be captured in time, process the information in time and reproduce it in time."

From the above analysis it is evident that most of the tools make a significant contribution to the timeliness of information. Electronic data transfer significantly improves timeliness. Developments in storage and databases also significantly improve the ability to have information when it is required. Communications can provide the information where it is required on time. Processing power greatly improves the capability to process large volumes of data and produce it on time. And finally, new developments in output and improved capabilities to produce information give much faster results. This is made possible by the applications software that drives towards the production of on-time information.

Comprehensibility

Paragraph 6.4.4 states "for the computer to produce comprehensible information, the tools must have the functionality and ability to present information to the user in an optimal format. The user must understand the communication from the computer, free from any distractions."

According to the analysis above, it is only output and applications software that contribute significantly to comprehensibility. It is only these two groups that significantly affect the presentation of information.

Controls support the output, and applications software functions and contributes to the quality of the presentations. Communications support the presentation format and databases enhance the transparency of the data to support the understanding of it. The other tools have very little to do with comprehensibility.

From the above analysis and evaluation it is evident that a user with a need to enhance relevancy of information should concentrate on providing sufficient memory and storage, ensure adequate database management, provide effective communications and have software applications that could access the data and filter appropriate information. Similarly, a user requiring an improvement in the accuracy of information should first ensure accurate data acquisition and application software to process the information before concentrating on other aspects. Similar deductions could be made for the other attributes from the above analysis.

13.4 SUMMARY

Chapter 5 commenced with designing a method to digest the overwhelming scenario of computer equipment, technologies and software. It succeeded in grouping all the tools responsible for producing information into logical units with similar characteristics that could be assessed.

Chapter 6 provided reasonable criteria to assess the contribution that each tool group could make to enhance the quality of information.

Each tool group was summarised and its characteristics determined, and then assessed against the criteria.

From this analysis and assessment of each tool group detailed in Chapters 7 to 12, a summarisation was compiled to judge the reasonableness of the individual assessments, and to evaluate the usefulness of the assessment to find a framework focusing on which tools makes what contribution. The assessment summary seems sufficient to support this notion. The assessment focuses attention on those tools that contribute more significantly to specific attributes of quality information. The assessment is sufficiently reasonable to go on to the next chapter. In the next chapter this assessment will be applied by evaluating sets of information in an illustrative company.

CHAPTER 14

IDENTIFICATION OF THE TOOLS THAT COULD IMPROVE THE QUALITY OF SPECIFIC INFORMATION COMPONENTS

14.1 INTRODUCTION

Chapter 4 categorised the main attributes of quality information. Chapters 5-13 considered the computer tools in the data processing cycle. These Chapters also considered the potential contribution that the tools could make towards producing quality information. Chapter 13 concluded with a summary of the potential contribution that the tools could make to improve quality information. The summary chart in Table 13.1 of the potential contribution of the tools to support specific attributes of quality information, serves as a guideline to the significance of different tools in the production of information. The assessment of the potential contribution in the previous Chapters did not consider the contribution of tools for any particular set of information.

This Chapter aims at illustrating how the assessment in the previous Chapter could assist with the evaluation of the tools to improve the quality of specific sets of information.

A kaleidoscope of information characteristics, their values, cost, users and classifications were the focal point of Chapter 3. From this Chapter it is evident that information consists of many facets. Before the quality attributes of information, and the contribution that specific tools make can be evaluated in a particular situation and for a particular set of information, it is important to identify what to evaluate. The information to be evaluated must be distinguishable and measurable. Chapter 14 will commence with describing what a measurable information component is. It will identify those information products that can be subjected to evaluation.

Although Chapter 4 identified the attributes of quality information, it did not offer any mechanism to evaluate the significance of the attributes for individual components of information. Chapter 14 will continue by developing criteria to measure the significance of the four quality attributes for different sets of information. It will then illustrate the evaluation of the quality attributes for specific information components.

After measurable information components have been identified, and the quality attributes for the components have been determined, the computer tools that could improve the quality attributes of the information component will be identified. The next step will be to illustrate how the assessment of tools in Chapter 13 can be used by matching the contribution of computer tools with their potential to produce the desired quality attributes of the information components.

A fictitious company will be used to illustrate the points made in this Chapter. Features of the fictitious company will be used to illustrate and explain the principles and evaluate the criteria. The next paragraph summarises the profile of the illustrative company.

14.2 ILLUSTRATIVE COMPANY

Statistics

- Company name: ABC Limited.
- Main business: Manufacturing and distribution of tinned food.
- Location: Head office and manufacturing plant in Isando, with 6 sales and distribution branches in Capetown, Bloemfontein, Durban, East London, Pretoria and Port Elizabeth.
- Number of staff: 550.
- Turnover: R500 million per annum.

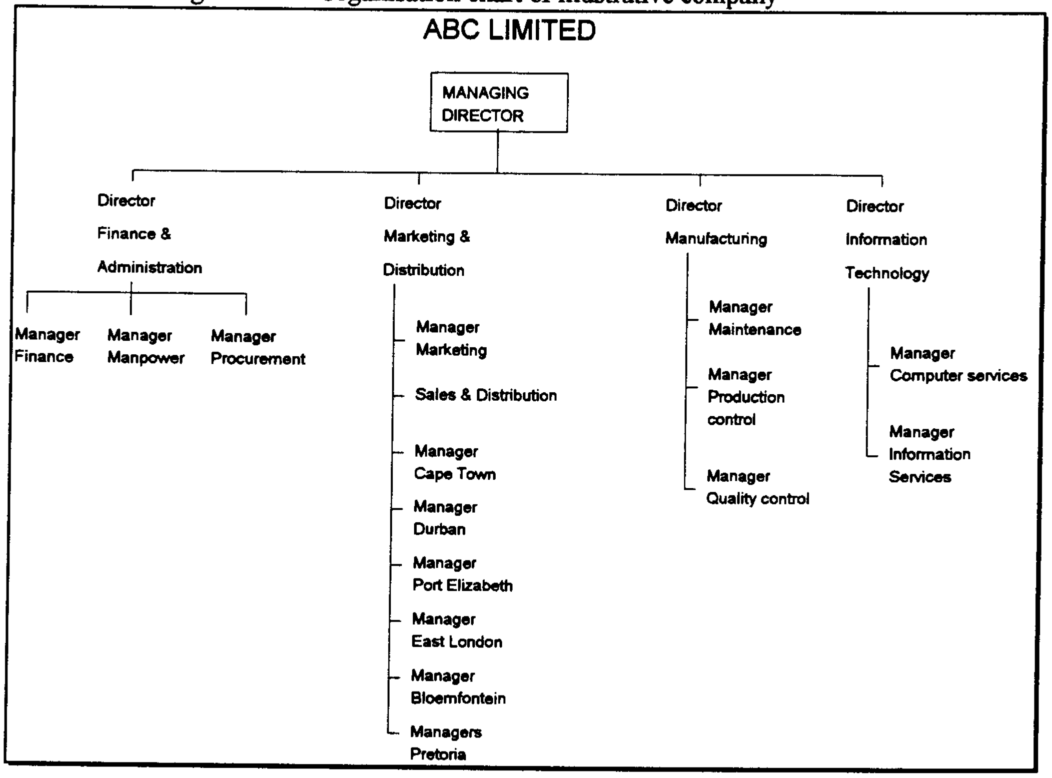
Organisational environment

- Top management: a managing director with directors for finance and administration, marketing and distribution, manufacturing, and information services.

- General management: Each branch has a manager responsible for all branch activities who reports to the director marketing and distribution; Other departmental managers include finance, human resources, marketing, sales & distribution, procurement, maintenance, production control, computer services and information management.
- Operations: Finance, administration and information services are centralised at Isando with a staff complement of 105. Procurement, maintenance and production are based in the factory in Isando with a staff complement of 275. Marketing and distribution are largely decentralised to all branches, with a small complement of staff at head office. 152 staff members are involved in this area.

The organisation is outlined in Figure 14.1

Figure 14.1 - Organisation chart of illustrative company



Computer environment

The director Information Technology is responsible for the management of a central computer centre equipped with a mainframe. A national communication network connects all the branches. The Branch manager in Pretoria installed a Local Area Network two years ago under the pretence that he could not get the information he required from Head Office. The LAN is not yet connected to the mainframe. The branch Manager in Durban decided four months ago to follow suit. Stand alone personal computers proliferated throughout the organisation during the last four years, so much so that the Director Information Technology formed a new section under the Manager Information Services to control and service the end-user computing developments in the organisation.

The application portfolio of the company includes a production planning and control system (PPC), warehousing with materials management, a sales and distribution system, human resource and personnel management system, a comprehensive financial system, some office automation applications such as electronic mail, and a variety of decision support systems.

Until recently, all application development was done in-house. However, a packaged financial system was bought and implemented two years ago. One of the key focus areas of the Manager Information Services is to integrate this financial system with the other operational systems in the organisation.

The application systems in the organisation produce a variety of regular and irregular reports. Some significant reports are listed in table 14.1.

Table 14.1 - Application reports for illustrative company

HUMAN RESOURCE MANAGEMENT	FINANCIAL SYSTEM	SALES AND DISTRIBUTION	MATERIALS MANAGEMENT	PRODUCTION PLANNING AND CONTROL
vacation and sick time accruals	trial balance	billing history per customer	inventory balance reports	bill of materials
performance review dates	balance sheet/income statement	invoices issued	suppliers orders	item master listing
employee career history	cash flow statement	customer orders	change to master data report	listing of routings
daily, weekly, monthly payroll reports	budget comparisons	sales statistics per area	inventory and order control	master production schedule
employee time and attendance	listing of transactions	sales representatives commission report	report per inventory item	planning bill
deduction reports	various levels of summarisation	back orders	inventory evaluation	resource requirements planning report
tax reports	customer lists	distribution route map	inventory location report	production planning report
disciplinary actions pending	historical data on sales	delivery schedule	issues	what-if analysis result
benefits program report	history of accounts	customer turnover analysis	scrapping report	component schedules
pension administration reports	age analysis	sales discount analysis	transfers of inventory	simulation report
employee notifications	cash-receipt register	product price schedule	cycle count adjustments	materials requirement planning
employee skills inventory	discount granted	customer by region report	list of outstanding orders	bill of materials explosion report
	overdue accounts report	credit control analysis	list of orders released	list of exception causing activities
	vendor history	list of black listed customers	picking list	capacity requirements planning report
	commitment analysis	outstanding customer orders	safety stock and re-order quantities	scheduled work centre load
	payment due date	gross profit analysis per customer	purchase price variance report	shop floor job cards
	list of balances		vendor performance report	shop floor performance reports
	discount available		unmatched orders	efficiency planning reports
	cheques for payment		open contracts	bar codes

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The features of the illustrative company will be used to demonstrate the evaluation of the performance of the computer tools to improve quality information.

14.3 COMPONENTS OF INFORMATION

14.3.1 Information components as a measurable entity

A wide range of information is used by the managers and operational staff of ABC Limited to make decisions or to perform types of action. The information users in ABC Limited receive a multitude of different reports and other forms of information. All the reports listed in Table 14.1 collectively are part of the information in the company. To evaluate the information quality of ABC Limited, it is not feasible to arrive at any meaningful assessment by merely considering all the information in general.

On any particular day, a user may use small units of information such as various reports and other visual information, the result of a discussion and other verbal information, or observations and other deductive information. The Managing Director of ABC Limited may receive a summary of the production for the week, a written report on the labour unrest in the factory, a phone call from an upset customer, and a graph comparing the sales of ABC's tinned food with that of a competitor's on a particular day. Before the MD can evaluate the quality of the information he has received, he must be able to attach his assessment to a particular unit or component of information that will allow for such an evaluation. It is more appropriate to evaluate the accuracy of the production summary, than to judge the accuracy of all the information he receives on a particular day. Once he has evaluated the individual components, he can then arrive at an overall assessment of the quality of the collection of information he has received.

Before the quality of information can be measured or evaluated it is appropriate to split the collection of information into entities or components that can be measured.

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14.3.2 The chara onents

The approach followed in this section to isolate information into smaller components, has largely been adopted from Burk. (Burk 1988: 45-69). The objective of Burk to classify information resources and to define basic units of measure, was aimed at developing a model to evaluate the value of information in an organisation. The objective of this study is slightly different in that it does not propose to evaluate the value of information, but the quality of a particular component of information. Furthermore, this study is not so much concerned with the sources and resources of information, but the end product of the information production process. The applicability of Burk's approach for this study as a framework will be explained hereafter. This approach has also been used by other researchers such as Horton and Edison. (Horton 1985; Edison 1983).

An information component can be regarded as a sub set of information configured by the requirements of the user to make decisions or take actions. The information component is produced to inform the user. The user should be able to judge whether the information component was successful in fulfilling his information needs. The information component should potentially be subjected to an information quality assessment.

For the purposes of this study, an information component is the entity to be evaluated for quality attributes. An information component has the following characteristics:

- It is associated with a specific user, or group of users, in a specific organisation.
- It has a homogeneous purpose or objective.
- It demands distinguishable and homogeneous information quality attributes.
- It is a sub set of information.
- It is produced by a specific information system.

The significance of these characteristics will be discussed in the following sub paragraphs:

Association with users

An information component is directly related to specific users in a particular organisation. Information only becomes of any value once it has a recipient. Without a recipient, information cannot fulfil its most basic objective which is to add to the knowledge of the recipient. An information component without a recipient can have no quality.

For example, the income statement of ABC might be produced in time, but if there is no information user for the report, the timeliness attribute has no significant value. An information component should therefore always have at least one user.

The recipient of information is not necessarily known when information is produced. Sometimes information is distributed to a wide range of recipients in case they might need that information. For example, the general ledger of ABC produces a list of transactions for each general ledger account. A variety of users might, or might not, use this listing. Possible users include the head office accountant, the auditors, the branch managers, the debtors clerk, etc. Although the recipient is not known as an individual, the information component will be targeted to users.

Information might be produced for a specific recipient. That does not exclude other recipients from benefiting from that information. An example would be when a sales report prepared specifically for the Marketing Manager, is passed on to the Managing Director at a later stage because there is a particular aspect of the report that both would have to discuss. The remaining contents of the report do not have any particular significance for the Managing Director. The Managing Director might evaluate the information component differently from the Marketing Director, because the report was not really intended for the Managing Director. It is therefore important to ensure that the information component is evaluated by the user to whom it was targeted.

The objective of any information component should be to meet the information needs of the recipients. The wider the range of possible recipients targeted with a specific information component, the more

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difficult it is to satisfy the needs of individual recipients. The more homogeneous the needs of the recipients, the closer the producer of the information component would be to meet the needs of most recipients. If a particular information component has users with very different information quality needs, it would be preferable to split the information component and produce information components that specifically meet the needs of the various users. For example, the sales clerk of ABC Limited produces a tabulation of sales figures per customer to all the sales representatives, the Sales & Distribution manager, the Branch managers, and the Director of marketing and distribution. This represents one information component produced with in the information system. Because the information took so long to be produced and distributed the Branch managers receive it too late. The Director of marketing and distribution is frustrated because he must wade through the detailed figures to calculate the monthly trend. He must also refer to other reports to obtain the previous month's information. The sales representatives tear off the sales information not applicable to their customers and throw it away. This single information component in ABC Ltd. should be split into several information components to meet the needs of the different types of users.

An information component must therefore have similar users. The similarity could be in the functions to be performed, decisions to be taken, or needs of the users.

Homogeneous purpose

Each information component should have an aim. For example, the aim of the sales report is to inform the user on the results of the sales for the period. The user could make a whole range of decisions, and take several actions based on the information. The quality attributes of the information components greatly affect the quality of the decisions of the user. The aim of the information component will be optimised when it has all the required quality attributes required by the users to fulfil the aim.

The purpose of a particular information component can differ from user to user. For example, the sales report could be used by the sales representatives to calculate their commission.; On the other hand, the Sales Manager could use the information to measure the actual

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performance against the targeted sales. The same report could also be used by the production manager to predict the production volumes for the next month. If the different objectives of the information component result in conflicting information quality expectations, separate information components should be distinguished. For example, the sales representatives might need their information 2 days after the month end to calculate the commissions; on the other hand, the production manager must receive the information every week. In such a case, it will be better to produce two information components, one for the representatives monthly, and one weekly report for the production manager.

The more homogeneous the purpose of an information component is among the users, the more accurate the assessment of the various users will be in fulfilling their expectations.

Homogeneous and distinguishable information quality attributes

The users create the expectations for information quality attributes of an information component.

For the relevancy attribute to be applicable, the user must require that the information be available, or accessible to him. Sometimes non-availability of one set of information could be substituted successfully by another, which makes the requirement for the relevancy attribute for the first set of information smaller. In other cases, the relevancy attribute might be linked to timing. If it is not directly available, a process could be initiated to obtain it from another source, since it is obtained within a specific period.

Accuracy is usually demanded for decisions or actions that leave little margin for error. Accuracy is relative, and could be expressed in either absolute terms, e.g., 100 % accurate, or relative terms, e.g., "the margin of error is acceptable". Accuracy is also dependant upon the perceptions of the user. The same set of information could have an acceptable level of accuracy for the one user, and be totally unacceptable for another - for the same type of decision or actions. This will largely depend on the availability of other sources of information or experience that the first user has.

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Information is timeous only if it is available before, or at the point of, a decision or an action. The urgency for timeous information is related to the period between the creation of the data and the ultimate decision or action to be taken on the information produced by it.

Comprehensibility is often intangible and almost exclusively dependant upon the preferences of the user. Certain types of presentation have been established as "acceptable" for certain decisions and actions, giving the appearance that the nature of the information primarily determines this attribute. E.g., Debtor statements are usually printed with an acceptable level of quality on pre-printed stationery. A margin of improvement still lies with the layout of statement, the information printed on the statement, the font types used, etc.

The quality attributes of an information component must be distinguishable. The users must be able to express their expectation of the attributes. When a specific information component is identified, the level of relevancy, accuracy, timing, and comprehensibility must be quantifiable by the users.

To have a measurable information component, the quality attributes must not only be distinguishable, but also reasonably homogeneous. If the quality attribute expectation of a specific information component, such as the timeliness of an income statement, is vastly different for the various users, the information component should be broken down into separate information components.

Sub set of information

The total population of information in any business consists of a multitude of different pieces of information. These pieces of information derive from different sources, for different purposes, on different media, with different content. In Chapter 3 the wide variety of types and uses of information was highlighted. Although this study has often referred to information and the qualities of it, it is not possible to measure the qualities of the total population of information, but only the sub sets of it.

An information component would therefore be a sub set of information that is separately identifiable.

Produced by specific information system

This study only concentrates on information produced by an information system. Other types of information can also be produced by systems other than computer information systems. An example would be discussions between users. Although they might have a very relevant information content, the verbal interchanges between the users are dependant upon the human abilities to retain, retrieve, and reproduce information, and not on any computer tools. It is not the intention of this study to consider such types of information.

14.3.3 Relationship between information components

Based on the characteristics identified above, a multitude of different information components can be identified in the organisation. Each information component can be considered in its own right. Examples of individual information components are:

- A report on the production cost of baked beans in the factory used by the supervisor.
- A report on the sales per customer per product used by the sales representatives.
- A market penetration analysis used by the director of marketing and distribution.

Several information components can be related to a specific department or functional group of users, such as the Finance or Marketing department. Although the individual information components might have different characteristics in terms of expected quality, the users of the information components are homogeneous. Examples would be all the different financial reports flowing from various sources to the financial department. The financial users might not be sensitive to the actual sources of the information components. They will, nevertheless, regard all the reports they receive as a combined source of information to base their decision making on.

Information components could also be related to the system producing them. The production system is a structured and integrated series of processes designed to produce the information components. The tools,

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highlighted in the previous Chapter, are the building blocks for these systems.

As an example, the information components identified above form part of the following systems:

- Production cost in a factory produced by the Product costing system.
- Sales per customer produced by the Sales and distribution system.
- Market penetration analysis produced by the Decision support system.

Linking the information component to the system provides a key to evaluate the impact of the tools on the quality of the information component.

Information components can also be related to similar information components in other organisations. However, the characteristics of these information components may differ considerably. It is therefore not possible, without substantial further research, to arrive at a general quality requirement for specific information components across different organisations.

14.4 EVALUATION OF QUALITY ATTRIBUTES OF INFORMATION COMPONENTS

14.4.1 Evaluation method

In the previous paragraph information components were identified as identifiable sets of information. These information components can be evaluated to find out to what extent they meet the expectations of the users. Chapter 4 discussed the main attributes of quality information The quality attributes of information represent the expectations of the users as to what they wish the information components to present. This Chapter aims at evaluating the performance of the tools against the quality of an information component. It is, first of all, necessary to determine the compliance of an information component to the expected quality attributes before the performance of the tools to produce the attribute can be evaluated.

To determine the compliance of an information component to the expected quality attributes, the perceived quality of the information component will be evaluated against the expected quality. In practice, compliance to an expected quality is measured when managers express their evaluation of the quality of an attribute of a specific component by suggesting that a report is not on time but that the information is relevant for them. They could also conclude that the report was well understood, and it was very accurate. They made a value judgement that a particular attribute has a certain significance. A subjective judgement was made. Although this type of measurement might be appropriate in general discussions, it is necessary to consider a more appropriate and objective technique to measure the significance of an attribute.

14.4.1 Evaluation scales

To measure something a scale is required. The scale should be sufficient to ensure sufficient objectivity. This means that if two people measure the same attribute under similar circumstances, they should reach the same conclusion. The more precise the measurement, the more likely the two users will not reach the same conclusion. To overcome the problem of precision, the scale could be adjusted. Instead of using an exact scale such as a numeric scale (e.g., 50%, 60%, 100%), a range scale could be used such as bad, good, excellent. A scale will be used to show 5 positions. The first position is completely on the low end. The second position is not too low, but not acceptable. The third position will suggest acceptance. The fourth position will indicate above standard. The final position will indicate excellence of acceptability. The labels for each position on the scale, e.g., "low," "medium" or "high" would be chosen to associate with what is being measured. For example, if the accuracy attribute is measured, the label "wrong" would be used to suggest the first position. It is significant to note that the optimum position on this scale is position 4. Although position 5 is beyond the expected, it does not improve the quality. It could, in fact, deteriorate the quality. For example, when information is "accurate," it is fine, if it is "too precise" it could distract the user or take too long to produce. Similarly the position 5 ratings for all attributes will suggest "over and above," or "far beyond." The scales for each attribute are detailed below in Table 14.2.

Table 14.2 - Scale labels for evaluation of attributes

ATTRIBUTE	POSITION	SCALE LABEL
Relevancy	1	not appropriate
	2	incomplete
	3	sufficient
	4	complete
	5	excessive
Accuracy	1	wrong
	2	very rough
	3	acceptable
	4	accurate
	5	too precise
Timeliness	1	not received
	2	sometimes received
	3	too late
	4	on time
	5	too early
Comprehensibility	1	non-comprehensible
	2	difficult to use and understand
	3	reasonably understood
	4	easy to use and understand
	5	inappropriate presentation

14.4.3 Attributes to be evaluated

The study will now consider the attributes to be evaluated. The main and sub attributes identified in Chapter 4 and summarised in Table 4.4 are repeated below in Table 14.3. However, here the sub attributes are grouped together in logical groupings. These logical groupings indicate that some main attributes could be sub divided for purposes of measuring their compliance with the expectations of the users.

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Table 14.3 - Sub division of main attributes

MAIN ATTRIBUTE	SUB ATTRIBUTES	DESCRIPTION OF SUB GROUP	SHORT NAME OF SUB GROUP
relevancy	sufficient detail not too much not too little complete acceptable selective comprehensive	These attributes refer to the adequacy of the detail of the information	Sufficient detail
	closeness to problem support decisions fitness pertinence appropriate authorised meaningful	These attributes refer to the support that the information gives for the decisions or actions	support decision
	ability to manipulate accessible available adaptable ease of access degree of integration flexible	These attributes refer to ability to access and work with information	availability
accuracy	limited noise verifiable precise credible reliable valid freedom from bias	No sub division of the main attribute	
timeliness	at the right time not too late on priority current on schedule out of time	No sub division of the main attribute	
comprehensibility	ease of use user friendly quantifiable clarity readily understood	These attributes refer to the perception and understanding of the user	understood
	adequately presented output quality simplicity reproducible understandable output	These attributes refer to the presentation format of the information	presentable

Relevancy can be sub-divided into "sufficient detail," "support decision" and "availability." Comprehensibility can be sub-divided into "understood" and "presentable." There is no need to sub divide accuracy and timeliness.

Using the scales detailed in Table 14.2 will enable a user to evaluate the attributes detailed in Table 14.3 for an information component. Examples of evaluations will be illustrated in paragraph 14.4.4.

14.4.4 Example of evaluation

To illustrate an evaluation based on the attributes and scales outlined above, a sales report from ABC company is analysed. The sales report reflects details of each product and the monthly sales quantities and values in tabular form. Figure 14.2 illustrates a page from the sales report.

The sales report is received by the regional managers two days after month end, just before they must submit their monthly reports. The regional managers use the report to compile their monthly sales return to the managing director. The regional managers regard the summary per sales area as critical as they must arrive at a meaningful decision on the turnover of each region. It is also the only source of this type of information. On closer scrutiny the users note that the quantities of items sold do not correspond with those calculated by the sales agents in each region. The sales agents' figures are regularly audited and are trustworthy. The information is re-entered from the sales report into a spreadsheet to calculate the monthly trends.

Figure 14.2 - Sample sales report

2/5/92

ABC LIMITED
SALES REPORT FOR APRIL 1992

	month sales quant	value	Cumm sales quant	value
Cape Region				
Beans 250gm	100000	57,000	2500000	1,425,000
Beans 500 gm	50000	52,000	1750000	1,820,000
Pineapple slices 275 gm	2500	1,875	34600	25,950
Pineapple pieces 275 gm	1305	1,109	35808	30,437
OFS Region				
Beans 250gm	75050	42,779	1780040	1,014,623
Beans 500 gm	40500	42,120	1350020	1,404,021
Pineapple slices 275 gm	3000	2,250	40300	30,225
Pineapple pieces 275 gm	1050	893	25700	21,845

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An evaluation of the above report is done in Table 14.4.

Table 14.4 - Example of an evaluation of the sales report

ATTRIBUTE	COMPLIANCE	RATING ON SCALE	COMMENTS
Sufficient detail	The report does not reflect a trend for each month. It also does not total the figures for each region	description: incomplete position: 2	Sufficient detail will depend on the detail used by the user. The component could have too much, sufficient or insufficient detail
Support decision	The monthly sales information required is reflected in the report	description complete position: 4	Relevancy to a decision depends on closeness to the decision. The component can be relevant or not relevant to the appropriate decision
availability	The only access to the information for the managers is by the report. To get the information into the spreadsheet it must be retyped.	description: not appropriate position: 1	Availability depends on the nature of the source of information. The information could either be easily accessed or not.
accuracy	The accuracy of the report is not accepted by the managers as it does not correspond to other information available	description: wrong position: 1	The degree of accuracy depends on the nature of the decision. The information is either accurate or not.
timeliness	The report is received in time for the manager to prepare his return	description: on time position: 4	Timeliness depends on the stage that the information is required for a decision or action. The information is either early, on time, or late.
understood	The information in the report is understood by the managers.	description: reasonably understood position: 3	The perception of the user depends on the ability of the user, and the format of presentation. The information is appropriately received or not.
presentable	The monthly trends could be presented better by graphs or comparative tables.	description: difficult to use and understand position: 2	Presentation techniques depend on the nature of the information. The information is either poorly or well presented.

Working through the examples in Table 14.4 reveals several observations:

- The rating is very subjective and completely dependent on the perceptions and opinions of the users.
- Various users of the same report could rate the same report differently.
- The possibility of obtaining a consistent rating for the same report by various users is remote.
- Although the rating may not be exact, and could be contested by another user, it shows the perceived conformance of the information component to an expected quality attribute.
- The scales identified in Table 14.2 help with plotting an evaluation better. For example, it is easier to decide that sufficient detail is complete, than to assign it to a 3 on a scale of 5.

The ability to evaluate an information component against expected attributes of quality has been explained. In the definition of the scales in paragraph 14.4.2 it was said that position 4 could be regarded as information quality. In the example, there are only two of the 7 attributes measured that could be regarded as optimum. The other attributes could be improved.

14.5 TOOLS THAT COULD IMPROVE THE QUALITY OF THE SALES REPORT

The final step in developing a mechanism to evaluate the contribution that specific tools make to enhance quality information is to compare the evaluation of an information component with the potential contribution that tools could make to improve the quality of information. The results of this comparison will indicate which tools, potentially, can be employed to achieve optimised information quality.

14.5.1 Comparing the attributes with the contribution of tools

Table 13.1 summarised the potential contribution that the tools could make in improving the quality of information for each attribute. From this table it is evident that some tools have a greater impact on specific attributes than others. For instance, data transfer, data capture, controls and models will most significantly affect the accuracy of information. On the other hand memory storage, communications, databases and models will affect relevancy the most.

If the evaluation of the sales report summarised in Table 14.4 is compared with the potential contribution that the tools can make, outlined in Chapters 7-12, the potential areas of tool improvement can be identified. Table 14.5 performs such a matching process.

Table 14.5 - Comparison between rating of attributes of sales report and significance of contribution of tools to attribute

ATTRIBUTE	SALES REPORT RATING	SIGNIFICANT TOOLS	SUPPORTIVE TOOLS
Relevancy	sufficient detail: incomplete support decision: complete availability: not appropriate	. memory and storage . communications . databases . applications software	. data transfer . data capture . processing . software . controls . output
Accuracy	wrong	. data transfer . data capture . controls . applications software	. processing . memory and storage . communications . software . databases
Timeliness	on time	. data transfer . processing . memory and storage . communications . databases . applications software . output	. data transfer . software
Comprehensibility	understood: reasonably understood presentable: difficult to use and understand	. applications software . output	. communications . software . databases . controls

Table 14.5 identifies the tools that can significantly enhance an attribute, others will play a more supportive role. A problem in a specific attribute could be with insufficient support, and not necessarily with the significant tools.

Although several tools can have an impact on an attribute, some could be irrelevant for a particular situation or some could operate quite satisfactorily, while only one or two of them could operate insufficiently, causing the production of sub-optimised quality information.

14.5.2 Interpretation of the comparison

During the evaluation of the sales report, certain reasons why the attributes were not optimised, were identified. When these reasons are analysed, the potential tools that could significantly enhance the quality of the sales report could be identified.

Those attributes that were not optimised for the sales report are discussed below so as to identify the tools that could improve the quality attribute. The following discussion refers to the detail in Table 14.5.

Relevancy

The detail of the report is incomplete because it does not reflect the trend for each month, nor the total figures for each month. Thus each significant tool for relevancy should be considered in order to decide if it could improve the situation. It might be because there is insufficient storage capacity, or the databases do not contain the necessary information. It is unlikely that insufficient communications are the reason. It is most likely that the application software does not use the information in the databases to reflect on the report. The fact that the figures are not totalled on the report, is solely an applications program issue. To optimise this attribute, the applications program should be re-visited. If that does not solve the problem, the situation should be evaluated again.

The availability of the information is not optimised because the information is not readily available for the user to rework the data, and calculate trends. The problem might disappear if the trends required are reported in the first place, and there is no need to manipulate the data further. This solution is closely related to the incompleteness of the information and will depend on the steps taken in the previous paragraph. If there is still a need to manipulate the information, the availability of the data should be improved. This could start with optimising the communications and networking that would result in improving the output media. This could further enhance the possibility of downloading the data with electronic transfer directly into the spreadsheet. The application software must be changed to support all these changes.

Accuracy

The information in the sales report is wrong because it does not agree with another set of verified information. The tools that would make the most significant improvement are: data transfer, data capture, controls and applications software. The best situation is to ensure that data is not re-entered into the sales system, and that the same data used by the sales agents to compile their information, is used for this sales report. This may be achieved by considering data transfer. There could also be a problem with the data input controls, resulting in input errors. These tools should be considered first before other solutions are contemplated.

Timeliness

Timeliness of the report is already optimised. This implies that those tools that affect timeliness operate efficiently. These tools are data capture, processing, memory and storage, communications, databases and application software. It was noted that applications software is having some shortcomings in other areas such as relevancy, comprehensibility and accuracy. It appears that it is in those aspects of application software that affect timing, that the programs operate efficiently.

Comprehensibility.

The report is reasonably understood but still difficult to use. This is mainly because the trends could be better presented by using graphs, or tabular detail of each month. Both applications programs and output could make a significant difference. By presenting the reports on screen, with graphics capabilities, the problem could probably be overcome.

The above evaluation illustrates the practical application of identifying the tools that can improve the quality of an information component.

14.6 SUMMARY

Chapter 14 aims at illustrating the practical application of evaluating the quality attributes of an information component, and of identifying the computer tools that can improve those qualities that are not optimised. This illustration is done with a sample sales report from an illustrative company.

The Chapter commences by giving some background of the illustrative company to ease the interpretation of the examples. It then continues to identify distinguishable and measurable information components. This was necessary as general information is too generic to measure. Only specific sets of information can be contemplated. The Chapter then reconsiders the attributes of quality information defined in Chapter 4, to bring it in line with evaluating the attributes for specific information components. Scales are developed to allow a user to rate how each attribute complies to the expected quality of the information component. The application of the scales is illustrated with a sales report. This evaluation highlights the attributes of the sales report's need for improvement. The Chapter concludes with the identification of the tools that can improve those attributes. The assessment of the tools that could potentially make a contribution derived in Chapter 13 was used.

This illustration concludes both Chapter 14 and Phase 2.

PHASE 3

PRODUCE FRAMEWORK

TO EVALUATE THE

PRODUCTION OF QUALITY INFORMATION

The final phase of this study will produce a framework to evaluate the production of quality information. It will use the results of Phase 1 and Phase 2 and apply them to suggest an approach that management could use to evaluate the appropriate focus when considering the optimisation of quality information.

CHAPTER 15

FRAMEWORK TO EVALUATE THE PRODUCTION OF QUALITY INFORMATION

15.1 INTRODUCTION

In the concluding Phase of this study, the final objective of the hypothesis will be unfolded. The previous Chapters aimed at developing an understanding of the subject matter, and establishing criteria to evaluate both the status of information quality and the computer tools that best could improve the quality of information. The hypothesis was stated as: "using the most appropriate computer equipment and applications, and managing the optimisation of the features of these tools, would lead to the improvement of information quality." This Chapter will compile a framework to select, and employ, the appropriate computer tools that will become powerful instruments to improve quality information. The result will be an improvement in correct decision making in business.

The process to formulate the framework will use the evaluation methods developed in previous Chapters to design a step by step approach to analyse the information received by the users, and to identify appropriate actions which will improve the quality of information by employing the most suitable computer tools. This Chapter will conclude with a summary of some reasons why an analysis of this kind is important for an organisation.

15.2 FORMULATING THE FRAMEWORK

15.2.1 Define the steps of the evaluation process

The steps to follow to perform an evaluation of the quality of information and possibilities of improvement flow logically from the results of phase 2. There are four major generic stages: Decide what to evaluate, gather the information, analyse the results and choose a plan of action. If the results of Phase 2 are added to these stages, then the following steps can be proposed to perform the evaluation and achieve the desired results:

1. Select the information area to be evaluated.
2. Decide on the information components to be evaluated.
3. Obtain responses from users of their assessment of information quality.
4. Convert the responses into quality attribute ratings.
5. Gather further information if required.
6. Match attributes to the potential computer tools.
7. Select the tools to work on.
8. Design improvement program.
9. Carry out improvement program.

Step 1 is necessary to confine the evaluation. It is impractical and virtually impossible to perform an evaluation of all information in an organisation simultaneously. The results of Phase 2 give content to and a method for steps 2 to 7. These steps will be described in further detail in the next paragraph. Steps 8 and 9 deal with the improvement actions. This study will not deal in detail with these steps.

15.2.2 Describing the main steps

Step 2: Decide on the information components to be evaluated and improved

Using the main characteristics of an information component as identified in Chapter 14 as a guideline, the information must be reduced into information components. The characteristics defined are:

- An information component is associated with a specific user, or group of users, in a specific organisation.
- It has a homogeneous purpose or objective.
- It demands distinguishable and homogeneous information quality attributes.
- It is a sub set of information.
- It is produced by a specific information system.

Usually any specific report from an information system in the organisation will comply with the above requirements. By listing these reports and results from the information system to be evaluated this step will be completed. This listing should be done by an information system and should contain the following information:

- Short description of information component.
- User or users of the information component.
- Purpose or objective of information component.

Step 3: Obtain responses from users on their assessment of the information quality.

Once the information components have been identified, responses can be obtained from the users on their evaluation of the quality attributes for each information component. To simplify responses, a questionnaire can be prepared specifying, for each information component, the attribute and the appropriate scale for evaluation developed in Table 14.2. A sample questionnaire is provided as Annexure E. This questionnaire was developed with information from Tables 14.2 and 14.4.

Step 4: Convert responses from users into quality attribute ratings for each information component

When the responses have been received from the users, each questionnaire must be analysed to identify those information components and attributes in need of improvement. This can be done by putting all the returns into a small database such as Dbase. The record layout should contain the following fields:

- Questionnaire reference.
- Information component code.
- Attribute code.
- Rating.

After all the questionnaires have been captured, the data must be sorted by attribute, by rating and by information component. The result will be that all information components with incomplete information, or all information components received too early will be exposed. By analysing this information, trends can be identified. These will give rise to the type of further information to be gathered.

Step 5: Gather further information if required.

It is expected that further information will be required to explain the results of the analysis in step 4. It may be necessary to gather background knowledge of the information systems that produce the information component. It will then be necessary to further investigate certain replies by asking the users for the reasons behind the replies.

Step 6: Match the tools contributing to specific attributes.

The first step in homing in on the tools that can contribute the most to improve the quality of the information component, is to use Table 13.1 to match the attributes to the tools. Table 13.1 was the summary of the assessments of the contribution of the tools to the attributes of quality information. The comparison to be done, should be similar to the one done in Table 14.6 for the sales report.

The result of this comparison must be added to the database questionnaire results compiled in step 4 by adding a field for the most likely computer tool to improve the quality of the information component. If more than one tool is involved, they too should be attached to the record.

Step 7: Select the tools to work on

The database can then be resorted to provide an analysis by tool and by information component. The result will clearly focus the attention on those tools that can potentially improve the information components the most.

The tools that can make the most significant contribution in improving the quality of the information have now been identified. All that remains to be done is to implement the improvements to the tools. This is done in steps 8 and 9, which are not dealt with in this study.

15.3 SUMMARY OF FRAMEWORK

By following the steps detailed in the previous paragraphs, an organisation can find out which tools to concentrate on to provide the most benefit for improving the quality of information. This will avoid focusing on incorrect areas. For example, there is a perception that the information in an organisation is inaccurate. This would give rise to developing a new information system. However, doing an analysis according to the framework could show that the information is not understood, or that the data capturing should change. Addressing the actual problems can result in substantial savings for the organisation.

15.4 CONCLUSION OF STUDY

15.4.1 Support of the hypothesis

The hypothesis was defined as follows: "using the most appropriate computer equipment and applications, and managing the optimisation of the features of these tools would lead to the improvement of information quality."

This study has considered quality information and the computer tools that can improve the production of better information. After stating the objectives and research approach in Chapter 1, it commenced with an overview of the historical development of computers. From this overview, it is apparant that the last 23 years has brought an ever-increasing focus on the development of improved computer tools to produce more efficient information. The more information that is being produced, the more focus there is on effective storage, manipulation, communication, processing and presentation of information.

Chapter 3 examined the nature and characteristics of information pointing towards the decisive impact that information has on the decisions and actions of decision makers. Good information, information that has quality, was considered in Chapter 4. The four main attributes of quality information relevancy, accuracy, timeliness and comprehensibility were clarified. From the literature considered in this Chapter it was evident that a gap exists between information produced by systems and the quality information that users expect. This pointed to the need for improvement in quality information.

Chapters 5-13 investigated the process of producing information from the initial stages of acquiring the data, through processing, communicating, storing, controlling, modelling and outputting the final information. Each building block of the information system, and the computer equipment used, was analysed to find out their effect on the process of producing information. The computer equipment was classified into groups, called computer tools. The potential contribution that these tools can make in improving the quality of information was considered and rated.

Chapter 14 developed a method of evaluating information by dividing it into smaller measurable components, performing an evaluation of the quality attributes of each component, and finally identifying those tools that could make the most significant contribution towards improving the quality of information components.

This Chapter concluded the study and proved the hypothesis by presenting a process of evaluation of quality information, and ways to improve it, by means of a practical framework. By using this framework organisations can improve the quality of their information, make better decisions and take more appropriate action by using the appropriate computer tools.

15.4.2 Recommendations

The study aims at providing a practical framework for management to improve quality information. It is recommended that this framework be used in an organisation to collect and analyse the information necessary to design a plan of action to improve the quality of information in a specific area.

15.4.3 Further areas of research

No any major focus on the inter-relationships between information quality and computer tools was evident from the literature study. This study aims at illustrating the importance of this relationship. Although the effect of computer tools was debated and illustrated, the study did not intend to field test the approach in the information management community. It did, however, will add substantial benefit by illustrating the relationship between information quality and computer tools and by refining a framework for evaluating this quality.

The study recognised the different contributions that individual tools within a building block can make to improve the quality of information. To ensure that the focus was not lost with attention to too much detail, the differential contributions of individual tools were ignored. The study focused only on groups of tools. Further studies could focus on individual tools, and highlight those tools' effect on particular developments in technology, which could impress the most on quality information.

Another aspect regarding computer tools that the study steered away from, was the effect that one tool group could have on another. For instance, if processing is bad, it pulls down the effectiveness of other tool groups such as applications software. The inter-relationships between tools for producing quality information, could be another important area to study further.

The attributes of quality information were deduced from the study. The literature showed the lack of commonalty among some sixty-four attributes of quality that were mentioned. Empirical studies could further enhance the understanding of exactly what users regard as the most important attributes of quality, and whether those attributes remain static.

Finally, in considering methods to improve quality information, the focus of the study was on computer tools. It was mentioned that the human factor, in enhancing or reducing the quality of information, would be substantial. It was not the intention of the study to focus on this factor. Considering the human factor, and the interaction between computer tools and it, would offer substantial rewards to improve the ability to enhance the quality of information.

ANNEXURE A

CLASSIFICATION OF INFORMATION

(refer Chapter 3)

A Internal versus external information

Information generated with an organisation's information system can be regarded as internal. Information used in the organisation originating from sources outside the organisation's own information system, is external information. If a business organisation operated in isolation from the rest of the world, information generated in the external environment would not have any significant influence on the activities of the enterprise. Only information generated internally would affect the on-going activities of this type of business. Normally, however, an enterprise has constant interaction with the environment in which it exists. External information is therefore important to decision-makers in an organisation, particularly at the strategic planning level. (Anthony 1980: 129). External information also influences macro organisational decisions and relate to long-term plans. It usually flows from the economic, political and environmental arenas, and from other businesses.

Until recently, external information was either written, audio-visual, or spoken. Today vast quantities of electronic information are available through public databases or other electronic media. Beltel is a good example of a public information network, and law reports on CD-ROM represents an example of external information available on electronic media.

An organisation usually has very little influence over the format, content or validity of external information. On the other hand, the creation of internal information is determined by an organisation itself. Internal information is by far the most important information for a business. (Terry 1970: 5).

B Systematic versus non-systematic information

Information can be either systematic of non-systematic. A large portion of systematic information flows through a formal system, but it is important to remember that much information reaches the manager from sources outside the formal system. Newspapers and other news media, conversations, and even a manager's perception of a colleague's facial expressions are important sources of non-systematic information. (Anthony 1980: 129).

Managers receive much of their information from discussions with people rather than from the computer. Managers often do not realize the extent to which the information received from discussions with people was originally provided by a computer system. (Scott 1986: 129).

The creation of systematic information is controllable, either by the organisation itself, or by external sources. Non-systematic information is much more uncontrollable, and is very dependant on the utilisation and interpretation of the user.

C Action versus non-action information

Action information induces the user to act. It generally relates to the day-to-day operation of an enterprise, for example, the receipt of an order from a customer. On receipt of the order the recipient is expected to take action to ensure that the customer receives his goods. Action information may call for immediate action, or it may be delayed.

Non-action information generally indicates that some action has already taken place, for example, notification that the customer's goods have been despatched to him. (Trickett 1972: 48).

Terry refers to these two types as 'active' and 'passive' information (Terry 1970: 5).

D Recurring versus non-recurring information

A fairly large proportion of the information generated in a business enterprise is recurring; for example, most performance reports are prepared at regular intervals. This type of information is generally used by the operational and management control decision makers.

Occasionally, special reports which are non-recurring, are prepared to cover a specific event or subject. These reports are used mainly by senior management and the strategic planning decision-makers. (Trickett 1972: 48).

E Quantitative versus non-quantitative information

Information can be quantitative or non-quantitative. Most of the impressions that managers pick up from informal conversations are non-quantitative. Non-quantitative information can also be produced by a formal system. For example, some companies have a formal system of recording information on employees. They send a team from the headquarters personnel department to each plant and sales office once a year. The team administers a questionnaire, and also conducts confidential interviews with all or a sample of employees, to establish the level of favourable (or unfavourable) attitudes of employees towards the company. The team reports its findings to both the manager of the unit and to headquarters. Its report is partially quantitative (an index of employee attitudes), but is primarily non-quantitative (a description of apparent causes for satisfaction or dissatisfaction). (Anthony 1980: 130).

F Accounting versus non-accounting information

Information can be accounting or non-accounting. A management control system is built around an accounting core. The outputs of a responsibility area are the goods and services that it provides to other responsibility areas and to customers. Accounting provides a way of aggregating these often heterogeneous products into a single figure, e.g. revenue. Some of the resources of a responsibility area are labour hours, kilograms of materials and machinery used. Accounting provides a way of aggregating these heterogeneous resource usages into a single amount, expenditure. Profit, which is the difference between revenue and expense, is an overall measure of the performance of the responsibility area, encompassing within it the results of actions that create revenue and the expenses associated with those actions. (Anthony 1980: 131). The financial control system is that part of the management control system that collects, reports and uses accounting information.

By far the largest quantity of information that flows through a business is operating information; that is, information that is generated in the course of day-to-day operations. A large portion of this information is non accounting such as production and sales statistics, fault reports, labour and machine hours, and units consumed. Sometimes the non-accounting information such as labour hours, is converted to accounting information such as labour cost. This conversion is necessary to report the information in the financial results of an organisation.

G Audio versus visual information

Information, as perceived by humans, is mainly perceived by their hearing and visual senses. The information visually perceived can be produced on paper, or in an electronic form, for example a visual display unit. Information presented visually to the user, increases the ability of the user to derive knowledge from it.

Audio information, especially in the business area, is not widely used to inform users. Situations do exist where users are audibly notified of a particular result or told what action to take.

H Historical versus future information

Time provides a frame of reference for classifying information. Historical information is drawn from past events and is generally used to develop standards of satisfactory performance and to establish a basis for future projections.

Information representing the future is often termed "planning". It could also be represented by forecasts, projections or budgets. Future information represents the expectations of an organisation. Well-defined expectation information is a quantitative picture of how an organisation models its future. These expectations are used for both performance and financial accounting purposes, to evaluate the process when it is completed.

Terry refers to this information as "past" and "future". (Terry 1970: 5).

I Formal versus informal information

Formal information refers to all information which is recorded in some form or other; thus all reports prepared within an organisation would be classified as formal information. Informal information refers to all information of personal observation or personal experience which is transmitted by verbal means.

Both types of information may be essential to the management and operation of an organisation, but formal information is the only valid output of the information system. An organisation whose existence depends primarily on informal information will not be a likely candidate to be supported effectively by a formal information system. (Burch 1979: 44).

Information used by top management is often informal, flowing from different sources, and absorbed in one framework for decision making. Operational and middle management are very dependant on formal information flowing from standard reports to make tactical decisions which pertain to short-term activities and the allocation of resources for the attainment of the objectives. Standards are fixed, and the results of decisions are deterministic.

ANNEXURE B

ADJECTIVES DESCRIBING QUALITY INFORMATION OR THE INVERSE OF IT

ability to manipulate
acceptance
accessible
accurate
accuracy
adaptability
appropriateness
authorised
browsability
clarity of message
clarity
closeness to problem
complete
comprehensive
comprehensiveness
credibility
currency
decision-relevance
degree of integration
dubious accuracy
ease of access
ease of use
fitness
flexibility
freedom from bias
frequency of use
inaccessible
inaccurate
insufficient
judgement reliability
limited noise
meaningful
not relevant
obsolete
on priority
on schedule
outside of control
out of time
output quality
pertinence
poorly presented
precision
quantifiability
readily understood
reducing noise
relevance
reliability
reproducibility
selectivity
simplicity
sufficient detail
support decisions
timeliness
timely
too late
too little
too much
understandable output
user friendly
validity
verifiability
verifiable

ANNEXURE C

LITERATURE SOURCES USED TO IDENTIFY RELEVANT NOMENCLATURES

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ANNEXURE D

SAMPLE QUESTIONNAIRE TO GATHER INFORMATION FOR STEP 3 OF THE FRAMEWORK

QUESTIONNAIRE
EVALUATION OF QUALITY OF INFORMATION

Complete the following questionnaire for each report.

Contact person:...
Contact telephone no.:...
Name of user(s):..
Description of report:...
Purpose of report:...

Tick the block of your choice

RELEVANCY OF INFORMATION

	not appropriate	incomplete	sufficient	complete	excessive
1 The report has sufficient detail (This will depend on the detail used by the user)					
2 The report supports the decisions (This will depend how relevant the information is for the decision or action to be taken)					
3 The information required is available (Whether the information required could be accessed will determine this)					

ACCURACY OF INFORMATION

4 The information is accurate
(this will depend on the type of decision to be taken)

wrong	very rough	acceptable	accurate	too precise

TIMELINESS OF INFORMATION

5 The information is on time
(This will depend on the stage that the information is required for a decision or action)

not received	sometimes	too late	on time	too early

COMPREHENSIBILITY OF INFORMATION

6 The information is understood
(This will depend on the background and skills of the user)

not comprehensible	difficult to use	reasonable understood	easy to use & understand	inappropriate presentation

7 The information is well presented

(Adequacy of the presentation techniques depends on the nature of the information)

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ANNEXURE E

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