EFFECTIVENESS MEASURES FOR GEOGRAPHICAL INFORMATION SYSTEMS (GIS)

A dissertation presented to
The Department of Geomatics
University of Cape Town

In partial fulfilment of the requirements for
the degree of Master of Science in Engineering
(Geographical Information Systems)

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September 1998

Declaration

I declare that this dissertation is my own work and where appropriate I have acknowledged the work of others. It is being submitted as a half thesis in fulfilment of the requirements for the course SUR505Z of the Department of Geomatics for the Degree of Master of Science at the University of Cape Town. It has not been submitted before for any degree or examination at any other University.

Signed by candidate

Christopher Barratt Tanner

1 st day of September 1998

Abstract

Geographical Information Systems (GIS) often do not meet the expectations of users and management, raising questions and doubts as to their overall success and effectiveness. To date the majority of GIS research has focused on technical issues, and management research has approached GIS effectiveness from a purely cost benefit perspective. This study adopts a holistic, multi-perspective approach to the issue of GIS effectiveness, identifying measures of effectiveness related to the fields of Information Systems (IS), Management Information Systems (MIS) and GIS. It applies these measures using the case study methodology in a small South African local authority, the Ceres Municipality.

Four research questions were posed, firstly, "How effective is GIS at the Ceres Municipality ?", secondly "What are appropriate measures of GIS effectiveness for this type of organisation ?", thirdly "Are existing Information Systems (IS) effectiveness measures applicable to the field of GIS ?" and finally " What organisational issues influence GIS Effectiveness ?".

From the literature reviewed, four themes were developed that were maintained throughout the case study. These are, firstly a holistic approach to GIS throughout the whole organisation. Secondly it is argued that for GIS to be truly effective it needs to support and be supported by the organisation's strategic goals and objectives. The concept of effectiveness is therefore seen as a strategic measure encompassing the operational measure of efficiency. The focus on the individual within the organisation rather than the organisation as a whole forms the third theme of the research. The fourth theme is the use of multiple and combined measures of GIS effectiveness and was developed from the availability of these alternative approaches which could be applied to the field of GIS. This is in contrast to existing GIS management theory, which emphasises technical efficiency and Cost Benefit Analysis (CBA) as effectiveness criteria. The study furthermore places less emphasis on in-depth analysis and more emphasis on comparative and overview analysis of the multiple measures and variables.

Of the various effectiveness measures identified in the literature, three measures were chosen for further analysis in the case study. These were Cost Benefit Analysis, Strategy Alignment and Systems Utilisation, providing a combination of qualitative and quantitative measures and a multi-perspective evaluation of GIS effectiveness. Cost benefit analysis has received wide

support in GIS management theory and is used as a baseline measure, against which the new GIS measures of Strategy Alignment and Utilisation can be compared and integrated.

The case study involved collecting data from a number of sources. These included direct observation, records, documentation, questionnaires, interviews and discussions. The study was performed across three departments in the organisation using a total of eight respondents at senior management, middle management and technical levels.

A cost benefit analysis was performed for historical five-year and future two-year periods with both past and future analyses resulting in favourable CBA ratios. The analyses were however limited by small sample sizes and the existence of a few high value benefits.

A measure of Strategy Alignment was developed as a further effectiveness measure of GIS. This involved the measurement of the existence and the mutual alignment of business, IT and GIS strategies. The overall level of strategy existence and strategy alignment was found to be low.

Systems utilisation was used as a surrogate measure of GIS effectiveness, and the psychometric measures of Perceived Usefulness, Perceived Ease of Use and Computer Self Efficacy were used as determinants of systems utilisation. These variables were measured by means of questionnaire instruments adopted from similar MIS research and by interviewee responses to perceptions of utilisation. Past and current utilisation was found to be low to moderate while predicted overall future utilisation of GIS was found to be moderate to high.

Further analyses were performed using matrices of strategic and tactical effectiveness where strategy alignment was used as the determinant of strategic effectiveness and utilisation was used as the determinant of tactical effectiveness. These were used for the past, current and predicted future time frames. This was found to be a useful method of combining variables.

Finally an overall GIS Effectiveness Framework is proposed as an all-inclusive summary of the dimension, measures, perspectives and methodologies used in the research, representing the author's holistic view of GIS effectiveness. The framework is proposed as a useful tool to be used as a starting point for other GIS effectiveness related research.

The main findings of the case study reveal varying levels of effectiveness depending on the approaches and measures used. The proposed overall effectiveness model that uses measures of utilisation and strategy alignment in addition to CBA was found to be more applicable than simple CBA alone due to the complexities that exist in the organisation and the shortcomings of the CBA measure when used in isolation.

The psychometric measures of user attitude as predictors of utilisation, adopted from the field of MIS, proved to be suitable for use in evaluating GIS effectiveness. The psychometric measures used were however simple and limited and require further research and validation.

The case study methodology was found to be well suited to the study of GIS management issues due to the complexities of the variables present and the uniqueness of each organisational situation.

This work is dedicated to my wife Liza, for her patience, support and encouragement to see me succeed.

Acknowledgements

I wish to thank Michael Barry of the Department of Geomatics at UCT for supervising this research and for his assistance and insight into the topics researched. Thanks are also extended to the councillors and staff of the Ceres Municipality for granting the opportunity to conduct this case study and especially to Dana Du Plessis, Deon Boshoff, Pierre de Jager and Brian van der Watt for their co-operation and assistance during interviews and discussions. To the directors at AOC for their encouragement of further study and for their financial assistance – I thank you and am most grateful. To David Friedman and Patrick Hill, thanks for your ideas and proof reading of the many drafts. Finally to my parents, thank you for instilling in me an appreciation of the pursuit of knowledge and for your continual support throughout my study years.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

GLOSSARY OF TERMS AND ABBREVIATIONS

ArcInfo – A GIS application program marketed by ESRI Corporation, USA.

CAD – Computer Aided Design

CBA – Cost Benefit Analysis

CSE – Computer Self Efficacy

Effectiveness – Measure of the impact of policies and programs (Worrall 1994).

Efficiency – Maximisation of the ratio of outputs to inputs (Worrall 1994).

GIS – Geographical Information System – A computerised system for the collection, storage, manipulation and output of information that is spatially referenced (Obermeyer & Pinto 1994)

IS – Information System

IT – Information Technology

MapInfo – A desktop mapping and GIS application program marketed by the MapInfo Corporation, USA.

MicroStation – A Computer Aided Design (CAD) application program marketed by the Bentley Corporation, USA.

MIS – Management Information System

MR – Managerial Rationalism. GIS implementation perspective with the emphasis on a traditional management approach. (Campbell & Masser 1995)

ReMap – A desktop GIS application program marketed by Computer Foundation, South Africa.

SI – Social Interactionism. GIS implementation perspective with the emphasis on the needs and role of the individual. (Campbell & Masser 1995)

TD – Technological Determinism. GIS implementation perspective with the emphasis on technical capabilities. (Campbell & Masser 1995)

TTF – Task Technology Fit

UltimateCad – A Computer Aided Design (CAD) application program marketed by Computer Foundation, South Africa.

CHAPTER ONE - INTRODUCTION

"Devices designed to gain information efficiency paradoxically produce conflict, anxiety and investment uncertainty" B.J Cullis (1994)

1.1 OVERVIEW

Geographical Information Systems (GIS) are yet another one of the technological innovations of the 20th century. As with many similar technologies, especially those related to computing, much debate exists relating to their overall value and effectiveness. Information Technology (IT) is even seen as creating value through rapid access to information, whilst simultaneously destroying profits due to the high costs of added infrastructure, training and employment of computing specialists (Hitt & Brynjolfsson 1994). It is from this apparent contradiction and many other similar doubts surrounding the success and justification of IT and GIS that this research has been approached.

There are many ways of evaluating these technologies in isolation, usually in technical terms (Campbell & Masser 1995). However to evaluate their true worth and overall effectiveness, these technologies need to be seen in their intended environment or context. In the case of GIS this invariably implies the context of an organisational structure. The study of IT has evolved from the computer science disciplines with roots in mathematics and systems theory to an emerging discipline that draws strongly on organisational and behavioural sciences as well (Miller 1989:5). This wider view of the effectiveness of technology needs to be studied as a system involving the technology itself and its interrelationships with the organisation.

GIS forms a subset of the wider field of Information Technology, where the term Information Technology refers not only to the technical innovation of the hardware and software, but also to the complex methods and knowledge that go with the innovation that link them together as systems. The operations of the organisation and business also exist as systems whereby resources are transformed and processed from

an external environment via an internal environment of the organisation and returned to the wider external environment. It follows that for any level of performance to be achieved, these transformations need to be optimised to be both efficient and effective. This study takes a holistic view of effectiveness of GIS in a municipal organisation, both in terms of the broad definition of effectiveness and the concept of GIS as an overall system rather than as an individual application.

The author has observed over a number of years that many organisations have embarked on lengthy and costly GIS implementation projects without knowing how to measure the overall effectiveness of these actions. It is the author's opinion that this is mostly due to a lack of suitable effectiveness measures applicable to GIS and a lack of understanding of the organisational influences on overall effectiveness.

In South Africa, as in many other countries in the world, GIS has found application in municipalities and other local government structures. The larger structures have had the opportunity to work with GIS technology over the last ten to fifteen years and usually have the internal resources to actively manage such systems. However smaller municipalities, although having seen a need for GIS usually do not have the insight or the resources to manage the technology, thereby raising questions as to its overall effectiveness.

In an attempt to study the question of GIS effectiveness in a small local authority, a case study was undertaken at the Ceres Municipality. This organisation was chosen since it represented a small organisation grappling with change and experiencing many of the uncertainties of IT and GIS mentioned thus far. The author also had the benefit of working closely with staff at various levels of the municipality over a number of years on GIS related projects.

In this chapter the background to the research and the basic definitions of Information Systems effectiveness are presented. From this the research questions are framed, followed by an overview of the structure of the thesis and the assumptions and limitations of the work. The chapter concludes with a summary of the contributions to be made by the research.

1.2 EFFECTIVENESS AS A PERFORMANCE MEASURE

The concepts of efficiency and effectiveness are common measures of performance used in many fields. Efficiency is concerned with the process of transformation of inputs to outputs and to what extent this process is optimised (Worrall 1994). Miller (1989:11) citing Drucker refers to efficiency as "doing things right". Effectiveness on the other hand is "doing the right things" and refers to optimising policies and decisions, i.e. "was the decision right in the first place ?" Efficiency is therefore an operational issue whereas effectiveness is concerned with strategic issues. Furthermore, effectiveness encompasses the concept of efficiency – consequently it can be argued that an effective organisation is efficient but an efficient organisation is not necessarily effective. Efficiency and effectiveness overlap, but effectiveness emphasises benefits, and efficiency emphasises costs (Miller 1989:11). Cost Benefit Analysis (CBA) is discussed further in Chapter Two and analysed for the Ceres case in Chapters Three and Four. From the point of view that effectiveness is a strategic measure, the case study has been approached from a holistic view of the organisation and it will be argued that for GIS to be a truly effective tool it needs to support and be supported by the overall organisation's reasons for existence and survival – in other words the organisation's strategic goals and objectives. From this a Strategy Alignment measure of GIS effectiveness is presented in Chapter Two and is further analysed in Chapters Three and Four dealing with the case study.

1.3 THE RESEARCH QUESTIONS

The research is exploratory and inductive in nature. It is therefore not possible to determine the validity of predetermined hypotheses. Consequently, the hypotheses have been framed as a set of four questions to develop the research. These are:

i. **How effective is GIS at Ceres Municipality ?**

The terms success, failure, efficiency and effectiveness are often used to describe GIS installations. These are usually subjective indicators, that are not easily quantifiable, and their definitions are vague. An understanding of effectiveness variables is required to assist the management of GIS at Ceres

Municipality. Once these variables have been identified, a form of quantification is required. This leads to the second question:

ii. **What are appropriate measures of GIS effectiveness for this type of organisation ?**

Measures of effectiveness, whether they be absolute or relative are essential for monitoring and gauging progress of any process. However the uniqueness of each organisation demands a unique set of effectiveness measures best suited to the particular circumstances and the problems at hand. Even if the measures cannot be easily applied, knowledge of their existence can provide an awareness of the variables that come into play.

iii. **Are existing Information Systems (IS) effectiveness measures applicable to the field of GIS ?**

Various measures of effectiveness have been developed for the fields of Information Systems (IS) and Management Information Systems (MIS). Since GIS can be considered as a special case of an information system, these effectiveness measures, possibly modified, could be applicable to GIS cases.

iv. **What organisational issues influence GIS effectiveness ?**

GIS often falls short of users' and management's expectations. Often the reasons are not technical but organisational in nature. A better understanding of these organisational issues and their influence on the effectiveness measures can provide GIS managers at Ceres Municipality with more insight into their GIS effectiveness.

In attempting to address these questions, the research examines the relevant literature relating to effectiveness measures in the fields of Information Systems (IS), Management Information Systems (MIS) and Geographical Information Systems (GIS). This is presented in the literature review in Chapter Two. Thereafter Chapter

Three deals with the background, research methodology and data collection for the case study of GIS effectiveness at the Ceres Municipality. Chapter Four contains the detailed analysis of the data collected and includes Cost Benefit Analysis (CBA), Systems Utilisation, Strategy Alignment as well as a discussion of the organisational issues affecting the research questions. Chapter Four concludes with a proposed Overall GIS Effectiveness Model and a discussion of its applicability to other organisations. Finally Chapter Five contains conclusions and recommendations. Detailed data, strategy documents and questionnaires appear in the appendices.

1.4 ASSUMPTIONS AND LIMITATIONS

For the purposes of this research, only the organisational and social issues relating to GIS effectiveness have been investigated. All technical issues, with the exception of certain aspects of the cost benefit analysis, have been ignored as being beyond the scope of the study. This however does not imply that technical issues do not have a bearing on the research questions. It is further assumed that the technical capacity and capability is in place.

1.4.1 POTENTIAL BIASES

There are a number of potential biases in the research. These are:

i) Single Case

The study involves a single case, which has been observed and analysed. The results are therefore not generalisable to other cases but should only be seen as indicators for other cases.

ii) Sample Selection

The case study research material was obtained by interviews and discussions with individuals in key positions in the case study organisation. It is assumed that these key personnel were the most qualified to reply to the research interview questions. This does not preclude other personnel having potential insight into the research issues.

iii) Sample Size

The study involved a limited number of participants. This was due to the small size of the organisation and the limited number of employees either directly or partially involved in the GIS implementation. The nature of the study places less significance on sample size with more emphasis on in–depth, qualitative assessment of an organisation in its working context.

iv) Interviewer Bias

Possible preconceived ideas of the author may have biased the results in that they may have influenced the manner in which the interview questions were phrased and directed. These influences were reduced as far as possible but due to the subjective and qualitative nature of the case study methodology, certain biases may still exist.

v) Implementation Solutions

The aim of the case study is to explore possible effectiveness measures applicable to the field of GIS. No attempt is made to address the GIS implementation issues facing the case study organisation. Some explanations, proposed solutions and courses of action have been mentioned. However, detailed solutions relating to implementation problems are beyond the scope of this study.

1.5 CONTRIBUTIONS OF THIS RESEARCH

Many GIS installations are only partially successful and do not generate the required returns on investment due to management, planning and implementation short-sightedness. The research and identification of possible measures of GIS effectiveness can be used to assist the implementation of other GIS projects.

This research makes an empirical contribution to GIS Management theory in that it investigates appropriate effectiveness measures and the organisational issues that influence GIS effectiveness in a South African local authority. Specifically, the research intends to make the following contributions to the established theory of GIS.

- Identify effectiveness measures applicable to GIS.
- Apply established IS and MIS theory of effectiveness to the field of GIS.
- Develop an Overall GIS Effectiveness Model
- Examine and test the applicability of these measures empirically by means of a case study.
- Identify areas for further research.

In the next chapter a literature review of established theory and previous work related to IT, GIS, organisations and effectiveness is presented.

CHAPTER TWO - LITERATURE REVIEW

2.1 INTRODUCTION

In order to more fully understand the dimensions of GIS effectiveness and to attempt to apply measures of effectiveness, a holistic view, encompassing an understanding of organisational and technological issues relating to GIS effectiveness is needed.

This chapter introduces GIS as a subset of Information Technology (IT). Thereafter the inter-relationships between Organisational Culture, Organisational Strategy and the manner in which IT in general and GIS are accommodated within the organisation are discussed. This includes the topics of data sharing and the role of information in the organisation. Finally the factors surrounding GIS diffusion are reviewed leading to possible measures of GIS effectiveness, some from GIS literature and others adopted from IS and MIS theory.

As stated in the introductory chapter, IT and consequently GIS are broad disciplines encompassing applied sciences such as computer science, as well as social sciences such as behavioural and organisational studies. The research questions deal with GIS effectiveness measures and their interrelationship with organisational issues. In order to review GIS as a technology, the following short description of Information Technology (IT) and Geographical Information Systems (GIS) is presented.

2.2 INFORMATION TECHNOLOGY (IT)

Computer based systems are a subset of technologies that should be viewed as packages which include hardware, software, data, people and techniques (Campbell & Masser 1995). Computer based technologies such as Information Technology are distinguished from mechanical technologies by their programmable nature, allowing them to be continuously redesigned and programmed (Campbell & Masser 1995, Sproull & Goodman 1990).

These definitions of IT raise two important issues relating to computer based technologies which have effectiveness implications. The first is the often intangible aspects of computerisation i.e. electronic storage, calculations and data transfer. In contrast to mechanical systems these functions can be difficult to perceive and quantify.

The second relates to the potential for change, both in the speed of processing as well as the development changes to the equipment and methods themselves. This need for change and the management of such change has enormous implications when viewed in an organisational context.

2.2.1 GIS AS A TECHNOLOGY

Geographic Information Systems (GIS) are a special case of the Information System (IS) dealing specifically with the spatial component of data and can be defined as "A computerised system for the collection, storage, manipulation and output of information that is spatially referenced" (Obermeyer & Pinto 1994).

Many definitions have been proposed for GIS. However, the overall systems environment encompassing GIS makes a precise definition difficult, if not impossible. The boundaries of GIS are vague and subject to change and the environment into which GIS is being introduced is also complex and changing (Worrall 1994). A user's definition will very often fit their particular user perspective, which may only be a small portion of an all-encompassing system. An example being a particular individual or department viewing the GIS from a software only perspective, and often heard statements such as "We have an ArcInfo GIS" or "We have a MapInfo GIS".

GIS should therefore always be seen in its broadest context ranging from the technical aspects such as hardware, software and data through to organisational aspects such as user attitudes and perceptions, the organisational structure and culture. It is this wider, all encompassing view of GIS technology, which needs to be considered when attempting to investigate effectiveness issues.

2.3 ORGANISATIONS

Since GIS invariably occurs within the context of an organisational structure, a review of the theory of organisations that is relevant to the research questions is presented here. This includes the topics of organisational culture, strategy and information sharing. These topics were used in the case study analysis in Chapters Three and Four.

In GIS studies, the unit of analysis is seldom an individual person and is most likely to be a group of people, or an entire organisation. The definition of its systems nature as well as its definition as a technology places GIS firmly in the organisational context with its associated complexities. Cullis (1994) defines an organisation as "A stable system of individuals who work together to achieve common goals through a hierarchy of ranks and a division of labour"

Technical know-how is often more highly prized than organisational sensitivity and GIS research has been dominantly of an operational and technical nature. An understanding of the organisational context is therefore crucial to successful GIS implementation. Within the organisation, with its many complexities and vast array of variables, is the individual which is the most important variable to consider (Campbell & Masser 1995).

Handy (1993) describes organisations as "first and foremost a fascinating collection of people." It is these people that make up the organisation, each with their individual attitudes, beliefs and culture that shape the organisation and influence its adoption, implementation and utilisation of technology.

The overriding message found in all the literature relating to organisational theory was the complexities involved and the massive variations in approaches to understanding of the organisation. The effectiveness of individual Information Systems and the total IS function only has meaning to the extent that IS contributes to the effectiveness of the organisation as a whole. Miller (1989:27), citing several sources discusses the lack of effectiveness models applicable to the theory of organisations and concludes firstly,

that it is futile to search for a single overarching theory of effectiveness that is applicable to all organisations and secondly, that the criteria for effectiveness can vary depending on the stage of growth, level structure, values and attitudes prevailing in the organisation. The role of individual attitudes and how these can shape behaviour are discussed in more depth in section 2.5.5 dealing with systems utilisation. The concept of values is determined largely by the organisational culture, which is discussed in the following section.

2.3.1 ORGANISATIONAL CULTURE

Management studies often refer to organisational cultures and how these influence the overall organisation. The author's previous experience with municipal organisations and work by others (Campbell & Masser 1995, Obermeyer & Pinto 1994) has indicated that the prevailing culture of an organisation has an influence on GIS effectiveness. The analysis of the Ceres Municipality case in Chapters Three and Four includes a brief analysis of the prevailing culture and its influence on GIS effectiveness. A short review of the concepts of organisational culture follows.

The concept of organisational culture is difficult to define but well put by Campbell & Masser (1995) citing Deal and Kennedy (1982) as "The way we do things around here". Hirscheim (1985) states that office cultures are not rational nor manifestly rule following. They are social arenas where power, ritual and myth predominate. The organisational culture can be seen as being made up of tangible and intangible aspects, the tangible being resources such as financial, manpower and skills together with the intangible aspects such as values, beliefs, ethics, morals, privacy, confidentiality and professionalism. How outsiders perceive the organisation would also contribute to this culture. The organisation culture therefore features strongly in the micro environment of the business entity model. Campbell & Masser (1995:18) mention how organisational studies should be seen as a form of historical analysis : "A process of uncovering traditions and rituals that have resulted in a particular style of working best described as a culture."

Campbell & Masser (1995) citing work by Handy (1993) define four dominant cultural types as power, role, task and person cultures. These are shown in Table 1.

Table 1 - Cultural Types (Handy 1993 in Campbell & Masser 1995)

CULTURAL TYPES			
POWER	**ROLE**	**TASK**	**PERSON**
Dominated by powerful head	Based on logic and rationality	Team based	Serves the individual
Absence of formal structures	Dominated by rules and procedures	Getting things done without control from the top	Organisational goals are secondary
Willingness to follow lead of charismatic central figure	Conformity and predictability		

Munshi (1996) describes Organisational Paradigms placed along a single dimension according to their extent of rational choice. These are from the lowest level to the highest, Neohumanism, Social Relativism, Radical Structuralism and Functionalism. Functionalism is characterised by a high degree of order and objectivity, making optimal decisions through objective and scientific means. Radical Structuralism allows for managers and workers to each have their own separate agendas. Social Relativism and Neohumanism emphasise subjective experiences of individuals with varying degrees of order and conflict. In these situations individuals are working toward company objectives but in their own way. In Neohumanism, divergent individual goals create conflict.

Although every organisation should be seen as unique it is possible to define cultural types. However to attempt to put any organisation into an exact category of cultural type is unwise due to the uniqueness of each organisation. The Handy (1993) definition in Table 1. provides a good set of broad categories, showing the large cultural variations that can exist within an organisation. Similarly the description of paradigms proposed by Munshi (1996) is meant to assist with the understanding of organisational culture in a broad sense. It is the author's opinion that the complexities of the real life situation within an organisation make the application of single paradigms impossible.

2.3.2 ORGANISATIONAL STRATEGY

One of the GIS effectiveness measures used in the case study in Chapters Three and Four is that of Strategy Alignment which is a measure of how closely GIS strategy is aligned with IT strategy and overall business strategy. In order to more fully understand the origins of this effectiveness measure, a review of the concepts of organisational strategy and its relevance to the research questions follows.

It is the author's view that the organisational strategy forms part of the overall organisational culture in the sense that the attitude and approach to the concept of strategy will be largely determined by the organisation's prevailing culture. In the case of private sector organisations, a large percentage of strategy can be termed competitive strategy rooted around the business principles of maximising benefits to shareholders. In the case of public sector organisations such as local government, strategies are less competitive and more service oriented.

Business strategies of public sector organisations, although largely uncompetitive still have a role in the functioning and direction of these organisations if they are expected to function effectively.

Talvakolian (1989:310) uses the typology originally developed by Miles and Snow (1978) to identify the basic competitive strategy types of organisations as

defenders, prospectors, analysers and reactors. These can be summarised as follows :

A *defender* is seen as an organisation with

- conservative competitive strategy
- no new product development
- centralised decision making
- autocratic management style
- activities structured around basic business functions
- orientation toward efficiency (cost saving)

A defender therefore relies on centralised control in a bureaucratic organisation to ensure both high quality and low prices for its products.

A *prospector* in contrast is seen as an organisation with

- aggressive competitive strategy
- pioneer in products/markets
- decentralised decision making
- participative management
- activities structured around product/market divisions
- orientation towards effectiveness (profit-making)

A prospector therefore has a decentralised control structure with minimal bureaucracy to rapidly adapt to change.

An *analyser* is seen as an organisation moderating between the extremes of the defender and the prospector. i.e.

- moderate competitive strategy
- balance between changes and stability
- balanced decision making structure
- matrix form of organisational structure
- combination of efficiency and effectiveness

A *reactor* has no distinct competitive strategy, makes decisions in a random fashion and its actions are taken as reactive rather than proactive.

Tavakolian (1989) found that IT structure is strongly related to competitive strategy and specifically that the degree of centralisation of IT activities is significantly related to competitive strategies. He further speculates that a conservative competitive strategy exerts pressure for the centralisation of IT responsibilities, while an aggressive competitive strategy exerts pressure for the decentralisation of IT responsibilities. The effect of degree of centralisation features strongly in IT effectiveness studies and can therefore be assumed to be an important influence on GIS effectiveness.

GIS should ideally be fully integrated within the IS/IT infrastructure of an organisation and be strongly linked to the organisation's business strategy and not be seen in isolation (Worrall 1994, MacDevette 1990). GIS has a role to play in not only being included in the overall business & IT strategy planning but also in providing the information required for the strategy decision making process (Obermeyer & Pinto 1994). Recent studies such as Worrall (1994), Campbell & Masser (1995), have shown that very few local authorities and departments have corporate business plans in place thereby putting any top-down implementation plan in jeopardy. MacDevette (1990) suggests that many organisations do not fully understand the nature of their business, thereby making strategic planning difficult if not impossible.

Meador (1997) stresses the need to "Align Information Technology with Competitive Strategy". The alignment approach is based on the common sense premise that the effective use of IT requires consistency between competitive strategy and IT strategy. Meador (1997) concludes that the most effective and sustainable examples of IT use occur when IT is woven into the very fibre of the organisation.

In the case of public sector organisations such as the Ceres Municipality analysed in this study, the role of strategy in the overall organisation's function is taking on a new significance. It is the author's opinion that whereas in the past such organisations could be classified as reactors which were uncompetitive and largely sustainable with little or no strategy, they now need to function more along the lines of business units and apply business principles in order to be sustainable. Examples are the privatisation of municipal services where local authorities may need to compete with private enterprise for the income derived from these services. For example, the changes in legislation regarding the supply of electricity and the formation of the National Electricity Regulator (NER) has forced local authorities to look elsewhere for sources of income. Previously they were able to resell electricity at high profit margins where this income formed a large percentage of the organisation's income. The role of strategy and competitive strategy is therefore significant for the future of these organisations and the established theory applicable to private sector organisations discussed above can be expected to be more and more applicable to municipal organisations.

The literature provides strong evidence for the alignment of business strategy with IT strategy (Meador 1997, Talvakolian 1989), and for links between GIS and IT strategy (Worrall 1994, McDevette 1990, Campbell & Masser 1995). It can therefore be argued that GIS effectiveness is strongly dependant on a formal implementation strategy and the alignment of this strategy with the organisation's IT and overall business strategies. Strategy alignment as a measure of GIS effectiveness is discussed further under section 2.5.2

2.3.3 ROLE OF INFORMATION IN ORGANISATIONS

The role of information in an organisation and the Information Age in general has become crucial to the survival of organisations (Toffler 1980), to facilitate, enhance and accelerate strategic execution and as an aid to the decision making process (Meador 1997).

Meador (1997) suggests that the traditional view of IT in the organisation is largely reactive – that is a response to existing strategy and business process and that the perspective of IT as a strictly support function for business strategy is becoming increasingly outdated. A more sensible approach would be to position IT in a pro-active role where strategies should be challenged, extended and perhaps modified in light of emerging technologies and applications (Meador 1997). Business should be seeking ways to exploit IT to transform their basic business. This "Business process reengineering" (BPR) is a radical, IT based redesign of workflows and processes within and between organisations (Shabana 1996).

Campbell & Masser (1995) describe the role of information as playing a pivotal role between the problem situation and the course of action required, where information is used as the ammunition in the decision making process.

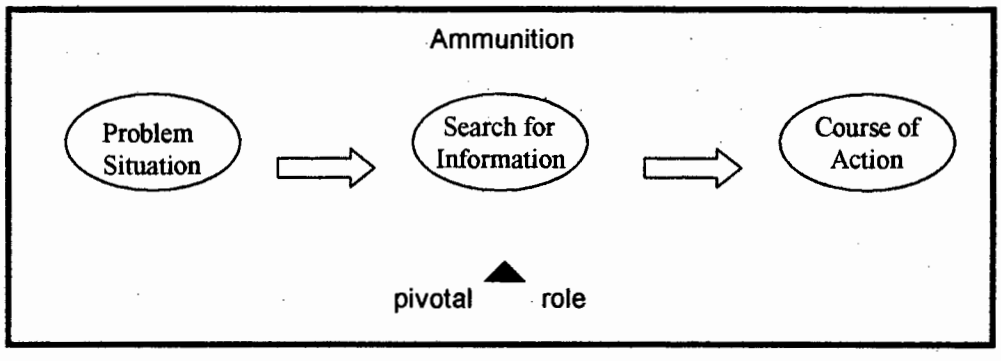

Figure 1 - Information as ammunition (Campbell & Masser 1995)

This view of computerisation supports bureaucratic rational decision making of strict, well-defined rules and procedures since computers can reinforce and emulate these rules and procedures. In contrast to this rational and systematic view of information supporting the decision making process, other studies have suggested that information and consequently IS and GIS have a more symbolic than substantive role to play (Feldman & March (1981) quoted in Campbell & Masser (1995)). Often organisations are forced to analyse whatever information is available, often making "seat of the pants" decisions based on past experience or gut instinct (Obermeyer & Pinto 1994).

These views see information as only a small part of the decision making process with other equally important forms of knowledge such as experience, expertise, beliefs, values and perceptions playing major roles. This perspective therefore views intuition and emotion as the key underlying factors in the decision making process. These two contrasting views of the role of information highlight the complexities of IS in organisations and how the organisational culture discussed under 2.3.1 influences the role of IS according to tradition, values and perceptions.

2.4 GIS DIFFUSION

2.4.1 INTRODUCTION

The development of GIS in an organisation is a long and ongoing process and consequently the effectiveness of GIS can be viewed in many different ways depending on the intended goals and objectives of the system. These views of effectiveness can be applied to the functional levels within an organisation namely strategic, management and operational and can be measured at the three phases of system development, namely the adoption phase, the implementation phase and the utilisation phase.

GIS Diffusion is seen as an umbrella term encompassing all the complex and interrelated processes responsible for the transfer of technology to the larger sections of the organisation (Campbell & Masser 1995:4) and is shown in figure 2. This diffusion can be seen as a time dependent and cyclical process starting with the initial awareness and adoption of the technology, through the implementation, to the routine usage stages.

The activities at the adoption end of the scale tend to be influenced by external (macro environment) factors such as the influence of system vendors and the adoption of systems in other similar organisations. Those at the utilisation end tend to be influenced by internal (micro environment) factors such as staff attitudes to using the technology, levels of staffing and training.

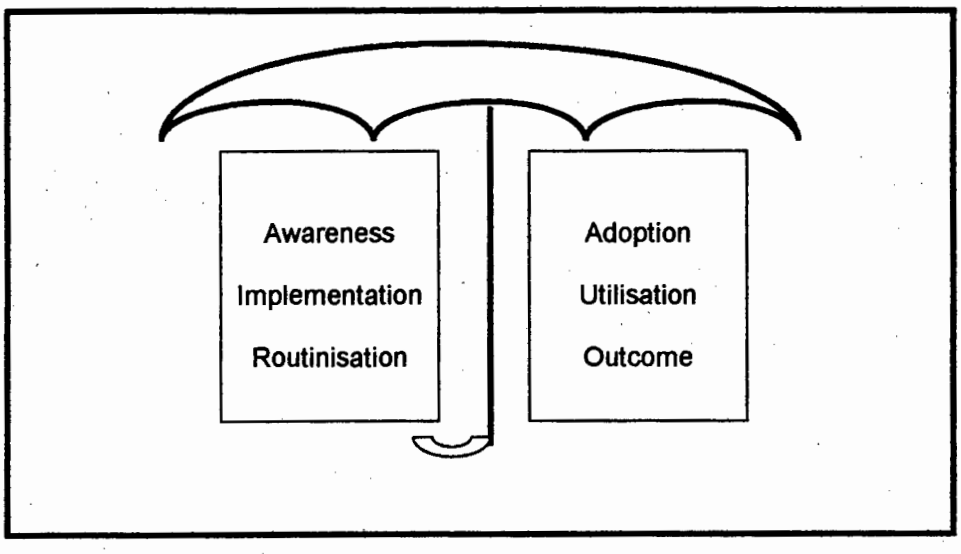

Figure 2 – GIS Diffusion (Campbell & Masser 1995).

The extents of these stages are shown in Figure 3. They are: i) The extent of adoption equating to the user realisation of potential of the system, and ii) The extent of implementation equating to the user realisation of utilisation (Campbell & Masser 1995).

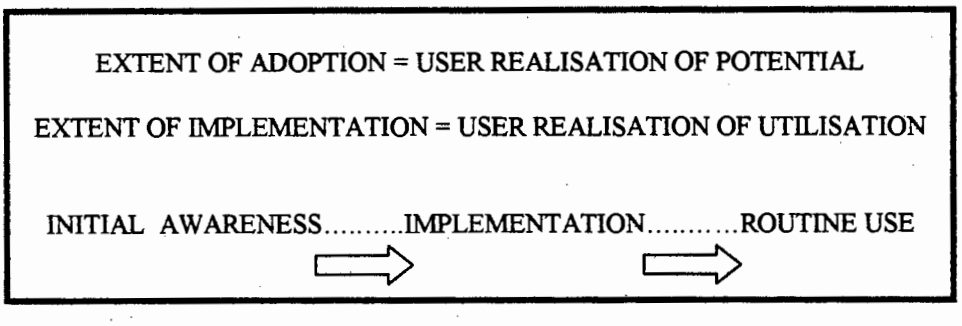

Figure 3 - Extents of adoption & implementation (Campbell & Masser 1995)

The terms "adoption" and "implementation" are often used to describe GIS installations. However their precise definitions are required to distinguish the distinct phases to which each pertain. Cullis (1994) defines adoption as "The decision to continue full use of an innovation" and implementation as "The assimilation of the technology within the organisation as an operational routine". These provide a simple model of expectations vs. reality and of initial perceptions vs. final utilisation.

2.4.2 IS IMPLEMENTATION PERSPECTIVES

Campbell & Masser (1995:26), identify three perspectives of computer based technology implementation in organisations. These are Technological Determinism, Managerial Rationalism and Social Interactionism. The main points of each can be summarised in point form as follows.

Technological Determinism (T.D.)

- Main emphasis on technical worth of innovation i.e. that the advantages of computer based innovation are so obvious that the implementation is a mere technical process.
- Human and organisational issues are largely overlooked with the most important quality being technical competence.
- Based on an utopian view of technological developments i.e. that it is inevitable that such developments will be extensively adopted.
- Assumes that adoption and acquisition automatically implies utilisation.
- Assumes that the organisational context is irrelevant.
- Introduction of technology motivated by desire to correct operational weaknesses and improve organisational effectiveness.
- Assumes that introduction will automatically improve working conditions.
- Effective utilisation depends on users (or potential users) comprehending the benefits of the technology.

Implications for GIS - This overriding emphasis on technical issues leads to situations where decisions regarding appropriate products and overall strategy are left to technical specialists who then go on to dominate the strategies.

This often leads to advanced, technically powerful systems with no regard for the organisational context. This perspective therefore assumes the narrow conceptualisation of technology as a set of machines and methods in isolation to the organisational context.

Managerial Rationalism (M.R.)

- Innovations are not expected to be used solely for their inherent technical potential but rather to follow management strategies.
- Effective utilisation results from a combination of rational management and technical competence.
- Assumes that individuals in organisations act rationally and follow the lead of management. Personal goals are secondary to achieving the goals of the organisation.
- The introduction of new technology needs to be managed and co-ordinated to yield its full potential to the organisation.
- A cookbook method of systems implementation is applicable i.e. where all the ingredients are collected and a set recipe is followed which will automatically lead to a well utilised system. In the case of GIS these ingredients are still seen as largely technical.

Implications for GIS - Most GIS implementation studies focus on the Managerial Rationalism perspective and are often done by people with management consulting experience. The corporate approach discussed in 2.4.3 is the epitome of Managerial Rationalism.

Social Interactionism (S.I.)

Technological Determinism and Managerial Rationalism perspectives are theoretical conceptions of how organisations ought to operate. In contrast, the Social Interactionism approach attempts to :

- Understand the social political realities of organisational life.
- Identify cause and effect relationships with implementation of IS.
- Accommodate confusing and contradictory experiences with IS e.g.
  - Centralising and de-centralising authority
  - Creating and destroying employment
  - Theoretical potential vs. practical realisation
  - Trade off between costs and benefits
- Understand how the outcomes of IS implementation using the same technology can vary considerably, thereby pointing to the study of organisational issues. Long (1987) as cited by Campbell & Masser (1995), found that in studies related to office automation, 90% of the failures related to organisational issues and the remainder to technical issues.
- Identify the organisational boundaries. In contrast to the M.R. approach, which is largely a top down strategy approach, the S.I. approach sees the organisation as being full of strategists at various levels in the organisation.
- Explain why individuals seldom respond to change as laid down by formal strategies. This occurs where staff members put their personal needs and benefits of GIS first, thereby putting the overall needs and benefits of the organisation secondary. These individual strategies can include personal status, promotion, job description and counter implementation strategies.
- Manage change with cognisance of scepticism and anxiety, factors which can often lead to failure to appreciate technology.
- Account for the symbolic value of new technology as being crucial to adoption and utilisation.
- Address and measure perceptions and beliefs of technology.

Implications for GIS - The S.I. perspective is new to the field of GIS. Most strategies found for implementation have focused on the purely technical or traditional management approaches. The S.I. perspective therefore offers a new

and possibly more meaningful approach to GIS management with emphasis on the individual.

These perspectives provide the conflicting paradigms of how implementation should work in theory i.e. the M.R. approach, compared to how the real organisation works in practice i.e the S.I. approach.

The implementation perspectives relevant to the case study are explored and analysed in Chapter Four

2.4.3 DEGREE OF CENTRALISATION

Campbell & Masser (1995:34), make definite distinctions between the corporate and the departmental or separate systems development approach to GIS implementation in local authorities, and discuss these in relation to the T.D, M.R and S.I implementation perspectives.

The supporters of corporate approaches have used three main arguments to support their theories – firstly the data sharing benefits, secondly the standardisation of resources and thirdly the top down management approach of enforcing corporate strategies and change on the entire organisation.

The implementation of an IT structure may be seen as threatening to managers (MacDevette 1990). Individuals may also feel under greater scrutiny and supervision and may resort to counter-implementation strategies such as prolonging implementation or undermining the system or other individuals. The case studies undertaken by Campbell & Masser (1995) in the United Kingdom found that an effective classically corporate implementation of GIS as per the traditional M.R perspective of implementation is often envisaged but seldom realised and is extremely rare in practise. By contrast the separate systems approach has the benefits of reinforcing the independence, sensitivity and individual capabilities present in any organisation and offers advantages to achieving utilisation.

Campbell & Masser's (1995) research findings support the S.I. perspective of GIS implementation, with its recognition of complex human behavioural aspects, and provides support for the development of separate systems as opposed to the classically corporate approaches favoured by the M.R. perspective.

Campbell & Masser (1995:101), identify five stereotype styles of systems implementation from case studies in the United Kingdom. These are shown in Table 2.

Table 2 - Organisation Stereotypes (Campbell & Masser 1995)

Paternalistic	Small staff Personal contact between departments "Family" disagreements Central IT specialists direct GIS
Conforming Adolescent	Larger organisations Departments fund & develop corporate GIS Experience limited - left to tech. specialists
Rebel Adolescent	Large Administrations Number of key departments with own expertise Departmental GIS alliances or go-it-alone Mavericks
Newly Independent	Departments with new-found independence Breakaway from one of the above Departmental GIS develops
Fiercely Independent	Introduction & development of GIS by single department Driven by individual or department impetus

In support of the shift from corporate to smaller departmental GIS are the emerging changes in GIS products with a shift to lower cost, desktop mapping GIS products (Worrall 1994, Tanner 1995). These smaller systems can be chosen for their specific strengths to suit a particular application or department and are usually PC based.

Recent business trends to establish smaller autonomous business units have tended to accelerate the process of fragmentation and make local authorities less corporate (Worrall 1994). The implementation of corporate systems in local authorities is further problematic due to funding issues since budgets are controlled departmentally (Worrall 1994).

A more recent development in business is the concept of outsourcing whereby organisations enter into management deals with outside companies to manage their IT requirements. The possible rise of GIS being offered as a bureau service can be expected to occur and influence the cost benefit equation (Worrall 1994).

The corporate approach views data and information as a corporate resource to be shared throughout the organisation. This assumes less duplication of effort in the capturing, storing and updating of the data. This immediately poses the question "Do organisations or individuals really want to share information ?" (Campbell & Masser 1995:42).

2.4.4 DATA SHARING

In practise the logic of data sharing is likely to result in political, economic and practical hurdles when faced with the realities of organisational life (Campbell & Masser 1995:43). These range from practical problems such as access via networking and information acquisition in a form immediately useable by non-technical specialists. Political hurdles are presented by ownership, and control of information and consequently the distribution of power. All these issues can be expected to have an influence on GIS effectiveness.

Obermeyer & Pinto (1994), draw on established theory of Taylorism and of Weberian concepts to explain subdivisions within organisations, with resulting fragmentation of data. The Taylor theory involves the establishment of tasks with specific functions and information and data essential to the task. Weber's theory of bureaucracy recognises the role of the professions in the organisation. These professions possess a body of knowledge, which is closely guarded.

Particularly in the case of highly technical fields, the master often must defer to its more knowledgeable servant (Obermeyer & Pinto 1994:104). This has parallels with the Technological Determinism perspective proposed by Campbell & Masser (1995) where implementation is driven and controlled by the technical specialist.

Obermeyer & Pinto (1994) provide an overall information-sharing model with six antecedents as determinants of whether sharing will take place. The consequences of information sharing are seen to be Efficiency, Effectiveness and Improved decision making and are shown in Figure 4. Information sharing is therefore seen as a key determinant of GIS effectiveness.

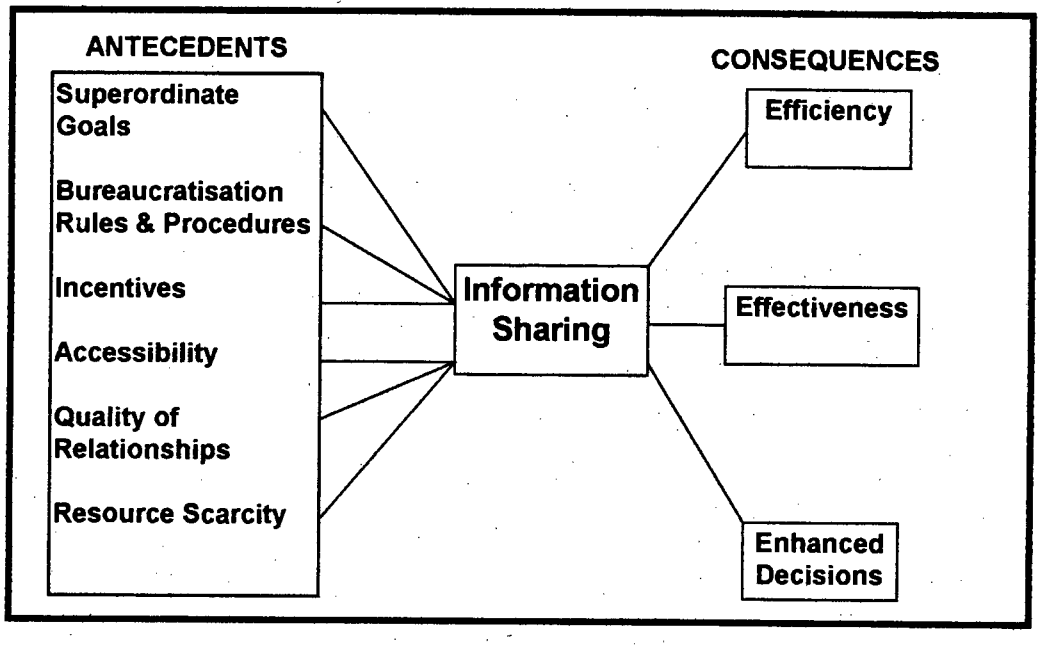

Figure 4 - Information sharing Model (Obermeyer & Pinto 1994)

2.5 GIS EFFECTIVENESS MEASURES

"...it has rightly been an objective of MIS research for at least two decades to determine the economic role of MIS. Today information system effectiveness continues to occupy the highest priority of the MIS research agenda" (Munshi 1996).

2.5.1 INTRODUCTION

The complexities and often high cost of IT implementation place it high on the enterprise's list for constant evaluation and measurement. Cronje, Neuland, Hugo and van Reenen (1987), refer to the "Control" phase of management as "Getting planning and performance to coincide". This is a continuous cyclical process; on the one hand it is the last step in the management task, on the other it is the starting point for planning and further strategy development. IT has become one of those technologies that are difficult to justify yet impossible to do without. One of the haunting problems facing IT management is how to justify such systems and how to measure systems quality and success factors such as cost, benefit, effectiveness, performance acceptance and usefulness, to mention but a few.

Definition :

Effectiveness is considered to be a measure of the impact of policies and programs while efficiency is geared to maximising the ratio of outputs to inputs (Worrall 1994). Consequently efficiency benefits are more capable of being measured than effectiveness benefits.

Effectiveness can be measured at any stage of the diffusion model viz. Adoption, Implementation or Utilisation stages. However GIS practitioners often imply "success" when in fact they mean adoption success or implementation success. A distinction needs to be made between corporate acquisition decisions and the user's decisions to use the acquired technology (Cullis 1994).

The unit of analysis in any such effectiveness study is usually the organisation but can be applied to the sub units within an organisation such as departments or

individuals. This is supported by the finding of Campbell & Masser (1995) relating to the importance of the individual and the support for the S.I. perspective.

Weill & Olsen (1995), refer to "Conversion Effectiveness" between IT and the required productive outputs from the system. This conversion effectiveness was found to be dependent on:

- Top management commitment to IT
- Previous experience with IT
- User satisfaction
- The turbulence of the political environment of the organisation.

When viewed prior to implementation, the concept of effectiveness needs to be seen in terms of "readiness" (Worrall 1994), to adopt and implement a new technology comprising a mix of organisational factors such as structure, culture, staffing and existing practises.

There is a wide spectrum within which the concept of effectiveness may be interpreted comprising a combination of quantitative and qualitative measures used ranging from simple quantitative cost benefit analysis to psychometric measures such as user satisfaction, attitudes and beliefs. However, effectiveness may be extremely difficult to quantify due to the intervening and extraneous variables (Miller 1989, Munshi 1996) which are often much more powerful than the information system itself (Munshi 1996).

The following measures were identified in the literature as existing measures of GIS or MIS effectiveness. The MIS measures may have possible applications in the field of GIS effectiveness.

2.5.2 STRATEGY ALIGNMENT

As a means of defining the specific ways that IT will be used within the organisation, it is important to measure the competitive and technology strategy issues facing the organisation, discussed under section 2.3.2. One such measure is that of Strategy Alignment which attempts to measure how closely IT strategy, and by extension GIS strategy, are aligned with overall business strategy.

Strategy alignment is measured at two distinct levels in the organisation corresponding to the strategic and functional levels of the management pyramid (Cronje, Neuland, Hugo & Van Reenen 1987). This approach provides for measuring the long term, overall business strategies at a strategic level, the medium term IT/GIS implementation plans as well as their mutual alignment.

Meador (1997) proposed three dimensions for assessing alignment of IT strategies with overall business strategies. These are:

- Ends and Means - The extent to which the organisation can reach its desired ends given existing IT capabilities.
- Time - The extent to which IT can respond to the pace of change in the organisation. Strategies need to anticipate the rapid technology developments of the IT world.
- Objectives & Values - Misalignment occurs when the objectives and values of the business are inconsistent with the objectives and values of IT management.

Meador (1997) further suggests reasons why the traditional approaches to IT planning are lacking.

- IT is not considered as a lever to change either the competitive strategy or the underlying business processes. Although IT is a

powerful tool, it is generally only considered after the general themes of the business strategy have been developed. i.e. in support of the general themes instead of being used in actually shaping them.

- Real benefit from IT comes from technology architecture not single applications. However, with traditional approaches architecture becomes important only after it has been determined which applications and data need to be supported. Examples would be the emerging internet, intranet and e-mail architectures as IT solutions forming part of overall strategy.

Due to the broad and varying nature of organisations and their strategies it is difficult, if not impossible, to define exact measures for determining strategy alignment. At best, strategy alignment can be measured in terms of an awareness of IT at the strategy decision levels of the organisation. This awareness should view IT as most strategic when it is most mundane, having thousands of small impacts through the organisation rather than single colossal, repeatable successes (Meador 1997). These concepts can be extended to measure alignment of GIS strategy with IT strategy and/or GIS strategy with business strategy.

In the absence of measurable scales for strategy alignment in the literature, and for the purposes of this study, the following categories of strategy existence and strategy alignment were developed.

Strategy Existence categories:

Low: Formal strategies for business, IT and GIS are non-existent, low awareness of the concepts of strategies.

Moderate: Awareness of the concepts and needs of strategies exists. Strategies exist in an informal, undocumented sense.

Strategy Alignment categories:

Low: No alignment between business, IT and GIS strategies. No reference by any strategy to any other strategy. i.e. the existence of strategies without reference, inclusion or integration of the others.

Moderate: Partial reference, inclusion or integration between the strategies. The references are mono-directional, for example where the business strategy may include reference to an IT strategy or the IT strategy includes reference to GIS strategy but the IT strategy exists independently and contains no reference to supporting the business strategy.

High: The strategies are highly integrated with bi-directional references.

The above-mentioned categories have been used in the strategy alignment analysis presented in Chapter Four.

2.5.3 FINANCIAL ANALYSES

These measures resort to pure financial and accounting terms using the business enterprise model for value maximisation where MIS offers economic value and that the value exceeds the cost (Munshi 1996). The methods measure the costs and benefits of a target system over time, compare potential return against some established hurdle rate and then decide whether the investment is worthwhile. Four basic techniques, with a number of variations exist. These are (Noble 1989):

- Payback period
- Return on Investment (ROI)
- Net present value (NPV)
- Expected Value Analysis - A method which uses probability and weighted averages to estimate cost savings.

These techniques, although very precise have various drawbacks, the most serious being their inability to address subjective criteria and the difficulties with assigning value to intangible benefits (Worrall 1994). These intangibles can include improved service levels, value of real-time information and better access to information. Assigning value to benefits is complex and subjective and is discussed further in the next section.

2.5.4 COST BENEFIT ANALYSIS (CBA)

CBA attempts to account for all costs and benefits by assigning monetary magnitudes to what are often intangible and subjective items. Simple CBA theory states that for a given installation a benefit/cost ratio can be calculated according to the formula (Dickinson & Calkins 1988):

$$\textbf{Benefit/Cost} = \frac{\Sigma\ \textbf{(Quantity demanded) (Product Value)}}{\Sigma\ \textbf{(All costs of GIS Implementation)}}$$

Should the ratio be greater or equal to one, the GIS installation is justified. Wilcox (1990) warns that CBA should at all times only be used as an indicator of the best solution, since a system with a low benefit/cost ratio may have a large number of non quantifiable benefits which may provide an optimal solution. Public sector organisations are obliged to take into account all internal and external aspects of their decision making whereas private sector firms may choose to ignore certain external factors. For this reason, Smith & Tomlinson (1992) suggest that straightforward CBA remains the best framework for analysing GIS in public sector organisations.

However although CBA appears to be a useful management tool, it is difficult to apply to GIS (Worrall 1994, Wilcox 1990, Dickinson & Calkins 1988). Although many of the various costs are easily identifiable, the biggest limitation of CBA is the meaningful definition of benefits. These are often intangible and expressed in terms of "improved decision making", "improved planning", "better access to data", "improved sharing...". Wilcox (1990:206), argues that all

benefits can be assigned value using sufficient support information and sufficient breakdown of the components factors. Statements of benefit such as "improved decision making" are therefore not sufficient for justification of GIS without further breakdown and analysis.

In many cases CBA is applied as an act of faith instead of as a result of critical evaluation and that the existence of formal cost benefit evaluation would appear to be the exception rather than the rule (Worrall 1994). The situation is further complicated by cases where vendors and users overemphasise benefits while underestimating costs to either sell products or to avoid further scrutiny and possible termination of GIS projects, thereby deliberately introducing bias to the CBA result.

The basic cost benefit analysis model includes three assumptions. These are (Dickinson & Calkins 1988:314) :

- The GIS products can be defined
- These products have economic value
- This economic value can be measured

Dickinson & Calkins (1988) identify three situations where the simple cost benefit model assumptions are not met.

Case 1 : the objectives of the GIS cannot be expressed as products

This is the situation where a GIS is used to improve a decision-making process. The objectives of implementing the GIS are frequently stated as improving the decision-making process, reducing uncertainty, or reducing risk. The GIS products in this case are responses to the *ad hoc* queries of the decision-makers. Hence, the outcome of the implementation is better performance as a result of better decision-making.

Case 2 : The economic value of one or more products cannot be measured

Many products from a GIS are inputs to a subsequent larger process with its own product. The measurable value is valid only for the final product of the larger process. When a GIS product (or even the whole GIS itself) is an input, a mechanism is needed to allocate the economic value back to individual inputs.

Case 3 : Implementation of the GIS affects the cost of existing products

In this case, the benefits of implementing the GIS are actually cost savings within the existing system (i.e., reducing the cost of production at a fixed level of output). Here, benefits are expressed as cost reductions or increased performance.

Dickinson & Calkins (1988) propose two alternative approaches to supplement the shortfalls existing in the basic CBA model. These are :

- Cost performance evaluation whereby potential cost savings are viewed as benefits and not be included in the costing portion of the model.
- Representing non-quantified benefits by order of magnitude estimates using estimates of the contribution of GIS to improved decision making. Such estimates would by their nature include a large element of uncertainty.

Smith & Tomlinson (1992) quantify benefits due to cost savings in staff time achieved by using GIS as opposed to producing existing manual information products. A further finding was that implementation of CBA requires careful definition and measurement of information products.

Wilcox (1990) suggests the development of homogeneous units of measure for information products as well as methodology for optimising supply and demand.

Dickinson & Calkins (1988) argue that depending on the purpose and expected uses of a GIS, alternative forms of economic evaluation to simple CBA may be more useful and realistic and suggest a more flexible approach to economic

evaluation since the intangible benefits are often identified but not quantified and thus excluded from many CBA evaluations. However these represent *real* benefits which cannot be ignored.

In summarising the critiques of CBA, although it has been widely used for GIS evaluation, it is difficult to implement and should not be seen as a "*one and only*" measure of effectiveness. CBA should therefore only be used with due cognisance of its limitations and in a flexible manner, possibly with other measures of effectiveness. A GIS cost benefit analysis of the Ceres Municipality is presented in Chapter Four.

2.5.5 SYSTEMS UTILISATION

The systems utilisation measure is based on the principle that if the system is being used it must be effective and the more it is used, the greater the effectiveness (Munshi 1996). Figure 5, traces a path between IT and performance assuming system utilisation as a key variable and describes usage as a tangible behavioural measure by which to assess changes in individual effectiveness and in sum overall organisational effectiveness. Clearly this link is not straightforward due to the complexities involved in modelling such situations and the many intervening variables.

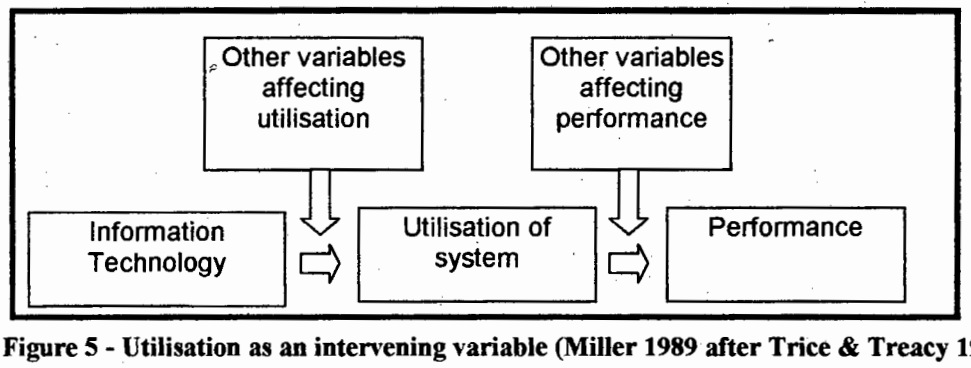

Figure 5 - Utilisation as an intervening variable (Miller 1989 after Trice & Treacy 1985)

The term utilisation can have different interpretations. On the one hand when defining GIS as a technology as discussed under section 2.2.1, the utilisation of GIS can be seen solely in terms of technical capabilities and functionality. As

discussed in Chapter One, GIS is viewed here as a system encompassing the software, hardware, data and expertise associated with the installation. In such cases a particular GIS installation may be termed under-utilised if only a percentage of the features of the system are utilised. On the other hand, utilisation may be interpreted to be the level of utilisation of the system as a percentage of its intended utilisation in terms of predetermined roles and derived benefits regardless of technical capability. Predetermined roles would be those roles of the GIS that would replace existing manual methods and those roles identified as supporting the overall organisation strategy. In other words to be effective the GIS needs to support the overall organisation strategy as discussed in sections 2.3.2 and 2.5.2. Ideally utilisation of GIS needs to be measured in these terms and not in terms of technical functionality. Obermeyer & Pinto (1994) discuss the dangers of high utilisation with associated misuse due to the system not being used for the right reasons.

In reality the two perspectives of utilisation, namely utilisation in terms of technical capability and utilisation in support of organisational strategy, and the misuse of the technology in either of these cases is complex and interrelated. For example the experimentation with functionality originally not intended to be used in support of strategy may initially be termed misuse and consequently ineffective use of the system. However such experimentation may lead to improvements in other areas thereby adding to the effectiveness of the system. In addition to this, the continually evolving, dynamic nature of such systems make the role of training, R&D and systems development inevitable.

For the purposes of this study and in the absence of suitable measurement scales in the literature reviewed, utilisation has been measured on a qualitative scale of low, moderate or high based on interviewee opinions. This has been deemed to be the overall level of utilisation encompassing support of organisation strategy, technical functionality and possible misuse. The levels of utilisation of GIS at the Ceres Municipality are analysed in Chapter Four, section 4.4.

2.5.5.1 User Attitudes and Behaviour

User attitudes and beliefs have been widely used as measures of IS effectiveness. Also termed psychometric measures, these measures have been developed as surrogates for value, systems quality, usage and other systems attributes (Miller 1989). The Social Interactionism (S.I) perspective proposed by Campbell & Masser (1995) acknowledges the role of the individual and the presence of perceptions, attitudes and beliefs in GIS implementation studies. Most of the utilisation research is based on well accepted psychological theories of attitude and behaviour, the most notable being the Theory of Reasoned Action (Ajzen & Fishbein 1980).

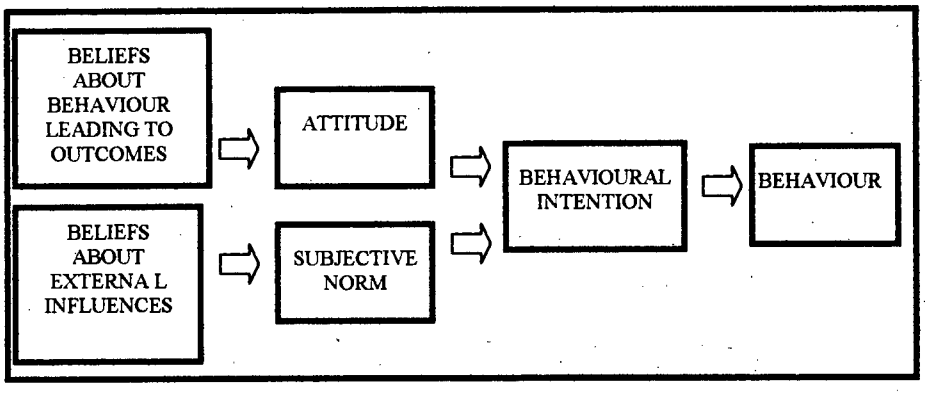

Figure 6 - Theory of Reasoned Action (Ajzen & Fishbein 1980).

This theory, shown in Figure 6 above, effectively describes the links between beliefs and behaviour, where beliefs are rational and attitudes are emotionally formed, based upon a set of beliefs. When applied to MIS studies, systems utilisation is seen as a behaviour and therefore the determinants of behaviour, i.e. attitudes, beliefs and intentions can be viewed as determinants of systems utilisation.

The Technology Acceptance Model (TAM) proposed by Davis (1989) is an adaptation of the Reasoned Action Model where attitude and behavioural intention are predictors of system utilisation and utilisation in

turn leads to individual and organisational performance. The model has received considerable empirical support (Taylor & Todd 1995).

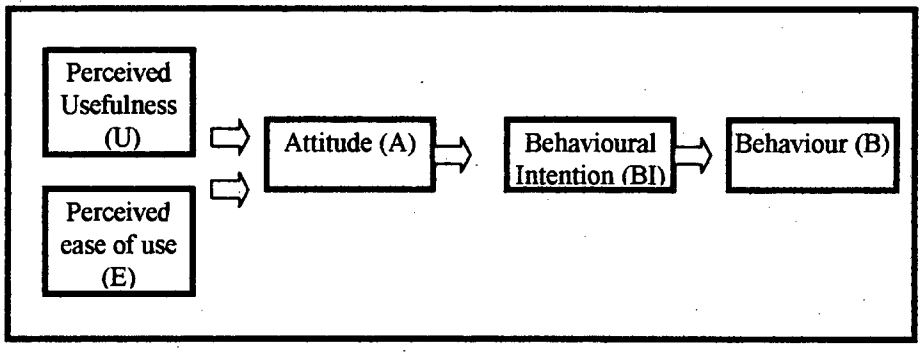

Figure 7 - Technology Acceptance Model (TAM). (Davis 1989)

According to the Technology Acceptance Model, usage behaviour (B) is a direct function of Behavioural Intention (BI). BI in turn is a function of attitude (A) towards usage, which reflects feelings of favourableness or unfavourableness to using the technology. Attitude (A) is determined jointly by perceived usefulness (U) and perceived ease of use (E). Perceived usefulness (U) reflects the belief that using the technology will enhance performance. Figure 7 shows these variables and the links between them. A measurement instrument consisting of 12 questions related to usefulness and ease of use was developed by Davis (1989) and has been applied as a predictor of future GIS utilisation in Chapter Four.

The Augmented TAM (Taylor & Todd 1995) shown in Figure 8, is an extension of the TAM where social influences (subjective norm) are modelled as determinants of behavioural intention and perceived behavioural control is modelled as a determinant of both intention and behaviour.

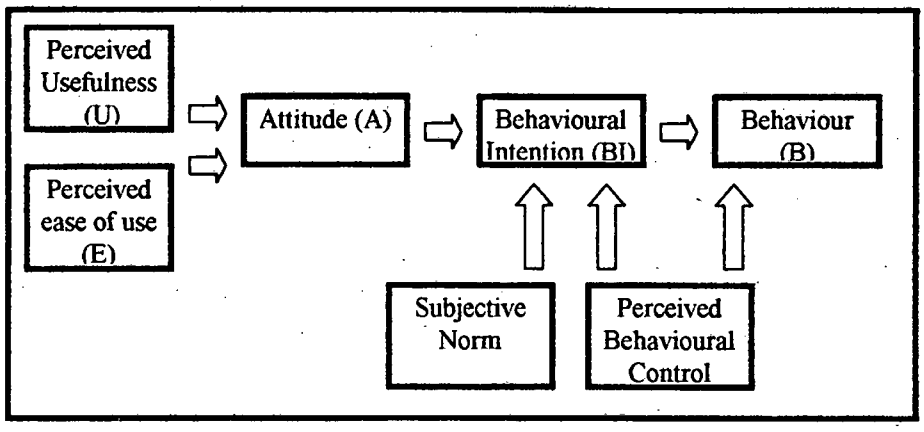

Figure 8 - Augmented Technology Acceptance Model (TAM) (Taylor & Todd 1995).

Taylor & Todd (1995) investigated the role of prior experience as an important determinant of behaviour using the augmented TAM. The goal of the research was to develop diagnostic tools to predict IS acceptance and facilitate changes before the users gain experience with the system. Their results showed that the augmented TAM could be applied to understand the behaviour of both experienced and inexperienced users. However the inexperienced users were found to place more focus on perceived usefulness or potential benefits of the system and to underestimate costs, whereas experienced users place more emphasis on control factors such as technical, time and cost limitations in implementing the system. An important conclusion was that such models could be used diagnostically prior to implementation of a system. The TAM provides a useful framework relating attitudes and determinants of attitude to overall behaviour and utilisation and may have application in the field of GIS.

2.5.5.2 Computer Self Efficacy (CSE)

CSE relates to an individual's beliefs about their own abilities to competently use computers. Compeau and Higgins (1995) developed and validated a measure of CSE, which is seen as a significant factor affecting system usage. The concept of self efficacy builds on the Theory of

Reasoned Action (Ajzen & Fishbein 1980) and Social Cognitive Theory (Bandura 1986), which examines behaviour in the presence of environmental influences. Thus, individuals choose the environments in which they exist in addition to being influenced by those environments (Compeau & Higgins 1995). Self efficacy is an important social psychology construct, which has been found to influence decisions about behaviour.

When applied to a MIS environment, CSE was found to play an important role in shaping individuals feelings and behaviours and hence system usage. In a broader sense CSE was seen as an important concept in organisations attempting to successfully implement MIS.

The factors influenced by CSE (Compeau & Higgins 1995) are :

Successful experience – The more successful interactions individuals have with computers, the more likely they are to develop high self efficacy.

Training – Important for new users since any problems due to inadequacies will lower the users sense of self efficacy and lead to a reluctance to use the technology

The concept of computer self efficacy has possible application in the field of GIS as a measure of an individual's confidence in using a computer related technology. A ten point CSE questionnaire, developed by Compeau & Higgins (1995) has been used in the case study analysis of GIS utilisation in Chapter Four.

2.5.6 TASK TECHNOLOGY FIT (TTF)

The Task Technology Fit (TTF) model developed by Goodhue & Thompson (1995) draws on the theory of fit as a predictor of systems performance. The model is the assertion that for IT to have a positive impact on performance it must be a good fit with the tasks it supports and it must be utilised. This second assumption relates to utilisation issues and the TTF model is seen as parallel and complimentary to systems usage models as predictors of individual performance. The TTF model is shown in Figure 9.

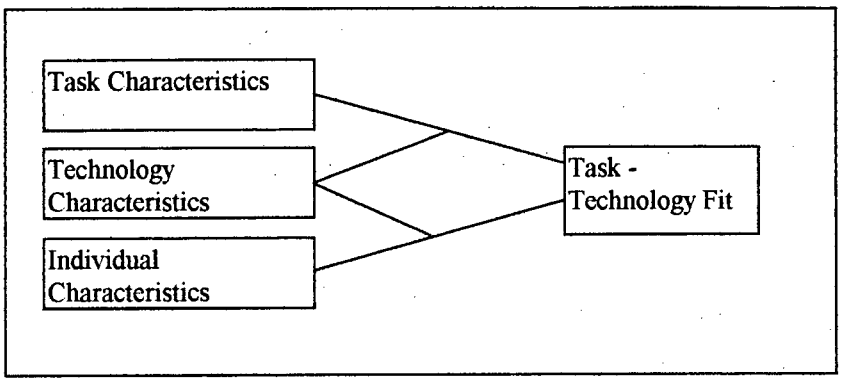

Figure 9 -Task Technology Fit (Goodhue & Thompson 1995)

2.5.7 COMBINED EFFECTIVENESS MEASURES

Munshi (1996) describes a useful framework for MIS effectiveness studies by relating three dimensions of effectiveness, namely scope, measurement and social paradigm. Scope relates to how broadly the concept of effectiveness is to be applied i.e. single application, departmental, organisational, industry, economy or the society-at-large levels. The measurement dimension relates to the measurement of variables of the reasoned action model discussed under 2.5.5.1 i.e. attitudes, behaviour, utilisation and performance. The social paradigm dimension relates to the four paradigms originally proposed by Hirschheim (1985) of Neohumanism, Social Relativism, Radical Structuralism and Functionalism discussed under section 2.3.1. Munshi (1996) then proposes two matrices relating measurement to scope and measurement to social paradigm. These are shown in Figures 10 & 11 respectively.

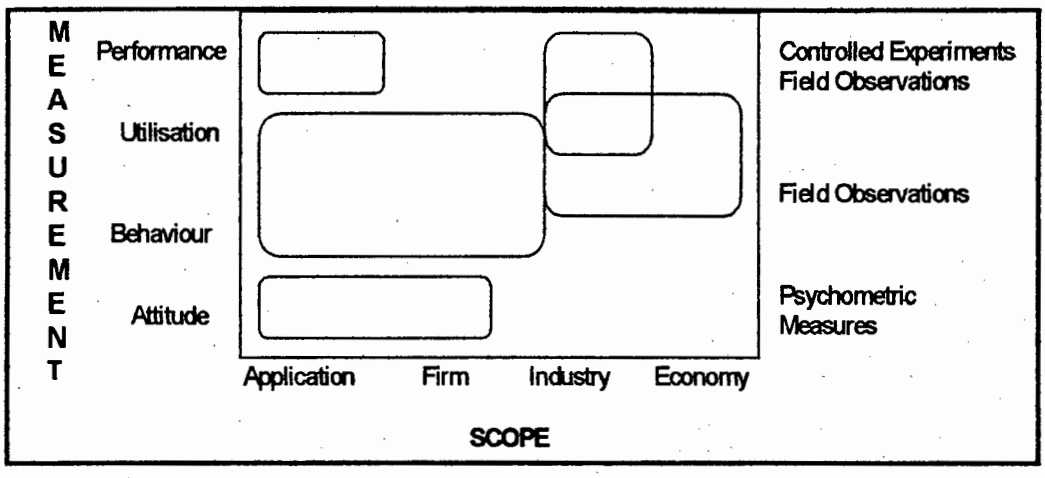

Figure 10 - MIS Effectiveness Framework. (Munshi 1996)

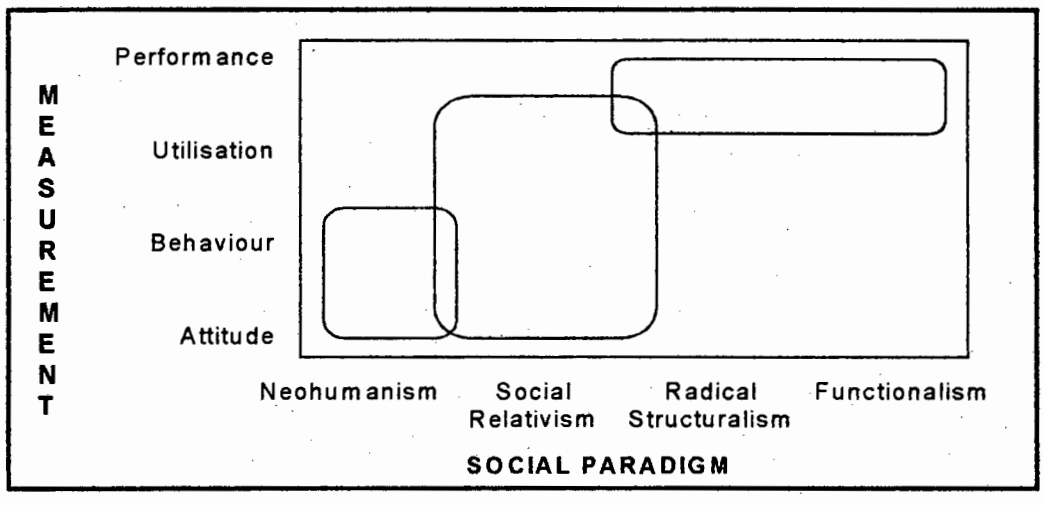

Figure 11 - MIS Effectiveness Framework. (Munshi 1996)

These matrices are useful in placing the effectiveness measures within the organisational context, thereby creating a fuller picture of effectiveness. The Social Paradigm scale relates closely to the M.R & S.I perspectives (Campbell & Masser 1995), with M.R equating to the Functionalism and S.I to the Neohumanism and Social Relativism ends of the Social Paradigm scale. The matrices also illustrate under what circumstances the psychometric, utilisation and performance measures of effectiveness are appropriate.

Schultz, Slevin & Pinto (1987) define two distinct phases of GIS in an organisation as the initiation and the implementation phases. The initiation phase being when the organisation becomes aware of the innovation and decides to adopt it. The implementation phase is when the organisation engages in the

activities to put the innovation into practice. These phases can be seen in broader terms as planning and action or as strategic and tactical phases. Schultz, Slevin & Pinto (1987) propose a Strategy / Tactics Effectiveness matrix shown in Figure 12. The matrix comprises four quadrants defined by low and high measures on each of the Tactics and Strategy axes.

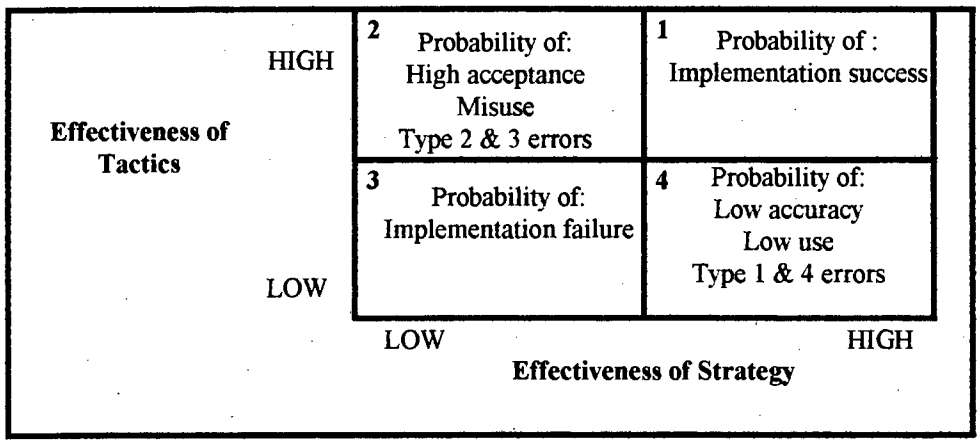

Figure 12 - GIS Implementation Effectiveness Matrix (Schultz, Slevin & Pinto 1987).

The following four situations are defined:

Quadrant 1 - High Strategy, High Tactics

This situation holds for systems that have high effectiveness in both tactics and strategy. Any organisation fitting this situation is predicted to be successful with GIS implementation.

Quadrant 2 - Low Strategy, High Tactics

This situation arises where initial strategy was lacking but subsequent tactical activities were high. This results in possible high use of the system but often for the wrong reasons or so-called misuse. The resulting high acceptance of the system however does not represent a successful system. The low strategy could result in a poorly conceived or unnecessary system that has received no initial buy-in from management. This situation has parallels with the Technological Determinism (T.D) perspective proposed by Campbell & Masser (1995) and discussed in section 2.4.2.

Quadrant 3 - Low Strategy, Low Tactics

This is the reciprocal of the first quadrant where both strategic and tactical functions are inadequately performed. Any system falling into this category would have a high likelihood of failure.

Quadrant 4 - High Strategy, Low Tactics

These situations arise when strategic vision from management is well defined and a GIS is defined as a solution. However due to poor tactical performance, the system does not get implemented or used due to low client acceptance. This situation has parallels with the Managerial Rationalism perspective proposed by Campbell & Masser (1995), where management dictates a rational implementation plan which shows little or no success due to the needs of the individual being overlooked.

Four types of errors that may occur in the GIS implementation process are defined. These are:

Type 1 errors - Action should have been taken but was not.

Type 2 errors - Taking action when none should have been taken.

Type 3 errors - Taking the wrong action.

Type 4 errors - Solution is discovered but not used.

The Strategy / Tactics effectiveness matrix shows the probability of type 2 & 3 errors occurring in quadrant 2, while type 1 & 4 errors are most likely to occur in quadrant 4.

The Strategy / Tactics effectiveness matrix provides a useful starting point for combining the various individual effectiveness measures reviewed in this chapter. Its adaptation and integration with the prevailing effectiveness theory is further investigated and applied in the case study in Chapter Four.

2.6 LITERATURE REVIEW CONCLUSIONS

The aim of the foregoing literature review was to investigate existing theories and previous studies relating to the research questions, namely the overall effectiveness of GIS and appropriate approaches and measures for GIS effectiveness at a small local authority. The review highlighted the complexities and varying and conflicting views on these issues and it is acknowledged that although the issues reviewed represent only a portion of the existing theories, especially those related to organisations, they nonetheless provide a sufficient theory base for the case study presented in Chapters Three and Four. The research questions dictated the broad topics of the review – these were GIS technology, organisations, GIS diffusion and effectiveness measures. From the review, four themes were developed which were maintained throughout the case study, these are discussed below.

The author's management studies and experience with other organisations led to a holistic approach to the study which included seeing GIS not just as a single computer application but rather as a complex technology system being implemented within an organisational context. Existing GIS literature confirmed the need for a shift in GIS research from that covering technical issues to that covering organisational, social and management issues and it is this holistic, overall approach which forms the first theme of the research. The case study therefore investigates GIS effectiveness across three departments and on two different levels of the Ceres Municipality by means of GIS effectiveness measures and an analysis of organisational factors, which may affect the GIS effectiveness. The main emphasis of the review was therefore from a management perspective as opposed to a technical perspective.

The theory of organisations is, in itself, complex and varied and only the topics of culture, strategy and role of information were reviewed as being relevant to the research questions. Strong evidence was found for the role of the various organisational strategies in IS studies and for the definition of effectiveness itself as a strategic measure as discussed in section 1.2. Organisational Strategy was therefore used as the second theme of the study and a measure of strategy alignment was

identified as an effectiveness measure and was applied in the case study presented in Chapters Three and Four.

The work by Campbell & Masser (1995) provided the concept of diffusion of GIS as an umbrella term dealing with the flow and dissemination of GIS technology through the organisation. This was reviewed in terms of the various approaches to implementing the technology and showed a need for a more interactionist approach to GIS implementation with emphasis on the needs and motivations of the individual as opposed to a purely technical or functional approach. The work by Munshi (1996) and Campbell & Masser (1995) which identifies the Neohumanism and Social Interactionism (S.I) perspectives of the organisation are particularly useful in providing a new emphasis on the role and influence of the individual on GIS effectiveness. This focus around the individual within the organisation as opposed to the organisation as a whole was also found in the literature relating to MIS effectiveness with the Theory of Reasoned Action and the emphasis on behaviour and attitude studies of the individual for measuring IS effectiveness. This emphasis on the role of the individual forms the third theme of the research.

Various effectiveness measures were identified from IS, MIS and GIS literature. The GIS literature concentrated almost solely on Cost Benefit Analysis (CBA) as an effectiveness measure. A review of the literature in the fields of IS and MIS however revealed useful research which could be applied in the field of GIS, providing various economic, psychometric and performance measures of effectiveness. These new and alternative approaches to measuring effectiveness draw from theory of social behaviour and attitude as determinants of systems utilisation. However due to the complexities and vast array of variables occurring in the organisation, a combination of effectiveness measures are possibly more suitable. The fourth theme of the case study is therefore the use of multiple and combined measures of GIS effectiveness and was developed from the availability of these alternative approaches which could be applied to the field of GIS. The study furthermore places less emphasis on in-depth analysis and more emphasis on comparative and overview analysis of the multiple measures and variables. The matrices of variables provided by Munshi (1996) and Shultz, Slevin

& Pinto (1987) provides a wider framework combining multiple measures within which GIS effectiveness can be evaluated.

Of the various effectiveness measures identified, three main measures were chosen for further analysis in the case study. These were strategy alignment, cost benefit analysis and systems utilisation. These measures provide a combination of qualitative and quantitative measures and a multi-perspective to GIS effectiveness. Furthermore the use of cost benefit analysis has received wide support in GIS management theory and shall be used as a baseline measure, against which the new GIS measures of strategy alignment and utilisation can be compared and combined. The CBA and TAM models are linked by the variable of perceived usefulness in the TAM which relates directly to perceived benefits in the CBA model. All were measurable within the constraints of the study by direct observation, analysis of records as well as interviews and questionnaires.

These are all investigated further in the case study presented in the following two chapters.

CHAPTER THREE - CASE STUDY OF GIS EFFECTIVENESS

"Information Systems Research Methodology – a doubtful science?" (Mumford 1985).

3.1 BACKGROUND

The case study was carried out at the Municipality of Ceres, a small local authority in the Western Cape Province of South Africa. GIS is currently used by the Town Civil Engineer's and Town Electrical Engineer's Departments, having evolved over the past five years from Computer Aided Design (CAD) systems. The author has been closely involved over the same five year period with the Civil Engineer's Department in the supply of aerial photography, digital mapping, cadastral data processing and certain CAD and GIS software.

The author had also worked closely with the Town Clerk and Town Secretary of the Administration Department with the design and implementation of database methods for property valuations and networking of hardware between the various departments. This work provided the opportunity to discuss and evaluate issues relating to GIS and IT in general with the Town Clerk and Town Secretary. This provided an alternative strategic oriented, non-technical perspective to the case study.

3.2 RESEARCH METHODOLOGY

The field of IS is relatively new when compared to well established fields such as engineering, physics and chemistry. As a fast emerging and dominant technology, the quest to fully understand IS has left researchers with few existing research tools which can be easily applied to IS research.

The organisational context of the issues of investigation, the researchers ongoing work in the study organisation and the review of research methodologies in general pointed to the adoption of the Single Case Study method of research. The case study approach was adopted since it provides a framework of research well suited to the real life situation present at the research organisation i.e. a contemporary set of events over which the investigator has little or no control. (Yin 1986, Cullis 1994).

The case study methodology has a number of limitations, the most notable being its lack of scientific rigour (Yin 1986, Lee 1989), largely due to the emphasis on a qualitative assessment of a real world setting. Lee (1989) also argues that a qualitative study of a single case can possess more analytic rigour than a statistical study using sophisticated numerical analysis and concludes that the case study methodology is still the most suitable for studies related to information systems. This is due to the methodology being able to address and explain the casual links of real life which are too complex for the more scientific survey or experiment methodology.

The complex inter-relationships between IS, IT, the organisation and society require new approaches and a pluralism of research methods which are neither solely qualitative nor quantitative (Mumford 1985).

3.3 EFFECTIVENESS CRITERIA

The review of existing theory related to GIS effectiveness in Chapter Two presented the multiple perspectives of effectiveness and the various measures available. The initial definitions of effectiveness and efficiency presented in Chapter One highlighted the strategic and operational perspectives of these and their mutual interdependence. The effectiveness matrices (Schultz, Slevin & Pinto 1987) reviewed in Chapter Two relate tactical or operational effectiveness with strategic effectiveness thereby providing a measure of overall effectiveness.

In terms of the research questions, the overall GIS effectiveness at the Ceres Municipality was determined by means of a case study using existing effectiveness measures previously applied to GIS studies and new effectiveness measures adopted from the field of MIS. The research has therefore been approached from a multi perspective view of GIS effectiveness. This is in contrast to existing GIS management theories that the author reviewed, which emphasise cost benefit analysis and technical efficiency as effectiveness criteria.

The cost benefit model has been widely proposed for measuring GIS effectiveness (Dickinson & Calkins 1988, Smith & Tomlinson 1992, Wilcox 1990, Worral 1994). However the reasoning of the model pre-supposes that between the cost and benefit phases, utilisation of the technology will occur, leading to the various benefits being realised. The estimation of costs and benefits is therefore only useful if the costs and especially the benefits are actually realised through action. For this reason, it is the author's opinion that a cost benefit analysis alone is insufficient for determining the overall effectiveness of GIS. In combination with cost benefit analysis, the measurement of utilisation is considered essential, since without utilisation occurring, the costs may be incurred but the expected benefits will never materialise.

The case study therefore uses multiple methods of effectiveness measurement to assess the costs, benefits, strategy and utilisation variables. In order to achieve this, the criteria for effectiveness for the case study have been selected as Cost Benefit Analysis (CBA), Strategy Alignment and Systems Utilisation, where utilisation is seen as dominant behaviour and the determinants of behaviour i.e. attitudes, beliefs, intentions and perceptions are viewed as determinants of systems utilisation. These criteria were chosen due to their considerable theoretical support found in the literature and because they represent the multi-dimensional analysis required to measure overall GIS effectiveness. In the absence of measurement scales for strategy alignment and systems utilisation, a set of scales were defined by the author for the purposes of this study - these are presented in sections 2.5.2 and 2.5.5. These measures were considered to be relevant to the Ceres case and were possible to evaluate given the time and resources available to the author. In addition, a number of organisational issues identified in the literature having possible influence on GIS effectiveness were investigated. These were Role of Information, Implementation Perspectives, Organisational Culture and Degree of Centralisation.

The following section details the data collection for these criteria and the quality and limitations of the data and the collection methods employed.

3.4 DATA COLLECTION

The preceding chapters have discussed effectiveness measures and their relevance to the Ceres case study. Due to the multi-perspective approach and the largely qualitative nature of the case study methodology, data was collected from a number of sources via different means as outlined below.

3.4.1 PILOT STUDY

A pilot interview study was undertaken prior to the main study in an attempt to identify broad issues relevant to GIS effectiveness, the research questions and to identify key personnel in the organisation who would be the most suitable for further interviews and questioning in the main study to follow. The pilot study approach is recommended as part of the overall case study methodology (Yin 1986) and was conducted in parallel with the ongoing review of the relevant literature. This ensured that the final main study would be balanced between the prevailing theory relating to effectiveness and possible fresh empirical evidence.

The pilot study was undertaken using staff from the Civil Engineering, Electrical Engineering, Administration and Health departments of the organisation. These candidates provided an initial insight into the use of GIS and the problems and expectations of the technology. These initial interviews revealed a number of technical issues relating to day to day operational concerns of the GIS. These are, however, beyond the scope of this case study and have been documented elsewhere.

The pilot study revealed a number of potential limitations of the study. The first being the limited sample size of interview and questionnaire respondents that were available for the study. Due to the small size of the organisation and the fact that GIS had not yet been widely accepted, a total of four primary candidates were available for the study. These were the Town Clerk, Mr. D Du Plessis, the Town Secretary Mr. D Boschoff, the Town Civil Engineer Mr. P De Jager and the Town Electrical Engineer Mr. B Van der Watt. These candidates were used for the interview and questionnaire parts of the study. In addition to

these main candidates, a further four persons in technician positions were available for the questionnaire parts of the study.

3.4.2 DATA COLLECTION METHODS

Four methods of data collection were employed namely:

i) Direct observation

The evolving systems at the case study organisation were observed over a period of approximately two years during which time the author was closely involved in the supply of mapping data, database design and networking of various aspects of their Information Systems. These observations were made during personal visits to the organisation, telephonic discussions and IT/GIS related meetings involving staff and vendors.

ii) Qualitative Interviews and Discussions

The interview questions were structured according to the research questions and the topics revealed in the literature review. The questions were phrased to elicit opinions and beliefs about issues critical to the research questions. These included the following:

- Definition of GIS benefits.
- Estimates of value of GIS benefits.
- Opinions on usage, ease of use, usefulness, corporate culture and strategy alignment.
- Opinions on organisational issues affecting GIS effectiveness.

Detailed interview frameworks appear in the appendices.

iii) Records and Documentation

Costs relating to all hardware, software, data and training were extracted from past expenditure and budget records.

iv) Questionnaires

Short questionnaires relating to psychometric measures of Computer Self Efficacy (CSE), Perceived Ease of Use (E) and Perceived Usefulness (U) were given to interviewees and other potential GIS users for completion. These were adapted from existing instruments identified in the literature review in Chapter Two section 2.5.5 which have been developed and empirically tested in the field of MIS effectiveness.

These questionnaires were completed outside of the interview times. Respondents were given the option to remain anonymous by not putting names to their responses and by faxing them back to the author.

The data collection methods employed were multiple and varied in keeping with the overall and multi perspective theme of GIS effectiveness. This provided a degree of triangulation of methods as opposed to a single perspective of say only cost benefit analysis. The methods employed therefore included all options open to the author given the constraints of the study. Limitations however do need to be acknowledged. These are firstly the small sample sizes. Although only a total of eight respondents were available for the study, they represented all of the staff involved with GIS and were distributed across three departments in the organisation. This spread of respondents on the one hand diluted the within-department results yet on the other hand assisted in provided a better overall perspective of GIS effectiveness throughout the organisation. Secondly the highly qualitative and subjective nature of the results need to be recognised – these represent the views and opinions of the interviewees and are open to interpretation and biases. The author's preconceived ideas and experience on the one hand can be seen as having contributed to the quality of the study but on the other hand have inevitably introduced biases. Thirdly the fact that the study represents a short timeframe out of a continually evolving and changing set of circumstances provides only a snapshot view of the organisation. Internal changes in methods and personnel as well as external legislative, social and political influences will all affect the results of this study. Finally the issues addressed cannot represent all the factors and influences present. The

complexities of the organisation, the limits to the measures and understanding of all the forces at play and the limits imposed by the study make this impossible. Hopefully the study has covered a large percentage of the factors surrounding GIS effectiveness in an organisation if this kind.

The results should not be viewed solely for their absolute value but rather for their relative value and the validity of the methods and overall approach to GIS effectiveness studies.

The detailed analysis of the data collected and the application of the effectiveness measures is presented in the following chapter.

CHAPTER FOUR - ANALYSIS OF DATA

4.1 PILOT STUDY

The pilot study revealed the following factors which could influence the GIS Effectiveness:

Firstly the use of different GIS/CAD systems between the civil and electrical engineering departments. The civil engineering department was using a combination of UltimateCad and ReMap software, the electrical department was using MicroStation. The respondents from each department had each achieved a fair level of proficiency with their respective systems and voiced concern about having to give up their system if a decision was made to standardise on another system.

Data sharing between the civil and electrical departments was very limited due mainly to the data formats of the different systems and the fact that the various departments were not networked at the time of the pilot study. Both departments had a need to view each others' services networks with securities in place to prevent unauthorised editing.

It was found that outside consultants had played a major role in the shaping of the current systems. In the case of the electrical department the software and data was acquired from a firm of consultants who had undertaken the design master plan of the electrical reticulation. This was acquired as part of the design and was deemed appropriate at the time due to the organisation's ongoing involvement with the consultants. A working system was therefore acquired without considering other alternatives.

Overall acceptance and success of the GIS was heavily dependent on commitment to the technology by top management, especially for obtaining resources. There was also a need for top management to more fully understand the GIS technology. Further interviews were therefore extended to include the Town Clerk and Town Secretary.

The pilot study confirmed the need for the investigation of reliable effectiveness measures, which could be applied to GIS implementation. The remainder of the case study focuses on Cost Benefit Analysis (CBA), Strategy Alignment, Systems Utilisation and Organisational Issues influencing GIS effectiveness. These are analysed in-depth in the remainder of this chapter.

4.2 COST BENEFIT ANALYSIS (CBA)

The literature review presented in Chapter Two highlighted the predominance of cost benefit analysis in GIS management with the exclusion of other measures of effectiveness. In support of an overall GIS effectiveness approach as outlined in the research questions, a cost benefit analysis was considered a good baseline measure of effectiveness which has been widely used by others in the field of GIS. A cost benefit analysis also represents a quantitative assessment of GIS effectiveness, while the other measures presented are all qualitative in nature thereby achieving a degree of triangulation of methodologies as discussed in section 3.2.

The cost benefit analysis was performed for the electrical and civil engineering departments for the period July 1992 to June 1997, corresponding to a five financial year period. These values were analysed from past historic records in the case of the costs and from subjective interview opinions in the case of past benefits achieved. The analysis was then extended by projecting costs and benefits over a future two year period. This was considered a sufficiently reasonable time period for estimating future costs and benefits, considering the high levels of change occurring with the GIS technology. The time limits imposed by the study and the emphasis on multiple and comparative measures as opposed to an individual in-depth measure precluded the gathering of detailed records and detailed analysis of costs and benefits. The monetary values associated with each of the identified costs and benefits as described in the following sections are therefore approximate and have been rounded to the nearest thousand Rands. As such, costs and benefits have been viewed in their simplest sense - factors such as opportunity costs and benefits have been excluded.

4.2.1 ANALYSIS OF COSTS

Costs have been defined as the direct monetary costs associated with the purchase of hardware, software, data, training and consulting fees relating to the CAD/GIS installations and were obtained from records of budget and expenditure. The historic cost data was considered accurate and reliable since it represented actual monies spent under budget allocations for the categories mentioned. Certain additional costs may have been incurred indirectly through monies spent on other items such as the cost of certain training covered by personnel budgets, however these were considered minimal and have therefore been ignored. The amounts shown under consulting for the civil engineering department were estimated at 1 percent of Capital Projects budgets. This was considered by the Town Engineer and the author as a reasonable estimate of the value of the survey, mapping and other data produced by these projects which would ultimately be included as GIS data. All past costs were discounted to July 1997 Rand net present values (NPV). The author estimates that the past costs are to within approximately 10 percent of actual costs incurred.

Future costs were obtained by escalating average past costs by 20 percent. This was considered a realistic escalation to account for inflation and to provide the necessary infrastructure to achieve the future benefits analysed in the next section. It has been assumed that the escalated costs could be accommodated in overall future budgets of the municipality – this was not investigated. Factors such as the trend in declining costs of computer hardware and software have been ignored in the analysis. It has further been assumed that the current systems in place will be retained and future costs will be contained to expanding and upgrading these systems.

In the case of the electrical engineering department, totals for the past 5-year period were obtained, amounting to R 466,000. Projected 7-year costs up to June 1999 amounted to R 734,000.

In the case of the civil engineering department, a breakdown of costs was available over the past 5-year period, totalling R 551,000. Projected 7-year costs totalled R 836,000.

A spreadsheet showing the breakdown of these costs appears in Appendix A3

4.2.2 ANALYSIS OF BENEFITS

As mentioned in the literature review of cost benefit analysis in Chapter Two, the biggest shortcoming of the CBA approach is the difficulty and highly subjective nature of defining and estimating the GIS benefits to the organisation. With these limitations in mind, an attempt was made to analyse the GIS benefits for the Ceres case by firstly defining a list of broad categories of GIS benefits – similar to those which were used in other CBA studies. Secondly the extent of the benefit in monetary terms was estimated from interviews and from the author's past experience with other GIS projects. An attempt was made to categorise these into tangible and intangible benefits with estimates of monetary values for each, either directly as income and cost savings or indirectly as time savings.

The assumed GIS benefits over the same five and seven year periods as those which were used in the cost analysis above were determined by means of discussion and interviews according to the list of categories (see appendix A2). The benefits were discussed and quantified in 1997 Rand terms. Since no historical records existed for actual benefits, it was assumed that these had developed to their current state over the 5-year implementation period.

The highly subjective nature of the analysis and the monetary values attached to both the tangible and intangible benefits makes this analysis inaccurate. It is the author's opinion that of the benefits defined, their monetary values are to within 20 percent of their actual values. Furthermore it is the author's opinion that the defined benefits represent approximately 80 percent of the total benefits attributable to the GIS, the remainder being highly intangible and therefore

indefinable. The analysis of benefits therefore represents a first and broad attempt at analysing a complex situation and was considered sufficient within the constraints of this study.

A detailed estimate of the benefits appears in Appendix A3

The cost benefit analysis showed benefits exceeding costs for the past and estimated future values in both the civil and electrical engineering departments with benefit cost (B/C) ratios ranging between 1.10 and 2.69. The 5 year ratios representing the past costs and benefits were 1.14 and 1.10 respectively, thereby showing benefits only marginally exceeding costs. Considering the estimated inaccuracies in the costs and benefits values, a worst case scenario would place benefits below the costs with B/C ratios of approximately 0.9 for both the civil and electrical engineering departments.

The predicted future analysis produced benefit values in excess of the costs with B/C ratios of 2.69 and 1.61 for the civil and electrical departments respectively. These high ratios were reliant on the achievement of a few key benefits, notably the improved level of services payments and the savings due to improved water loss management. The analysis is therefore sensitive to these benefits being achieved as envisaged.

Many of the benefits are derived from savings in staff due to GIS functions taking over manually performed tasks. For example the savings from fewer field maintenance crews due to better management of the water reticulation network using GIS and for planned maintenance instead of ad-hoc maintenance. These were seen as very theoretical benefits, not easily achievable in practice. In the case of the reticulation management, any maintenance crew savings would immediately be offset by the cost of the GIS itself and other expert staff or consultants to manage the planned maintenance programs. In addition to the problems of defining benefits and assigning values to them, the analysis is highly sensitive to the probability of the estimated benefits actually occurring in practice.

Table 3 shows a summary of the costs, benefits and benefit/cost ratios achieved in the analysis

Table 3 - Summary of Cost Benefit Analysis

	COST	BENEFIT	NET	B/C Ratio
CIVIL 5 yr	R 551,000	R 631,000	R 80,000	1.15
CIVIL 7 yr	R 836,000	R 2,253,000	R 1,417,000	2.69
ELECT. 5 yr	R 466,000	R 512,000	R 46,000	1.10
ELECT. 7 yr	R 734,000	R 1,183,000	R 449,000	1.61

4.3 STRATEGY AND STRATEGY ALIGNMENT

Interviewees were asked to categorise the organisation's competitive strategy according to the types defined in section 2.3.2 of the literature review. All respondents agreed that the municipality fell into the defender category, due primarily to very little or no competitive strategy and the centralised, autocratic management of local authorities. The interpretation of competitive strategy varied between the respondents. Some saw a municipal organisation as being totally uncompetitive and unlike a business organisation. Others agreed that a degree of competitive strategy does exist in the sense that the municipality needs to be competitive in attracting and keeping residents, tourism, business and investment for the town. However it was agreed that such a strategy would be conservative and not as dynamic as that found in the private sector.

The literature review in Chapter Two presents strategy alignment as a measure of GIS effectiveness whereby the existence and mutual alignment of business, IT and GIS strategies are investigated.

In an attempt to gauge the level of alignment of GIS, IT and overall business strategies, various questions were addressed by means of interviews and discussions to determine awareness, importance and foreseeable problems with the strategy alignment approach. (Interview questions appear in Appendix A2.)

For the civil and electrical engineering departments, strategy alignment was gauged by the existence and content of strategy relating directly to GIS implementation. At the Town Secretary and Town Clerk interviews, the overall organisational strategies and the inclusion of IT in these strategies (which assumed GIS as a subset of IT) were discussed.

The following findings were made:

Formal documented strategies existed for achieving the vision and objectives of the organisation. These had been developed in strategy sessions by a strategy planning committee of 45 people, involving the most senior officials of the municipality, councillors and an external consultant (see Appendix A1).

The various internal and external critical issues identified in the Business Strategy documents were analysed for possible GIS relevance. Of the 37 critical issues identified in 1996, ten issues could be directly addressed using GIS technology and a further nine issues could use GIS to a certain degree. Of the six strategies identified in the 1993 document, five had the potential of a GIS component in their implementation.

A review of the strategies revealed only one direct reference to IT, although the respondents agreed that IT would be indirectly employed in achieving the objectives.

All respondents acknowledged the definite need for strategies and acknowledged that IT would need to play a major role in achieving such strategies.

The existence of a formal set of business strategies seemed partly due to management foresight and partly due to conditions imposed by new local government acts which provide for an "Integrated Development Plan" (IDP) and a "Human Development Index" (HDI).

Although these strategies had been formulated, there seemed to be insufficient commitment from all levels to follow through and see them implemented. This was

evident by the fact that the strategies as they were formulated, were not seen as central to the organisation's survival. They were also seen as strategies which were formulated and agreed without an emphasis on following them through and measuring their progress. i.e. more a case of them being seen as a one off exercise as opposed to a continuous exercise. In all cases there was a strong desire to achieve the benefits of GIS and to see the systems succeed.

From the abovementioned findings, the overall strategy existence and strategy alignment was measured according to the criteria defined in section 2.5.2 and are discussed further in the following section.

4.3.1 STRATEGY EXISTANCE

No formal documented GIS strategies were found to exist in either the civil or electrical engineering departments. However in both cases informal GIS implementation strategies had developed. These were in both cases driven by the respective heads of department in as far as annual budgeting for GIS related expenditure and their individual desires to see the systems grow and succeed. In the case of the electrical engineering department, a further informal strategy existed in the form of the role of an outside consultant for the formulation and promotion of the electrical master plan, which has a high GIS component.

A moderate awareness of the concepts and importance of strategies was shown by the interviewees. Most respondents acknowledged the overall importance of information and how very often the right sort of information for decision making is unavailable. It was felt that a large percentage of the information pertaining to the organisation is of a geographical nature, thereby necessitating the use and importance of GIS.

The overall strategy existence was therefore categorised as low to moderate since formal documented business strategies existed, informal GIS strategy existed and a certain level of awareness of strategy was present.

4.3.2 STRATEGY ALIGNMENT

Although formal documented business strategies exist, only one made reference to IT, this being despite the fact that approximately half of the strategies could be achieved through the use of GIS. No IT or GIS strategies were found to exist and therefore no alignment could be determined. The overall strategy alignment was therefore found to be low.

4.4 SYSTEMS UTILISATION

The literature review presented in Chapter Two identified systems utilisation as a surrogate for systems effectiveness. However due to the highly subjective and qualitative nature of utilisation and the overlap between functional use, strategic use and misuse, the study measures utilisation in terms of overall utilisation on a scale of low, moderate or high from a purely subjective interviewee perspective. In keeping with the time frames of the cost benefit analysis in section 4.2, overall utilisation was measured for past, current and future time periods. The past and current utilisation was measured in the civil and electrical engineering departments and was extended to the administration department for the prediction of future utilisation. The sample represents a mix of experienced and inexperienced GIS users. The results are presented below:

4.4.1 PAST AND CURRENT UTILISATION

GIS utilisation over the 5-year implementation period up to July 1997 was gauged by discussion and interviews. Usage was defined by the extent that the systems were used to their fullest potential in terms of their technical capabilities as well as for the strategic tasks for which they were intended.

In the case of the electrical engineers department, the general feeling amongst interviewees was that in terms of technical capabilities, MicroStation was under utilised. Its Computer Aided Draughting (CAD) capabilities in particular were not used and the system was only being used as a data viewing and query tool most of the time. In terms of being used for the tasks as it was intended, it was moderately utilised with an estimated usage of approximately 4hrs per day by 2

staff members. The civil engineering department showed a similar pattern with both the UltimateCad and the ReMap GIS being used to about 10% of their full technical capabilities and only moderately used for their intended tasks. This was attributed to a lack of computer skills amongst staff members, a need for training and staff resignations.

4.4.2 FUTURE UTILISATION

Future GIS utilisation was predicted partly by consideration of the challenges facing the organisation and partly by psychometric measures of user perceptions, attitudes and computing confidence. The psychometric measures were determined by means of questionnaires adapted to refer specifically to GIS. These were distributed to eight respondents in the civil engineering, electrical engineering and administration departments. (See Appendix A4 for questionnaire content). The response rate was 100 %.

Measures of Perceived Usefulness (U) and Perceived Ease of Use (E) originally developed by Davis (1989) in the form of a 12 point questionnaire was adapted to refer to GIS usage. Scores for each question were calculated using values between 1 and 7 corresponding to the extremely unlikely and the extremely likely responses. These were added to give a total out of a possible 42, represented as a percentage. The following results were obtained.

4.4.2.1 Perceived Usefulness (U)

Scores for perceived usefulness for all respondents ranged between 69% and 100%, indicating a high degree of awareness and understanding of GIS technology and its perceived usefulness relating to their job descriptions. High scores (100%) were obtained from respondents already using GIS (Civil and Electrical engineering staff) as well as from non-technical staff currently not using GIS (Town Clerk and Town Secretary) indicating a high level of awareness of GIS in the Administration section and at top management level. The results therefore indicate a high level of perceived usefulness of GIS technology

which can be expected to positively influence attitudes towards future utilisation of the GIS technology.

4.4.2.2 Perceived Ease of use (E)

Scores for perceived ease of use ranged between 57% and 98%. Respondents not yet using GIS generally achieved the lower scores. However, in two cases, non GIS users achieved scores of 76% and 86%. This was possibly attributable to a lack of appreciation of the complexities of GIS concepts. The results therefore show moderate to high levels of perceived ease of use. This can be expected to positively influence future utilisation of the GIS technology.

4.4.2.3 Computer Self Efficacy

A computer self efficacy (CSE) measure consisting of ten questions originally developed by Compeau & Higgins (1995) was adapted to refer to GIS usage. The CSE test was used as an indicator of user confidence in using GIS technology, which in turn can be expected to affect the individual's utilisation of the GIS technology and hence its effectiveness. Each question was scored between 0 and 10, indicating levels of confidence, providing a total CSE score out of 100, represented as a percentage. (See Appendix A4 for questionnaire content) The questionnaire was phrased to refer to the use of a new GIS software package. The following results were obtained, split between current GIS users and potential future users.

Current GIS users

The responses showed a moderate degree of confidence with scores between 59% and 73%. This was to be expected since the respondents had used GIS systems as well as other computer software and would not be too intimidated if faced with using a new GIS system.

Potential GIS users

Scores ranged between 35% and 59%. This was attributable to very little exposure to computing in general and hence a low level of confidence in using computer based technologies.

The results of the CSE test generally followed those of the perceived ease of use (E) test, i.e. respondents with low CSE scores also had the lower ease of use (E) scores.

The generally low scores for computer self efficiency, especially amongst current non-users of the GIS can be expected to negatively affect attitude towards using the GIS technology. These low levels of computing confidence point to a need for training in all aspects of computing. This need was fortunately well recognised by all interviewees.

The utilisation measures used and described above were considered accurate and meaningful despite their highly subjective and qualitative nature. By using multiple psychometric measures, namely perceived usefulness, perceived ease of use and self efficacy, a reliable initial indication was obtained of users' attitudes towards using GIS technology. The results are however limited by the small sample sizes and the fact that any changes in the group of respondents could significantly affect the results.

The results of the utilisation measures are summarised in Table 4 below:

Table 4 - Summary of utilisation measures

PAST & CURRENT UTILISATION		
	CIVIL	ELECTRICAL
Usage	low	moderate

FUTURE UTILISATION		
	CURRENT USERS	FUTURE USERS
Perceived Usefulness (U)	high	moderate - high
Perceived Ease of Use (E)	moderate to high	moderate
Computer Self Efficacy (CSE)	moderate	low - moderate

4.4.2.4 Overall Future Utilisation of GIS

In addition to the measures of future utilisation mentioned above, the following factors were considered in estimating the overall future utilisation of GIS technology.

In terms of the future challenges facing the organisation, it was felt that GIS technology had a leading role to play in the overall IT strategies and hence utilisation would be high . However this would be dependent on many factors, some of which are discussed under section 4.5

The overall future utilisation of the GIS's can be predicted to be moderate to high due to the following factors:

- Renewed awareness of GIS – This has occurred largely due to an increased awareness of IT in general by management, brought about by budget cuts and the need to re-evaluate the role of all personnel and systems.
- Necessity to use IT/GIS to achieve business goals - Definite goals, partly driven by central and provincial government legislation, such as the delivery of housing and services has required innovative thinking and a search for appropriate tools to assist in achieving these goals.

- Recognition of need for training – Taylor & Todd (1995) mention the *expectation gap* between what are behavioural intentions and actual behaviours. This gap was found to be largest for inexperienced users. The challenge therefore is to narrow this gap by giving users more realistic expectations and by increasing their level of experience by on-going training.
- Moderate to high levels of Perceived Usefulness and Ease of Use.

4.5 ORGANISATIONAL ISSUES INFLUENCING GIS EFFECTIVENESS

A number of organisational issues with possible influence over GIS costs, benefits, strategy, utilisation and hence effectiveness were investigated. These issues had been identified in the literature review and were investigated by means of interviews and discussions. The issues were:

4.5.1 ROLE OF INFORMATION IN THE ORGANISATION

The literature review presented in Chapter Two revealed two contradicting views of the role of information in the organisation. These are a proactive role of information as opposed to a reactive role and a rational role as opposed to a symbolic role. These opposing perspectives and other issues surrounding the role of information were explored through interviews and discussions and are briefly discussed here.

The general consensus amongst respondents was that IT has an essential role to play in the organisation. There was however a distinction made between accumulating and having information as opposed to actually understanding it and having the experience to appreciate its value. It was agreed that many decisions were still made on past experience and intuition however with the backup of relevant information thereby acknowledging a certain level of symbolic value of information.

The interview responses and the analysis of the documented strategies presented in section 4.3 revealed a definite reactive role to the value and potential role of information. This was evidenced by the fact that only one of the existing documented business strategies made reference to the role of IT in the organisation.

The role of information and the requirements of new legislation governing local authorities was emphasised by most respondents. This is especially relevant for the new policies of openness surrounding local government where employees,

4.5.3 ORGANISATIONAL CULTURE

Interviewees were questioned about their definition of the organisational culture, the manner in which this culture is changing and how it can influence measures of GIS effectiveness. Organisation culture was categorised according to the Handy (1993) definitions of Power, Role, Task or Person cultures presented in section 2.3.1.

General agreement existed amongst all the respondents that the Municipality had in the past followed a role culture, based on logic and rationality, dominated by the rules and procedures typical of municipal organisations with conformity and predictability. It was further generally agreed that the future culture will however change to a more task-oriented culture with emphasis on community involvement and a higher degree of openness and accountability.

This new culture should lend itself to better overall communication between all role players in the town and hence more careful evaluation of possible costs and benefits associated with GIS decisions. Similarly the GIS itself should provide a means to supply the information and communication needed for the new task culture.

4.5.4 DEGREE OF CENTRALISATION

The literature review in sections 2.4.3 and 2.3.2 discussed the concepts of corporate and departmental implementation perspectives (Campbell & Masser 1995) as well as degree of centralisation and competitive strategy (Talvakolian 1989). These concepts were explored in the case study by means of interviews and discussion in an attempt to determine their influence on overall GIS effectiveness.

Regarding the degree of centralisation, opinions varied between the engineering and administrative sections. The engineering departments were in favour of maintaining the separate systems currently in place, mainly for the technical strengths of the respective systems and a reluctance by each of the Civil and

Electrical Engineering departments to abandon their systems in favour of the other. It was felt that separate systems approaches had their shortcomings mainly in terms of data exchange but that these problems could be easily overcome by co-ordinating data capture and exchange situations. The administration section tended to see beyond the technical considerations of the systems and were in favour of a single GIS for all users. This stemmed partly from their position in the municipality being above the Engineering departments and hence seeing a greater need for co-ordination and dissemination of information through the organisation, and partly from a lack of understanding of the technical strengths and weaknesses of the individual systems already in place.

It was generally felt that the abandonment of the separate systems in favour of one central corporate system would not be justified in terms of costs and disruption. The risk of alienating certain individuals by imposing a system on them that they did not want to use would lead to under utilisation and hence ineffectiveness. These views correspond closely with the findings of Campbell & Masser (1995) which favour separate departmental systems with individual champions which tend to have greater performance and effectiveness.

The categorising of the municipality as a "defender" as discussed in section 2.3.2 and 4.3 would suggest that the associated conservative competitive strategy would indicate a corporate rather than a departmental GIS approach. The findings therefore show conflicting opinions on the corporate and departmental perspectives. The respective departmental heads have favoured and promoted a departmental GIS implementation, which would suggest a more competitive strategy than the "defender" definition.

From the foregoing, an attempt was made to categorise the municipality according to the stereotypes identified by Campbell & Masser (1995) and presented in section 2.4.4. The municipality could be termed "Paternalistic" due to the fact that it has a small staff with personal contact between the departments. However the strong departmental approach to the GIS implementation suggests that the "fiercely independent" stereotype is also

present. It was agreed by the majority of the interviewees and it is the author's opinion that the municipality does not fit a single stereotype as defined by Campbell & Masser.

4.6 DEVELOPMENT OF AN OVERALL GIS EFFECTIVENESS MODEL

The Strategy Tactics Effectiveness Matrix (Schultz, Slevin & Pinto 1987) described in section 2.5.7 is seen as appropriate for evaluating overall GIS effectiveness by combining and relating planning or strategy effectiveness with action or tactical effectiveness. The matrix furthermore relates the various phases of the innovation and provides an indication of the types of situation and problems associated with each. This model is therefore proposed as the core of a more detailed model using other measures found in the literature relating to IS and GIS effectiveness.

4.6.1 PROPOSED AUGMENTED STRATEGY TACTICS EFFECTIVENESS MATRIX

Although the Shultz, Slevin & Pinto (1987) matrix applies to the initiation & implementation phases of GIS, it could be expanded to include the more common three phase approach as defined by Campbell & Masser (1995). That is GIS adoption, implementation and utilisation. The initiation phase defined by Schultz, Slevin & Pinto equating directly to the adoption phase of the three-phase approach. The utilisation phase of the three-phase approach addresses the longer term, ongoing use of GIS, whereas the implementation phase is seen to be more of a short to medium term phase. The inclusion of an utilisation phase is well supported by the use of systems utilisation as a surrogate for effectiveness, (Campbell & Masser 1995, Miller 1989, Obermeyer & Pinto 1994) and others.

Utilisation is therefore proposed as the key variable for the Tactics axis of the proposed augmented effectiveness matrix. Although other "action" or tactical events take place with GIS such as data capture tasks, systems programming and others, they all imply a certain degree of utilisation. This utilisation should be seen in its broadest sense to include use of GIS products such as maps, reports etc. and not necessarily only hands-on use of the system at a computer terminal. The extent of utilisation is determined by the past and current utilisation as well as the previously defined predictors of future utilisation

namely Perceived Usefulness (U), Perceived Ease of Use (E) and Computer Self Efficacy (CSE) as measured in the previous sections.

Strategy alignment is proposed as the key variable for the Strategy axis of the proposed matrix. Whereas strategy in the Schultz, Slevin & Pinto model refers to the strategy of GIS implementation only, the strategy alignment of the augmented matrix proposes that strategy refers to all strategies of the organisation, including Business, Information Systems and GIS strategies.

The measures of strategy alignment and utilisation as determined in the previous sections were used in the Effectiveness Matrix analysis for the Past / Current GIS Implementation and Future GIS Implementation. The following matrices were derived:

4.6.1.1 Past and Current Implementation

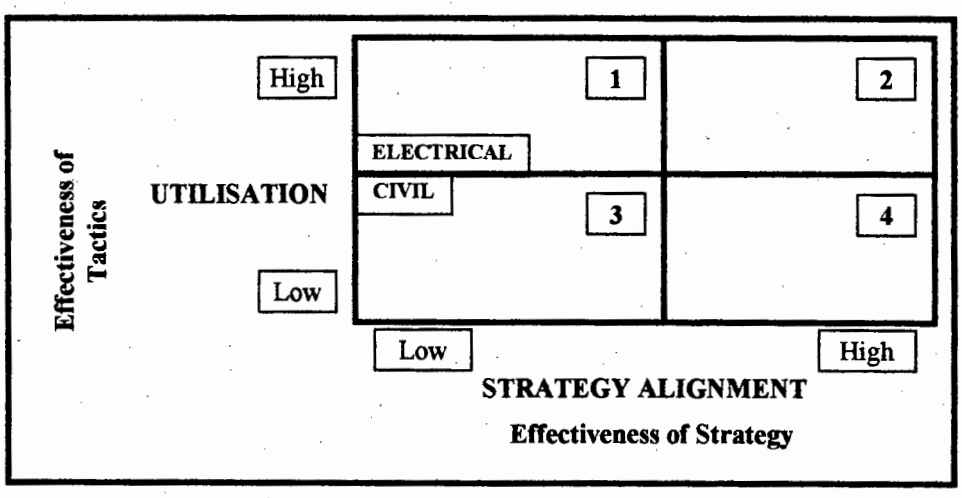

Figure 13 - Effectiveness Matrix - Past and Current Implementation

The analysis of the past and current GIS implementation in the preceding sections places the Electrical Engineering Department in quadrant 2 of the matrix showing moderate to high utilisation but minimal strategy alignment. This corresponds to the high use of the system but for the wrong reasons and misuse as described by Schultz, Slevin & Pinto

(1987). The Civil Engineering Department fitted into quadrant 3 of the matrix due to only moderate utilisation and low strategy alignment.

4.6.1.2 Predicted Future Implementation

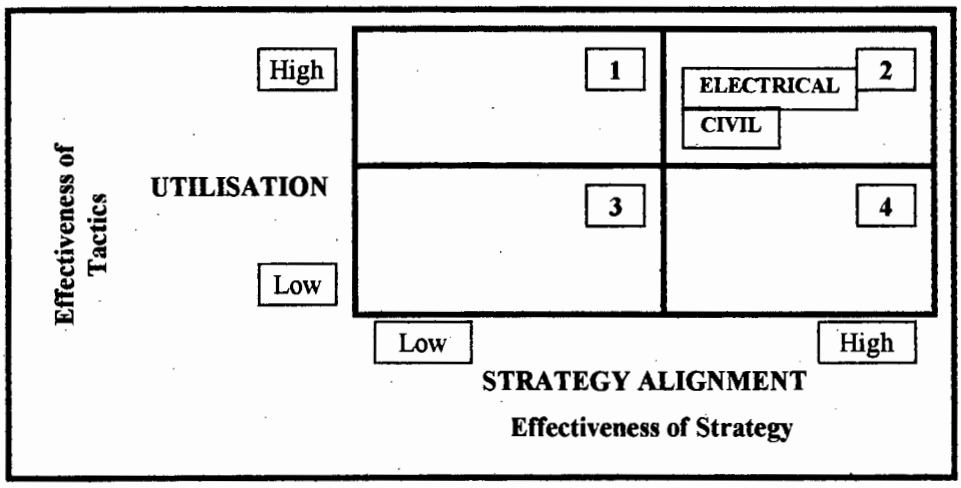

Figure 14 - Effectiveness Matrix - Predicted Future Implementation

The predicted future implementation matrix places both the Engineering Departments in quadrant 1 of the matrix, with the Civil Department achieving slightly higher utilisation than the Electrical Department due to more staff, more applications and potential benefits identified in the cost benefit analysis. For the higher levels of utilisation to occur, the identified need for training will have to materialise and the potential benefits will need to be realised through action. For both departments it has been assumed that at least a moderate level of strategy alignment will be achieved through the actions of the individual departments in formulating their own GIS strategies and those of the Administration Department in their efforts to align all strategies.

The proposed augmented strategy tactics effectiveness matrix provides a useful means of relating the previously measured determinants and individual measures of GIS strategy and tactics effectiveness. It provides a first stage of achieving multiple and combined measures of GIS effectiveness, identified as a theme of the research. In keeping with and

expanding on this theme, the following section develops an overall framework encompassing all of the concepts and themes explored thus far.

4.6.2 PROPOSED GIS EFFECTIVENESS FRAMEWORK

The literature review presented in Chapter Two identified the various measures applicable to effectiveness of information systems. However these measures were only single perspectives of cost, benefit, strategy and utilisation. The fact that the organisation is not always rational, and that individuals' actions, politics and conflict can cause deviation from the business enterprise ideal, where MIS offers economic value which exceeds the cost (Munshi 1996), points to neither a purely functional nor a purely subjective approach to GIS effectiveness.

The case study has shown how GIS effectiveness can be viewed holistically using a multi-perspective approach and a combination of quantitative and qualitative measures. Furthermore the case study highlighted the conflicting outcomes of GIS effectiveness measurement when using single perspective approaches and the limitations involved with each. It is from these limitations of single perspectives of GIS effectiveness and in keeping with the theme of a holistic overall approach that the need for an overall GIS effectiveness framework exists. Such a framework would combine many of the perspectives and measures identified thus far into a concise framework for other GIS effectiveness studies. The proposed framework has been developed by drawing on all aspects of GIS effectiveness from existing theory identified in the literature review as well as the evidence and experience gained in the case study.

This framework is therefore proposed as an overall framework for approaching GIS effectiveness measurement in other organisations, relating social paradigm, variables and methodology and is shown in figure 15 below.

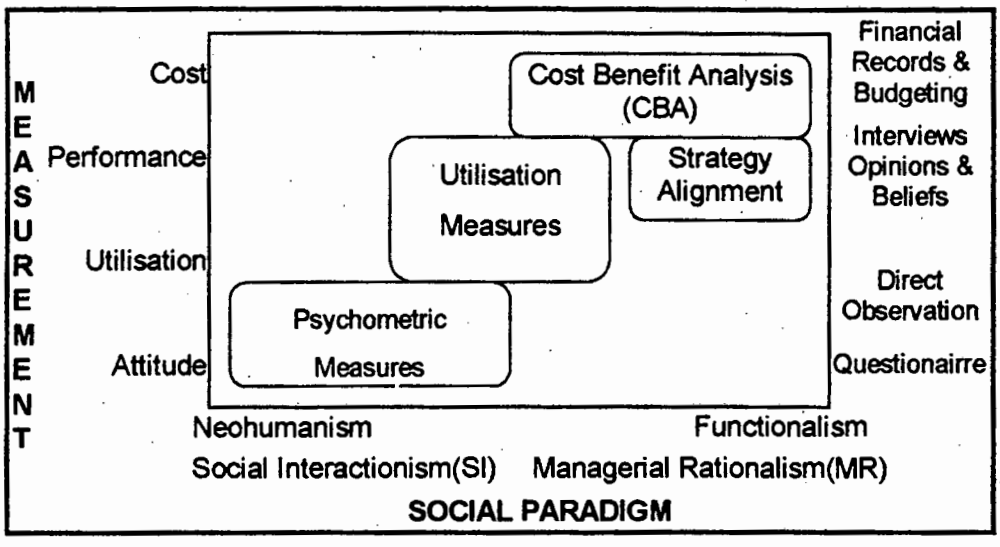

Figure 15 - GIS Effectiveness Framework

The left hand vertical axis of the framework refers to the measurement dimensions of Attitude, Behaviour, Utilisation, Performance and Cost. The dimensions are the same as those used by Munshi (1996) in his framework for MIS effectiveness with the exception of cost which has been added since it forms a logical progression, following on from utilisation and performance. The dimension of cost has formed the basis of GIS management theory and has been widely used mainly as part of cost benefit analysis. The dimensions of attitude and behaviour form the core of the Theory of Reasoned Action and the Technology Acceptance Model (TAM) which have considerable support in the study of IS and MIS effectiveness and which have shown to be applicable to the study of GIS effectiveness as shown in this case study. Although behaviours can be varied, it is primarily the behaviour of utilisation that is considered here.

The horizontal axis of the proposed framework refers to the extremes of rational choice as defined by Munshi (1996), ranging from Neohumanism through to Functionalism. For the sake of simplicity the intermediate levels have been omitted. The GIS implementation perspectives defined by Campbell & Masser (1995) are also seen to represent the social dimension of GIS effectiveness and are placed along the horizontal axis in parallel with the Munshi scales. These extremes range from the Social Interactionism (S.I) perspective equating to

Munshi's Neohumanism to the Managerial Rationalism (M.R) equating to Munshi's Functionalism.

The frames contained within the axes refer to the GIS effectiveness measures identified in the literature review and empirically tested in the case study. Each frame is placed according to its level of dimension measurement and social paradigm. The complexities of these dimensions as evidenced in the case study preclude any exact placement of the frames and a certain degree of overlap will exist.

Finally the right hand vertical axis of the framework refers to the research methodology and instruments applicable to each frame of GIS effectiveness measure. These range from questionnaire instruments for psychometric measures such as Computer Self Efficacy (CSE), Perceived Usefulness (U) and Perceived Ease of Use (E) through to organisational records of costs and documented strategies. Direct observation applies to all the measures. Again these methodology categories are not precise and a certain degree of overlapping exists.

The proposed framework is therefore an all inclusive summary of the dimension, measures, perspectives and methodologies used in this research. Each has a sound theoretical base and each has been empirically applied and adapted to the GIS effectiveness case study at the Ceres Municipality. Furthermore the proposed framework represents the first and fourth themes identified in section 2.6 namely that of a holistic approach to GIS effectiveness and the use of multiple and combined measures of GIS effectiveness. The framework is therefore proposed as a useful tool to be used as a starting point for other GIS effectiveness related research. It must be noted that the framework represents one of many combinations of the variables present. The author therefore does not preclude the inclusion or exclusion of certain variables. Furthermore the framework as defined represents the author's holistic view which may differ considerably to the views of others. However it is this subjective and imprecise nature which makes the study of these variables so complex and interesting.

This chapter began by empirically testing and adapting the various measures of effectiveness in a case study of GIS effectiveness at the Ceres Municipality, initially as individual measures and then as combinations of measures. Finally an overall GIS effectiveness framework was developed.

The following chapter is the last in the research and offers conclusions and recommendations pertaining to all the foregoing work.

CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS

This research was motivated by the need to understand the concept of effectiveness as applied to GIS. The initial research questions presented in Chapter One set out to investigate four questions. These were firstly, "How effective is GIS at the Ceres Municipality ?", secondly, "What are appropriate measures of GIS effectiveness for this type of organisation ?", thirdly, "Are existing Information Systems (IS) effectiveness measures applicable to the field of GIS ?" and finally, "What organisational issues influence GIS Effectiveness ?".

The literature review identified numerous perspectives, measures and theory relating to these questions from which four themes were identified for the case study. These were firstly an overall holistic approach to GIS effectiveness, secondly the role of organisational strategy and strategy alignment, thirdly the emphasis on the individual and finally the use of multiple and combined measures of GIS effectiveness.

The case study then attempted to answer the research questions within the themes identified. The following conclusions can be drawn from the findings in Chapter Four:

The various measures identified in the literature and used in the case study revealed varying and conflicting levels of overall GIS effectiveness at the Ceres Municipality. In terms of simple cost benefit analysis, the GIS was found to be highly effective with both 5 year and 7 year benefits exceeding costs. This outcome was however dependant on the future realisation of a few high value benefits. The CBA therefore confirmed the complexities and high degree of subjectiveness involved in defining and quantifying the GIS costs and especially the benefits. This led to a degree of inaccuracy in the cost benefit ratios measured. When extended to include measures of utilisation and strategy alignment, the effectiveness was shown to be low to moderate.

The single biggest drawback of the CBA approach besides the subjectiveness of the definition of the costs and benefits is the assumption that utilisation will take place. The case showed that although benefits were identified as having occurred, thereby

indicating utilisation to have occurred, the measures of utilisation were low to moderate. This points to one or more of the following scenarios:

- An overestimation of the defined benefits.
- An underestimation of the levels of utilisation.
- The benefits as defined were all attributable to GIS and did correspond to the low to moderate levels of utilisation. This would indicate much higher levels of benefits if the utilisation could be improved.

This clearly indicates the shortcomings of the CBA measure of effectiveness when used in isolation. The proposed overall effectiveness model that uses measures of utilisation and strategy alignment in addition to CBA was found to be more applicable than simple CBA alone due to the complexities that exist in the organisation and the shortcomings of the CBA measure.

What may emerge in the future is that by going through the CBA exercise, management and users will be more aware of all the variables and factors at play and will act to ensure that the GIS is in line with corporate strategy, even if the calculated costs and benefits are subject to bias and may be unreliable.

It is recommended that any future strategy planning should ensure proper alignment of the business, IT and GIS strategies. In the case of the business strategies, IT and GIS should be actively investigated as a means of achieving the business objectives. This should entail IT and GIS actually shaping the strategies and not merely being implemented afterwards. In the case of the GIS strategy formulation, this should always be formulated with the overall business strategies in mind, requiring that the staff involved with the GIS should be aware and involved with the business strategies to ensure their proper alignment. Similarly the non technical staff should be aware of the GIS technology's capabilities and limitations.

The psychometric measures of user attitude as predictors of utilisation, namely perceived usefulness, perceived ease of use and computer self efficacy, adopted from the field of MIS proved to be suitable and useful in evaluating GIS effectiveness. They were found to have considerable theoretical and empirical support and could be

directly applied to the field of GIS. The questionnaire instruments used were however simple and limited. The identification and use of other measures is an avenue for further research.

The analysis of the organisational issues affecting GIS effectiveness revealed the following.

The role of information in the organisation was still seen as largely reactive to changing circumstances as opposed to being proactive in actually shaping circumstances and strategy. An increase in the levels of strategy awareness and alignment as required for the envisaged future success of GIS at the Municipality will go a long way to addressing these problems.

The analysis of the degree of centralisation revealed a strong desire and commitment to separate departmental approaches to GIS implementation. This coincided with the findings of Campbell & Masser (1995) in the United Kingdom which showed a shift from largely unsuccessful corporate systems to smaller effective departmental systems. From the criteria and categories provided in the literature it was difficult to place the Ceres Municipality into a single stereotype of organisational type or GIS implementation perspective. This further proves the highly individual and unique set of circumstances surrounding GIS within an organisation and the high degree of complexity in attempting to analyse the circumstances.

The case study revealed indications of a move away from the purely rational approach to GIS implementation to an approach more suited to the needs of the individual. This will need to be continued and improved in the future to ensure GIS Effectiveness. The Social Interactionism (S.I) and Neohumanism perspectives are best suited for this.

The case study results prove the need for a multifaceted approach to evaluating GIS effectiveness and how the use of single measures of effectiveness in isolation cannot account for all the organisational influences on effectiveness.

The case study provided an initial insight into the application of new and multiple measures of GIS effectiveness. Further research is required to validate and improve these measures. The proposed GIS Effectiveness Framework provides a good overall framework relating the various variables, methodologies and implementation perspectives identified in the literature and developed in the case study. This framework needs to be further validated in studies of other organisations.

As a final point, it can be concluded that given all the complexities of organisations, technology and human behaviour as well as their interrelationships, effectiveness remains a highly subjective criteria. The issues surrounding GIS effectiveness are unique for each organisation and unique for situations within that organisation, with no fixed cookbook approach to evaluating them. As was done in this study, each study of GIS effectiveness needs to treated as a unique case study and measured in an investigative and exploratory manner. The case study methodology is therefore seen as highly successful for the study of GIS management issues.

The study has provided a perspective on the effectiveness of GIS at the Ceres Municipality. However, although receiving sufficient input from interviewees, the perspectives presented remain largely those of the author and may be seen in a totally different light by others.

The study further represented a snapshot in time of prevailing circumstances in an ever changing world. Handy (1995) refers to the changing worlds of organisations being beyond certainty. The author believes that, for similar reasons, the study of GIS effectiveness is also beyond certainty.

This study has however, hopefully opened up new perspectives on how to view and approach GIS effectiveness by following a theme of a holistic view of a prevailing situation. It is hoped that this work can be further refined, validated or refuted by others.

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APPENDICES

APPENDIX A1 - STRATEGY DOCUMENTS

A1.1 – STRATEGIC PLANNING DOCUMENT SEPTEMBER 1993

The following summary represents the main points of a formal strategy document prepared for the Ceres Municipality by consultant Nico McLachlan of Gouws Woods and Associates. Source – Internal Document Ceres Municipality – Strategic Planning Workshop, 1 September 1993.

Strategy No 1

The establishment of Ceres as a primary local authority with extended borders.

- Determination of boundaries
  Include surrounding areas
  Options:
    Ceres/Nduli
    Ceres/Nduli/Prince Alfred Hamlet
    Ceres/Nduli/Prince Alfred Hamlet/District
    Old Witzenberg Divisional Council (include Tulbach Magisterial District)
- Promulgation of new law
- Formation of boundary delimitation board.
- Input from authorities (Ceres/Nduli/Prince Alfred/Breerivier Regional Services Council/District).
    - Services rendered
    - Costs
    - Personnel
    - Vehicles and equipment
- Political input.
- Formation of new Negotiating Forum.
- Discussions to be implemented with other authorities.
- Collection of information from authorities
    - Services
    - Costs
    - Effectiveness

Strategy No 2

The development of tourism as an alternative industry within the confines of the local and regional economy.

- Determination of area to be marketed.
- Boundaries
- Include Wolseley and Tulbach
- Opportunities and limitations
- Determination of Marketing, Development and Financial sub-plans.

Strategy No 3

The extension of the income base of the local authority by amongst others industrial support to the soft fruit industry, stimulation of residential development and the accommodation industry.

Development Plan

- Determination of ground for development.
- Survey of available potential ground.
- Determination of owners and their future plans.
- Determination of existing proclaimed ground and which is under-utilised (coverage/height restrictions) which is not used for its designated purpose.
- Determination of what cannot be developed due to
    - Flood lines
    - Roads/railway lines
    - Servitude's and open spaces
    - Infrastructure needs and costs

Marketing Plan
- Liaison with developers, consultants.
- Discussions with industries etc. in Ceres.
- Discussions with industries etc. outside of Ceres.
- Package deal to be made available to attract industry to establish in Ceres.
- RSC funds generated within the new primary local authority area.

Strategy No 4

A. Re-evaluation of the Ceres Master Plan.

B. Development of land-use plan for the greater local authority.

A. ***Master Plan***
- Electricity
- Generation
- Distribution

- Water Supply
- Source
- Distribution Network

- Sewerage
- Collection network
- Treatment

- Refuse Removal
- Collection
- Disposal sites

Structure Planning

Introduction

Position and Background

Physical Elements

Climate

Rainfall

Wind

Temperature

Terrain

Relief dams and drainage

Slope analysis

Flood areas

Geology

Agricultural land and potential

Tree and shrub land

Urban morphology and sociological considerations

Ground use

Residential

Industry

Business

Public

Open areas

Zonings and group areas

Ground ownership

Summary of Planning considerations

Physical limitations and usefulness

Statutory and social limitations and usefulness

Demographics

Population growth
Population groups
Economic activity

Projections and Traffic

Population projections
Work opportunities and ground usage
Zonings
Traffic study
Planning suggestions
Residential areas
Schools
Central business
Suburban centres
Industry
Open space
Cemeteries
Show grounds
Airfields

B. ***Land use Plan of Sub region***

- Position
- Historical background
- Physical and natural characteristics
  - Topography
  - Regional elements
  - Climate
  - Plant life
  - General geology
- Physical Infrastructure
  - Roads
  - Railways
  - Power supply
  - Water sources
  - Airfields
  - Sewage works
  - Construction materials
  - Pumping sites
  - Services between towns
  - Environmental impact studies
- Economic Activities
  - Recreation and conservation
  - Agriculture
  - Forestry
  - Industry
  - Per capita income and welfare
  - Urban and rural incomes
  - Relative distribution of incomes

Strategy No 5

Development of a social development plan for Ceres

Primary Health Care Services

All primary health care to be provided by local authorities.

Housing

Community Facilities

Recreational facilities
Swimming pool for Bella Vista
Sports grounds
Day sites picnic spots
Public toilet facilities
Libraries

Strategy No 6

The establishment and maintenance of an internal and external image building program.

Strategy for internal contact and communication

All possible methods to improve communication within departments as well as between departments and between officials.

External communication

All possible methods for contact with the total community and to provide all relevant information to the total community in the form of information sessions, written communication and forums.

A 1.2 - STRATEGIC PLANNING REPORT – OCTOBER 1996

The following summary represents the main points of a formal strategy document prepared for the Ceres Municipality by consultant Vernon Rose of Vernon Rose and Associates. Source – Internal Document Ceres Municipality – Strategic Planning Report, 2-3 October 1996.

OBJECTIVES

Participants determined the following objectives for the two days

- To understand the term "Strategic Planning"
- To meet and address the challenges of the new South Africa
- To get the Councilors to understand the demands of the officials so that there is a common focus point.
- To understand the national structure of our government and its impact locally:
- A short, medium and long term economic strategy
- How councilors can support each other to provide a better service
- How to work with the Budget of our town
- To explain the basic principals of strategic planning
- Make improvements to structure own strategic planning
- Define the role of the council to the community
- Working on a strategic plan to include other important citizens of the town
- Establish a communication and marketing plan
- To include all development into a strategic plan
- To determine what to include strategically and not
- How to join the technical function of the municipality and the political dynamics inside the council
- Hope to address the environmental issue.

METHODOLOGY

- Participatory Basis
- Practical Component
- Ice-Breakers

WHY STRATEGIC PLANNING ?

Participants forwarded the following reasons for the importance of strategic planning:

- To prepare you for what is coming
- To prosper in desired positions
- To make daily jobs goal orientated
- To achieve your goals
- To stay in control
- To know / or determine the advantages and disadvantages of your goals
- To avoid fiscal pitfalls in the long-run
- No plan No budget
- To replace empty promises with goals
- "The future is a moving target – idea is to shoot where it is going to be"
- To secure the future
- To secure funding
- To remain competitive
- To remain viable
- To make management and decision making easier
- To satisfy the community
- Help us to make decisions
- To integrate planning

STEPS IN THE STRATEGIC PLANNING PROCESS

We discussed the steps in the Strategic Planning Process and they include:

- History
- Vision / Mission-Statement
- S.W.O.T
- Identifying Critical Issues / Concerns
- Prioritizing the Concerns
- Evaluation and Monitoring
- Developing Objectives and Action Plans

MISSION STATEMENT
By following the guidelines, the group developed the following Mission Statement:

CERES Municipality focuses on responsible and effective rendering of services to improve the quality of life of all its inhabitants.

S.W.O.T
An Analysis of the Organisations Strengths, Weaknesses, Opportunities and Threats were done.

IDENTIFYING CRITICAL ISSUES / CONCERNS
Participants were given the task to identify internal as well as external issues that the municipality had to address. The following issues were identified and later prioritized.

INTERNAL ISSUES / CONCERNS

FINANCES
- Loss of Revenue
- Non-payment of Services
- Costs of Municipal Services

INTERNAL & EXTERNAL COMMUNICATION
- Communication
- Community expectations of the Council
- Image to the public
- Image of Municipality

HUMAN RESOURCES
- Productivity
- Loss of Key Personnel
- Loss of Personnel (skilled)
- Irresponsible Affirmative Action

COUNCILLOR'S POLICY
- Role of a Councilor and role of a Community Leader
- Councilor's vs. staff capabilities and powers
- Interest of councilor's at unions, personnel, administration
- Discipline
- Irrational decision-making
- Biased councilors
- Acceptance of policy

PLANNING INFRASTRUCTURE
- Information Systems (integrated)
- Long-term Planning
- Land Prices and Availability
- Capacity of services
- Co-ordination of projects

TEAM BUILDING (CAPACITY BUILDING)

- Diversity
- Treasuring the value of Councilor's capabilities

EXTERNAL CONCERNS

LOCAL ECONOMIC DEVELOPMENT

- Revenue sources
- Unemployment
- Industries
- Informal Trading
- Seasonal Bound on Job opportunities
- Income resources limited

LAND AVAILABILITY

- Shortage of land

HOUSING

- Influx of people
- Informal housing and squatting
- Housing shortage

RDP FORUM

- RDP Forums
- RDP

SETTING OBJECTIVES

On this occasion we discussed the basic principles around planning and to reach clarity on who does what, where, when and how

GUIDELINES FOR SETTING OBJECTIVES

The group came up with the following guidelines for setting objectives:

- Clear guidelines
- Clear steps to be taken
- Clarity on the set goals
- Clear / set parameters – time frames
- Must be challenging
- Must be available
- Able to be evaluated
- Commitment / Determination
- Must fall within a particular performance area

DEVELOPMENT OF OBJECTIVES

Participants used an example and the given guidelines and formulated the following objectives

INTERNAL OBJECTIVES

OBJECTIVE: FINANCE
To implement a long term financial strategy in order to increase income, to promote Masakhane and to keep increase of municipal service charges below inflation over the next 3-5 years

PLAN OF ACTION

- Identify sources of income problem areas

- Develop a strategy for Masakhana
- Submit a report to Council
- Implement

OBJECTIVE: COMMUNICATION
To develop a communication strategy to improve the image of the Municipal over the next 3-4 years

PLAN OF ACTION
- To meet with a communication's specialist
- To present a draft strategy to Council
- To implement the plan

OBJECTIVE: HUMAN RESOURCES
To implement a Human Resources Strategy

PLAN OF ACTION
- Appoint Personnel Officer
- Identify and prioritise key elements of Human Resources management plan by Personnel Officer
- Present a planned program to address the issues in sub. par. 2 above, to Council
- Implement and Evaluate

OBJECTIVE: COUNCILLORS
To conclude the role and function of councilors

PLAN OF ACTION
- DA handles the portfolio
- Forming a work session to establish at which point councilors can be made aware on the contents of the policy
- For any further work resulting from above mentioned work session

OBJECTIVE: TEAM BUILDING
To conclude the competence and quality of services provided to the community

PLAN OF ACTION
- Identify a consultant for the presentation
- Presentation of qualified consultants

EXTERNAL OBJECTIVES

OBJECTIVE: RDP
To implement a Strategy to get the RDP functioning

PLAN OF ACTION
- Appointment of RDP official
- Identifying and prioritise problem areas
- Address problem areas
- Evaluate steps 1-3 continuously and take remedial steps (council)
- Evaluate the functioning of the forum in terms of project progress

OBJECTIVE: HOUSING
To implement a strategy to speed up the housing process to prevent squatting

PLAN OF ACTION
- Identify the problem areas
- Table a report to Council to address the problem areas
- Implementation of actions plans

OBJECTIVE: LOCAL ECONOMIC DEVELOPMENT PLAN
To implement a local economic development plan for Ceres Municipality and district to create orderly future planning

PLAN OF ACTION
- Identifying of an appropriate consultant
- Consultant to determine needs and the role players
- Consultant's presentation

OBJECTIVE: AREA IDENTIFICATION
To plan an integrated development plan for Ceres

PLAN OF ACTION
- To discuss and plan time schedule with consultant
- To present time schedules to the Council
- To compile one project from all running projects in Ceres

APPENDIX A2 - INTERVIEW FRAMEWORK AND QUESTIONS

The following interview framework was used when conducting interviews:

1. **INTRODUCTION**

Description of case study - part of MSc at University of Cape Town.
Reasons for case study
- understand the organisation
- GIS not always effective
- How to measure effectiveness
- Technical vs. organisational problems

2. **STRATEGY ALIGNMENT**

BACKGROUND

ORIGINAL strategies (1993)

- Values system
- Mission
- Vision
- Strategies (6)

NEW strategies (1996)

Reason for strategic plan

- Mission
- Critical concerns - internal
  - external

Questions:

Do you think strategies are necessary ?

Is there commitment to these strategies ?

Can IT help in achieving these business objectives ?

Can GIS help in achieving these business objectives ?

Should information strategy be included in these strategies ?

(IT can influence the strategy and be influenced by it)

Defender **Prospector** **Analyser** **Reactor**

How does your organisation fit?

Should IT feature strongly in any future strategies ?

Can IT respond fast enough to the changes in the organisation ?

Should the organisation be actively considering the latest developments in IT, or adopting a wait and see attitude ?

Does any formal strategy exist for GIS?

Are the strategies aligned ?

What is the general awareness of GIS in the organisation?

How do you define GIS? (software, hardware, data, training people, culture etc.)

3. ROLE OF INFORMATION IN THE ORGANISATION.

Does it support decision making or are decisions based on past experience, intuition ?

Does information have a symbolic / fashionable role ?

Do you think all information would assist the decision making process if it was more readily available?

Do you know of examples where more information would have assisted with major decisions? Would this have saved costs ?

Would access to too much information be a threat to the benefits of personal interaction ?

Does control of too much information lead to too much power ?

How would you gauge the attitude towards IS & GIS

at council level

at top official level

at middle management level

4. ORGANISATION CULTURE

Four dominant culture types

POWER	ROLE	TASK	PERSON
Dominated by powerful head	Based on logic and rationality	Team based	Serves the individual
Absence of formal structures	Dominated by rules and procedures	Getting things done without control from the top	Organisational goals are secondary
Willingness to follow lead of charismatic central figure	Conformity and predictability		

- How does your organisation fit ?

- Has the culture developed historically ?
- have recent changes affected this culture ?
- Do you think it will change further ?
- Are cultures different at different levels in the organisation ?
- How else would you describe the organisational culture?

e.g. ethics, morals , privacy, confidentiality, responsible, values, service orientated

5. DEGREE OF CENTRALISATION

How should GIS be implemented?

Corporate	vs.	**Departmental**
Different priorities of users		
Control of Information		
Disagreements		Independence
Distribution of power		Individual capabilities
Individuals feel threatened		Costs of duplicate data
Counter implementation		Lower cost GIS
Data sharing		Newer systems that integrate
Less organisational efficiency		

How do you see the current situation i.e. different systems in the Electrical & Civil departments ?

For further GIS in other departments, what route should be followed ?

Is outsourcing an alternative ?

6. IMPLEMENTATION PERSPECTIVES

three perspectives

T.D.	M.R.	S.I.
Only technical issues	Rational top down	User sensitivity

Do you agree or disagree with the following statements.

- The main requirements for choosing and making GIS work are technical. (TD)
- The advantages of GIS are obvious. (TD)
- The introduction of GIS will automatically improve working conditions and decision making. (TD)
- Once purchased and installed the GIS will automatically be used. (TD)
- GIS will eventually be adopted by all municipalities. (TD)
- What are more important, technical issues or organisational issues and human issues? (TD/MR)
- Technical specialist should be in charge of the system. (TD)
- GIS is not expected to be used for its technical properties but also to achieve management strategies. (MR)
- GIS implementation should follow a set recipe as used by other authorities. (MR)
- Following this recipe will automatically lead to a successful system. (MR)
- Do you think individuals in the organisation are committed to following the organisation goals or their personal goals. (SI)
- GIS may never be totally successful. (SI)
- Does GIS success depends on dictation by top management or consensus amongst all levels. (SI)
- Personal agendas such as personal status, promotion and authority play a big role (SI)
- The possibility exists that certain individuals would counter GIS implementation attempts. (SI)

7. MEASURES OF EFFECTIVENESS

Is it necessary to measure the effectiveness of GIS ?

How would you measure how effective the system is ?

- Measure how GIS is achieving the organisation strategies ?
- Compare costs with benefits. How would you define benefits ?
- Measure how much the system is used ?
- Measure users' attitude, behaviour and perceptions of the system ?

  i.e. How useful they think it is ?, and

How easy they think it is to use ?

8. OTHER QUESTIONS

- Role of consultants ?
- Role of vendors ? Pressure to buy ?
- Loss of expertise ?
- Choice of GIS manager ? Individual versus committee?
- How do you see the future of the organisation and the role of GIS ?

9. SYSTEMS UTILISATION QUESTIONS

GIS definition: H/W, SW, Data, CAD etc.

SYSTEM FUNCTIONALITY

- Has GIS as a (complete) Technology got the functionality to meet the organisations needs ?
- Your own job needs ?
- Has your current GIS got sufficient functionality to fulfil the organisation needs ?
- Your own job needs ?

SYSTEMS USAGE (Past - Present - Future)

- Is the GIS used to its full capacity ?
- Used as originally intended, i.e. the reasons for which it was purchased ?
- Used sufficiently to fulfil your job needs ?

10. GIS BENEFITS QUESTIONS

GIS purpose & aims ?

Tangible Benefits (In terms of savings in staff time, costs, consultants fees, & sale of data, maps etc.)

Producing maps (Topo, Cadastral, Services, Zonings, erf diagrams)

Display/Query information (Erf info, valuations, contours, detail)

Spatial Analysis (Erven within radius, within suburb. Buffers from roads, pipes etc.)

Access to information by other departments (e.g. Elec. Treasury, Health)

Supply of Digital Data (To consultants, builders, public etc. - Savings in time & cost, charging for supply)

Other staff savings (Field visits, opening services, public enquiries, council reports)

Intangible Benefits

Better decision making (Management & council level)

Reduction of risk

Data backup

Improved services payments (Measure as % improvement)

Improved service to public

Improved Safety (e.g. Location of pipes, cables etc.)

Future Benefits (Routing, Crime analysis, Services payments, health services)

A3.2 BENEFITS - CIVIL ENGINEERING DEPARTMENT

Tangible Benefits (In terms of savings in staff time, costs, consultants fees, & sale of data, maps etc.)

Producing maps (Topo, Cadastral, Services, Zonings, erf diagrams)

Estimated saving of 2 drawing office staff members **R100 000 pa.**

(Assume saving of first person in 2nd year and second in 4 Th year of implementation)

Display/Query information (Erf info, valuations, contours, detail)

Estimated saving of 1 administration staff member **R50 000 pa.**

(Assume saving in 4 Th year of implementation)

Spatial Analysis (Erven within radius, within suburb, Buffers from roads, pipes etc.)

No estimated benefits

Access to information by other departments (e.g. Elec. Treasury, Health)

Estimate saving of 1hr per day by Technical Assistant i.e. R 70 000 pa / 8 **R 8750 pa.**

(Assume saving in 4 Th year of implementation)

Supply of Digital Data (To consultants, builders, public etc. - Savings in time & cost charging for supply)

No estimated benefits

Other Staff savings (Field visits, opening services, public enquiries, council reports)

Estimated savings due to reduced field checks

Estimate 1 Superintendent and 2 workers **R 80 000 pa**

(Assume saving in 4 Th year of implementation)

Intangible Benefits

Better decision making (Management & council level)

Estimate 10 hrs per month saving due to quicker access to information **R 5800 pa**

Reduction of risk

No estimated benefits

Data backup

Estimated value of data for insurance purposes (R 750 000-00)

Estimated insurance premium (willingness to pay) **R 12 000 pa**

(Implemented pro-rata over 5 yr. period)

Improved services payments (Measure as % improvement)

Estimated potential of 20 % improvement

Estimated as a future benefit, 10% pa improvement over next 2 years **R 149 000 pa**

Improved service to public

Definite benefits exist but not quantified

Improved Safety (e.g. Location of pipes, cables etc.)

Possible benefits exist but not quantified

Future Benefits (Routing, Crime analysis, Services payments, health services)

Reduced water losses (Currently 20% of R 3 million annual water bill))

Estimated 5% reduction possible using GIS **R 150 000 pa**

Improved maintenance - i.e. managed maintenance as opposed to continuous ad-hoc maintenance

Estimate reduce maintenance teams by 33% (1 Snr supervisor & 4 labourers) **R 180 000 pa**

A3.3 BENEFITS - ELECTRICAL ENGINEERING DEPARTMENT

Tangible Benefits (In terms of savings in staff time, costs, consultants fees, & sale of data, maps etc.)

Producing maps (Topo, Cadastral, Services, Zonings, erf diagrams)

Producing sets of plans for contractors. Previous manual methods, estimate 1 week (R1000) of updating & draughting. With GIS estimate R100. Saving R900 every 2 months **R 5400 pa**

Assume benefit from year 2

Display/Query information (Erf info, valuations, contours, detail)

Research and extraction of data for municipal yearbook

Manually estimate 1 week (R1000)

With GIS 4 hours. Estimated saving 36 hrs **R 900 pa**

National Electricity Regulator (NER) requests for data & plans

estimate saving full time Technical Assistant **R 60 000 pa**

Assume benefit from year 3

Spatial Analysis (Erven within radius, within suburb, Buffers from roads, pipes etc.)

No benefits identified

Access to information by other departments (e.g. Elec. Treasury, Health)

Supply of Electricity Statistics

Estimated saving of 2 days per month **R 4 500 pa**

Assume benefit from year 2

Supply of position of electrical services to Civil Engineering Department

15 days per month **R 30 000 pa**

Assume benefit from year 3

Supply of Digital Data (To consultants, builders, public etc. - Savings in time & cost Charging for supply)

No estimate attempted

Other Staff savings (Field visits, opening services, public enquiries, council reports)

Field staff exposing services

estimate R 300/day, 3 days per month **R 10 800 pa**

Assume benefit from year 2

Intangible Benefits

Better decision making (Management & council level)

No estimated benefits

Reduction of risk

Potential losses to fruit juice industry R40 000 /day

Assume at least 1 day per year preventative downtime due to better electricity supply management due to GIS **R 40 000 pa**

(Implemented pro-rata over 5 yr. period)

Data backup

GIS data probable insured value R300 000 to R500 000

Insurance premium willingness to pay R1000/month **R 12 000 pa**

(Implemented pro-rata over 5 yr. period)

Improved services payments (Measure as % improvement)

Current losses Nduli area 50% non payments of R23 000/month

Reduce to 15% i.e. gain additional 35% R16 100/month **R 96 600 pa**

(Possible future benefit, implemented over future 2 yr. period at 17,5 % pa.)

Improved service to public

Definite benefits exist but not quantified

Improved Safety (e.g. Location of pipes, cables etc.)

No estimated benefits

Future Benefits (Routing, Crime analysis, Services payments, health services)

Savings on annual audit costs currently R 60 000 pa

assume 25% saving **R15 000 pa**

APPENDIX A 3.4 – BENEFITS - CIVIL ENGINEERING DEPARTMENT

BENEFITS - Civil Dept.						PRESENT			FUTURE
year	92/93	93/94	94/95	95/96	96/97	TOTAL	97/98	98/99	TOTAL
Tangible Benefits									
Producing Maps		R 50,000	R 50,000	R 100,000	R 100,000	R 300,000	R 100,000	R 100,000	R 500,000
Display/Query				R 50,000	R 50,000	R 100,000	R 50,000	R 50,000	R 200,000
Spatial Analysis									
Access to Information				R 8,750	R 8,750	R 17,500	R 8,750	R 8,750	R 35,000
Supply of Digital Data									
Other Staff Savings				R 80,000	R 80,000	R 160,000	R 80,000	R 80,000	R 320,000
Intangible Benefits									
Better Decision Making			R 5,800	R 5,800	R 5,800	R 17,400	R 5,800	R 5,800	R 29,000
Reduction of Risk									
Data Backup	R 2,400	R 4,800	R 7,200	R 9,600	R 12,000	R 36,000	R 12,000	R 12,000	R 60,000
Improved Services payments							R 149,000	R 300,000	R 449,000
Improved Service to Public									
Improved Safety									
Future Benefits							R 330,000	R 330,000	R 660,000
TOTAL						**R 631,000**			**R 2,253,000**

APPENDIX A 3.5 – BENEFITS - ELECTRICAL ENGINEERING DEPARTMENT

BENEFITS - Electrical Dept.						PRESENT			FUTURE
year	92/93	93/94	94/95	95/96	96/97	TOTAL	97/98	98/99	TOTAL
Tangible Benefits									
Producing Maps		R 5,400	R 5,400	R 5,400	R 5,400	R 21,600	R 5,400	R 5,400	R 32,400
Display/Query			R 60,900	R 60,900	R 60,900	R 182,700	R 60,900	R 60,900	R 304,500
Spatial Analysis									
Access to Information		R 4,500	R 4,500	R 4,500	R 4,500	R 18,000	R 4,500	R 4,500	R 27,000
Supply of Digital Data			R 30,000	R 30,000	R 30,000	R 90,000	R 30,000	R 30,000	R 150,000
Other Staff Savings		R 10,800	R 10,800	R 10,800	R 10,800	R 43,200	R 10,800	R 10,800	R 64,800
Intangible Benefits									
Better Decision Making									
Reduction of Risk	R 8,000	R 16,000	R 24,000	R 32,000	R 40,000	R 120,000	R 48,000	R 56,000	R 224,000
Data Backup	R 2,400	R 4,800	R 7,200	R 9,600	R 12,000	R 36,000	R 12,000	R 12,000	R 60,000
Improved Services payments							R 96,600	R 193,200	R 289,800
Improved Service to Public									
Improved Safety									
Future Benefits							R 15,000	R 15,000	R 30,000
TOTAL						**R 512,000**			**R 1,183,000**

APPENDIX A4 QUESTIONNAIRES

COMPUTER SELF EFFICACY QUESTIONNAIRE

Often in our jobs we are told about software packages that are available to make work easier. For the following questions, imagine that you were given a new GIS software package to start using. Assume that you have never used it before.

Indicate YES or NO. If you choose YES, indicate your confidence between 1 & 10
Please be totally honest. The results will remain anonymous

I COULD COMPLETE THE JOB USING THE GIS SOFTWARE .....

		Not at all confident					Moderately confident				Totally confident
Q1...if there was no one around to tell me what to do as I go	YES / NO	1	2	3	4	5	6	7	8	9	10
Q2. if I had never used a package like it before	YES / NO	1	2	3	4	5	6	7	8	9	10
Q3. if I had only the software manuals for reference	YES / NO	1	2	3	4	5	6	7	8	9	10
Q4. if I had seen someone else using it before trying it myself	YES / NO	1	2	3	4	5	6	7	8	9	10
Q5. if I could call someone for help if I got stuck	YES / NO	1	2	3	4	5	6	7	8	9	10
Q6. if someone else had helped me get started	YES / NO	1	2	3	4	5	6	7	8	9	10
Q7. if I had a lot of time to complete the job	YES / NO	1	2	3	4	5	6	7	8	9	10
Q8. if I had just the built-in help facility for assistance	YES / NO	1	2	3	4	5	6	7	8	9	10
Q9. if someone showed me how to do it first	YES / NO	1	2	3	4	5	6	7	8	9	10
Q10. if I had used similar packages before this one to do the same job	YES / NO	1	2	3	4	5	6	7	8	9	10

MEASUREMENT SCALES FOR PERCEIVED USEFULNESS AND PERCEIVED EASE OF USE

PERCEIVED USEFULNESS

Using GIS in my job would enable me to accomplish tasks more quickly.

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

Using GIS would improve my job performance

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

Using GIS in my job would increase my productivity

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

Using GIS would enhance my effectiveness on the job

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

Using GIS would make it easier to do my job

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

I would find GIS useful in my job

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

PERCEIVED EASE OF USE

Learning to operate GIS would be easy for me

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

I would find it easy to get GIS to do what I want it to do

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

My interaction with GIS would be clear and understandable

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

I would find GIS to be flexible to interact with

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

It would be easy for me to become skilful at using GIS

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely

I would find GIS easy to use

likely | _____ | _____ | _____ | _____ | _____ | _____ | _____ | unlikely
extremely quite slightly neither slightly quite extremely