IDENTIFYING AND EVALUATING CRITICAL SUCCESS FACTORS IN THE IMPLEMENTATION OF A GEOGRAPHIC INFORMATION SYSTEM (GIS): A LOCAL AUTHORITY CASE STUDY

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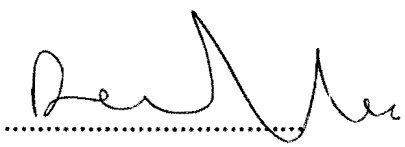
Declaration

I declare that this dissertation is my own work and where appropriate I have acknowledged the work of others. The dissertation 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 in Engineering at the University of Cape Town. It has not been submitted before for any degree or examination at another University.



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10th day of January 2000

Abstract

This single case study examines the analysis of the Critical Success Factors (CSF) involved in the implementation of a GIS. The study is in reaction to the problems users were having in implementing a Geographic Information System (GIS) in a small local authority, where the author was employed. Although the organisation had been using a GIS for some years, progress was below standard.

From the initial investigations, it was evident that relevant literature was scant. The majority of information on successful GIS implementation was documented by vendors who supplied the software. These documents were of sites where GIS had been implemented and can be referred to as anecdotal case histories. The format of these reports was unscientific and lacked the rigours associated with academic research found in case studies.

This study aims to test if existing methodology for identifying CSF in IS can be applied to implementing a GIS in a local authority, and this methodology is based on management information science (MIS) theory. The author shows that there are parallels between IS and GIS and that it is possible to use IS theory on CSF, specifically in GIS implementation. He has used the case study method in order to collect data from various sources. The nature of this data is qualitative rather than quantitative.

The research was carried out in four phases. The first phase, which was the longest, documented the different stadia and described the experiences of the author as the GIS manager with regard to the implementation. This is the control data set in the study which is compared with the data collected to test the two IS methodologies. The CSF which the author determined in this part of the research were: active top management support, qualified staff and a consolidated budget to ensure that all resources were pooled. These were established from observations and deductions from the experiences recorded in the study. The second phase was twofold and firstly involved a review of literature on methods to determine CSF in MIS planning; secondly it determined the similarity between GIS and IS

theory. The author argues that, because of these similarities, IS theory on CSF can be extended to GIS implementation. The third phase required the author to test the two methodologies discussed in the literature review, both of which have limitations regarding their small sample size.

The first method was the CSF method developed by Rockart (1979). This included interviewing senior management in the organisation with regard to their goals and CSF in order to achieve these targets, since according to Rockart, there are a few CSF in each organisation which require to be performed well if the ultimate goals of the organisation are to be met. The CSF elicited from the these qualitative interviews are consolidated and a set of CSF are formulated for the organisation.

The second, a quantitative method, is a set of key development success factors developed by Rainer (*et al* 1995) for EIS (Executive Information Systems). This work has been adapted by the author who circulated a questionnaire of 23 factors among eight members of staff to test CSF in the organisation.

The analysis of these results of the two methods is comparative in nature showing a definite pattern and correlation with that observed by the author in the case study. The final phase is the conclusions and recommendations based on the results of this case study.

Finally the author concluded that IS methodologies used to determine CSF can be used to determine CSF for GIS implementation and that CSF derived from IS research can be used in local authority GIS implementation. The methods were valid as the comparative analysis of the results in the final chapter, shows that there is significant agreement between the results using the different methods.

Dedication

This thesis is dedicated in memory of my mother who made my studies possible and who encouraged me in my studies in her own special way, but passed in away in September 1998 before this thesis was completed.

Acknowledgements

I wish to give a special thanks to Michael Barry of the Department of Geomatics at UCT for his guidance, supervision and for his assistance and insight into the topics researched. Thanks are also extended to the Paarl Municipality for granting me the opportunity to conduct this case study and especially Anton Swanevelder and the other Heads of Department who were involved in the interviews and discussions as well as all the staff who responded to the questionnaires. Also to be thanked is Ms Sarah Daitsh at the African Studies Library at UCT, for the assistance in locating source material and Associate Professor Tim Dunne of the Department Statistical Sciences with whom the author had discussions regarding the use of statistics on small samples and the results of the eight questionnaires.

Further, the following persons' assistance was also received with thanks, Ms Lani Roux and Ms Glynnis Barodien with whom discussions were held during the year in research seminars. To Chris Tanner and Charles Press, for your ideas and who assisted with the final proof reading of the thesis.

Finally, thanks to my family for their patience.

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GLOSSARY OF TERMS AND ABBREVIATIONS

CSF	Critical Success Factors are those few areas where excellent performance is essential if the ultimate goals of the organisation are to be met. (Rockart 1979:85)
Executive Sponsor	A person who champions the project and develops support for the GIS, allocating the necessary resources, participating in the system's development, and handling political resistance. (Adapted from Rainer et al 1995:84)
GIS	An institutional entity reflecting an organisational structure that integrates technology with a database, expertise and continuing financial support over time. (Hendricks 1998:627)
Implementation	"The process through which an innovation is communicated through certain channels over time among the members of a social system." (Rogers, 1983 cited in Obermeyer, N.J. and Pinto, J.K., 1994 :p14)
Operational Sponsor	Person responsible for the day-to-day development of the system, who understands the business and has a good working relationship with the firm's executives. (Rainer et al 1995:85)

CHAPTER ONE
INTRODUCTION

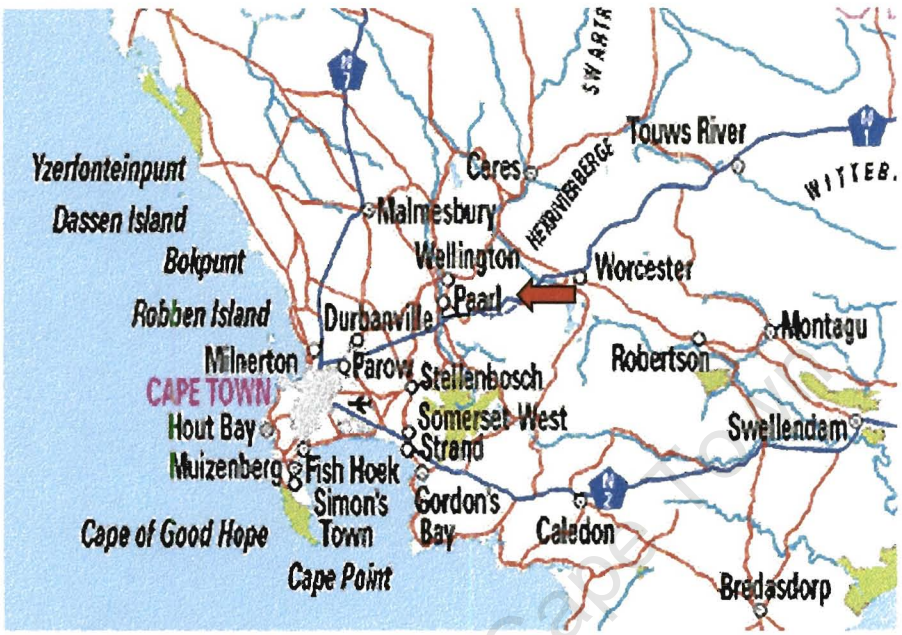

Figure 1 Locality Plan for Paarl (map from Map Studio, 1999)

1.1 OVERVIEW

This study investigates, identifies and analyses the critical success factors (CSF) inherent in implementing a geographic information system (GIS) at Paarl Municipality, a small local authority[1] in the Western Cape Province of South Africa.

The main users of geographic information systems have traditionally been large public and private organisations, primarily due to the expense involved in purchasing equipment and software in the past. The author has observed during this research that only in the last few years have a number of smaller local authorities in the Western Cape, such as Wellington, Bellville[2] and Ceres, seen the need for GIS and attempted to make use of these systems.

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[1] Grade 10 Local Authority (National Bargaining Council)

[2] Now incorporated in the City of Tygerberg since May 1996

At present although GIS are readily available and more affordable[3] to the smaller and medium-size local authorities, there is no assurance that the implementation will be successful. According to Huxhold *et al* (1995:10,44) meteoric technical advances in software and hardware have enabled the personal computer (PC) to become more powerful and reliable while Openshaw (1991: 624) states that the price of computer power has fallen by a factor of between a hundred and a thousand in five years. Due to technological advance and lower costs, users can now purchase proprietary GIS although the author maintains that the popularity of GIS is no guarantee that these GIS will be successfully installed and implemented.

Paarl Municipality, for more than ten years, from 1989 to the present, has been in the process of implementing a GIS. This until 1998 had cost the organisation, excluding salaries, over R410 000 in purchases of hardware, software and training[4]. Although GIS have been implemented in various municipalities, the degree of success varies[5]. This research explores methodologies that can be used to identify CSF in GIS implementation. However according to Onsrud *et al* (1992:43), lack of success can be to the detriment of the organisation, and a methodology to identify CSF will contribute to reducing the uncertainty in implementing these systems.

The author has noted in the literature that there has been research into CSF in Information Systems (IS), Information Technology (IT) and Management Information Systems (MIS) implementation processes, although the body of literature did not refer to GIS. This research is important because while various methodologies to identify success factors in IS implementation have been reported, there has been little reported on the CSF in implementing GIS at local authorities. This research therefore

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[3]From authors notes on address by Mr Neville Riley, City Planner, City of Cape (CCC) Town, 1990-5-29, Cape Town, Holiday Inn to Institute of Professional Land Surveyors and discussions with Mr M Barry 1999-11 -6, who was part of the GIS process at CCC in 1990.

[4]Department Planning and Development files ref 283 vol 1 - vol 4 (See Appendix C and D)

[5] Field Notes, telephone calls to various municipalities October 1994.

links and draws parallels between IS and GIS theory in order to identify the CSF in the GIS implementation process.

The premise that IS theory can be used for CSF in GIS implementation forms the basis of the objectives of this study which have been set out in the next section.

1.2 OBJECTIVES OF STUDY

The objectives of this research are to test if existing methodological theory for identifying CSF in IS implementation can be applied to implementing a GIS in a local authority.

The case study research method has been used in this study of the implementation of GIS at Paarl Municipality. A set of CSF in GIS implementation is proposed and describes how an organisation, such as a small local authority, could effectively manage the implementation.

In the following section, the hypothesis and research questions from these objectives are stated.

1.3 HYPOTHESIS AND RESEARCH QUESTIONS

The following hypotheses are posited:

(a) The IS methodologies used to identify CSF can also be used to determine CSF for GIS implementation at a local authority.

(b) The CSF derived from IS research can be used in local authority GIS implementation.

The following key questions are then explored to test the hypotheses:

- What are the CSF in implementing GIS at Paarl Municipality based on the author's actual experience?
- Can an IS methodology be used to identify CSF in GIS, and which methods of identifying CSF were most suitable in the Paarl case study?
- Can a tentative set of CSF be compiled for implementing GIS in similar organisations? If so, what are these factors?

The importance of this research with regard to CSF for GIS implementation is explained in the next section while existing theory relating to CSF in IS is described in the literature reviewed in Chapter Two.

1.4 CSF FOR INFORMATION SYSTEM AND GIS RESEARCH

GIS differs from IS in that a substantially larger proportion of the data is spatial. Spatial data differs from other "regular" data in how entities are defined and in the relationship between them. For example, a polygon may represent an area. These particular entities do not appear in other types of computer data (Becker *et al*, 1998).

Given that GIS incorporate both spatial and non-spatial data, they require larger data storage than IS. For this reason, GIS technology is complex and not only produces but also consumes a vast amount of data. Although Miller (1989:4) does not directly refer to GIS data, he states that there is a common concern that management has lost control of data processing and it is suggested that this problem of IS planning has become a key issue facing management (Miller 1985:83). The author also believes that GIS managers are facing similar problems in the implementation process. According to Miller (1989:12), many explanations are advanced for the observed success and failure of IS, but few have withstood rigorous testing. The literature review in Chapter Two expands on these problems.

Previous research on ways to improve the success rate of information systems is indicative of the "long history of failure in this field" (Miller 1989:11). Moreover, it is

reported that organisations have an extremely poor record in installing IS on time and within budget, in fulfilling the real needs of the user and in allowing adaptation to changing environmental conditions (McFarlan 1981:143). The author has observed and noted from meetings with staff at other organisations that various local authorities are experiencing similar problems with their GIS planning and implementation. This is also recently confirmed by Tanner (1998:2) who has similarly noted that smaller municipalities do not have the insight or the resources to manage the technology.

Previous research indicates that the CSF method can be used to improve the success of IS planning, whereas in the author's analysis of the literature it is suggested that there is a strong link, as well as parallels, between IS and GIS. This link will support the hypotheses (a) and (b) mentioned in the previous section.

In order to justify and call a GIS an IS, Hendricks (1998:627) adopts a broad definition. He states that GIS is an institutional entity reflecting an organisational structure which integrates technology with a database, expertise and continuing financial support over time. Although there are many GIS definitions, the author supports this statement and has selected it as it is most appropriate because of this parallel with IS and since the theory for CSF used in this research is from IS theory. In the authors opinion this serves as an important link and justifies the use of the terms of this definition when the Paarl Municipality case study is examined.

In summary, the author has adapted previous IS research on success factors and extended it to include the field of GIS. The contributions of this research into CSF in GIS implementation are covered in the next section.

1.5 CONTRIBUTION OF THIS RESEARCH

Onsrud *et al* (1992:34) state that the case study approach to the evaluation of GIS implementation can provide a useful and practical means for the GIS community to isolate those factors and processes that are critical for inclusion in prescriptive

implementation and improvement strategies. This case study provides first-hand information regarding this process, particularly with regard to CSF issues.
The computer equipment, software and data that form an integral part of a GIS are expensive capital items which should be integrated and developed in the organisation over time. This development, however, depends on CSF so that by identifying these, GIS resources and funds can be better utilised.

A major benefit that this research sets out to achieve is an improvement in the understanding of the factors related to success or failure when implementing the GIS in a local authority. From the author's experience in the workplace and at other local authorities, there is a considerable time lapse from the adoption of the technology to the time when benefits of the implementation are achieved. It is therefore essential for those implementing GIS to understand the factors which are critical to success.

Finally, it is the management of these implementation issues which decides if the process will be a success or failure (Campbell 1994:322). The research into CSF is thus important, not only for this reason but also for financial justification. By managing the implementation successfully, local authorities could affect savings on shorter start-up times and fewer lost opportunities. The method and structure of this research is detailed in the next section.

1.6 RESEARCH METHOD

A single case study was adopted for this research. Paarl Municipality, where the author is employed as a Professional Land Surveyor in the Department Planning and Development, was selected as the venue for the case study. The Department gave permission for the research to be carried out in April 1997[6], provided that information pertaining to an individual or organisation should not be abused.

The research is a single case study based on the experience of the implementation of

[6] Letter ref 210/3 dated 1997-04-23 (See Appendix A)

a GIS at Paarl Municipality where the author had a dual task between 1993 and 1999. Firstly, he was to investigate the CSF for an academic degree. Although this work was not commissioned, the local authority agreed to the subject of the research. He also acted as GIS Manager, and part of the responsibility was to assist the local authority with the implementation of the system.

The reasons why a case study methodology has been used are explained in the next paragraph. The case study examines phenomena in their natural settings and presents the collection of a variety of data by several different means from a range of sources (Yin 1986:20). These data include minutes of all computer advisory meetings and GIS user group meetings, letters and memoranda, formal reports, archival and financial records, questionnaires, informal discussions with GIS users, open-ended and structured interviews with managers and direct observation and participation by the author. A comprehensive description of the implementation process based on this material is described in Chapter Three.

According to Benbasat *et al*(1987: 370) a case study can be used to examine a phenomenon in its natural real-world setting. However, although multiple methods can be employed for data collection and gathering information, the single case study method is best suited to IS research because the technology is new and interest has shifted to organisational rather than technical issues (Benbasat *et al* 1987: 382). This view still prevails and is maintained by authors, such as Hendricks (1998: 621) and Campbell (1994: 309) who state that organisational issues are relevant for GIS implementation. A single case study is therefore appropriate where the situation was previously inaccessible to scientific investigation.

Lee (1989:34) observes that four problems were identified when a single case study was examined, namely:

- making controlled observations
- making controlled deductions

- allowing for replicability
- allowing for generalisibility

Although the use of a case study methodology for MIS has been questioned in the past Lee (1989:41) states that MIS case studies are, however, capable of achieving the same scientific objective through different means. This study has been divided into four phases which are now described in more detail.

In Phase One, the organisation and the GIS implementation process is discussed in detail. The author has adopted the definition of GIS "An institutional entity reflecting an organisational structure that integrates technology with a database, expertise and continuing financial support over time" because of its parallels with IS. This definition has assisted the author in analysing the CSF determined from his experiences and observations in the organisational context. This material is presented in Chapter Three.

Phase Two includes an extensive literature review that was conducted on case study research methods, GIS implementation as well as literature on IS implementation from doctoral theses and MIS journals. This information is evaluated and discussed in the literature review in Chapter Two.

Phase Three examines and explains the system of qualitative interviews and quantitative questionnaires in order to test the IS methodologies discussed in Chapter Two. This additional information and collection of data are discussed in Chapters Four and Five respectively.

The last phase includes a summary and analysis of the data. The work in this thesis is summarised in the conclusions and recommendations in Chapter Six , which ends with a proposal for management action and a recommendation for future researchers.

Certain assumptions and limitations made in this research are described in section 1.7 below.

1.7 ASSUMPTIONS AND LIMITATIONS

The following assumptions and limitations apply in this research:

- The GIS users, directly or partially involved in the implementation at Paarl Municipality at present, are limited and this has restricted the number of questionnaires completed in the study. Only eight persons were actively involved with the use of GIS at the time the study was undertaken. A case study method is therefore ideal.
- The purpose of this case study is to examine the phenomenon for research purposes. However, there is a participant observer bias bearing in mind that the author and researcher is the GIS Manager involved in the implementation process and interviews, and in these situations informal manipulation may occur. Due to the small number of interviewees, there is no fool-proof method of avoiding bias. The CSF method developed by Rockart is flexible, which can result in research being done in too casual a manner. This could cause the method to fail.
- There may be limitations regarding generalisability to the larger population and a lack of sampling controls in a single case study of a qualitative nature. This is due to the small number of employees used in the study. The study will nevertheless contribute to theory and provide data for further comparative research.

1.8 SUMMARY

The basis of this single case study is to test if existing methodological theory for identifying CSF in IS implementation can be applied to the implementation of a GIS at a small local authority. Previously, the GIS implementation process, with regard to CSF, had not been thoroughly researched. However because these systems are now used by more of the smaller local authorities, it is important to understand the factors involved to ensure that GIS are implemented successfully. The study shows that there are parallels between IS and GIS. It is therefore, possible to use previous IS research

on CSF and apply these to GIS implementation. In Chapter Two, the two proposed methodologies are examined in the context of this thesis and the literature relevant to this case study is reviewed. In Chapter Three the case study in the context of Paarl Municipality is presented and the CSF determined from the author's experience analysed. This is followed in Chapter Four and Five by a discussion of the results from the two methodologies adopted by the author to test the CSF for GIS implementation. The results of the tests are analysed at the end of each of these chapters. In the final chapter of this thesis, Chapter Six, the author compares the three methods and evaluates the findings of the CSF with a view to identifying what general lessons can be learnt from these experiences.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, the differences between case histories and case studies are discussed as well as their relevance to this study. This is covered in the next two sections. Section 2.4 of this chapter examines some case-study findings in the literature on GIS implementation at other local authorities and these findings are summarised in section 2.5. The two proposed methodologies applicable to IS theory and reasons for their adoption in this research are covered in the sections 2.6 to 2.8. The first is the CSF method developed by Rockart (1979); The second is "The Keys to Executive Information System Success" by Rainer *et al* (1995) which has been adapted by the author for GIS use. These theories are explained and their relevance to this research is argued. In the discussion that follows in section 2.9, the author establishes the parallels and links between GIS and IS theory which form the basis of the hypotheses which are set out in Chapter One. A brief review of organisational theory and culture, that is relevant to this case study is explained in section 2.10.

2.2 WHAT IS A CASE HISTORY?

A literature review was conducted on GIS implementation and IS Planning. Although a plethora of literature was available on the subject, most of the literature reviewed on GIS implementation was dominated by ad-hoc application descriptions from past successes and failures. These studies could be more correctly labelled "case histories" rather than case studies. The author has noted that these case histories are anecdotal and are usually based on experiences in a single company or organisation and reported after the event has occurred. They usually appear in trade magazines and give narrative descriptions of the event. These articles are mainly documented by vendors (for example, Articles in Municipal Engineer May

1992, Computer Graphics April 1993), and lack the rigour associated with academic research. Such writings are generally unsubstantiated and therefore cannot contribute to the development of GIS implementation theory.

2.3 WHAT IS A CASE STUDY?

The author has found that literature on GIS implementation, although having increased significantly in volume in recent years, remains largely unfocused. Many of the articles discuss implementation techniques in a general sense, whereas little systematic analysis has been undertaken to evaluate the underlying assumptions concerning the implementation of GIS. As a result there are no benchmarks against which GIS implementation may be assessed, and this has been widely reported by various authors (Campbell 1991, Onsrud and Pinto 1991:448, Obermeyer and Pinto 1994:15).

In the GIS community, there have been few theory-focused studies (Onsrud *et al* 1992:43). It is reported in literature, that there are few such studies on CSF in the implementation of GIS (Campbell and Masser,1992a). The Paarl case study therefore is important in this regard.

A case study is more systematic and employs empirical methods against which results are tested. The use of logical and often rigorous research methods in order to prove or develop existing theory, is explained by Benbasat *et al* (1987:370) and Yin (1986:78). This case study examines a phenomenon in its natural setting and employs multiple methods of data collection to gather information. These data are elaborated on in Chapters Three, Four and Five.

In the following section, the case study findings on GIS implementation in British local government are discussed.

2.4 OTHER CASE STUDY FINDINGS

Authors have indicated in their research and reports that GIS implementation is not a straightforward process (Campbell *et al*, 1992b) (Becker,1998). Becker has produced a three-volume comprehensive GIS Development Guide as a point in case, and this is indicative of the complexities involved in the process of GIS implementation. According to him certain problems, are known to occur:

- Staff not fully understanding the technology prior to extensive training
- Development time estimates differing from actual task times
- Great uncertainty about costs
- A likelihood that programmatic changes will be needed during the development phases, etc.

Becker (1998:4) observes that these are normal conditions in the adoption of a new technology while the author believes that even with such a thorough guide these problems may still occur. These factors need not be the norm and could be avoided if a model for GIS implementation using CSF was followed. The case study in Chapter Three shows that these problems also prevailed in this study. Findings at other local authorities where case studies were conducted indicated that these issues revolved around technical, data and organisational problems as well as implementation (Campbell *et al* 1992b, Campbell *et al*,1992a).

According to previous research in GIS implementation, there are three sets of conditions that are likely to make a significant contribution towards effective implementation of GIS ((Campbell 1990a, Masser 1992, Masser and Campbell 1991) cited in Campbell 1994: 315):

- An information management strategy which identifies the needs of users and takes account of the resources at the disposal of the organisation

- Commitment to and participation in the implementation of any form of information technology by individuals at all levels of the organisation
- A high degree of organisational and environmental stability.

These three conditions form the basis for the framework of analysis adopted by Campbell and are discussed in the following paragraphs. Campbell has used the "user" as the criterion for the analysis in her case study.

(a) Information Management Strategy

The emphasis of such a strategy is to identify the information priorities of an organisation. The author notes that similar conclusions in studies of the impacts of user involvement in the IS development process were found in the literature reviewed. In particular, the greater the amount of user involvement in the development process, the greater are the chances for a successful system (Rainer *et al* 1995:95).

Huxhold *et al* (1995:104) similarly stresses the importance of business functions to the whole process of GIS implementation. Miller also has stated that the organisation's information needs must be part of the overall strategy in order to succeed (Miller 1985:184). These parallels confirm and validate the author's argument that IS theory may be extended to include GIS.

It has also been shown in previous research that, for the effective implementation of a GIS, an information management strategy is an important prerequisite. This, according to Campbell (1994:316) is not only a document to provide a framework for direction but it is a strategy to identify the information priorities of the organisation, that is key data sets. She stresses that the value of the information management system depends on identifying the information sets that are essential to the operation of the organisation.

Studies by Campbell concluded that staff throughout the organisation must share and accept the priorities which were developed. Findings suggest that the majority of information being captured for the GIS is not of sufficient interest to be accessed outside the original holding department. This resulted in considerable differences in the priorities of users in terms of the data collected (Campbell 1994:317). In the author's experience this is also valid for the Paarl case study where different departments vie for resources and the allocation of funds to complete projects.

It is therefore suggested by Campbell (*ibid*) that the needs of users be assessed and not only the supply of information. Users' needs include important issues such as the time required to respond to a request for information and ease of use. Campbell also reveals that less tangible resources, such as the level of experience in handling spatial data and the ability of staff within the organisation to cope with change, can play a part in GIS implementation. In conclusion, it may be argued that information management strategy is valid for any form of computer technology. From this discussion it is understood that all information should be part of the overall strategy of the organisation.

(b) Commitment and Participation

Campbell (1994:317) stresses that successful implementation of any form of information technology requires the commitment of staff throughout the organisation to the implementation project and the necessary mechanism should be provided to facilitate the process. In the author's experience in the Paarl case study, this participation took the form of regular GIS user group meetings, computer steering committee meetings and internal departmental meetings. These mechanisms have been shown in studies, as a means of achieving widespread participation (for example, Campbell 1994:319, Murray 1992). It has also been shown that the need for commitment and total staff involvement is no less critical in the case of

GIS than any other form of IT. This is argued from the point that traditionally the introduction of computer-based systems were regarded as a purely technical activity. In the past there was a tendency to separate design from use.

Research has shown that there was a tendency, even in smaller authorities, for "family squabbles" to develop between departments. Few organisations exhibited any indication of corporate working in the general way in which service delivery was organised. This was because departments were keen to maintain their independence and tendered to be sceptical about any project that appeared to compromise their position (Campbell 1994:318). In the author's analysis of the staff interviewed in this case study, as well as from experience, departments were always keen to maintain this independence. As a result, few of the departmental GIS applications are fully integrated into the network.

(c) Instability

To achieve successful implementation, the organisation must be able to accommodate change as well as the introduction of GIS. Once a GIS has been introduced, the assumptions and goals on which the process of implementation was based should not be altered, as this threatens the success of the project (Campbell 1994:321).

2.5 SUMMARY OF CASE STUDY FINDINGS

Previous analysis of case study findings in British local government indicates that while the successful implementation of GIS may not be impossible, it is extremely difficult (Campbell 1994:321), since it is as much social and political in nature as technical. This explains why Hendricks (1998:627) argues in favour of a broader type of definition of GIS that includes all aspects of the organisation as well as resources.

According to the conclusions of Campbell, the findings in British local government were that those organisations with the level of skills and expertise amongst the staff, had an improved capacity to accept GIS implementation. It was also noted that an innovative culture in the organisation was responsible for attracting the right individual into the work place (Campbell 1994:321). By comparison, in the Paarl case study, two staff in critical GIS positions resigned in 1998 and that the organisation has taken more than a year to replace one post while the other is still vacant after unsuccessful attempts to fill it.

Refining the initial three factors for successful implementation using data from the case studies, Campbell shows that there are four factors necessary for achieving successful implementation:

- Simple applications producing information which is fundamental to the work of potential users
- An awareness of the limitations of the organisation in terms of the range of available resources
- User-directed implementation involving the participation and commitment of all stakeholders in the project
- A long measure of stability in terms of the general organisational context and personnel, or alternatively, an ability to cope with change.

These factors demonstrate the importance of designing an information management system strategy which identifies the core information needs of the users and the type of service they require. The findings conclude that successful GIS implementation may be extremely difficult unless greater consideration is given to the organisational and human dimensions of implementation (Campbell 1994:322)

In the next section the author discusses the reasons for adopting the IS methodology proposed in this thesis together with the two methodologies used in

this research. It is shown that the methods are suitable for determining CSF in GIS implementation.

2.6 INFORMATION SYSTEM METHODOLOGIES

Two methodologies are discussed in the literature reviewed in this chapter:

- The CSF method developed by Rockart (1979)

- The Keys to Executive Information System Success developed by Rainer *et al* (1995)

The latter has been adapted by the author for GIS use.

The author has chosen two different methodologies in order to test the validity of the results, thus providing a measure of triangulation in the process (Yin 1993:69). By comparing the results of these two methods with the core results from the case study of the GIS manager's experiences, a certain measure of agreement and reliability will be achieved.

According to Miller (1985:183), information system planning is a key issue facing management, and the author believes these issues remain relevant to GIS implementation today. Miller (1985:184) proposes that a comprehensive plan for IS should be part of any organisation's set-up, because most companies' goals and objectives are not usable for IS planning purposes. Similarly, a GIS should have a clear set of objectives defined at each step which should be aligned with the corporate vision, mission and goals. In Chapter Four the author analyses the CSF for GIS implementation to be aligned with these goals and objectives.

The author argues in the last section of this chapter that there are parallels between GIS and IS theory, and he therefore believes that GIS must form a vital part of the

organisation's IS planning. There are several methods, for determining IS needs of an organisation. Rockart (1979) states that methods such as "By-product technique", "Null Approach", "Key Indicator System", and "Total Study Process", can be used but concludes that these systems have deficiencies in determining CSF needs. The CSF approach, on the other hand, has been shown to be efficient and effective by Rockart (1979). Other authors, such as Miller (1985:184), mention the use of "Strategy Set Transformation" as a methodology to develop CSF but this method is only successful if a strategic plan is in place. In the absence of a strategic plan, Miller (*ibid*) suggests that Rockart's CSF method is the most suitable for establishing key objectives and strategies because it identifies the critical success factors, that support the attainment of organisational goals. As GIS is part of the IS process, the CSF for GIS implementation must be determined. This research tests the methodology to establish if this can be achieved.

The second methodology proposed to determine CSF has been adapted from the research carried out by Rainer *et al* (1995) who used the system to determine "The Keys to Executive Information System (EIS) Success". EIS are high-level decision-making processes and these furnish the information needs which are relevant to the organisation's CSF which, in turn are difficult to provide through normal computer-based IS. Similarly, according to Huxhold *et al* (1995:118), GIS support high level decision making. On this basis the author argues that the results from the research on successful EIS also apply to successful GIS implementation as "The Keys to Successful EIS Development" are a form of CSF method. The author compares the results of this method with the qualitative input from the interviews based on the first CSF method. These results are also compared with the GIS manager's CSF.

In the following section, the first methodology, the CSF by Rockart is examined in more detail.

2.7 METHODOLOGY FOR CRITICAL SUCCESS FACTORS (CSF)

Rockart (1979:85) popularized the definition and concept of CSF that is that the CSF for any business are the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organisation. Typically, three to six factors viewed by executives as critical to meeting strategic goals are relevant for the company to be successful, and these, according to Rockart, are the few key areas where **"things must go right"** for the business to flourish. If results in these areas are not satisfactory, the organisation's outputs for the period will be below standard.

Rockart (*ibid*) states that the CSF support the attainment of organisational goals, which represent the end points that an organisation aims to reach. These factors, however, are the areas in which good performance is necessary to ensure attainment of these goals. Furthermore, CSF are applicable to any company operating in a particular industry (*ibid*). The author believes this method may also be applicable to GIS.

Rockart (1979:92) identifies four prime sources of Critical Success Factors:

- Structure of the particular industry: each industry by its very nature has a set of CSF that are determined by the industry itself
- Competitive strategy, industry position and geographic location: each company in an industry is in an individual situation determined by its history and current competitive strategy
- Environmental factors: CSF also change in various situations
- Temporal factors: these are activities that are significant for the success of an organisation for a particular period of time.

Rockart (1979: 92) finds that few companies' information systems support their

CSF. In his observations their IS is built primarily around data that are easy to collect while IS, on the whole, process largely financial accounting data aimed at providing historical information. In the author's experience, this is similar to the existing financial IS in the organisation in this study.

Other authors, such as Laudon and Laudon (1996:401, 402), also refer to CSF as the strategic analysis approach, arguing that information requirements of an organisation are determined by a small number of CSF of managers. According to them, the important foundation of the strategic analysis approach is that there is a smaller number of objectives that managers can easily identify and focus on. This is a similar premise to that proposed by Rockart whose method has been used by many researchers and has therefore been found to be robust over time (for example Faull 1986, Miller 1985). Miller (1985:185) states that it is a methodology for the initial and explicit linking of overall goals and objectives to IS requirements. There are other methods which are mentioned in the literature on IS planning. However, the author has chosen the CSF by Rockart because it is reported to be highly effective. According to Miller (1985:184), who has based some of his research on Rockart's method, the CSF method is an effective methodology in order to establish key objectives and strategies in the absence of any other strategic plan. A second reason for the use of CSF method in this case study is that there was no strategic plan in place in the organisation at the time the study was undertaken.

The CSF method used by Rockart to help executives define their significant information needs consists of a series of two or more interviews. At the first interview the executive's goals are recorded, and are referred to as the current information needs. The CSF that underlie these goals are discussed. The results from all the interviews are then combined and refined. During the second interview, the reviewed results are sharpened up in order to obtain final agreement between all the participants. This is referred to as the CSF for that particular organisation and the process of determining such CSF is shown in Figure 2.

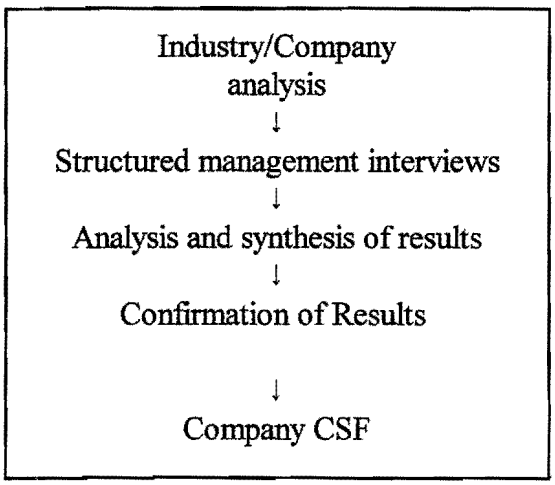

Figure 2 The CSF process (adapted from Miller 1985:185)

As mentioned, this method has been successfully used by various researchers including the author who has used this method by Rockart in this case study. Due to his involvement at Paarl Municipality over the duration of the study, the length of the interviews could be shortened appreciably.

The second, more recently developed, methodology that can be used to determine IS success factors is discussed in the next section.

2.8 KEYS TO SUCCESSFUL GIS DEVELOPMENT

This is the second method proposed by the author to determine CSF in GIS implementation. Rainer *et al* (1995:83) have produced a model for successful EIS[1] development and operation. An EIS is a high-level IS which provides executives with easy access to internal and external information that is relevant to their CSF (Watson *et al* 1991:14). It is data-intensive and effective data management is important (Rainer *et al* 1995:85). These are similar attributes of a GIS. In the last section of this chapter, Huxhold also argues that GIS is a high-level decision-

[1] Executive Information System

making system. The author, meanwhile, believes that the method used for the analysis of the implementation process for GIS and IS should be similar.

Rainer *et al* (1995:83) examines the variables that contribute to the successful development and ongoing operation of EIS. According to his research, there is evidence to support and integrate his findings with the existing literature on IS success. It is the author's opinion, however, that the system developed by Rainer can be adapted and is valid for use in GIS implementation.

The research by Rainer *et al* (1995:92) was carried out in two phases:

- In the first phase, 48 individuals, in open-ended interviews were asked to define success factors. These interviewees were selected from executive users, EIS professionals, vendors and consultants and came from a total of seven organisations. All the respondents in Rainer's research were actively involved in the actual development and operation of EIS and the data collected from them was used to form the basis of the questionnaire. These findings of Rainer were then compressed into short phrases or single words to describe a concept in the questionnaire.
- The second phase used a survey methodology to gather forced responses from 149 firms, to specific, preselected items on the questionnaire. These firms included government agencies, not unlike the organisation in this case study. A wider sample was used to increase the general application and refine the results from the initial study. Rainer found that the results of the interviews and questionnaire were not significantly different. The relative importance of the various keys was assessed by counting the number of participants who mentioned each key and determining the arithmetic average. The findings were ranked from top to bottom in importance (see Table 1).

In this instance, the author has used only part of Rainer's research with regard to the development cycle and not the ongoing phase as this is outside the scope of this study. He has used the questionnaire developed by Rainer on a sample of eight persons involved in the implementation of the GIS.

Rainer concludes that his overall findings may be extended directly to the literature on successful IS. The author, on the other hand, has adapted this theory for GIS implementation use. He has used this methodology in this research so that the information can be obtained from the respondents quickly. The author also believes that, because Rainer included government organisations in his research, which made up the third biggest sample[2] in his data, the results should be applicable to Paarl Municipality.

This method differs from the first CSF approach in that respondents are required to respond to specific preselected items making this a forced response. There is a possibility of information loss using this technique, but this is minimal according to Rainer *et al* (1995:93) who suggest that this method of condensed or summarised information often presents a clearer picture of the structure and meaning underlying a data set.

According to Rainer's findings (1995:88), there are 23 keys to successful development. These are set out in the table below (Table 1).

Keys	Rank
Executive sponsorship	1
Top management support	2
Define information requirements	3
Link GIS contents to business	4
Deliver initial version quickly	5

[2] 10% out of a sample of 149

Develop system with users' needs in mind	6
GIS support staff	7
Manage data	8
Work closely with executives	9
Manage user expectations	10
Evolutionary development approach	11
Start with high payoff applications	12
Operating sponsor	13
Appropriate IS staff	14
Sell the GIS concept	15
Appropriate hardware technology	16
Manage organisational resistance	17
GIS support for the executives' staff	18
Manage system spread and evolution	19
Appropriate software technology	20
Cost considerations	21
Provide benefits statement	22
Use consultants	23

Table 1. Keys to Successful GIS Development (Adapted from Rainer et al 1995)

These keys, ranked in importance, have been adapted for GIS implementation. The author has replaced the use of the word EIS with GIS where required in the table. In order to compare the CSF with the first methodology described, only the top eight rankings in the results from the questionnaires are referred to by the author in the analysis presented in Chapter Five.

According to Rainer (1995:88), the important expected keys are:

- executive sponsorship
- define information requirements
- top management support
- manage data.

These keys are often cited in literature. It is suggested by Rainer that it is more than just the executive sponsor's support that is required for successful development. Staff find that the operators' cost consideration are usually low on the list of their priorities although managers might rate this more important.

Two other important keys referred to in Rainer's study that do not receive high priority are appropriate IS staff and operating sponsors. Rainer attributes this to the assumption that technical skills are provided by IS and are readily available. Another problem is the failure to recognise the importance of the operating sponsor. From Rainer's experience, the highly successful EIS are managed on a daily basis by someone who has a strong vision for the system and who knows the business systems and requirements of the organisation (Rainer *et al* 1995:90). He analysed these results and determined these factors underlying the development issues:

- executive professional relationships
- professional issues
- executive involvement issues.

Rainer finds that executive involvement in the EIS development process is of paramount importance.

The next section demonstrates that calling GIS an IS is justified. It also shows that IS, MIS and IT planning tools can be used and are relevant and applicable to GIS.

2.9 PARALLELS of GIS, MIS, IT and IS

As mentioned in the overview in Chapter One, there has been a rapid advance in GIS technology. According to Onsrud *et al* (1991:463) and Hendricks *et al* (1998:621), this advance has been concentrated on the technical side. As a result, the accompanying understanding of the human side of these systems has been neglected. Similarly with IS, as stated by Miller in the introduction in Chapter One, managers have "lost control" (Miller 1989:4).

In IS system planning, Miller emphasises that it is important to link overall goals and objectives with IS requirements. Goals are the standards by which a company aims to be measured and the targets which it hopes to achieve. CSF, he explains, are what an organisation has to do to achieve these end results (Miller 1985:184,185). He uses Rockart's theory in his research.

Similarly, GIS authors in the literature reviewed also emphasise this premise. Huxhold *et al* (1995:15) deals with GIS as an application of IT, in the belief that the same IS data management principles and organisational theories applicable to IS, IT and MIS apply in addition to the geographic needs of an organisation. This theory the author argues permits the use of IS principles to be extended to include GIS. Other researchers refer to GIS as a subset of IS (for example Tanner 1998:1)

According to Huxhold (1995:104), the organisational structure and technology tend to change more often than business functions and the information required by the organisation. Business functions can be determined from the existing organisational structure, units comprising it, legislation, mandates and strategic plans and CSF . Business functions are stable and therefore important to the functioning of an organisation. They can be determined by the CSF method.

Huxhold stresses that the primary focus of GIS implementation is not necessary to determine how the information is created, what processes are or will be required

to process it. He maintains that it is rather the intent to identify which business functions will be included in GIS implementation and what type of information will be handled by the GIS.

Huxhold (1995:35-36) states that it is important for investigators of GIS technology to follow trends closely in the larger MIS field "given its 30-odd years of development history" when seeking successful implementation and use of GIS. Successful GIS implementation includes successfully dealing with characteristics of organisations' culture, the dynamics of people interacting in teams, change process and the impacts of introducing new technology. Analysed from this perspective, IS theory should also be applicable to GIS.

Huxhold (1995:118) then refers to Rockart's study on CSF, proposing that the significance of these finding to GIS is equally relevant. He views GIS as drawing attention to higher-level decision-making, and supporting those functions with GIS rather than applying it solely to support functions as mapping and record keeping, "the GIS equivalent of accounting". It is therefore suggested by the author that GIS, too, should be a form of EIS.

From these parallels, it is proposed that MIS planning practices and principles may therefore be used for GIS implementation. GIS is part of IT, the only difference being that the data in GIS is spatial and not simple alphanumeric text.

It is evident from the literature reviewed that it is possible for GIS to form a subset of the wider field of IT. The research by Rockart and Rainer *et al* may therefore be extended directly to include GIS implementation.

2.10 ORGANISATIONAL THEORY

The aim of this section is to examine organisational theory with regard to the implementation of GIS at Paarl Municipality. The discussion in this section will be

used in the case study observations and experiences related by the author in Chapter Three.

Various models for organisational theory have been proposed by authors in the past. However, what is best is often subject to much contention. This is especially so when these theories involve spatial IS (Groot 1992). Barry and Butcher (1998:192), on the other hand, indicate that introducing and diffusing new technology and systems in an organisation often requires organisational change. This is also an important aspect in the Paarl case study, where a GIS has been introduced. The organisational profile is examined using the observations reported on in the case study, and this change could have a bearing on the CSF at Paarl Municipality. This analysis is crucial in formulating a GIS design and implementation strategy.

According to Plant (1989), meanwhile, there are four organisation profiles or types that make up the key elements of an organisation's culture (see Figure 3).

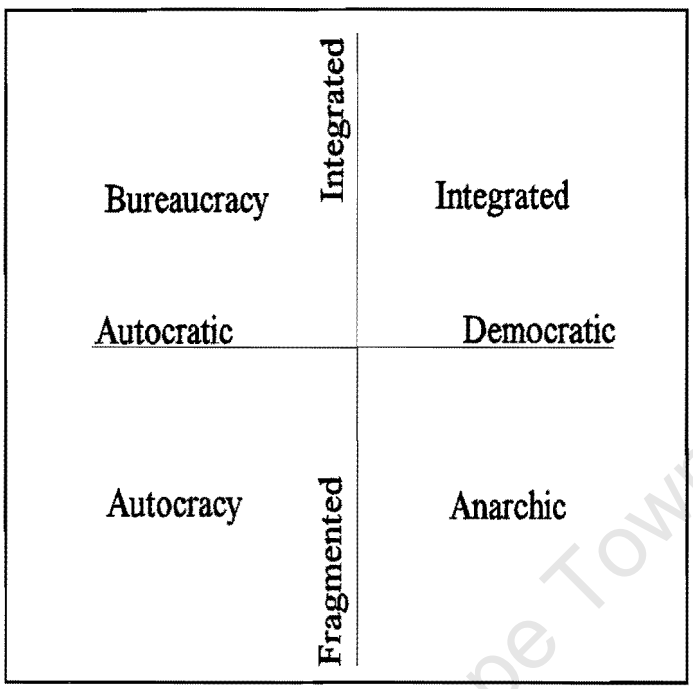

Figure 3. Plant's cultural types (1989)

The horizontal axis "Autocratic - Democratic" indicates how the decision making process in the organisation is formulated for problem solving, that is "Are people excluded from the decision making process or involved?" The vertical axis "Fragmented - Integrated" indicates how well the sub-parts of the organisation are synchronised. That is. "Is everyone working towards the same goal or vision?" Depending where on the two axes the organisation is positioned depends, in turn in which quadrant the organisation is, such as Bureaucracy, Integrated, Anarchic, Autocracy. This is not a static model, but dynamic and depends on the organisation's life cycle. It is reported that the threat of new technology is more pronounced in an organisation with a bureaucratic structure, and such structures are heavily hierarchical. They are found in most government agencies at all levels (Parker 1988). People are less important because the system makes decisions, and the system was created to provide continuity and command by power from above. A bureaucratic system does not need to be competitive because there is no competition. According to Parker, this extends to the GIS, but what is the motive

for its use? In the final section in this chapter the preceding sections are summarised.

2.11 RELEVANCE TO RESEARCH

This section explains the relevance of the literature to the research. In the Overview in Chapter One, this study is introduced as an investigation to identify and analyse the CSF in implementing a GIS at a small local authority. This was extended to form the objectives of this study in order to test a methodology for identifying CSF in GIS from adapted IS theory, based on a case study method. From this objective, two hypotheses were framed regarding the relevance of IS methodologies for GIS implementation and secondly, to establish if CSF from IS research could be used for GIS implementation.

The literature reviewed in this Chapter introduced the reader to the concept of case studies and explained its importance to this study. The literature review then elaborated on the two IS methods and processes involved to determine the CSF. The author argued that GIS and MIS, IT and IS had a common link and that the methodologies developed for IS could be extended to include GIS implementation. This argument was supported by the reviewed literature. It was therefore possible to collect data from a GIS implementation case study and use adapted IS theory as the framework of analysis. In Chapter Three a detailed history and organisational context is reviewed.

CHAPTER THREE

CASE STUDY OBSERVATIONS - PAARL MUNICIPALITY

Figure 4. Paarl Municipality Civic Centre

3.1 INTRODUCTION

The main objective of this chapter is to describe, examine and present the author's experiences as a participant observer in the implementation of a GIS at Paarl Municipality. As mentioned in Chapter One, the author has adopted the GIS definition by Hendricks (1998:627) which comprises "an institutional entity reflecting an organisational structure that integrates technology with a database, expertise and continuing financial support over time" as a basis for analysing the CSF determined by the author. The descriptions and analysis are presented where possible in chronological order, and for this purpose the case study observations are grouped in three phases, namely:

- Phase One - The initial period 1988 - 1992

- Phase Two - The investigation period 1993 - 1996
- Phase Three - The implementation period 1997 - 1999

At the end of each phase, the author discusses and analyses the phase using the criteria of the definition. In the preceding chapter, the author also reviewed the findings of certain case studies of local authorities in the United Kingdom. This is used in a comparative analysis of the Paarl case study. In Chapters Four and Five, additional data is collected by means of qualitative interviews and quantitative questionnaires in order to test the two IS methodologies and confirm the set of CSF applicable for Paarl. A brief historical outline of the organisation follows.

3.2 BACKGROUND TO ORGANISATION

The town of Paarl is over 300 years old, situated about 60 km north east of Cape Town[1]. Paarl Municipality is an independent local authority whose main function is to provide services within its boundaries to ±105 000 inhabitants[2]. These services include roads, water, sewerage, health, electricity, planning and development, as well as administrative functions such as rates collection and financial control.

The Municipality employs approximately 1 400 personnel. The main business areas of the organisation are centralised in the following core departments: Town Engineer, Town Electrical Engineer, Department Planning and Development, Town Treasurer and Town Secretary. During the period of this study, the author witnessed three changes in the position of Chief Executive Officer[3]. The Head of Planning and Development has, however, remained unaltered.

[1] See figure 1 on page 1 of Chapter One

[2] 1996 Census data

[3] Town Clerk

3.3 OVERVIEW OF INFORMATION TECHNOLOGY (IT) HISTORY

Historically, the Town Treasurer was responsible for the maintenance of the mainframe computer and data processing. In 1980 the municipality acquired its first main-frame computer, a Burroughs Model B1855 which was replaced with a Burroughs B1900 in 1985. There was no local area network which would allow for different computers in the organisation to communicate with each other and share information. In 1994 a Novell Network for PC's was introduced and a wide area network (WAN) was established, and in the following year the main frame computer was upgraded to an Unysis A14 main frame. The operating system was MCP which was connected to a DMS2 data base. Dumb terminals in various sections connected users to the main frame. The functions of the computer were solely financial and used for processing rates and account billing. In 1999, the mainframe system was replaced with a Sun E450 (using Solaris for Sun) Unix based system with a Natural Adabas data base. A new financial system was also purchased[4].

In the last two years at the Municipality, there has been a complete transformation of the computer system in the workplace. A local area network was created and PC's have replaced the old main-frame terminals.

3.4 PHASE ONE - THE INITIAL PERIOD 1988 - 1992

The first steps to implement a GIS in the organisation were taken by Department Planning and Development in 1988 with a view to its use by the Town Planning section in that department. At this stage other departments were reluctant to become involved. There was only one member of staff with a PC whose function it was to support the GIS in that department. No formal training was given other than the short course offered by the vendor when the software was installed.

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[4] Venus System (Q- Data)

3.4.1 Organisational Hierarchy in Department Planning And Development

This department has recently undergone a major re-organisation with regard to duties and division name changes. These changes bring it more into line with similar changes experienced at other local authorities in the greater Cape Town Metropole. The functions of the department are controlled by a Head of Department who is assisted by three divisional heads, who manage Town Planning, Technical Support Services and Building Services. Until 1993, the GIS resided under the Senior Town Planner. The duties and single staff member were then transferred to Technical Support Services. This division, which was headed by the author, had two main functions: survey and valuations. It was responsible for maintaining a manual cadastral database which consisted of a large selection of paper maps, as well as handling valuations The layout of the staff positions is indicated in Figure 5 below, showing the Head of Department with two divisions below only. (The Building Control Division has not been indicated). GIS is responsible to the Senior Town Planner while the author is responsible for the two separate sections.

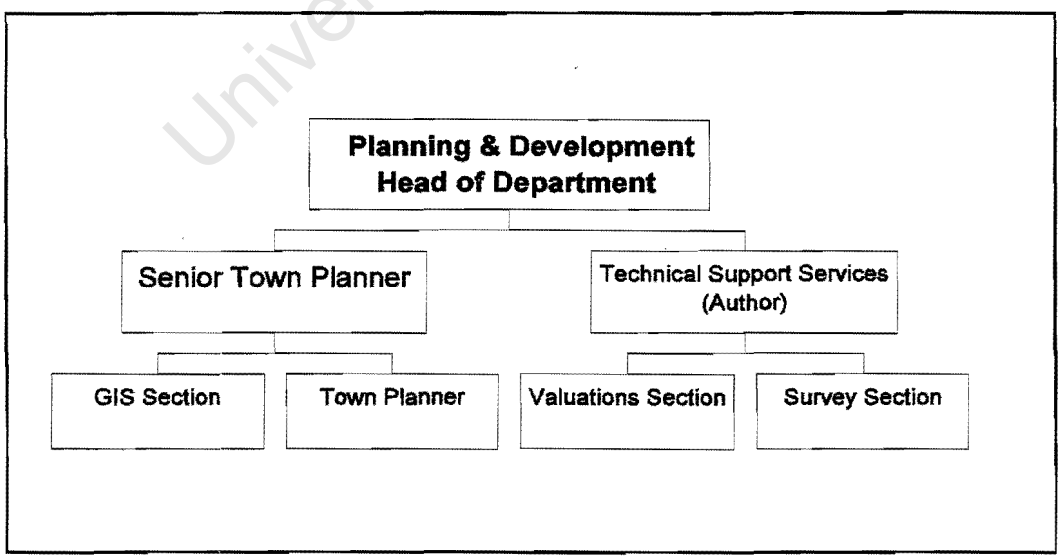

Figure 5 Layout of staff functions 1988-1992

3.4.2 Reasons for Initial Stand Alone GIS Purchase

The Head of Department Planning and Development was responsible for the introduction of GIS to the municipality in 1988, having seen the product demonstrated on a visit to the United States. Initially, no other departments were interested in the product. The primary intended use of the GIS in the Town Planning Section was to be able to print out a zoning map and overlay it with the 1:1000 scale topographical mapping[5] of Paarl. This mapping was of a translucent material and the underlying erf zonings could then have been noted under the topographical detail.

The following written motivation[6] and criteria were used to purchase of the GIS software PC ArcInfo:

- The system was most suitable for municipal use
- Major towns and planning institutions were users of ArcInfo
- ArcInfo complied with the municipal requirements at the time
- The system could manipulate 16 databases simultaneously
- The system was compatible with the needs of the other two engineering departments
- The system could be linked to the main-frame computer.

3.4.3 Initial Purchase of PC

The GIS implementation was initiated by the purchase in August 1989 of one copy of PC ArcInfo software and a standalone Silicon 286[7] computer system with the necessary peripherals. This included an A1 size plotter[8] and an A3 size digitiser

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[5]Aerial Photography Flown 1980

[6]Memorandum from Town Planner, Ref 283 dated 9 August 1989.

[7] Personnel Computer 16mhz

[8] Calcomp 8 pen plotter

tablet[9].

3.4.4 Cost Implications

The initial cost of purchasing the equipment for the GIS was approximately R70,000, which included the computer, plotter and the PC ArcInfo Starter Kit software. Two staff members from the department were trained in the use of the software during November 1989. Details of the costs are as follows:

Hardware (PC, digitiser, plotter)	R36 545
Software	R23 590
Training	R 2 500
Installation	R 1 000
Total	R63 635

The computer system was further upgraded at a cost of R6 113 in July 1993. At that stage purchases of computer-related equipment were motivated by the Head of Department and budgeted for accordingly. There was then no computer steering committee to advise departmental heads or the Municipality with regard to the choice. Computer equipment was purchased and ordered individually by each department. Moreover, there was no recognised standard in the Municipality for equipment purchases.

3.4.5 Initial Data Capture

The first phase of the implementation involved the capture of the cadastral attribute data for approximately 16 000 erven. This consisted of land use, erf size, erf number and zoning and was available in registers and from maps. The capture was carried out by the one full-time staff member and was finally completed in June 1992 after 18 months.

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[9] 16 Button mouse

The second phase involved the capture of the cadastral information, the defining of erf boundaries with regard to their spatial position. An attempt was made in 1990 to capture this data by digitising Survey-General Noting Sheets. These Noting Sheets are maps on which the boundaries of properties are annotated with reference to a grid based on the national co-ordinate system. This task was abandoned when it became impossible to edge match adjoining noting sheets. An A3 size digitiser was used for the task, and this proved impractical.

The data capture of the cadastral information using the co-ordinate data taken from approved Surveyor-General diagrams was initiated in June 1992, and this method was used until the complete cadastral data for the town was obtained by agreement with the telephone utility company (Telkom) in 1994. Paarl Municipality would supply the data capture office at Telkom with newly approved General-Plans and diagrams of erven in exchange for this digital cadastral base map. During this period, the attribute data were constantly updated and the coordinates of new erven were captured by entering co-ordinate data by hand.

Of the two staff members, only one continued to show an interest and continued to use the software and capture data. As part of the initial data capture, the local representative of the vendors who supplied the software assisted the department in the task of formulating a set of functional specifications (Appendix B).The author was part of this process. In 1992, other departments in the Municipality began to show an interest in acquiring a GIS and the Chief Internal Auditor was requested to compile a report on the progress made since the implementation of the GIS in the Department Planning and Development.

3.4.6 GIS Progress to 1992

In 1992, the Chief Internal Auditor presented a report to Council on various problems that were being experienced with the GIS. This report mentioned that because Paarl goes back three centuries, many of the town's erven had no up-to-date

coordinate information or none at all. This meant that erven might need to be surveyed to obtain this information. The report noted that an acceptable and efficient database structure still needed to be developed in order to make use of the full potential of the GIS system. Other departments such as the two engineering divisions, although not involved with the development of the GIS, also required cadastral data. It was recommended that a decision be taken on whether to implement and develop a corporate GIS in which case the Planning Department's system might require certain changes. Furthermore, if the corporate GIS was not attainable, the Town Planning Department should complete the GIS project as soon as possible in order to make efficient use of the equipment and resources. Assistance with the database design and data capture might further be required.

In 1992, the internal auditor[10] reported that in order for the system to be used to its full potential, it would need to be upgraded at great expense. Until then, R162 000,00 had already been spent. An additional amount of R60 000,00 in labour costs was still required to complete the cadastral base map in the following 18 months and even then it was uncertain whether the other departments would be able to use it. It was also stated that it would be necessary to establish a computer network.

The internal auditor also reported that, since the purchase of the GIS system in 1989, only limited progress was made with the implementation of the non-spatial data. During this time, the internal auditor alleged that little progress was made with the capture of spatial data.

In November 1992, a decision was taken by the Municipal Council to investigate the implementation of a corporate GIS in order to include all other departments[11].

[10] Chief Internal Auditors report 22/5/1992

[11] Finance Minutes Clause 15 dated 17/9/92

3.4.7 Summary and Analysis of Phase One

In summary, the author joined the organisation in December 1990, by which time the initial decision and purchase of the single GIS package had been made. However, the author was not aware of the GIS in his organisation until a few months later. The GIS was in its infancy at that stage. Meanwhile, the Head of Planning and Development who had championed the idea, had handed the duties of managing the system to a senior member of the Town Planning staff, who had no computer experience or knowledge of GIS. There was no formal strategy in place within the department to guide personnel in its use.

In the author's experience, these were experimental years. There was only one member of staff with limited GIS training who was required to perform other duties as well as GIS functions. The budget was limited and no upgrades to the software were purchased to maintain the system, so that it soon became outdated with the result that the vendors of the ArcInfo software had difficulty providing support. In the author's opinion the introduction of the GIS by the Head of Department was a "bold" step in view of the cultural profile of the organisation. The Town Engineer did not wish to become involved, this could have be seen as an "institutional threat" (Parker 1988:1). This department already had systems in place that worked and there was no need to change them then. At the end of the initial period, only one of the two members of staff sent for training was still interested in the use of GIS. This could be perceived as a "cognitive threat" where the fear of new technology overwhelms the incumbent to such an effect that the member withdraws (Parker 1988:2).

Drawbacks which, according to the author, were critical at this stage included the lack of a budget for continued financial support. The total expenditure between 1988 and 1993 on hardware was only about R73 000. In the author's experience there was no budgeting for GIS development. No official support was budgeted for although the vendors provided ad hoc assistance. The shortage of manpower and staff not fully

understanding the software and technical capabilities was also a problem. As proof of this was the fact that the Calcomp plotter was hardly ever used and was still in mint condition when it was made redundant a few years later. The initial methods to capture data were exploratory and when they did not work, another method was used.

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3.5 PHASE TWO - THE INVESTIGATION PERIOD 1993 - 1996

The main aim of Phase Two is to describe the decision to investigate GIS on a corporate level and the formation of steering committees to assist in the process. The needs assessments of the other departments were also investigated.

3.5.1 Corporate GIS Decision

In November 1992, the Council of the Municipality of Paarl decided to investigate the possibility of developing a corporate GIS according to actual needs[12]. Other Departments in the Municipality wished to computerise their information and an investigation was initiated to determine the optimum upgrade route for the Municipality of Paarl's Geographic Information System.

3.5.2 Computer Advisory Committee

A Computer Advisory Committee (CAC), a steering committee, was formed at the same time as this decision in order to formalise the management of the process and to ensure that cost-effective and user-oriented computer systems were developed. Based on the functional specification[13] already prepared for the Planning Department, the other departments prepared a needs assessment which included other system requirements apart from the spatial referenced geographic information.

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[12] Minutes of Finance Committee Clause (15) 1992-09-17

[13] Appendix B

3.5.3 Staff Layout in Department Planning and Development

Figure 6 below shows the staff layout in relation to the GIS section. The major change is that the line function of the GIS section reports directly to the GIS manager. This is still the case at present.

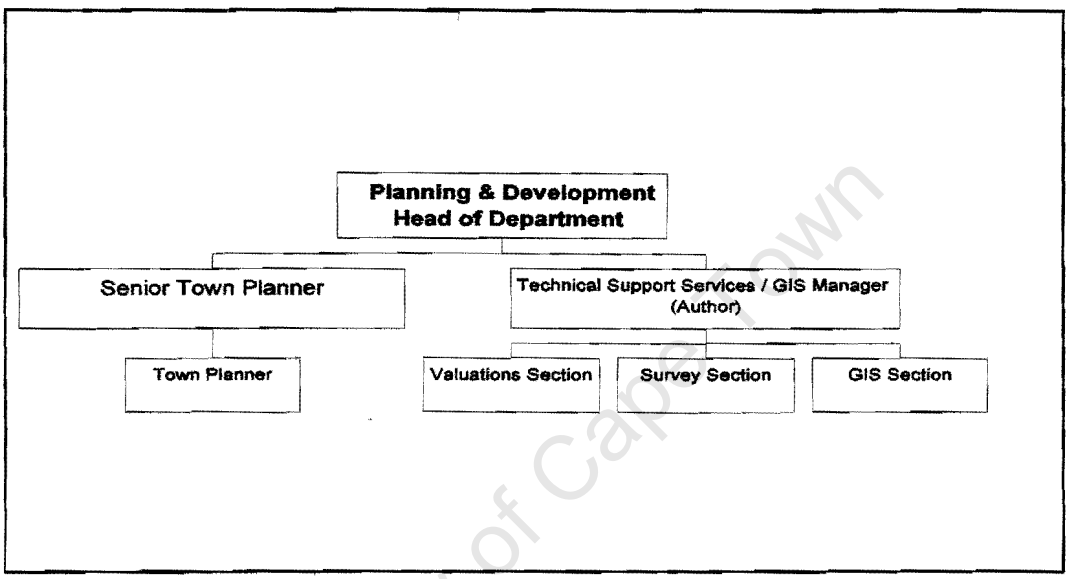

Figure 6 Layout of staff functions 1993-1999

3.5.4 Needs Assessment of Various Departments

(a) Town Engineer

The Town Engineer reported that the needs determination for his department could not be seen in isolation from the rest of the Municipality, the reason being that the identified needs were also primary functions in other departments or sections. It was hoped that the available technology would be used to make effective management decisions in a fast-changing environment.

The following spatial referenced services and general information were determined by the Town Engineer to be of priority and immediately available in digital format.

Services

- water network
- sewerage network
- storm water network
- pavement management system
- bridge control system
- electrical network
- Telkom services
- roads
- fire hydrants
- refuse removal routes
- trees on sidewalks and in parks
- traffic counts
- plan index
- public open space irrigation

Cadastral Data

- erf number
- street number
- owner and address
- tenant
- size of erf
- service history (water usage, etc)
- zoning
- building plans

(b) Town Engineer Electrical

The Town Engineer Electrical indicated that it was his department's priority to install the electrical network on the system and to be able to retrieve

information regarding the other services, such as water, sewerage and Telkom telephone cables.

(c) Health Department

The Health Department reported that it was evident that they were not keeping pace with computer technology and were developing in isolation from the rest of the Municipality in terms of computer-orientated management, planning and use. Only manual filing systems were in place. The department could therefore benefit from the GIS.

3.5.5 Recommendation of Corporate GIS

In December 1992, having discussed the needs assessments and reports from the Electrical-, Town Engineer-, and Health Departments, the CAC recommended that a corporate GIS be developed for the Municipality in the shortest possible time.

The Committee recommended that the development of the GIS should be according to the following guidelines, that:

(a) The system must be corporate. In other words basic information such as situation and zoning of erven, ownership, addresses and basic infrastructure networks was required by all departments. The most effective way to ensure integrity and prevent duplication was to centralise data collection in the department where it had its source.

(b) A network of micro-computers should be established to ensure that information was connected between departments, and each department would have more than one computer connected to the network.

(c) The computer network should be able to communicate with the main-frame

computer because there was a considerable amount of data already in the existing computer system.

(d) The GIS project should be completed in phases according to a predetermined plan.

(e) The project must show results within 12 to 18 months.

The executive committee approved these recommendations in March 1993 and the necessary GIS implementation was started.

3.5.6 GIS Implementation Strategy

In the author's experience, the CAC was not in a position to recommend a specific GIS/CAD software package as clarity on certain issues still needed to be obtained. The CAC nevertheless, recommended that the following steps, investigations and preparation work be adopted:

(a) Orientation of users

The Secretary of the Committee would provide each department with an information sheet in order to explain the broad concepts.

(b) Assistance from Division Town Planning

The Town Planner was already in the process of capturing erven with the help of ArcInfo GIS, and the capture of the cadastral data was a starting point as well as a prerequisite for the further development of the GIS. It was therefore important that the process be speeded up and that funds be made available so that the Town Planner could finalise the project within four to six months, or earlier. If necessary, the task was to be contracted out.

(c) Meetings with ArcInfo Consultants

The representative of ArcInfo was asked to provide information on the upgrading of the existing GIS system and operation in a network environment with regard to the needs of the other departments. It was also important to obtain confirmation that all the existing coordinate data could be transferred to another GIS system should Council decide not to purchase further ArcInfo software in the future.

(d) Visits to other GIS sites

The Committee decided to visit two or three municipalities with existing GIS capabilities in order to obtain information on the pros and cons of features of certain software packages. Demonstrations of certain packages should also be arranged.

(e) Availability of data

The capture and editing of input data could be time-consuming. When data was captured it should be in the correct format, and all departments were therefore requested to investigate what elements of the total global GIS data model were available and to what level of accuracy the coordinate data should be captured.

3.5.7 GIS Implementation Strategy Results

The GIS implementation strategy was followed up with a report on the following issues.

(a) Meeting with Consultants

In February 1993, the representative of the ArcInfo software was invited to address the CAC[14]. He reported that certain steps should be completed

[14] Minutes of CAC Meeting 1993-02-11

before the technical design of a GIS could be started:

- Each department should carry out a needs assessment.
- A certain member of staff should coordinate the task.
- It should be decided which needs are common and which are unique.
- A functional specification should be written up in which each request is described in detail. Each department should do its own research and the CAC would arrange interviews with each one to synchronise similar needs.
- A project proposal for GIS should be formulated and presented to management.
- When the project was approved, a specific individual, or preferably the steering committee, must coordinate and monitor it.

(b) Visits to other GIS sites

Cape Town Municipality was visited with a view to gaining more knowledge of the workings and nature of a GIS. Other sites included a visit and demonstration of a Computer Aided Design (CAD) package used at Goodwood Municipality. This meeting was arranged by the Vector Group of companies. The Municipalities of Parow and Wellington were also visited in order to gain more knowledge of alternative products.

3.5.8 Limited Implementation Strategy

The corporate GIS project was approved in principle and it was decided to follow a limited implementation strategy. The question of responsibility for judging the merits of project proposals then arose. After discussions with the Department Heads and the Town Clerk, it was decided that the CAC would investigate the merits of each application and make recommendations to senior management.

In order to inform management and proceed with the investigation, the CAC decided:

(a) To invite the ArcInfo system specialist to evaluate the existing GIS system. The aim this evaluation was to acquire expert opinion with regard to the strong and weak points and to ascertain if the system could serve as a corporate basis in a network environment. This was deemed to be urgent as it would influence the choice of a GIS or CAD system and the method for capturing coordinate data[15].

(b) To invite the ArcInfo consultants to present a executive (non-technical) information seminar to top management.

3.5.9 Problems in GIS Identified by Consultant

The ArcInfo consultants, Geographic Information Management Systems (GIMS), were requested to report and evaluate the system and to prepare a written report which is summarised as follows.

(a) The system was initially operated and managed by the Planning Department. One person was allocated to the operation of the GIS, another allocated to the management of the system. The operational person did not report to the GIS Manager.

(b) Operators and managers were not dedicated to the task of cadastral data capture and had many other tasks to attend to.

(c) The Municipality did not have any local area network which would allow different computers to communicate with each other and share information.

GIMS concluded in their report that, using the data capture rates and assuming that

[15] Minutes CAC Meeting 1993/4/1

the Municipality did not increase its GIS resources, the task of capturing the complete cadastral spatial database from survey diagrams would take in the region of six and a half years. During this period, no other spatial data could be captured. The implication was that it would not be possible to increase the data capture speeds without increasing the number of computer workstations and operators.

3.5.10 GIS Requirements Determined by Consultants

The GIS requirements in July 1994 were determined by GIMS[16] at a conceptual level by interviewing relevant staff requiring GIS capabilities. From these interviews, two primary requirements were identified:

(a) The spatial database needed to be captured at a faster rate and should include features other than cadastral data. This requirement was for query purposes rather than design.

(b) The information captured should be made available to decision makers and management staff using a technology that did not require any specialist training and was easy to use.

3.5.11 GIS Recommendations by Consultants

The consultants made the following recommendations:

- Paarl Municipality should develop GIS standards which should include hardware, software, communications, data and operations. These standards should apply to the Municipality as a whole.
- A computer network should be installed to allow the sharing of information and resources. The network should be stable and adhere to international standards.

[16] GIMS Report October 1993

- Managers and decision makers should attend a computer-awareness course.
- Managers and people wishing to access the spatial information should be given a suitably configured computer connected to the network and running ArcView. The implementation should be phased , that is one or two individuals at a time.
- The Departments wishing to commence capturing spatial information should be provided with a suitably configured computer and PC ArcInfo and should operate and capture according to the Paarl information standards. The new data-capture people should also receive the necessary training.
- A lower accuracy version of the Cadastral database should be developed in the short term. It is probably cost-justified to offer the creation of this database out on contract. The high resolution version of the database should be re-evaluated and, if required, should continue to be captured as was currently the situation.
- The existing PC ArcInfo software should be upgraded to the most current version so that it can take advantage of the more modern computer technology and the users will benefit from the additional functionality.
- The management of the GIS tasks should be planned and managed carefully. All development should follow strict standards.

3.5.12 Proposed CAD System for the Municipality

During the process of investigating the GIS, members of the CAC mentioned that CAD might be an alternative option to GIS. The Committee was of the opinion that a corporate CAD system would meet the immediate needs of the technical departments and recommended that a CAD package that could function in a network environment be purchased[17]. There did not appear to be a need for a complete GIS system at that stage. Once the CAD system had been implemented successfully, the method to upgrade it to a full GIS system could then be investigated. The feeling at these meetings were that various CAD packages should rather be evaluated.

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[17] Minutes CAC Meeting 1993/4/30

It was also mentioned that the proposed CAD package should be compatible with ArcInfo to ensure that data could be transferred easily between the systems. ArcInfo were marketing a system known as ArcCAD.

In June 1993, it was reported that the Executive and Finance Committees had approved the corporate GIS and that purposeful planning could be started. The Executive Committee then requested that the CAC prepare a further motivation for their proposal of why a CAD should be implemented[18] and that demonstrations of a CAD be presented by ArcInfo to the Departments of the Town Engineer and Town Electrical Engineer. At that time, there appeared to be two schools of thought: One for CAD, and the other for GIS.

The Executive Committee decided in March 1993 that a corporate GIS be developed for the Municipality and with the following guidelines[19]:

- The system must be corporate.
- Every department must have access to the corporate database and a computer network should therefore be installed.
- The GIS should be implemented in phases according to a preplanned strategy.

The decision having been taken, information pertaining to possible implementation strategy was gathered and this was achieved by means of attending demonstrations and arranging visits to other institutions. The CAC still believed the CAD was the best option to pursue. As a starting point, it was decided to advise the Executive Committee to purchase a CAD system which could later be upgraded to a full GIS. The reason for this approach was that before a GIS could be developed, data had first to be collected and edited and this could be done by CAD.

[18] Memorandum from Town Secretary to CAC 1993/8/10

[19] Executive Committee Meeting Minutes 1993/3/16

3.5.13 Reasons for CAD

The rationale for the CAC's decision was that:

- It was clearly evident that an instant GIS could not be purchased.
- A GIS is only the end product of a well structured and controlled system development process in which the users and technical computer personnel are closely involved . (The development of a full GIS could take from three to five years.)
- It is the user's responsibility, at the starting point of any system development to specify the needs so that the aims are clear to the computer personnel who have to develop the data basis.
- The Municipality was not prepared or at a stage which was geared for a full GIS development. This was because staff had little experience with the electronic manipulation of geographic data. With the possible exception of the Town Planning Department, the other departments' requirements needed to be clarified.
- Without a so-called functional specification from each department, it would be almost impossible to formulate a data structure for a corporate GIS.

3.5.14 Recommendation for CAD

It was therefore decided that a CAD-based system should just be established at the Municipality. In time, the GIS needs would crystalise and the necessary system changes could be made to accommodate them. The CAD would need to be completely compatible with the GIS software if and when the Municipality was ready to upgrade.

3.5.15 Choice of GIS/CAD Product

The CAC therefore recommended that:

(a) A GIS be developed in phases for the Municipality. The first phase would be the capture and editing of data with the help of CAD software. After the GIS needs had been assessed and the data structure formulated, the project could move to the GIS phase.

(b) Several CAD software packages be purchased in order to commence capturing and editing coordinate data. The Town Planning Department was to provide the basis plan in electronic format.

(c) The CAC arrange separate meetings and information sessions with the Town Planner, the Town Engineer and the Town Electrical Engineer in order to obtain more detailed information so as to motivate their position why CAD should be used.

(d) A Data Administrator in the Department Town Treasurer be appointed to assume responsibility for the detail planning, development and coordinating of the GIS project.

In December 1993, a request by the Town Engineer to purchase a CAD computer and software was postponed until March of the following year because detail planning was incomplete.

The Executive Committee considered and approved the items as set out in paragraphs (a) to (d) with the proviso that representatives from the two Engineering Departments be also represented on the CAC and that the author's appointment as the GIS Manager[20] be negotiated.

3.5.16 Executive Seminar Held

The top management of Paarl Municipality attended an GIS technology update

[20] Memorandum To CAC from Town Secretary 1993/12/21 ref O2/2

presented by the vendors of ArcInfo. This was a two-hour power slide presentation that explained the benefits and use of GIS in the workplace. The management committee then requested the CAC to motivate further why the CAD should initially be purchased in place of a GIS. The impression had been created that CAD was the correct route to follow.

3.5.17 Further Issues Raised by Computer Steering Committee

In May 1994 the following questions were still being asked at CAC meetings:

- Does the Municipality need GIS ?
- To what level would GIS be used?
- What would the GIS be used for?

The CAC committee then identified the following problems.

(a) The cadastral base map consisted of registered and unregistered properties and the Treasury system was based on registered properties only.

(b) The capture of services from the engineering service plans required up-to-date plans which did not exist.

(c) Plans could be digitised or scanned but no method could be identified to be most suitable.

(d) Discussions were held with Telkom to obtain cadastral data base and exchange data, but decisions had not been finalised.

It was therefore decided that the following functions were required:

- To acquire all missing cadastral information
- To maintain current cadastral data

- To produce plans indicating registered properties
- To produce a more detailed property record
- To capture information so that it can be used
- To capture Engineering services
- To acquire Telkom services network
- To digitise or scan plans
- To produce plans and refer to engineers for control purposes and checking
- To control all data entering the system.

3.5.18 Progress Report and Follow-Up to Implementation Strategy

In July 1994, the CAC submitted a progress report[21] in which it was stated that during the last months three possible systems were investigated, namely PC ArcInfo, Allymap[22] and Regis. It was apparent that the new generation PC ArcInfo software complied with the needs of all departments. The objections and criticism previously attached to ArcInfo was mainly based on its price and user friendliness. The new version was an improvement in this respect and the price more market-related.

Other aspects that still needed to be cleared before a final decision was taken regarding the specific purchase, was the issue of service and maintenance in the Western Cape. A final decision was expected in August from the vendors in this regard.

3.5.19 Final Selection of Product

Due to competition between suppliers, the costs of GIS and CAD products had in the meantime fallen while the quality of CAD products had improved. Many different systems were now available on the market. The CAC and departments obtained

[21] Memorandum CAC to Town Secretary 1994/7/27

[22] Product by Allyson Lawless

information on Regis and ArcInfo as both these systems were well-known and complied with the requirements of a full GIS.

Nevertheless it was decided that the ArcInfo product be selected because:

(a) There was then a limited CAD/GIS market and few products complied with the departments requirements.

(b) In 1989, there were major quality differences between the cheaper CAD systems and GIS systems.

(c) Limited funds, as well as a limited knowledge of the complexity and potential usefulness of GIS systems, led to a cautious attitude being adopted. The ArcInfo (Starter Kit) would therefore be a less costly beginning.

(d) The ArcInfo (Starter Kit) could be used to promote computer literacy and to capture data.

3.5.20 Report on Proposed Implementation Phases GIS

In July 1994, the GIS Manager (GIS) submitted a report regarding the implementation of a GIS at Paarl Municipality. This described the methodology required for planning. The report was, in brief, to investigate and report back to the CAC on the best strategy to adopt for the implementation of a corporate GIS and five phases were planned[23]:

Phase 1

Approval for the proposal and funding of the project

Phase 2

Planning stage and appointment of a steering committee (one person as data manager); a small budget to be set up for amounts needed at short notice

[23]Memorandum from CAC 1994/7/15

Phase 3a

Spatial needs assessment

Phase 3b

Detailed needs assessment

Phase 4

Detailed project proposal, limitation and risks, to accept or reject

Personnel and financial implications

Phase 5

Decision on hardware and software

Project initiation / contract out

3.5.21 Progress of Implementation as at July 1994

Phase 1 and part of Phase 2 had already been completed. Part of the needs assessment of Phase 3 had also been completed whereas Phase 5 had in part been addressed although no benchmarks or tender specifications had been set for possible equipment. The report further stated that GIS system planning could not be seen in isolation from organisational issues that were evident in the normal mundane routine of the work environment. It would take a major paradigm 'mind set' shift to implement.

From the outset users needed to be aware that the costs of successful implementation and effective use of a software package extended far beyond the actual cost of the computer package. Other particularly expensive factors that should be budgeted for were:

- Time spent to access users' needs
- Visits to software houses and time spent attending demonstrations

- Meetings, feedback and discussions regarding relevant packages
- Implementation, testing and conversion of data
- Training
- Development of documentation.

3.5.22 Organisational Issues in GIS Implementation

Although the Municipality had taken the initiative to approve a corporate GIS, there were still many issues to be raised regarding inter-organisational arrangements before any money could be spent. It was therefore crucial that a proper methodology be followed. Three departments, Engineering, Electrical and Town Planning were identified as GIS sites. Due to the urgency regarding the implementation and preparation of reports, it was decided to concentrate only on those departments in order to determine needs. A needs assessment questionnaire (see Appendix F) was drawn up, and approximately ten personnel in each of the identified departments were interviewed in July 1994.

3.5.23 Needs Assessment Regarding GIS Use

A questionnaire to develop a needs assessment was drawn up and various staff members of the three departments were interviewed regarding their work (Appendix F).

Briefly, some of the following points were noted:

- Employees were not aware of a vision or mission statement
- Technological awareness was poor
- There was much duplication regarding updating of maps
- Time delays existed in obtaining information
- Accuracy problems existed with available information
- Information was not easily accessible
- There was no transparency in information

- Poor information resulted in delays in work due to breakages in other services
- Maps were used to make decisions and convey information.

3.5.24 Comments on Needs Assessment

From the problem recognition point of view, there appeared to be a definite need for a GIS. However, the poor accuracy of the spatial information regarding services would unfortunately only be perpetuated in a GIS. This information would need to be recorded far more accurately if the information was to be of any value. Although a CAD had been recommended as an initial phase to start collecting service data, it was important to remember that the capture phase was not simply the re-drawing of paper plans in a CAD system. It was rather the building up of a complete inventory of each item with all known attributes for the following purposes:

- To establish the exact location in relation to other services
- To export to design software for analysis of existing conditions and planned extensions
- To import design results for easier interpretation of anomalies
- To schedule quantities for various statistical reports needed annually
- To locate and view maintenance activities
- To study consumption and user demands by report and graphical display.

3.5.25 Recommendations From Needs Assessment

It was therefore concluded that it might not be practical to handle this project strictly theoretically or in text-book fashion, bearing in mind that there was already a GIS system which could possibly be upgraded. Moreover, the staff already had a rough concept of what was involved in the process.

The primary aim was therefore to implement a GIS for the Municipality for greater ease in obtaining information and to improve communication between departments.

It was mentioned that computerisation, merely for the automation of a task, had a cost benefit ratio of 1:1 and thus no cost advantages would be achieved. However, when integration of data for different uses takes place, the cost benefit ratio increases and the benefits outweigh the costs.

3.5.26 User Groups , Orientation of Users

In order to remain up to date with the market and technology, it was desirable that staff members be afforded the opportunity to attend seminars and GIS presentations. Both Regis and ArcInfo offered well organised user groups that met on a regular basis and it was important that these group meeting be attended in order to exchange ideas and solve problems. A subscription to one of the GIS magazines was also recommended in order to keep abreast with important international issues.

3.5.27 Recommendation Process For Purchase of Equipment

(a) It was noted that ArcInfo were world leaders in the field of GIS expertise. Three GIS software packages Allymap, Regis and ArcInfo were demonstrated at the offices of the Municipality. ArcInfo presented new windows-based technology which was far more user friendly than the initial software released and competitively priced.

(b) It was reported that it would be advantageous to learn the new technology. Experience obtained from it could then be used to make slight adjustments later. The idea was to " Move in a zig zag path."[24]

(c) Certain shortcomings had meanwhile been identified with the existing version of PC ArcInfo. It could not be used on a network, neither was there a maintenance contract. As a result there was no vendor support and the version was never upgraded to take advantage of the latest technology.

[24] Authors notes from CAC meetings 1994.

3.5.28 Recommendation of ArcInfo Product, 1995

It was therefore recommended that the PC ArcInfo system be retained but that it be upgraded to the latest windows version and that a maintenance contract be taken out. It was mentioned that the discipline of the vendor would result in better project support. The supplier of ArcInfo offered a hotline telephone support to clients on a contract.

At previous CAC meetings, it was agreed that the decision to buy hardware and software was being taken early in the GIS implementation cycle and not strictly according to theoretical norms. This was because the Department Planning and Development already had an ArcInfo system installed from which experience had been gained. It was also well known that ArcInfo was a reliable vendor and supplier and a world leader in the GIS field. Moreover, the company had a development strategy with regard to GIS products.

With any purchase, there was some risk and slight adjustments would have to be made later. The computer industry was dynamic and it was impossible to predict exactly and with any certainty what technological advances would be made in the future.

GIMS, in a demonstration of ArcInfo, indicated that the basic requirement demanded that the system be easy to use and not command-driven. It needed to be up-and-running almost immediately. The emphasis in the work place was not design but rather on drawing capabilities.

The following issues still had to be addressed:

- Maintenance contracts
- Information on upgrading

- ArcInfo: yes or no?
- Third party packages
- General.

(a) Maintenance Contracts

It had been intimated that the suppliers of ArcInfo, GIMS were unable to guarantee software support other than by telephone. Being Johannesburg based, they had closed their Cape Town office and could not find a member of staff to manage it. Regis, on the other hand was based in Cape Town and able to give support on site.

Software support or maintenance, as it is more commonly known, is a means of protecting an organisation's investment. Furthermore, having a maintenance contract ensures that the organisation has the latest version of the software and any problems are dealt with promptly. Such a contract can also influence the performance of the software. Maintenance disciplines the vendor to provide good service and maintain contact with the client base.

The maintenance can be offered through a hotline via the telephone to the vendor's office or by means of a computer link. The computer link comes in two forms, either Internet or a modem link via the normal telephone line and PC using special software such as "PC Anywhere". Both suppliers , GIMS and Regis, could offer that service although it was never tested to see if files could be transferred. Both suppliers agreed that the system worked well.

The problem with a maintenance contract is that if a decision is made not to purchase a contract, there is still an obligation to purchase all the upgrades at the same rate as for a contract. To upgrade the existing PC ArcInfo system in the Planning Department to the latest version would have cost more than the cost to purchase of the latest version of ArcInfo 3.4.2d (R22 000).

(b) Upgrade of Software

The difference in prices between vendors was formerly cause for concern. At this stage (1994) the prices were market-related and in all probability indicated the competitive nature that suppliers had been forced into with their products. More important was the support and development strategy that the company offered.

The system in use in the Planning Department was PC ArcInfo version 3.1 which was more than four years old and had never been upgraded. This version could not operate in a windows environment and would cost more to upgrade than to replace with the latest version.

(c) Choice of Vendor

The developers of ArcInfo, Environmental Systems Research Institute (ESRI) were world leaders in GIS development. ArcInfo had become the market leader and almost a standard in GIS technologies in the USA. With the demise of sanctions, this product and support were now freely available in South Africa. The system could operate on two platforms, namely the PC version using DOS and Windows 3.1 or the Sun work station that used a Unix operating system. The cost of the latter system was approximately R121 000 for the first licence. As these costs were prohibitive, this system was not investigated further.

Regis, on the other hand operated on a PC platform and used Windows NT operating system. This was a recent development and replaced the conventional DOS operating system.

As part of the investigation into the selection of a software package, a list of users was obtained from both Regis and ArcInfo regarding sites where their

software had been installed. These lists reported where business had been done rather than indicating an organisational preference to software. Some sites used both Regis and ArcInfo software.

Many of the sites were single stand-alone PCs within the organisation and were not on a corporate level. Five Regis sites in and around Cape Town were contacted for comment in September 1994, four of which had stand-alone PCs. It was noted that users were generally reluctant to provide information with regard to the implementation. One user, who was using Regis on a network, was experiencing problems with regard to response times. Another of the sites, where a study had been carried out, was not fully implemented and was not successfully managed due to inadequate planning and under-staffing. It was found that ArcInfo was mainly being used in an Unix environment which required expensive workstation platforms on which to operate.

It was pointed out that Regis was developed by a small group of people (Computer Foundation) in South Africa whereas ArcInfo had been developed by ESRI, one of the world leaders in GIS.

d) Additional Requirements

The Town Electrical Engineer required specialist software in order to model electrical networks on a graphical interface and this was only available in the Unix format. It was decided that the selection of third party packages could be postponed so as not to delay the GIS implementation process.

e) General

After concluding an agreement to exchange data, all the cadastral data for the Paarl Municipal area was received from Telkom. This data was to be

converted and edited from their computer system to an ArcInfo format.

3.5.29 Preferred Supplier and Decision

In December 1994, Council accepted the recommendation that the ArcInfo system be purchased.[25] The purchased software was expected to be delivered in May 1995, and on-site training for six people was to be arranged.

The CAC was convinced that, of the three systems viewed, ArcInfo offered the best value for money. It appeared that the new generation ArcInfo software complied with the requirements of all the departments and that the price of the product was market related. The Steering Committee was also satisfied that the system support and maintenance could be provided on a continuous basis.

The Steering Committee therefore advised that:

- The present system be upgraded and the latest version of PC ArcInfo be purchased for the three departments
- The cadastral database of Paarl be obtained from Telkom with whom the Municipality had been negotiating
- A maintenance contract for PC ArcInfo be taken out
- The necessary computer workstations be purchased
- At least one person assigned to operate the workstation in each of the departments be appointed to receive training in the use of the software and to serve as the liaison official with the GIS project manager during the implementation of the system
- The people nominated be allowed to attend GIS courses and seminars where necessary
- The existing duties of the project manager for the GIS be re-arranged so that that person can give the necessary attention to development and

[25] Finance Minutes Clause 58 dated 1/12/94.

co-ordinating the GIS project.

It was noted that the non-cadastral information, such as sewerage-water pipes and other networks, was not in the correct format to be captured in a GIS as this information was entirely on paper plans. It was therefore proposed that this aspect be investigated to establish the most cost-effective method to capture this data (that is new digital aerial photography and scanning of existing aerial photographs).

3.5.30 Data Capture

One of the main problems encountered during the implementation of the GIS was the capture of data. During the initial stages and planning for data capture various organisations were requested to capture service data on a quotation basis, and the following are recorded experiences of some of the events.

(a) Organisation X

This firm of consulting engineers was involved in the upgrading of engineering services for a township. As it had all the engineering drawings and service plans on CAD, it was decided to appoint the firm to capture all these services in an ArcInfo format. Normal tender conditions were dispensed with for these reasons. The appointment was confirmed in 1995 and the completed data only handed over in April 1996. Certain details needed to be corrected which were eventually required to be finalised by Municipal staff as no progress was made with the consultant.

(b) Organisation Y

Details of the services in the Municipality are recorded on topographical plans. Where new extensions are constructed as built service plans became available. However as certain areas of the town are so old, no plans exist. In one area, where there were such plans, it was decided to contract the digitising and capture of the plans out to a consultant. The firm was given a

set of as-built plans as well as a mandate to capture and prepare in ArcInfo format a data capture proposal to the value of R5000. This exercise was carried out to ascertain the work that could be done with limited finance. Although the services on the plans were captured, certain of the normal procedures of data validity were not completed.

3.5.31 Computer Peripherals, A0 Printer Purchased

In April 1996, an AO inkjet printer was purchased to replace the pen plotter which was never really put to full operational use. The pen plotter could no longer handle the software and was resulting in frustration in terms of time and productivity trying to figure out the problem. There appeared to be no driver program available or it was too costly to warrant buying one. It was therefore decided to purchase something compatible with present software.

In March 1996, the Town Engineer requested that an A0 digitising tablet be purchased to augment the data capture as that Department was in the process of capturing data for the GIS system. Many large plans indicated services which could be included in the data base and the digitiser be used in order to capture this data in-house.

3.5.32 Data Archiving

Data was backed up on the server daily and downloaded to tape streamers on a weekly basis. Should a problem occur and data needed to be retrieved, the correct tape had to be located and placed on the server. GIS data requires that data sets be quickly and easily viewed without going through this process. It was thus suggested that data archiving to CD be used.

3.5.33 CAD Package Purchase

In August 1996, the Town Engineer requested permission to purchase a new CAD package on the market. The CAC meanwhile, supported the idea that when new software appeared on the market that addressed a specific need, it be evaluated. However, it was important to realise that the upgrading of programmes also affected other users of existing software. If a decision was taken to upgrade, then all users should upgrade. The GIS Manger was asked to investigate whether the new programme fulfilled the requirements and if it was necessary to upgrade. Staff did not report back and as a result the package was never purchased.

3.5.34 Digitising Problems

The GIS Manager reported that in order to digitise in-house, there was a need for equipment, space and personnel. Equipment needed to be purchased and maintained. For GIS purposes, a A0 double precision digitiser was required and a maintenance contract to test and calibrate the machine on a regular basis needed to be negotiated. If the digitiser was to be used continuously, a separate PC should be acquired. Sufficient office space for the digitising environment and equipment was also necessary.

In addition dedicated personnel were required to capture the data. If additional staff were employed for this purpose, then extra expense would be incurred. On the other hand, if present employees undertook the task, it would be done at the cost of other work. There would also be no set time limit in which to complete the work. As a result, other tasks became more important and took precedent eventually. Staff also went on leave or were sick which could result in uncompleted work. Staff lost enthusiasm as the job progressed as it became mundane and less challenging.

The advantages for sub-contracting out were that the Municipality did not have to purchase or maintain equipment. Reputable organisations had the correct equipment,

logistics and expert staff to digitise, all of which could be specified in contract conditions. These organisations specialised in this type of work with the result that data was available much faster and the cost of the delay was much less.

These organisations were geared to capturing data, whereas the Town Engineer was more concerned with querying the data. The sub-contractor could be set a time limit in which to complete the work and any errors and problems in the data had to be rectified at their expense.

In an organisation with limited GIS staff and available resources it would not be viable for any personnel to be dedicated to full-time data capture. The present staff were required to manage, plan and query data. Should others be employed to digitise on a large scale, certain functions of the this work would eventually not be completed. Due to the considerable amount of data required to be captured, the cost of delays would be compounded. It was therefore recommended that organisations with the correct expertise, equipment and knowledge, who are able to capture data on a system compatible with ArcInfo, should be contracted to do the work.

In 1997, a six-month contract was awarded to Ninham Shand to digitise all the 1:1000 scale topographical plans on which service data had been annotated. This firm was appointed after obtaining three quotations based on an example of the work to be done.

3.5.35 Computer Expansion

Between May and December 1995, the computer network was expanded and computers upgraded, and inkjet printers replaced dot matrix printers en masse. The capture of data was experimented with and courses in ArcInfo were attended. The attendance of these courses was motivated in order to ensure optimum use of the GIS. However because training courses were expensive the CAC advised that alternative arrangements be investigated. ArcView software was made available

through ESRI and this appeared to revolutionise the use of ArcInfo.

3.5.36 Software Support Agreement

The software support agreement was applicable on a yearly basis which did not coincide with the organisation's financial year. This resulted in there not always being sufficient funds available to pay these accounts in total and these could only be paid pro rata to help spread the cost between financial years.

However the annual support contract entitled the user to unlimited telephone support on the software program, discount on software upgrades and special product announcements.

3.5.37 Corporate Budgeting

In August 1996, the CAC reported that the successful implementation of GIS should be the primary focus when budgeting proposals for technical systems were being considered. As the GIS and other computer systems were developed, there were common points of interest between the technical and Treasury systems, such as exchange of data. It therefore had become increasingly important to ensure that the computer-based information system was managed and controlled on a corporate level.

3.5.38 Summary Phase Two

During the period of investigation (1993-1996) Council took the decision to use GIS on a corporate level. The equipment was purchased and members of staff received training in the use of the software. The author was also requested to undertake the role of GIS Manager although this was not his sole responsibility. He also managed the Valuation, Survey and Technical Support Services Section as part of his job description.

Purchases and other motivations were handled through the CAC made up of technical staff and the Head of Data Processing (IT). In the author's experience, the committee functioned well, having regular meetings which were minuted. These meetings were additional to the author's GIS meetings. Matters discussed at the CAC were not only GIS but also included all IT issues.

The author found, this phase of the implementation to be was more about problem-solving than data capture. The three departments involved had upgraded the software to PC ArcInfo 3.5 and ArcView3 and quotations for contracts were obtained from various companies for data capture. These companies were also using the work to gain GIS experience, and as proved to be the case, they were often not sure what to do. It appeared that the level of expertise with regard to municipal requirements was also lacking in the private sector. The choice of the equipment and discussions regarding GIS from 1993 to 1995 seemed to be unnecessarily protracted. This may have been due to the process involved in obtaining approval from Council. Staff were always keen to purchase the latest software or hardware without the necessary motivation. On occasion, the author had to advise Council not to consider requests for additional equipment such as the AO digitiser and CAD packages.

Although data could be accessed from the main frame via terminals, the data could not be downloaded to the GIS without a written request to the Chief Data Processor. There was a lapse between the time a request was submitted and when the data was made available. This was due to programs needing to be written in order to retrieve this information from the main frame. Each of the three departments still only had one staff member involved with the GIS. In June 1996, it was reported at the interdepartmental GIS meeting that other duties were disrupting GIS work[26]. Staff had already mentioned at previous meetings[27] that GIS work was not progressing due to other workloads and this problem was reiterated at subsequent meetings.

[26] Minutes GIS Interdepartmental Meeting 1996/7/1

[27] Minutes GIS meeting 1995/8/7

The expenditure during this four-year period on hardware and software as well as data capture contracted out was about R242,000.

The Departments of the Town Engineer and Town Electrical Engineer each nominated a person within their departments to attend to their GIS requirements. The GIS work was added to their other work and no new staff were employed. In figure 7 the overall GIS operator functions (shown in red) within the municipal setup are shown. This figure excludes the other departments and sections not involved in the GIS. The GIS Manager is in the Department Town Planning and Development. The Town Engineer and Town Electrical Engineer each have a GIS operator who reports to an assistant.

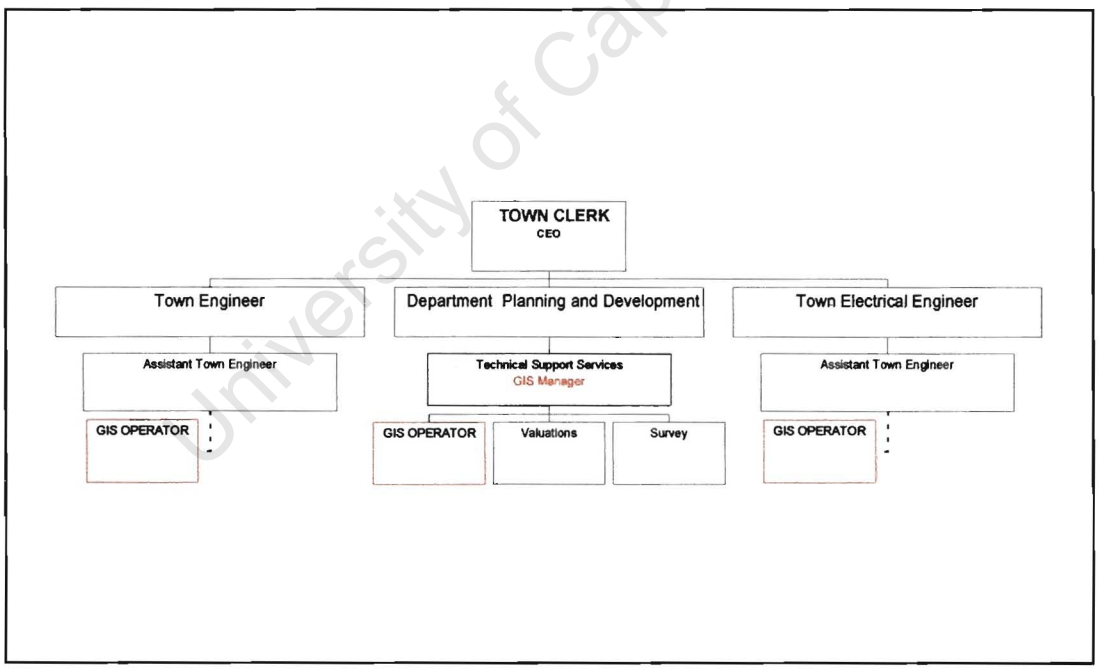

Figure 7 Layout of overall GIS functions 1993-1999

3.6 PHASE THREE - THE IMPLEMENTATION PERIOD 1997 - 1999

In February 1997, the Internal Auditor, who was also the secretary of the CAC, prepared a report[28] on the computerisation of Paarl Municipality. This included certain questions with regard to the present and future use of GIS in the organisation.

- The basic infrastructure and equipment had been purchased and the CAC was of the opinion that immediate attention must be given to data capture.
- The Heads Committee was recommended, on the advice of the CAC, to prepare a corporate budget. This would put the CAC and the GIS Manager or in a better managerial position in order to accomplish goals.

In January 1997, the Town Secretary requested the CAC to prepare a report on the future vision of the GIS system at the Municipality. The Heads Committee appointed the Head of the Health Department as chairman of the CAC.

3.6.1 Year 2000 Masterplan, Town Engineer

The Town Engineer prepared a Year 2000 Masterplan in 1997 which made the following recommendations:

- That the 1:10 000 topographical sheets need to be digitised or scanned and the data captured of these images
- That network security must be handled by the IT Department
- That standards be set for all attributes and spatial data and how to capture it.
- That staff set up the program, go through course material and familiarise themselves with equipment and manuals.
- That the data base be designed and structured.
- That the naming convention be consistent across the whole field.
- That a data dictionary be established.

[28] Memorandum from Chief Internal Auditor 1997/2/26

- That the collection for updating data be centralised.

3.6.2 Budget Issues Regarding Regulations

Purchases were regulated according to certain procedures as set out in the Municipal Ordinance 20 of 1974 as well as on instructions of the Auditor General. Requests for equipment which were of a capital nature and which could not be purchased during a current financial year on the capital or operating budget had to be proposed six to eight months in advance of the new budget. These included new computers as well as amounts for upgrades and data capture. Items for the whole Municipality from all the departments were added and a process of prioritising followed which saw items deleted from the proposed budget because of a lack of funds. Items that survived the various rounds eventually appeared on the capital expenditure for the next financial year. If the total purchase price of any item or group of items exceeded a certain amount, they had be put out to tender in terms of the Auditor General's regulations, unless Council was given reasons why calling for tenders was not necessary.

The problems with this process with regard to GIS were that there were delays in purchasing equipment. All tender recommendations were also required to be reported to Council for approval. In other words if items of a capital nature needed to go out to tender, they had to be specified in detail so as to avoid inferior goods or services being offered at low prices, which, in the author's observation, could not sustain the vendor. It was important to prevent inferior equipment being added to sophisticated computer networks. It was preferable to write the tender in such a way so as to prevent this. Council was not obliged to accept a department's recommendation regarding the selection of equipment. The hardware to run the GIS should not be off-the-shelf items with no reliable back-up.

Departments budgeted separately for GIS-related equipment and this procedure resulted in problems for the implementation where other equipment was budgeted for in favour of important GIS items which should have had a higher priority. This

has resulted for instance in GIS development being delayed and postponed because of a shortage of funds or mis-allocation of funds. This problem had, however been addressed and a consolidated computer budget involving all departments was now prepared for approval. Any deletions or scrapping of items would be referred back to the CAC who would then decide which on priorities. The Committee could only comment on the equipment and not the financial aspect. The function of the department heads was to ensure there were sufficient funds.

3.6.3 New Staff

In early 1997, the GIS operator in the Department Planning and Development resigned. This post was filled three months later by an incumbent with tertiary qualification in GIS as well as previous experience. A post of MIS Manager in the Town Engineer's Department was also advertised and filled with another incumbent qualified in GIS. In the author's experience, these two staff members provided valuable service to the GIS capabilities of the municipality in that they were knowledgeable in the theory of GIS as well as the practical aspects.

This period did not see the introduction of new hardware but was more of a production phase. The major GIS purchases were for data, digital photography and training and the Department Planning and Development was able to produce zoning maps and queries using the system. Maps produced on the GIS were also being sold to the public as well as professionals. A map viewer was installed on the network that enabled other users to query property information. The system, in the author's opinion, was functioning. Staff still submitted requests for other options and GIS software which the author was required to motivate against. Staff appeared to think that there were easier options.

Various reports were also prepared during this period. In 1997, the Town Electrical Engineer acquired the services of a partially qualified tertiary GIS student to assist that department with a needs assessment over six months. The assistant's task was

solely to prepare a user analysis which was divided into two phases: The first phase was the GIS information dissemination amongst the 150 staff members that included existing and future GIS users, and this entailed the presentation of lectures, talks and videos; In the second phase, the necessary interviews and questionnaires were conducted to collect the user needs. The data collected was analysed and prepared in a bound document for the conceptual systems design.[29] The author found that this was intelligently and thoroughly done and that it provided all the information for the conceptual design stage of a GIS. From his confidential discussions with the assistant, it was clear that certain senior officials in the department, at the outset were not initially co-operating with the needs analysis process.

In December 1998, after a request from the Heads of Department, the GIS manager submitted a "GIS Data - GIS Action Plan"[30] document to Council it which it was recommended:

- That the initial GIS database building phase be outsourced
- That the serving of data be done using a Relational Database Management System (RDMS)
- That the data be maintained directly by users at the operational level using specially developed data maintenance applications.

In 1997, the MIS Manager in the Town Engineer's Department prepared an Information Technology Plan[31] for the Municipality. The incumbent accepted this task with the proviso that this was his only task for the period. His recommendations were as follows:

- The full integration of GIS management into the IT Section

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[29] Paarl Municipality, Electricity Department, Managing A GIS: User Requirements.

[30] Report, GIS Manager, 9 December 1998, File Ref 283

[31] Paarl Municipality, Information Technology Plan, January 1998

- The expansion of GIS functionality to other departments and sections, specifically the Fire Brigade, Traffic and Housing sections at the Town Secretary Department and the Health Services Department
- The compilation and maintenance of the electrical and utilities databases with the aid of Global Positioning Systems (GPS) surveys
- The integration of telemetry and GIS for certain applications
- The implementation of a corporate database management system and related procedures for seamless integration of GIS and other data at Paarl Municipality.

Towards the end of 1998, both the GIS operator in the Planning and Development Department and the MIS Manager in the Town Engineer's Department resigned to take up more lucrative jobs in the GIS industry. The vacancy in the MIS post subsequently took over a year to fill while the GIS post was still vacant after the same period. In the author's experience, the application process is delayed by procedures in the Town Secretaries office and political wrangling. The GIS post, in particular, had been advertised once but, by the time the applicants were invited for interviews, they had already found suitable jobs elsewhere. The data maintained by the Department Planning and Development had not been maintained for over a year now at the time of writing (1999). Moreover, the author considers the use of the GIS to be dysfunctional. As this department is responsible for the cadastral base and property information, no other departments who use the system can obtain reliable information as the base map is out of date.

In November 1999, after the post had again been advertised, Council recommended a candidate for the post against the specific recommendation of the Department. The effect of this is that neither the GIS Manager or the Department has the final say on staff appointments for this important section. In other words, Council has either not been adequately informed on the requirements of GIS or appointments are political and the requirements of the Department are not significant.

3.6.4 Summary - Phase Three

The period of implementation has established the GIS solidly in the working environment, and has seen a growth in GIS applications which were used in presenting information in reports. The appointment of professional operators and MIS specialists provide much needed skills to the working environment. From experience, the data storage of GIS data has been a problem, and there are no systems in place to ensure that the data is verified. The present data storage system is in flat files. Moreover, the proposed RDMS has not been purchased although it was budgeted for. The staff resignations towards the end of 1998 and delay in new appointments have seriously affected the GIS progress to such an extent that the GIS in the Department Planning and Development is no longer operative. The author believes that staff replacements should not take more than three months.

3.7 ANALYSIS OF CASE STUDY

In this chapter, the author's observations and experiences over the almost nine years are recorded. The case history was recorded in three sections:

- The initial period 1988- 1992
- The investigation period 1993-1996
- The implementation period 1997-1999

In Chapter One the author stated with reasons that the definition "GIS is an institutional entity reflecting an organisational structure which integrates technology with a database, expertise and continuing financial support over time" would be adopted in order to support the analysis of the CSF in Chapter Three. From the analysis of each period, it was evident that in this study certain trends in the implementation process were observed which were significant in the author's opinion, experience and compliance with this definition.

Even though there was a champion to initiate the GIS process, there was little

progress in the initial period. This could be attributed to lack of funding, top management support and a documented strategy. The job descriptions of the GIS operators were not clearly defined. In particular it was reported that there were occasions when other work outside the field of GIS impeded the GIS work program. This was particularly so in the case of the GIS manager. Because of the budget process, an artificial climate was created in which staff tended to 'chase technology' with requests for new equipment because they were not sure of requirements twelve months in advance. As a result software, and to a lesser extent hardware, was never fully utilised. The input of suitably qualified GIS staff made a meaningful contribution. This was evident in the later period. However, when these staff left, their program of work was not continued. From these occurrences, certain CSF can be established. These CSF are detailed next.

The analysis of the author's observations and experiences points to a number of important CSF such as active top management support throughout the GIS process. This can be associated with the institutional entity referred to in the definition. Qualified GIS staff with defined GIS roles and a strategy to ensure a continued operation in the event of staff shortages can be linked to the section on expertise in the GIS definition. The GIS budget process which is at present fragmented, should be considered in its entirety to pool resources, including staff, work-programs, data and hardware. These items can be associated in the definition with continuing financial support over time. At the time of writing, all these items are all dealt with separately, as well as subdivided in different departments. These factors mentioned in this paragraph have been chosen by the author because in his experience and from his observations they can be substantiated and justified from the definition adopted. On this basis the author suggests in no order of priority that the core CSF are:

- Support from top management throughout the GIS process
- Qualified GIS staff with defined roles
- A strategy to ensure a continued operation in the event of staff shortages
- A consolidated GIS budget process.

These CSF encompass the 'institutional entity', 'expertise' and 'financial support over time' referred to in terms of the GIS definition adopted. Hendricks (1998:627) has used that definition to justify calling GIS an IS. Further the theory on CSF has also been based on MIS theory. The author therefore believes that these CSF are appropriate in this study then as they link GIS to IS and the theory of CSF which has been based on MIS theory. Moreover, the author believes that the application of all these CSF in the work place and not just one or two would be required to ensure success of the implementation.

In Chapter Three, the author examined and detailed the CSF for the Paarl case study. This represents the core data set in terms of the study. In Chapters Four and Five the methodologies developed by Rockart (1979) and Rainer *et al* (1995) respectively, are tested in a GIS environment and CSF are determined using these methods. The CSF identified in this chapter are compared with these results in the Chapter Six.

CHAPTER FOUR

CRITICAL SUCCESS FACTOR METHOD

4.1 INTRODUCTION

The aim of Chapter Four is to report on the testing of the CSF method by Rockart, adopted by the author, for research in GIS implementation. Chapter Two described one of the methods to attain these CSF which was to use IS theory and in particular the CSF methodology (see Section 2.7) developed by Rockart (1979). The objective of this method, by means of interviews, was to formulate a set of CSF from each of the manager's goals, as these goals often influence the CSF. This chapter outlines the collection of data used in this part of the research. The data set comprises a series of qualitative interviews with senior management of the Paarl Municipality in which their goals, and ultimately the CSF, are examined. These goals pertaining to GIS are discussed and a draft set of CSF is developed. Further interviews were held to discuss the draft CSF and to confirm their relevance. The replies were then analysed and combined to develop a final set of CSF for this method.

In Chapter Five, the second method proposed by the author is examined. This tests IS theory on the GIS implementation using 'the key development success factors' developed by Rainer *et al* (1995).

4.2 INTERVIEWS FOR CSF METHOD

Individual interviews with the Heads of the Departments of the Town Engineer, Town Electrical Engineer, Planning and Development and Town Treasurer were conducted in June 1998. The Heads of Department report directly to the CEO and are part of the senior management team at Paarl Municipality who in turn report to the Council which is represented by elected officials of the community. It was explained to each Departmental Head that the interviews were part of the

implementation program of the GIS at the Municipality as well as contributing towards research for an academic degree. The process adopted by Rockart for CSF was explained to the interviewees. In summary, it is the theory that each manager has his goals within the organisation and that the CSF were the few targets that the organisation had to meet to achieve these goals. The four Departments were chosen as they were the only divisions currently involved with the implementation of the GIS or with IS.

The interviews were analysed according to the need for GIS components. These structured open-ended interviews provided an adequate means of obtaining the data required for analysis. Each of the interviewees were contacted beforehand and a convenient time and place for the interview was arranged. The first part of the interview detailed the goals of the Department as well as those of the manager. The second part of the interview covered the CSF necessary to achieve these goals with GIS. A summary of each interview follows.

(a) Town Engineer (non-Electrical)

The mission of the Town Engineer[1] is to provide numerous services efficiently and effectively. These include the supply of water, sewerage treatment, cleansing services, streets, drainage, parks and recreation facilities. The role of GIS was to support the achievement of this goal and the requisite CSF were:

- Improving levels of service to the public
- Providing information quickly
- Improving management tools
- Ensuring that the programs were simple to use.

[1] Mayor's Report July 1997

From the interview with the Town Engineer,[2] it was noted that his Department required reliable information at short notice due to unexpected breakages in essential services during working hours as well as outside that time. The public expect to have problems, such as breakages in services, rectified quickly. Ideally, GIS programs should be simple, the reason being that qualified staff were difficult to place and more staff should be able to use the GIS. The Department had recently been unable to fill an MIS post for over a year which resulted in delays in implementing the GIS in that department. This in turn had a negative effect on the rest of the organisation. Moreover the department, as previously reported only had one staff member actively involved in GIS operations which meant that GIS planning and actual operations were hampered due to lack of suitable staff. If suitable GIS staff were available the level of service to the public could be improved.

(b) Town Electrical Engineer

The mission[3] of the department is to establish a strong electrical network to provide electricity cost-effectively and safely. In brief, this can be achieved:

- By upgrading of electrical network
- By continuously monitoring the network
- By curtailing losses from the electrical network
- By developing staff
- By complying with all relevant legislation
- By delivering a high quality service with accurate information and prompt responses.

[2] Interview with Town Engineer, 1998/6/25 and September 1999

[3] Town Electrical Engineer: Business Plan 1997

In his interview[4], the Town Electrical Engineer stated that the CSF to be considered for the successful implementation of a GIS were:

- The need for a good information system
- The real time reliability of information
- The correct staff with the right training
- The timeous provision of accurate information in order to attend to problems.

This department had recently completed a user requirements analysis for GIS. From the interview and participation in the user requirement analysis, it was evident that reliable and accurate information was required on account of the hazards of working with electricity. There was also a staff shortage in relation to those with a working knowledge of the GIS software. Problems with the services occurred unexpectedly and the staff had to rely on accurate information to undertake repairs 24 hours a day. Only one staff member in this department was involved in the GIS program. The author observed on many occasions that the work done by the GIS section was not supervised due to lack of knowledge of GIS among senior management.

(c) Town Treasurer

The mission of the Department of the Town Treasurer is to provide a viable financial base from which the Municipality could operate. In order to achieve this, the following goals had to be met:

- The delivery of accurate and timeous accounts
- Ensuring that all monies received were secured and banked
- The timeous payment of debtors
- The sound financial control with the eventual drawing up of financial

[4] Interview with Town Electrical Engineer 1998/6/29 and September 1999.

statements at the year end which reflect the true financial position of Council.

From this interview[5], it was analysed that the GIS and IS in the Municipality would be better met if the following CSF were achieved.

- An improved use of statistics
- The importance of the correct staff to do the job
- The continuous upgrading of equipment.

This department was involved in controlling the financial information system of the Municipality. According to the Town Treasurer, the existing system performed adequately. Moreover, during the year, control of the IS was removed and placed under the control of the Town Clerk, in order that the IS should be more representative of the whole Municipality. From the author's experience in the GIS user group meetings, other service departments required additional information from the system which was not always readily available[6]. According to the Town Treasurer however this was not so and it was the users who did not know how to use the financial information system correctly.

During the course of 1999, it was decided to purchase a new financial information system, although the Town Treasurer believed that the conversion to the new system would set the implementation of GIS back between 12 and 18 months. This was because the reasons for and the approach were totally unacceptable in the opinion of the Town Treasurer. Due to foreseeable delays in the implementation of the new system, data would not be available for use. The Town Treasurer was also convinced that

[5] Interview with Town Treasurer 1998/6/29 and September 1999.

[6] GIS user group minutes 1996/9/9

he had not been properly consulted in the process, in the extent that he had decided to take early retirement. It can therefore be deduced that the implementation and choice of a new system requires the active involvement of staff affected by it. In this case, a senior member of the staff was excluded or ignored, which led to his early retirement. This scenario has placed the GIS implementation at high risk of being unable to deliver a service to users.

(d) Town Planning

The mission[7] of the Department Planning and Development is to set a broad framework within which harmonious and orderly development can take place and fulfill community needs. The goals required to achieve this are:

- By managing development through the relevant legislation
- By formulating development strategy from strategic planning
- By providing and maintaining municipal buildings and housing.

Through the GIS section, the Surveying and Technical Support Services Division had to provide geographic information in an attribute or spatial form to both the Municipality and the public at large. The factors[8] considered to be vital to the success of the GIS were:

- An implementation program
- Ensuing all staff were partners in the process
- Analysing the situation first and implementing according to a plan
- Adequate resources in terms of money, trained staff, information and time
- A logical and clear plan.

[7] Mayors Report July 1997

[8] Interview with Head of Dept Town Planning 1998/7/2 and September 1999.

This Department initiated the development of GIS within the Municipality and has been connected with the implementation of GIS for the longest time. From the author's involvement in this division, it was noted that the most important information required was for planning purposes rather than for sudden breakages and unplanned service occurrences which occurred in the other two engineering departments. Since the initial interview (in July 1998), a critical member of GIS staff has resigned, and by December 1999, this post had still not been filled. This has rendered the GIS Section non-operational.

4.3 CRITICAL SUCCESS FACTORS FOR GIS IMPLEMENTATION

Based on the theory of Rockart, the initial responses from the interviews were analysed and then used in condensed form in the follow-up discussions with the each interviewee in order to reach consensus on all the issues. The CSF that these managers would have to focus on were elicited from their responses and five CSF were developed to form the core CSF for this method. Using this technique, these are the business functions or CSF that must be performed well in order for the GIS implementation to succeed:

- Employing appropriately trained staff to do the job
- The information system must be easy to use, (that is the hardware and software need to be user-friendly)
- All the staff members should be partners in the process, as the GIS should include all aspects of the business of the organisation
- A good implementation program is required which is well documented, clearly written and easily understood by everyone
- Information must be reliable and readily accessible.

The interviewees all agreed that these CSF met the requirements of their departments although not all the interviewees had mentioned all these factors initially. These CSF

are examined more fully below:

The following was mentioned by all respondents as CSF.

- **Employing appropriately trained staff to do the job**

During the last year, it was noted that two staff involved with the GIS in the organisation resigned to take up more lucrative posts elsewhere. These posts were still vacant after a year and attempts to fill them were unsuccessful. The demand for excellent staff appears to be an overall problem in the GIS industry. The Town Engineer stated that GIS planning and actual operations were hampered due to lack of suitable staff. This had a negative affect on the level of service given to the public. The Town Electrical Engineer, Town Planner and the Town Treasure similarly mentioned the importance of the need for the correct staff. All these departments appeared to have experienced problems in obtaining suitable candidates for IT related positions. In her case study findings Campbell (1994:321) found that a long measure of stability in terms of general organisational context and personnel was required for achieving success. The CSF determined by all the respondents is therefore comparable and appropriate in terms of previous case study findings.

The following was mentioned by the Town Engineer, Town Electrical Engineer and Town Treasurer but not by the Town Planner.

- **The information system must be easy to use**

The author believes that people do not want to struggle to obtain information. He observed that staff sometimes found it easier to remove a paper copy of a plan than to use the GIS to extract the information. People want ready access to information which will make their task easier. The Town Engineer required the GIS to improve the delivery of information which in turn would enable staff to improve the level of service to the public. The Town Electrical Engineer does not refer directly to an easy

to use system but rather a "good information system". If the system was easy to use the Town Treasurer would be able to make use of the statistics to improve financial control. Campbell (1994:321) found that simple applications producing information were necessary for achieving successful implementation. The CSF determined by the three respondents is valid in terms of similar case study findings.

The following were mentioned by the Town Planner but not by the Town Engineer, Town Electrical Engineer or Town Treasurer.

- **All the staff members should be partners in the process**
- **A good implementation program is required**

Although only one of the interviewees had mentioned these two points in the initial discussion, they all agreed in the end that these factors were important. The Town Planner had been involved from the outset with the implementation of the GIS program at the municipality and was more aware of all the GIS implementation issues. It is for this reason that although only one person has mentioned them, they cannot be excluded. It was mentioned previously that the CAC was chaired by the Head of the Department of Health. Moreover, in the Master Computer Plan, it was recommended more senior staff become involved. Each department in this study had its own GIS or IS section and regular GIS meetings were held between staff of the different departments. There should therefore be more support from top management for the implementation. Each department had its own program for the GIS implementation, not all of which were documented correctly. A GIS Development Guide (Becker 1998) could be more thoroughly used for this purpose. Campbell (1994:321) found that participation and commitment of all stakeholders in the project was necessary. The CSF determined only by the Town Planner can be justified even though it was mentioned by one respondent only. The Town Planner was also involved with the GIS from its inception at the Municipality and took an active role in the documentation of the functional specifications of the department. This person was therefore more aware of the role all stakeholders have in the implementation

process.

The interviewees all agreed that:

- **Information must be reliable and readily accessible.**

In order for the Town Engineer to improve levels of service to the public the information on the GIS must be reliable and accessible. Similarly the Town Electrical Engineer required accurate information as inaccurate data could put lives at risk. The Town Treasurer could only improve his financial control if the statistics were based on reliable information. Not all the departments had been able to make full use of the available data. The capturing of data was an ongoing process. Each department had its own data capturing program. There were also different levels of reliability of data. No meta data was readily available. Because of budget controls and staff shortage it was difficult to collect and maintain the data at all times. Campbell (1994:321) found that "information which is fundamental to the work of potential users" was required to ensure successful implementation. The author contends that reliable and readily accessible information are similar in context to Campbells findings and the adoption of this factor as a CSF can be justified in this section of the study.

4.4 SUMMARY

The CSF method proved most effective in determining a short list of issues which was agreed on by all participants. However this list has not been prioritised by the author. None of the Heads recorded a need for continued financial support as a CSF. The reason for this could be that as the Heads are responsible for drawing up the budget, they do not perceive this to be a problem. According to the GIS definition adopted, there should be continued financial support for GIS to succeed.

In the Literature Review in Chapter Two, it was mentioned that CSF are the few areas in an organisation which if performed well, will ensure that the overall goals

of the organisation are attained. The author has noted that because of the structure of the organisation, the goals set by the managers of the Departments were mainly service-orientated. In his opinion GIS, if successfully implemented, could therefore assist them in achieving these goals.

In this chapter, the data that were collected to test the CSF methodology were summarised, and a final set of five CSF was determined in terms of the techniques used by Rockart. Although senior management were interviewed, this process should have been extended to include town councillors as without their support managers' objectives and ultimately the CSF will not succeed, if they cannot select and appoint staff to do the work.

The CSF found necessary for achieving successful GIS implementation using the CSF method are similar in content to previous case study findings by Campbell (1994:321). Their use can therefore be justified in this study.

In Chapter Five the "Key Development Success Factor" method by Rainer *et al* (1995) is tested. In the final Chapter these two methods are compared with the Paarl case study findings in Chapter Three.

CHAPTER FIVE

KEY DEVELOPMENT SUCCESS FACTORS

5.1 BACKGROUND

The main aim of this chapter is to report on the findings of the data collected in the study by means of the questionnaire on 'Key development success factors', adapted from Rainer *et al* (1995). The author has used part of Rainer's results, which he has adapted for GIS, as a basis for his questionnaire. In this study, the author investigates the responses from the eight quantitative questionnaires which he believes can be used to determine CSF in GIS implementation. However, due to the small data set, there are limitations in generalising these results to a larger population. These results should therefore be seen as a snapshot at a certain stage of the implementation. In the literature review in Chapter Two (Section 2.8), the author outlined the process by which Rainer *et al* (1995) determined the CSF for EIS, drawing on the parallels between IS and GIS theory in order to adapt Rainer's research for GIS use. He then describes four CSF in Chapter Three and in Chapter Four he examines the results of a series of qualitative interviews using the CSF method. Five CSF were determined using this method. In Chapter Five, eight CSF are selected from the questionnaire. The author justifies the use of only a number of CSF as "there are only a few areas where excellent performance is essential if the ultimate goals of the organisation are to be met" (Rockart 1979). Chapter Six presents the conclusion and comparison between the three sets of results and a summary of the research.

5.2 KEY DEVELOPMENT SUCCESS FACTORS

The questionnaire consisting of 23 key success factors, (see Chapter Two, Section 2.8), was given to the eight users involved in the day-to-day use of the GIS at the Municipality (Appendix E). These personnel included the three operators of the GIS

and their direct supervisors. As mentioned in the preceding section, the small sample made it difficult to establish any statistical support against which the results could be verified. Therefore the naïve statistics, such as the average and standard deviation, were used to analyse the data.[1] Moreover, because of the small data set, the standard deviation appears not a reliable indicator for the reason that any outliers cause the data to be skewed. In this data set, the professional insight is therefore more important, and for this reason the discussion is presented in simple numeric terms, and indicating remarkable disparities only. Following the results obtained by Rainer *et al* (1995), the questions were retyped in a table format and placed in alphabetical order from 1 to 23. The reasons for the questionnaire and research were explained to each of the respondents before the time, with emphasis on certain concepts and terms in the questionnaire which could have been misleading, such as 'Executive sponsorship' and 'Operating sponsor'. These terms are explained in the glossary. The respondents were requested to rank the factors 'keys' in order of importance from 1 to 23 on the questionnaire. The results were then collected by the author and the data was entered in a table (Table 2). In order to ensure anonymity, each of the completed questionnaires were numbered individually from A1 to A8 as seen on the top row of the table of results.

In Table 2, the results from the eight respondents numbered A1 to A8 are shown. The first column indicates the key factors numbered 1 to 23, while the second column in a brief phrase describes the success factor as defined by Rainer *et al* (1995) in his research. Only the term EIS has been replaced by GIS. Each of the results from A1 to A8 are noted below these columns corresponding to the concept. In the last two columns, the mean results and standard deviation are indicated. The relative importance of the various keys were determined from the arithmetic average of the key.

From the results, the author observed that top management support and appropriate support are key CSF elements determined by the users who nearly all agreed that

[1] Discussion with Prof Dunne, Dept. Statistical Science, University of Cape Town

consultants are low on the list of priorities. One reason could be that consultants are seen to be a job threat to staff members. Staff therefore, appear to want to solve the problems themselves. From the author's experience, consultants did not perform as expected when GIS data was captured on contract. It was also noted that A7 did not fit the pattern[2] of the other replies. If the results from A7 are ignored the standard deviation of the results improved slightly and there was only a small change in the ranking of the keys.

[2] Discussion with Prof Dunne, Dept. Statistical Science, University of Cape Town

		A1	A2	A3	A4	A5	A6	A7	A8	$\bar{x}$	std
Rank	Key success factor										
1	Executive sponsorship	5	3	8	2	6	3	10	4	5	2.7
2	Appropriate IS staff	2	4	5	5	1	2	15	2	5	4.5
3	Appropriate software technology	4	10	6	6	16	6	1	1	6	4.9
4	Develop system with users' needs in mind	7	1	10	3	14	7	4	5	7	4.1
5	Appropriate hardware technology	3	13	7	7	15	5	2	3	7	4.8
6	Define information requirements	1	12	3	8	13	13	3	10	8	5
7	Top management support	6	19	2	1	3	1	20	13	8	8.1
8	GIS support staff	13	5	12	14	2	9	8	6	9	4.1
9	Link GIS contents to business objectives	14	6	4	10	5	16	18	7	10	5.3
10	Cost considerations	12	9	9	4	12	8	16	18	11	4.7
11	Manage data	10	14	13	9	17	17	5	8	12	4.2
12	Operating sponsor	11	2	21	19	23	4	22	21	13	8.9
13	Manage user expectations	20	7	14	11	20	21	7	9	14	5.9
14	Manage organizational resistance	18	15	16	13	8	19	6	19	14	5.1
15	Sell the GIS concept	15	18	1	12	10	18	23	12	14	6.6
16	Work closely with executives	16	21	17	16	4	11	14	14	14	5
17	Evolutionary development approach	21	11	11	22	11	15	17	11	15	4.6
18	GIS support for the executives' staff	22	20	15	17	7	10	9	16	15	5.4
19	Provide benefits statement	17	17	20	15	9	22	11	15	16	4.3
20	Deliver initial version quickly	8	22	19	21	19	14	21	17	18	4.6
21	Start with high payoff applications	9	8	22	23	21	23	12	23	18	6.7
22	Manage system spread and evolution	19	16	18	18	18	20	19	20	19	1.5
23	Use consultants	23	23	23	20	22	12	13	22	20	4.6

Table 2. GIS Success Factors

5.3 CSF ANALYSIS

According to Rainer *et al* (1995:83), there is evidence to support the existing literature on IS success. However, the definition of CSF by Rockart has been adopted in this research and it is therefore only "those few area where excellent

performance is essential if the ultimate goals of the organisation are to be met" that should to be taken into account in the final results. For this reason, it is necessary to concentrate on these few factors only. The author has used the first eight keys in relative importance in this analysis (indicated in red tone on table 2) in order to be consistent with the definition and to compare the results with the core data in this study in Chapter Six.

These results indicate that five out of the initial eight factors that Rainer ranked in order of importance were also found to be important by the eight respondents in this study. These are highlighted in bold text below.

The keys ranked in relative importance and determined in this study from the respondents were:

- **Executive sponsorship**
- Appropriate IS staff
- Appropriate software technology
- **Develop system with users' needs in mind**
- Appropriate hardware technology
- **Define information requirements**
- **Top management support**
- **GIS support staff**

In his study Rainer determined that the factors necessary for the successful development of an EIS were:

- **Executive sponsorship**
- **Top management support**
- **Define information requirements**
- Link EIS contents to business
- Deliver initial version quickly

- **Develop system with users' needs in mind**
- **EIS support staff**
- Manage data

Because the study by Rainer can be extended to include other IS, the author has replaced EIS with GIS as mentioned previously. There is therefore significant agreement between Rainer's findings and the results from the questionnaires if the first eight ranked keys are compared. These findings indicate that in the context of the Paarl study if would be possible to use Rainer's results in order to base a set of CSF on. The personnel used in the study have also been involved with the GIS for a number of years and therefore have the hindsight on which to base their choices on. This has enabled them to define their needs regarding the implementation process. It is therefore possible that in a new organisation starting out with a GIS, staff might not be able to understand all the issues involved in the GIS and that in that case it might be preferable to use Rainer's results as a key in the implementation process.

5.4 SUMMARY

The aim of this Chapter was to report on the test conducted using the adapted questionnaire based on the research findings by Rainer *et al* (1995). This was the second method adopted by the author to test whether IS methodologies used to identify CSF can also be used to determine CSF for GIS implementation at a local authority. The results of the first eight ranked keys from the questionnaires proved to be comparable with previous research on this topic and were therefore consistent with success factors in IS theory. Due to the small sample of responses in the test, it may be possible to achieve improved results overall if the interviews using the CSF of Rockart (1979) include the topics detailed in the questionnaire. In the final Chapter, the author will compare the results from the three methods and draw conclusions on the research questions and hypothesis.

CHAPTER SIX

CONCLUSIONS

6.1 INTRODUCTION

This Chapter summarises and provides a synthesis of the conclusions of each method of evaluating CSF, and a comparative analysis of the results. In Chapter One the author introduced this study with the objective of testing if existing methodological theory for identifying CSF in IS implementation can be applied to GIS implementation, and the objectives and hypotheses of this study were posited. In the literature review in Chapter Two the author introduced the reader to two current methodologies that were appropriate for determining CSF in IS as well as conclusions from other case study findings. The first method was the CSF method developed by Rockart (1979) and the second the "keys to information system success" method by Rainer *et al* (1995) for EIS[1] use. An EIS is a high-level decision making system. The latter was adapted by the author for GIS. Moreover, according to Huxhold (1995:118), GIS supported higher-level decision-making. This enabled the author to extend the theory of MIS planning principles to include GIS. In Chapter Three the author's experiences in the organisation over a period of the nearly nine years were documented using single case study methodology. This forms the core data for comparing the results of the other two methodologies in Chapter Four and Five. From these results and experiences the author has developed a set of CSF for Paarl Municipality.

In Chapter Four and Five the author tested the two methods by Rockart (1979) and Rainer et al (1995) using qualitative interviews and quantitative questionnaires respectively.

In this final Chapter a summary of the three evaluated methods; the case study, CSF

[1] Executive Information System

and the "key development success factors" is made. This is done by means of a table that indicates the results obtained using the three methods (see Table 3, Comparison of CSF). From these results the author draws conclusions to general theory, the validity of the hypothesis as well as the research questions and finally areas for further research.

6.2 CSF ANALYSIS

The author has compared the CSF derived from this research in Table 3 (Section 6.3). In this table the source of the results are indicated along the top row. These are: CSF method results, key factor results and the case study results. In the author's opinion the results may be arranged in appropriate groups based on similar concepts as it is convenient to compare them using this method. These groups are numbered one to four in the left hand margin of the table. The groups have been defined as:

1. Information CSF
2. Technical CSF
3. Professional CSF
4. Strategic CSF

In the following sections a synthesis of the conclusions is provided:

6.2.1 CSF Method

This method by Rockart (1979) was based on qualitative interviews. In this process broad concepts were condensed into short sentences to form the CSF. This method does not depend on the number of respondents. The results represent a snapshot of the CSF at a certain period of the implementation. It is also noted that these results were obtained from senior management staff with limited or no practical GIS experience. The results as examined previously in Chapter Four are comparable to case study findings determined by Campbell (1994:321). The test using this method therefore is reliable and supports the theory that IS methodology can be used for GIS

implementation in the Paarl context.

6.2.2 Key Success Factor Method

This method by Rainer *et al* (1995) was based on the responses of quantitative questionnaires. The results also represent a snapshot at a particular period of the implementation. The method did not allow for interaction between the author and the eight respondents. The respondents were involved and familiar with GIS. The method used condensed ideas set out in short sentences which were required to be interpreted into broad concepts by the respondents. The results, discussed in Chapter Five were compared with Rainer's findings. This test therefore supports the theory that IS methodology can be used for GIS implementation in the Paarl context although only five out of eight CSF were common to both sets of data.

6.2.3 Case Study

This method was based on single case study methodology. Data was collected over a period of nine years. The author determined a set of CSF based on his observations and experiences and used the GIS definition "an institutional entity reflecting an organisational structure that integrates technology with a database, expertise and continuing financial support over time" as a framework for analysis. The use of the definition was justified by the author as there were parallels in this definition that linked IS theory to GIS. The case study results were determined from deduction and experiences in the work place (see Chapter Three). The CSF determined by the author are valid in this study as they are comparable to the results obtained using the CSF and Key Success Factor Method as well as the GIS definition adopted. The use of the single case study method to determine CSF for GIS implementation proved reliable. This data serves as the core data in this research as it has been observed by the author and validated by other IS findings and the two methodologies tested.

6.3 SUMMARY OF CSF

In Table 3 the comparison of the results of the CSF obtained from the two tests and

the case study is shown. All three methods noted that technical and professional issues were CSF. The CSF method and Key Factors results had information factors as additional CSF. These methods had information, technical and professional issues as CSF, whereas the case study only determined technical, professional and strategic issues as CSF. The CSF method and case study had strategic factors as CSF.

The reason the CSF method may have information, technical, professional and strategic issues as CSF is that the method involved obtaining synergy amongst the participants in the interviews in order to arrive at a final answer acceptable to all.

The Key Factors method was based on a questionnaire which required a forced response to certain factors. Only the first eight keys were used in the result. This may have materially affected the final result. This may indicate why only issues such as information, technical and professional are shown.

In the case study results, technical, professional and strategic factors are CSF issues but information is not. In terms of the study this factor did not appear to be a CSF although it may still be important. Moreover, in terms of the CSF methodology Rockart (1979) noted that there were typically only three to six factors that were critical in order to be successful and where "things must go right". The comparison of the CSF (Table 3) is shown on the following page.

Table 3 Comparison of CSF

	CSF METHOD RESULTS	KEY FACTORS RESULTS	CASE STUDY RESULTS
1	The information system must be easy to use	Develop system with users' needs in mind	
	Information must be reliable and readily accessible	Define information requirements	
2	Employing appropriately trained staff to do the job	Appropriate IS staff	Qualified GIS staff with defined roles
		Appropriate software technology	
		Appropriate hardware technology	
		GIS support staff	
3	All the staff members should be partners in the process, as the GIS should include all aspects of the business of the organisation	Executive sponsorship	Support from top management throughout the GIS process
		Top management support	A consolidated GIS budget process
4	A good implementation program is required which is well documented, clearly written and easily understood by everyone		A strategy to ensure a continued operation in the event of staff shortages

6.4 CONCLUSIONS FOR THE HYPOTHESES

The objective of this study was to test a methodology for identifying CSF in GIS implementation. The theory from IS principles was adapted and tested on GIS implementation within the organisation. The hypotheses that were posited were to establish:

(a) If IS methodologies used to determine CSF can be used to determine CSF for GIS implementation at a small local authority.

(b) If CSF derived from IS research can be used in local authority GIS implementation.

From the above hypotheses, three research questions were formulated:

(i) What are the Critical Success Factors in implementing GIS at the Paarl Municipality based on actual experience?

We can shown conclusively that in the case of Paarl that the four CSF determined are valid and can be justified from the author's observations and deductions in Chapter Three as well as the reliable results obtained from the other two methods used. These CSF are:

- Support from top management throughout the GIS process
- Qualified GIS staff with defined roles
- A strategy to ensure a continued operation in the event of staff shortages
- A consolidated GIS budget process.

(ii) Can an IS methodology be used to identify CSF in GIS, and which methods of identifying CSF were most suitable in the Paarl case study?

In the Paarl Municipality case study the results from the tests on CSF method by Rockart (1979), although more time-consuming, elicited better and more detailed responses to that of the key factor approach by Rainer *et al* (1995) which was a condensed summary of information. In this research the author's experiences nevertheless remain the core data set against which these methods need to be compared. There were subtle differences in the CSF determined by the three methods, such as the use of phrases; appropriately trained staff, appropriate IS staff and qualified staff (See Table 3). Reference was also made to "All the staff must be partners in the process" or only "Top management support". The trends from the tests using Rockart (1979) and Rainer *et al* (1995), however compared favourably with the core data set, mentioned in section 6.4.(i). The author found that in the Paarl case these particular IS methodologies using small data sets, could persuasively be used to identify CSF in GIS.

(iii) Can a tentative set of CSF be compiled for implementing GIS in similar organisations? If so, what are they?

In the Paarl situation the results derived by the author from his observations and experiences must be considered as the primary CSF as this data are most reliable in spite of bias. These are mentioned in section 6.4.(i) above. It has also been shown that the IS theory is relevant to GIS in this study. However each organisation has its own CSF. These CSF change with time and the growth of the organisation. The issues surrounding GIS implementation are unique and vary for each organisation and are not static. This is shown by the subtle differences in the semantics of the CSF in the table. In another organisation at a similar stage of development these CSF could serve as a useful business tool for promoting GIS implementation or as a common core

set for all organisations. The prominence of particular factors change, and it is therefore speculative or not conclusively shown that these CSF can be generalised to a wider population.

6.5 RECOMMENDATIONS FOR FURTHER RESEARCH

From these findings and review of the literature, the author concludes that it is possible to extend IS planning and principle theory to include GIS. The results of this study also indicate that IS methodologies may be used to determine CSF in GIS implementation.

Therefore, in the Paarl Municipality situation, both hypotheses (a) and (b) are valid and it is possible to use CSF derived from IS research in local authority GIS implementation.

Although the sample size mentioned previously was too small to draw any statistical conclusion from the results, reliable results using the three methods were obtained. However it would be useful if this study was tested and extended to other local authorities who are experiencing similar problems with GIS implementation. As both the interviews and keys method results were based on small samples, the author believes that there could be an advantage if the key factor method was combined with the interview process to determine the CSF. This would ensure that more variables and factors with regard to GIS are taken into consideration.

6.6 CONCLUSIONS

This single case study has shown that IS theory can be extended to include GIS. In doing so, IS practices and principles theory can used to implement GIS. The author has collected data from three sources and successfully validated it with data derived from IS literature. It has been shown by this study that reliable CSF can be derived from either the CSF method developed by Rockart (1979) or the questionnaire

developed for 'Key development success factors' by Rainer *et al* (1995) even though the latter method was simple and limited . This research has shown that in terms of the research objectives, the two IS methods by Rockart (1979) and Rainer *et al* (1995) are valid for GIS in the Paarl context. Although the single case study method was based on qualitative rather than quantitative methods, this in no way detracted from the results. The CSF were dependent on many factors within the organisation, such as, technology, human behaviour and other complexities. The CSF may themselves be grouped according to information, technical, professional and strategic factors. This adds to the complexity of GIS implementation. In the Paarl case study, the CSF are in themselves recommendations which can be used by managers to improve service delivery. This will be to the benefit the organisation. Using these CSF, managers will be able to identify the business functions needed to be addressed for CSF in GIS implementation. Based on the CSF derived for the Paarl situation, managers should ideally be able to 'gain control' of data.

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APPENDIX A

LETTER OF AUTHORITY TO CONDUCT RESEARCH

23 April 1997

REF 210/3

MEMORANDUM

TO: MR D FRIEDMAN

THESIS: IMPLEMENTATION OF A GIS AT A LOCAL AUTHORITY.

1. Your memorandum dated 1997-04-18 to me refers.

2. I tabled your request at the Heads of Departments Committee meeting on 22 April 1997 and it was unanimously agreed that your request be acceded to provided that information pertaining to an individual or organisation shall not be used in such a way that privacy/confidentiality is lost.

Signed: Mr WA Swanevelder

TOWN PLANNER AND LAND SURVEYOR

APPENDIX B

Department Planning and Development Functional Specifications

INTRODUCTION

The Department Planning and Development is in need of a geographic information system in a planning, decision making and land use control capacity and to assist in the frequent queries directed to this department.

The information (spacial and non-spacial) must be well defined and very accurate for use in mapping and/or reporting, using the unique erf number as link between the spacial and non-spacial data.

The cadastral data-base must be accessible to other departments for a read-only purpose and the updating is the responsibility of the department in control of that function.

The department needs this information in 3 formats, i.e.

1. Production of Plans

   - A base plan at a set scale (1:1000) is needed to overlay on the existing topo-grid;
   - This plan must display (in combinations) different attributes eg. zoning, land use, etc., with specific qualities eg. erf sizes.
   - The production of plans at various scales with various annotations.

2. Producing Property Records

   All erven in Paarl are to be individually plotted along with all available information concerning the specified erf.

3. Schedule Information

   Attributes are to be grouped together according to required specifications, listed according to a variable and where needed, totalled.

PRODUCTION OF PLANS

The main source of information is the different base maps concerning zoning, topographic map, survey records, property records and building plans as well as the services map of the Engineers' departments. Currently these are all isolated and at different scales. Co-ordinating different maps takes place manually which is both tedious and time consuming. These have to be integrated to form a base map for all resulting work.

1. The Base map 1 : 1000

This must indicate:

Cadastral boundaries of properties
Property numbers
Street names
North point
Border
Titles, scale and log
Date
Berg River Centre line

The cadastral boundaries are derived from land surveyed co-ordinates of each property. Where no co-ordinates are available, an alternative has to be found. This alternative may be "theoretical co-ordinates" calculated from diagram data.

The grid of the base map must co-incide with the grid of the topographical map.

2. Geographic distribution

The following attributes must be able to be over-layed over the base map at various scales:

Zonings
Land Uses
Contours } one coverage
Grid }
Electrical Services
Water mains / Storm water / Sewer / river
Telephone lines
Roads / Rail line (Transport Map)
Road improvement lines
Land Value Contours : Municipal Valuations
Market / Values

Plans indicating national monuments and buildings older than 50 years are needed on a weekly basis. An attribute such as age must be stored in such a way that the erf automatically becomes part of the "50 years buildings" the very year it becomes of

such age.

The need for other specified qualities may be required in future e.g.:

- Properties with a defined vacant extent although the property has been developed - with a view to diversification, or
- Properties above a certain height level - with a view to locating future reservoirs.

PRODUCING PROPERTY RECORDS

The information contained both in the Plan Production Functions and Numerical Information are needed to produce a complete and accurate property record of each erf. This will serve as an accurate source of information for development. These records are essential during Interim and Council Valuations and are used daily.

The information contained in the property record can be divided into to categories, i.e.:

A. Graphic Information

B. Descriptive Information

A. Graphic Information

1. Cadastral
   - Position of erf (provide for more than 1 street boundary)
   - Erf dimensions
   - North point
   - Scale
2. Valuation Information
   (Siting of Structures) Position of buildings (structures) and improvements (including e.g. stoep, pergola, garage, swimming pool)
3. Zonings
   - Secondary zoning(s) - the dividing line must be indicated
4. Zoning Restrictions
   - Street widening line as well as the distance from such line to the centre line of the street
   - Building lines
5. Title Conditions
   (Servitudes, etc.) Servitudes and Right of Way must be displayed
6. Approved Encroachments

7.	Services	Electricity, Water and Sewer connection positions	

B. **Descriptive Information**

1.	Property Information	Erf Number Erf Size Sizes of components of buildings, e.g. stoep, pergola, swimming pool, etc. Number of storeys	
2.	Location	Street address/es (more than one possible) Area Code Neighbourhood (where applicable)	
3.	Zonings	Primary zoning Secondary zoning(s) as well as size of each zoning Conditions attached to the applicable zoning	
4.	Land Use	Primary Use Secondary Use Total dwelling units General condition(s) of building(s) (poor, fair, good)	
5.	Services	Street access Water Sewer Electricity No Services	Y/N Y/N Y/N Y/N Y/N
6.	Conservation Status	National monuments and date of such proclamation Area of exceptional significance Date of building	Y/N
7.	Zoning Restriction	Building plans Coverage 1. Currently 2. Permitted (Indicated in % and m^2) Mass 1. Currently 2. Permitted	
8.	Title Restriction	Reference to Township	

9.	Approved Departures	
10.	Registration	Title Deed Number Registered Owner Not Registered - indicate registered mother erf Redundant - where needed show consolidations, subdivisions, where excluded from municipal area
11.	Specified requirements	Existing parking
12.	Valuation	Municipal and market value of both land and building(s) Date of property surveyed
13.	Type and Number of facilities : Type of	External Walls Roof and Extent of overhang Ceilings Gutter Floor Window Frames Kitchen
	Number of	Bathrooms Floors Toilets Habitable rooms
14.	Availability of	Built-in Cupboards Hot water installation Fire place Electricity

SCHEDULED INFORMATION

All information contained in the system, either from the maps or from the individual property record, must be available (grouped and/or listed) in any combination or relationship according to the required specifications and where needed, totalled.

This information may be needed in report format or for questionnaires and queries (daily / weekly / monthly).

Spatial information can be defined as data having a fixed position in space. All other information, e.g. time, can be seen as non-spatial information.

SPATIAL INFORMATION

A point, having a co-ordinate and height, is the most basic primary spatial unit.

The cadastral erf with its erf number acts as a primary spatial unit. All associated information will be manipulated according to required specifications.

For example:. All vacant erven with a Single Dwelling Residential zoning of which the Municipality is the owner;

The total floor space of business buildings in Lady Grey Street;

The total number of flats in the CBD;

Valuation per m^2 with a certain residential area.

NON-SPATIAL INFORMATION

The system must provide for non-spacial information. Census information such as population, sex, age and income groups is important. Climate, traffic flow, etc. may also be built in.

E.g. The population on the erf by age, income, group, etc.;

Means of transport from various areas to industrial areas.

SPATIAL INFORMATION

A - PLANS

BASE MAP		
	AVAILABILITY	SOURCES
Cadastral boundaries	Not available	GP + diagrams prior 1965 ± 3000 erven
	In process on system	GP's after 1965 + approved 56 diagrams

Property number Street names North point Border Title, scales, logo Date	Available after cadastral boundaries completed	Diagrams and Street Name Maps
Berg River	Available	Topo-maps digitized

GEOGRAPHIC DISTRIBUTION		
	AVAILABILITY	SOURCES
Zonings	In system	
Land Uses	In system	
Contours	Available	1 : 1000 topo-maps digitized
Grids	In system (layer)	
Electrical Services Water mains / storm water, etc.	Available	Engineer maps
Telephone lines	Available	Telkom maps
Transport map	Available	Engineer maps
Road improvement lines	Available	Improvement line map and co-ordinates
Land value contours Municipal Market	Values available Contours not available Values available Contours available	Valuation roll To be construction and digitized Deeds Registration List To be constructed and digitized
National Monuments	Available	National Monuments File

B - PROPERTY RECORDS

GRAPHIC INFORMATION		
	AVAILABILITY	SOURCES
Siting of structures	Available	Property Records - digitized
Zonings (secondary)	Available	Zoning Map, Zoning Files (107)
Zoning Restrictions	Available	Zoning Map, Zoning Files (107, 109)
Title Conditions (servitudes)	Available	Title Deeds, Township Files, Sub-divisional Files
Approved encroachments	Available	Plans
Services positioning	Available	Engineer Maps

DESCRIPTIVE INFORMATION		
	AVAILABILITY	SOURCES
Property Information	Available	Property Records
Location : Street Neighbourhood	Available	Engineer Maps, Town Maps
Area Code	In system	
Zonings : Zone Area per zone Conditions	In system Available Available	 Derived from cadastral and zoning information Zoning Files
Land Use : Primary Secondary Dwelling Units General Conditions	In system In system In system Not available	 Site inspection necessary
ServicesNo Services Other Services	In system Available	 Engineer department
Conservation status Date of building	Available Not available	National Monuments Files Survey of building plans necessary

Zoning Restrictions: Building lines Coverage and Mass	 Available Not available	 Planning and Township Files Survey of building plans necessary
Title Restrictions	Available	Township and Sub-divisional Files
Approved departures	Available	Town Planning register
Registration : Title Deed	In system Available	 Deed Register List
Specified Requirements	Not available	Survey necessary
Valuation	Available	Valuation Roll
Facilities	Available	Property Records

APPENDIX C

GIS COSTS 1989 - 1996

Information extracted from the Department Planning and Development GIS files and budget records.

Purchase	Amount in RANDS	Total/year	Year
Software	26657		
installation	1130		
training	2825		
hardware	41295		
sundries	87		
book	339		
		R72333	1989
upgrades	6113	R6113	1993
upgrades	971		
data	1596		
data	3830		
data	320		
		R6717	1994
software	82285		
training	11172		
upgrades	5000		
software	513		
data	160		
New computer x3	69690		
		R168820	1995
maintenance	5700		
data	4959		
printer	2200		
cd	2000		
equipment	1222		
training	1080		
training	6298		
training	5438		
training	2900		
plotter	52000		
magazine	500		
assessment	2668		
		R86965	1996

APPENDIX D

GIS COSTS 1997-1999

Information extracted from the Department Planning and Development GIS files and budget records.

PURCHASE	Amount in Rands	Total / year	Year
maintenance	7068		
equipment	18000		
software	8500		
upgrades	2500		
upgrades	4674		
licence	2997		
software	5500		
training	3192		
training	4400		
upgrades	2066		
data	4218		
memory	2050		
data mbekweni	24000		
magazine	600		
		R89765	1997
Dig Orthphoto	17556		
Data capture	12000		
software	10000		
		R39556	1998
Data Capture	30000		
Software	17000		
Viewer	10000		
RDMS	250000		
		R307000	1999
Total all years	R777269	R777269	

APPENDIX E

KEYS TO SUCCESSFUL GIS DEVELOPMENT QUESTIONNAIRE

KEYS TO SUCCESSFUL GIS DEVELOPMENT	RANK
Appropriate software technology	
Appropriate IS staff	
Appropriate hardware technology	
Coat considerations	
Define information requirements	
Deliver initial version quickly	
Develop system with users' needs in mind	
Evolutionary development approach	
Executive sponsorship	
GIS support staff	
GIS support for executives' staff	
Link GIS contents to business objectives	
Manage Data	
Manage organisational resistance	
Manage system spread and evolution	
Manage user expectations	
Operating sponsor	
Provide benefits statements	
Sell the GIS concept	
Start with high payoff applications	
Top management support	
Use consultants	
Work closely with executives	
Completed by:	

APPENDIX F

This questionnaire was prepared by the author and used in the initial stages of the GIS implementation.

NEEDS ASSESSMENT QUESTIONNAIRE 1994

A. ORGANISATIONAL ISSUES

1. Are you aware of a vision mission statement for Paarl Municipality?
2. What are your goals and objectives?
3. What department do you work for?
4. In what branch?
5. What position do you hold?
6. What tasks are you responsible for?
7. Do you use a computer?
8. How computer literate are you; 0-40%, 41-60%, 61-100%?
9. What are your information sources?
10. Is the information quick and easy to obtain?
11. How do you present your reports?
12. What do you do with your spatial data?
13. What problems have you got that are difficult to solve?

B. MAPPING

1. Do you use maps?
2. Do you add value to the map?
3. If yes, what value?
4. How can additional information enhance this?
5. What decisions are made using maps?
6. What do you use the map for?
7. What maps do you use?
8. At what scale are the maps needed?
9. What precision is needed? Co-ordinate, erf , cm, or m?

10. Who supplies the maps?
11. How regular are the maps used? Daily, weekly or monthly?
12. What is the geographical extent of your work?
13. Are the maps updated / replaced?
14. Who updates your maps, is there a standard?
15. Who checks to see if the information is correct?
16. What problems do you have with your current map system?

C. DATA BASE

1. Where do you get your data from?
2. How do you store your data?
3. How do you up-date your data?
4. How regularly do you up-date your data?
5. How do you check your data?
6. What problems do you experience with your present system?