The effective implementation of GIS in Local Government using diffusion theory

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Abstract

Geographical Information Systems (GIS) are proving difficult to both define and effectively implement in Victorian Local Government. Current innovation diffusion theory, and emerging GIS and IS implementation theory are used to develop a framework for the implementation of either a new GIS, or for improving a currently ineffective GIS. The thesis describes a method of practically redefining GIS in the Local Government environment and then applying diffusion principles during the implementation of GIS.

The first area of new investigation in the thesis is the approach to defining the GIS requirements of Local Government. In this thesis, GIS in Local Government is defined by starting with the business requirements and then letting them define the high level technical and functional requirements. This obtains a different answer from the traditional approach of assuming that current generic high level technical and functional definitions of GIS are correct, and that implementation is a selection and fine tuning process. The new approach is based mainly on the "productional perspective" developed in recent theoretical GIS diffusion studies. The major difference is that GIS implementation in Local Government does not necessarily include the requirement for the design and construction of a specific GIS database. The GIS simply consists of graphical maps that spatially index and read existing non spatial databases within the Local Government IS environment.

The second area of new investigation is the practical effects of diffusion forces during implementation. While the productional perspective was developed partially from diffusion theory, the basic concepts of diffusion theory were reapplied directly to events during GIS implementation in Local Government. Many specific aspects of implementation are identified as being influenced directly by basic diffusion forces. Measures for positively allowing for these are developed during this thesis.

The outcome of the thesis reflects both the theoretical background studied, and the extensive practical experience of the author obtained during the implementation of GIS in about 30 Local Governments.

Declaration

This is to certify that:

(i) the thesis comprises only my original work.

(ii) due acknowledgment has been made in the text to all other materials used.

(iii) the thesis is approximately 30,000 words in length, exclusive of tables, maps, bibliographies, appendices and footnotes.

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(Phillip J Dooley)

Acknowledgements

I would like to thank my many clients for the support and trust to allow me to research and implement many of the techniques described in this thesis. In particular I would like to thank the City of Port Phillip and the City of Bayside.

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Last but not least, I would like to thank my wife and family for the support and sacrifice necessary to allow me to undertake this work.

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Fitzgerald, M., Dooley, P. and Chan, T.O., 1999, Just when you thought you had finished the GIS implementation (Hong Kong: Infrastructure ’99, Conference for Local Government and Public Authorities).

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1 INTRODUCTION

1.1 BACKGROUND

Currently there is no common strategy for successful Geographic Information System (GIS) implementation in Local Government. There are varying perceptions of what GIS is and how it should be implemented. While being considered a part of Information Technology, GIS has some critical differences. This causes both the implementation processes and results to vary widely. Depending on the criteria of success, the experience of the author is that over half of all current GIS implementations in Local Government in Victoria do not deliver substantial economic benefit.

Local Government commonly believes that GIS implementation consists of the purchase of software and data, however it has become apparent that a successful implementation is much more complex and extends over several years. Masser and Onsrud (1993) described the current situation as follows: *"The present scene has been characterised as vendors 'throwing bricks' leaving the clients to 'build the house.' An important research theme would be to model what different clients need in order to 'build the house' with the practical target of defining possible sources of such support*." (Masser and Onsrud, 1993) This thesis aims to look at the "*build the house*" component, and assumes that the vendor may have already "*thrown the bricks*".

Diffusion theory, mainly developed in North America and the United Kingdom, provides a body of research within which to quantify and investigate the factors that must be considered during a full Local Government GIS implementation. *"Diffusion is the process by which an* ***innovation*** *is* ***communicated through certain channels over time*** *and among the members of a* ***social system****."* (Rogers, 1995)

There has been considerable research into the effects of diffusion on GIS implementations in general, and into implementation methods in the Information Systems

(IS) environment. However, the question of predicting how diffusion will specifically affect the future implementation of GIS in a Local Government requires more investigation.

If GIS is to become an effective part of Local Government Business Process, then a generic implementation framework must be developed that includes an allowance for diffusion theory.

1.2 OBJECTIVES

Using the above definition of diffusion, the aim of the thesis is to define a process by which GIS (***an innovation***) can be effectively implemented (***communicated through certain channels over time***) in Local Government (***among members of a social system***).

Thus the main objective of the thesis is the application of diffusion theory to current IS and GIS implementation theory and practices to improve GIS implementations in Local Government in Victoria. This will be done by developing a new GIS implementation framework for Local Government that caters for the influence of diffusion, and is flexible enough to work in any Local Government.

1.3 METHODOLOGY

The thesis has three core components:

1. A background section where the setting and current research in the relevant areas is reviewed and understood.
2. A research section where the background is cohesively combined to develop a new GIS implementation framework for Victorian Local Government.
3. A research section where the forces of diffusion are identified and discussed against relevant parts of the new implementation framework.

The background section starts by reviewing basic diffusion theory. This has two applications during the thesis: as a basis for the more advanced GIS implementation theory reviewed in Chapter 3, and as a source of all of the direct diffusion influences that are identified in Chapter 7 as occurring during GIS implementation. This chapter covers all of the main diffusion theory components and dynamics, from which the relevant parts are selected during the rest of the thesis. The third chapter reviews three main sources of implementation theory: the body of theory used for implementing Information Technology and Information Systems, the theory used for implementing GIS, and the emerging implementation theory by people like Chan, Williamson and Masser which is based on diffusion theory. Again this chapter discusses a broad range of theories, some of which are not used, but have been included here to show they have been considered. The fourth chapter describes the typical structure of Local Government in Victoria. The fifth chapter briefly defines GIS from the traditional technical and identificational perspectives, and then describes the emerging organisational and productional perspectives of GIS.

The most important background theories used in the thesis are the emerging GIS implementation theory and the redefining of GIS from a productional perspective. These are both mainly developed in the various works of Masser, and Chan and Williamson. Core diffusion theory is also important because it is the basis of these works, and also directly identifiable and active during GIS implementation in Local Government.

The first research sections combine the current body of research to develop a new GIS implementation framework for Local Government. The framework provides a new method for defining GIS in each Local Government from a business process perspective. In Chapter 7 the influences of diffusion are then identified within this framework, and the framework is evaluated for its effectiveness against the influences of diffusion, and thus the ability to make a GIS implementation successful.

The framework developed includes steps for identifying clear definitions of GIS as an innovation in the relevant Local Government environment, and the ability to measure a successful implementation. *"How one should measure or evaluate 'effective use',* *'optimal use', and 'use success' remains as a significant research challenge."* (Masser and Onsrud, 1993)

1.4 HYPOTHESIS

That in order for a Local Government GIS implementation to be successful, it is necessary to develop an implementation process that allows for the influences of diffusion.

1.5 SCOPE

Certain software characteristics may be dictated by the diffusion process, however this thesis must be independent of the current technical ability of GIS software, and concentrate on the innovation characteristic of GIS.

In order to focus the thesis, the definition of the type of GIS implementation being considered is further bounded by the following:

(1) An emphasis in the perspective of this thesis is the innovation of GIS as the mapping of current corporate data, as distinct from the efficient managing of current spatial data. Most current Local Government GIS research refers to the latter only (Campbell and Masser, 1995).

(2) The success of GIS implementation depends on a suitable IT environment. The new implementation model must be able to identify and measure the impact of IT deficiencies, however a GIS implementation must be separated from an IT hardware/ software implementation.

The thesis assumes that all Victorian Local Governments have some GIS knowledge and technology, however they may not currently be obtaining full economic benefit from this. The knowledge has been partly obtained from State Government initiatives for all Local Governments to participate in the maintenance in the state's digital map infrastructure.

The methodology developed must firstly measure the current level of GIS diffusion and thus the current level of economic benefit. Secondly, it must develop a strategy to move the organisation to the state of obtaining the full benefit of GIS.

"Is the dawning of the information age, if that is what is taking place, about technological innovation or the capacity of organisations to absorb change?" (Campbell and Masser, 1995)

1.6 ASSUMPTIONS

It is assumed that GIS is usually of benefit to a Local Government, and that the need for a GIS implementation does not need to be justified.

1.7 STRUCTURE

The structure of the thesis is as follows:

1.7.1 THEORY OF DIFFUSION (CHAPTER 2)

Chapter 2 aims to address the framework for the "effectively implemented (***communicated through certain channels over time***)" component of the thesis.

In order to develop a methodology that includes diffusion factors, Chapter 2 describes the components and relationships defined in basic diffusion theory. There has been considerable research into diffusion itself, and particularly in the general GIS environment. The current research into diffusion of GIS in Local Government has been more a case of measuring GIS penetration at a particular point in time rather than predicting the diffusion dynamics during and after implementation. The emphasis of this thesis is the prediction of the diffusion dynamics, so a combination of generic diffusion theory and current diffusion research into State Government will be the theoretical basis of the new research.

1.7.2 GIS Implementation Theory (Chapter 3)

The chapter starts with a discussion on the relationship between Information Systems and GIS, and thus the best theoretical basis for GIS implementation. It then gives an overview of both bodies of theory, and the emerging theories which combine both of the previous theories with diffusion theory.

1.7.3 Local Government (Chapter 4)

Chapter 4 will define the generic setting for the thesis. This will describe the **social system** (Local Government) from both a functional and structural perspective as it exists in Victoria.

There are many definitions of GIS used, and the structure of Local Government can vary widely and is not well documented. In the case of Victorian Local Government, the structure of the social system becomes complex because of the "Purchaser/Provider Model" which has resulted in the tendering and fragmentation of Local Government. There are at least three social systems in Local Government: the State/Country, an individual Local Government, and a Business Unit within a Local Government.

1.7.4 A Geographical Information System (Chapter 5)

This chapter clarifies the definition of GIS from the identificational perspective, the technological perspective (both structural and functional), and then describes the new productional perspective currently being developed by Chan and Williamson. Their productional perspective gives the implementation framework for the rest of the thesis. The chapter also discusses the emerging GIS implementation theories that are based on the productional perspective. These are the works where Chan and Williamson have used diffusion theory to enhance both the definitions of GIS and GIS implementation theory.

1.7.5 Definition of GIS in Local Government (Chapter 6)

This chapter defines GIS in the local government environment from the theoretical framework in Chapter 5. The chapter quantifies and expands the definitions of both Business Process GIS and Infrastructure GIS. While the chapter starts with existing theory, it develops extra definitions of GIS that are not derived from current theory, and makes a major contribution towards defining the current theory in practical and quantifiable terms in the Local Government environment. In particular the definition of Business Process GIS is greatly developed from the current theoretical base.

1.7.6 Implementation of GIS in Local Government (Chapter 7)

The thesis tests the hypothesis that diffusion affects the implementation of GIS by further developing the implementation framework and identifying all of the components that are affected by diffusion. This is done by describing a high level, non technical implementation process, emphasising the areas where diffusion occurs.

1.7.7 Conclusion and Recommendations (Chapter 8)

The main conclusion is that the effect of diffusion on GIS implementation in Local Government is substantial and that it is possible to implement GIS effectively by allowing for these effects.

1.7.8 *THESIS STRUCTURE SUMMARY*

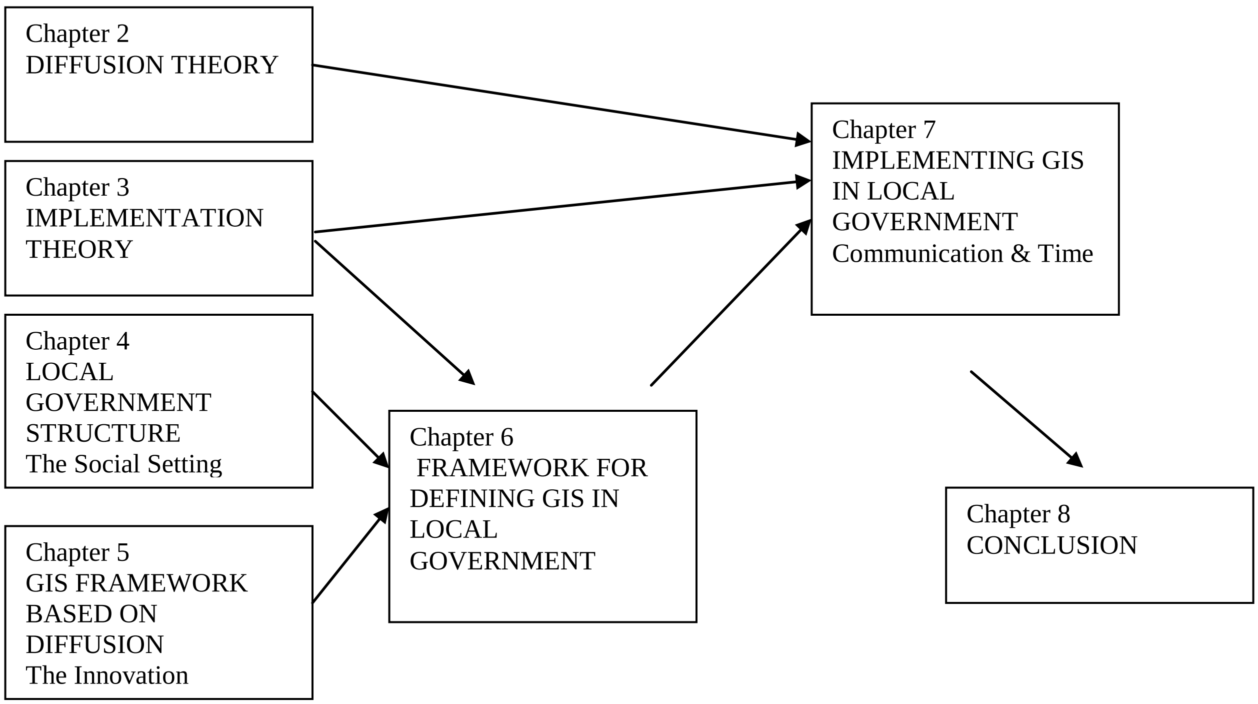


Figure 1.1 Thesis Structure

1.8 CONCLUSION

While it is accepted that GIS is of benefit to Local Government, there is no clear process for quantifying and then obtaining that benefit. The process must look at implementation from all aspects of the organisation, not just the technical detail. The most difficult aspect is the fact that GIS is a new technology, and thus strongly influenced by the diffusion process that occurs with any innovation.

This chapter described how this problem occurs and outlined the steps that this thesis will go through to research the existing theoretical base and then derive and apply the necessary diffusion principals to solve the problem.

2 THEORY OF DIFFUSION

2.1 INTRODUCTION

This chapter aims to describe the concepts, terms and dynamics of diffusion theory that are the basis of this thesis. The initial theory comes from *Diffusion of Innovations* by Everett M. Rogers, which itself is a summary of the current status of diffusion theory. As well as Rogers' current work (1995), the 1962 version of Rogers is referenced where some of the concepts are put in a more concise manner. The body of work by Rogers is seen as a better theoretical basis for this thesis than a lot of the recent more applied work.

The communication and adoption of an innovation (GIS) by a social system (Local Government), occurs within three main frameworks that are described by Rogers (1995):

1. ***The innovation development process*** covers the time from the identification of a problem, through the creation and commercialisation of an innovation to assist in the problem solution, to the adoption of a solution to the original problem.

2. After commercialisation, ***the diffusion of an innovation through an organisation*** occurs where a target social system, such as a Local Government business unit, collectively decides to adopt an innovation.

3. Within the target social system, there is also the ***innovation–decision process***, which like the second framework starts when the innovation has been commercialised. This is the process that an individual would go through in deciding to adopt the innovation and occurs in parallel to the organisation diffusion process, although an individual may adopt an innovation outside the organisational structure.

These frameworks exist for each combination of commercialised innovation and social system, and the diffusion process itself is a dynamic that occurs across all three settings. Previous work has not, however, combined the three frameworks; this will be discussed later in the thesis.

The following sections describe diffusion itself, and then the three frameworks within which it operates. As this thesis is concentrating on predicting diffusion forces, the relevant concepts will be covered in more detail than other components of diffusion theory.

2.2 DIFFUSION THEORY

At the heart of diffusion theory remains the following definition:
"Diffusion is the process by which an ***innovation*** *is* ***communicated through certain channels over time*** *and among the members of a* ***social system****."* (Rogers, 1995).

The various components of the definition will be defined and explained.

2.2.1 INNOVATION

Chapter 2.3 will fully describe the innovation development process, which is why an innovation occurs and how an innovation develops to become available to a target community. The diffusion process occurs in conjunction with the innovation development process, thus the two have to be considered in parallel. This section will concentrate on the characteristics of an innovation.

An innovation is an idea that is perceived as new to an individual. It may not be new to a similar person in a different social system, however the term innovation is defined relative to the perception of the target social system, not the technical aspects of the innovation. This is the main difference between an innovation and technology. An innovation does not have to be stimulated by a problem in the target social system, but may have already occurred in a similar social system. There is, however, always an element of reinvention of an innovation when adopted by a different social system.

Rogers (1962) defined five characteristics of an innovation that will have a major impact on the rate of adoption:

1. *Relative advantage;*
2. *Compatibility;*
3. *Complexity;*
4. *Divisibility;*
5. *Communicability.*

If the rate of adoption of GIS is to be increased, these characteristics become important.

RELATIVE ADVANTAGE

The innovation must deliver an advantage relative to the status quo. The absolute details of the advantage an innovation will give are not as important as the advantage relative to the current local environment. If the local environment is not conducive to taking advantage of the innovation, then the adoption rate will be slower. Economic performance is one part of relative advantage.

COMPATIBILITY

The compatibility of an innovation with existing systems will affect the rate of adoption, and in fact adoption of an innovation may be triggered by the adoption of another compatible innovation. This compatibility can be seen in the common use of video recorders. The innovation of the video recorder would not have been successful without the previous innovation of the television. Similarly, the use of GIS on the Windows operating system is another example of one innovation depending on a previous one.

COMPLEXITY

The rate of adoption will be affected by the perceived complexity of the innovation, which is more important than the actual complexity. The potential end user will adopt more quickly if they perceive the innovation as being simple.

DIVISIBILITY

If the innovation can be implemented in parts or tried over time, then the decision to adopt will be faster. This particularly applies among early adopters.

COMMUNICABILITY

Innovations are not likely to be adopted quickly through a social system if the results are not easily visible to the other members of the system. Success has to be able to be demonstrated and understood.

SUMMARY

In assisting and predicting the diffusion of an innovation, the five innovation characteristics must be identified and strengthened in order for diffusion to occur efficiently. If GIS is the innovation being considered, then the core aspect of this thesis is the identification and presentation of these characteristics during GIS implementation, not the technical definition of the GIS product.

2.2.2 COMMUNICATION

An innovation may commonly be communicated during the diffusion process through several channels. The main types of communication channels correlate to the position on the diffusion time scale, as explained in the next section, however there are several generic types of communicators and several dynamics that are important.

HOMOPHILY

"Homophily is the degree to which two or more individuals who interact are similar in certain attributes, such as beliefs, education, social status and the like." (Rogers, 1995). The opposite of this is heterophily, which is where two individuals have very different backgrounds. The effectiveness of communication is directly proportional to the degree of homophily between the individuals.

COSMOPOLITENESS

"Cosmopoliteness is the degree to which an individual's orientation is external to a particular social system." (Rogers, 1962). Some people only communicate within their social system, while others have a variety of information sources, for example the Internet. This will be a core indicator of their receptiveness to change.

THE CHANGE AGENT

"A change agent is a professional person who attempts to influence adoption decisions in a direction that he feels is desirable." (Rogers, 1962). Change agents are usually not part of the target social system, or part of the technical group that commercialised the innovation. More commonly they are likely to be professionals with the skill to communicate effectively in a homophilious manner with both the creators of the innovation and the recipients, without belonging to either group, i.e., in a bridging role. Typically they have good technical knowledge and the ability to communicate this knowledge in the form of concepts that the target social system will understand. The role of the change agent is examined in detail, as this role is synonymous with the role of a GIS Project Manager.

Rogers (1995) identifies seven key roles that are necessary for a change agent to undertake to introduce an innovation:

1. ***To develop a need for change***. The client needs to be aware and accept the need for change. This occurs through the change agent, who makes the client aware of current problems, points out new options available in solving them, and convinces the client that they have the ability to solve the problems.
2. ***To establish an information-exchange relationship***. The change agent has to obtain the client's trust and be perceived as credible. The credibility of the innovation in the eyes of the client is directly related to the credibility of the change agent.
3. ***To diagnose problems***. The change agent must relate the introduction of the innovation to the operational problems of the client, in terms that the client understands.

4. ***To create an intent in the client to change***. The aim of the above three steps is to create positive motivation for the client to change to the new innovation.
5. ***To translate an intent to action***. The change agent can indirectly influence the client's decision to adopt an innovation through opinion leaders and peers.
6. ***To stabilise adoption and prevent discontinuance***. Once adoption has occurred, the change agent has the role of reinforcing the reasons for adopting the innovation, and thus preventing discontinuance.
7. ***To achieve a terminal relationship***. Over time the role of the change agent should diminish until it is no longer required. This is during the later part of the diffusion process.

Research shows that some of the core characteristics of a change agent that cause failure are: Personality (28%), training (15%), vocational interests (11%), attitudes (9%) and learning ability (0%) (Rogers, 1962). The critical point is that a change agent's communication ability is more important than their technical knowledge.

OPINION LEADERS

"Opinion leaders are defined as those individuals from whom others seek information and advice." (Rogers, 1962). Typically opinion leaders are the people who influence the decisions of others within the social system. Opinion leaders differ from innovators in that they have followers throughout the social system, and their role in the diffusion process is critical.

In analysing the relationship between change agents and opinion leaders, Rogers (1995) makes the following generalisation: *"Change agent success in securing the adoption of innovations by clients is positively related to the extent that he or she works through opinion leaders."*

DECENTRALISED DIFFUSION SYSTEMS

Decentralised diffusion systems contrast to centralised diffusion systems in that the spread of knowledge is not controlled in a linear manner and directed totally through a single change agent. Diffusion occurs more naturally starting from innovators within the social system in a manner controlled by the social system. Key characteristics are the wide sharing of power among members of the social system, and high levels of reinvention during the diffusion process. The two diffusion systems can be combined to form a hybrid system where required.

2.2.3 Over Time

Rogers (1962) defined two main time dynamics that occur, namely adoption and diffusion.

*The **diffusion process** is the spread of a new idea from its source of invention or creation to its ultimate users or adopters.*

***Adoption** is the decision to continue full use of an innovation.*

The adoption process differs from the diffusion process in that adoption is the process between a person hearing about an innovation and that person deciding to use the innovation. Diffusion is about the spread of an innovation from the source to the eventual adopter, thus the diffusion period is the time from the first awareness to the last adopter in a given social system. Adoption is a process that occurs within the diffusion process that relates to an individual. The adoption process that relates to an individual is fully explored in Section 2.4.

DIFFUSION

History shows that there is a considerable time lag (Rogers discusses this in terms of years) between the discovery of an innovation and the wide adoption of the innovation by the general public. The process of deciding to adopt the innovation in the intervening period is known as diffusion. The time taken for an individual to decide to adopt an innovation will have a normal distribution, and the position of individuals across the time/distribution curve will be determined by their personality and standing in the social system. The time taken by individuals to adopt an innovation when compared to the average of the social system can be divided into several categories: *"innovators, early adopters, early majority, late majority and laggards."* (Rogers, 1962).

Each of these categories can be superimposed on a normal distribution to the relative proportions of each category and how they relate to the time scale of the innovation adoption.

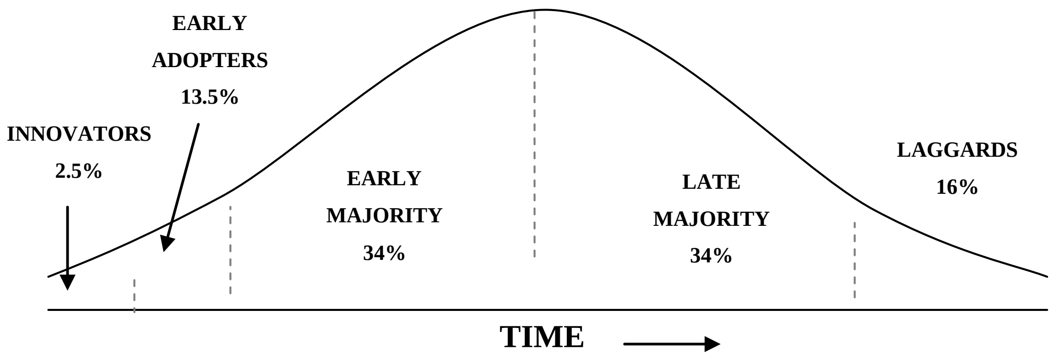


Figure 2.1 The Categorisation of Adopters over Time. (Adapted from Rogers (1995, p262))

There is a large degree of dependency between the types over time. For example, if there are no innovators in the social system interested in the innovation, then it is unlikely that an early adopter would adopt the innovation.

ADOPTER CATEGORIES

The identification of the people who fit the various adopter categories, and thus perform the diffusion process, is a fundamental part of a GIS implementation. The following are typical profiles of the five adopter categories:

(1) Innovators:

Innovators will always be the first to adopt, and will form a very small percentage of the social system. They will have outgoing personalities and actively seek innovations to adopt, in a similar manner to seeking dangerous sports. They will not conform locally and will have a very wide circle of external contacts. The following are some of their common characteristics:

- Innovators will have a high deviation from the considered norm of their social system, and a low level of conformity.

- Innovators usually belong to cliques and organisations consisting of other innovators.
- The critical role of an innovator is to introduce the innovation from external sources to the opinion leaders of the social system. Innovators themselves will not be opinion leaders.
- Innovators lack respect in a social system, which is why the early adopters are so important.

(2) Early Adopters:

These differ from the innovators in that they are considered normal by the social system. They are usually a reference point for acceptable behaviour for the rest of the community, and often the opinion leaders. An early adopter would adopt the innovation before 85% of the social system.

The identification of early adopters is critical to the diffusion of an innovation, and the following core characteristics have been identified:

- Early adopters will have a different mental ability to the rest of their social setting, as they have no reference points within their local community.
- Early adopters will be more cosmopolite than later adopters.
- Early adopters will lead opinion in the social system.
- Early adopters will communicate with innovators more and see them as less deviant.
- Early adopters will be younger.
- Early adopters will use a wider source of information than late adopters and will utilise the following communication channels:
  - Impersonal sources.
  - More cosmopolite sources more than local sources.
  - Closer contact with the origin of the innovation.
  - A wider source of information than late adopters.

(3) Early Majority:

These people are not leaders, but follow them very closely. They perform the critical role of legitimising the innovation. The early majority would make up the balance of the first

50% of the adopters. Commonly an early majority would communicate with an early adopter, but not an innovator.

(4) Late Majority:

These people will naturally follow the early majority because of weight of opinion, but would not otherwise use the innovation. They are the majority of the second half of the adopters.

(5) Laggards:

These people use the past as a reference point for their actions. They are not easily swayed by popular opinion and are relatively isolated from the general community. Adoption, if it occurs at all, may be a long time after the rest of the social system.

SUMMARY

Within these categories, effective communication rarely occurs outside adjacent categories, which is usually the limit of the homophily. One of the differences between early and late adopters is the ability for early adopters to visualise the concept in their own situation, while late adopters wait to see it in action. This in turn affects the adoption time, as early adopters do not necessarily become aware of the innovation earlier. Research indicates that for the late majority the awareness to trial stage is substantially longer than the trial to adoption stage, and the trial to adoption stage is proportionally longer for early adopters. The encouragement of a free trial speeds up the whole adoption process considerably.

2.2.4 Through a Social System

A social system is a population of individuals who are functionally differentiated and engaged in collective problem solving behaviour (Rogers, 1962).

A social system has the core characteristic of a group of people who interact on an ongoing basis, and have a common activity or cause. All of the previously described personality types (early adopters, early majority etc.) will be found within any social system A social system must have enough participants to enable statistical deviation to occur.

Rogers (1962) identifies the two relevant activities within a social system as the communication patterns and the authority/hierarchical structure. These have to be identified as part of the definition of the relevant social system, as the social system is the starting point for the identification of the other components of the diffusion of an innovation. (The other starting point is the definition of the innovation itself.)

2.3 THE INNOVATION DEVELOPMENT PROCESS

In order to address the effective diffusion of an innovation within a given social system, it is necessary to widen the scope of interest to the whole development process of the innovation being considered. The process starts at the time when the need for the innovation is recognised, and finishes with the complete adoption or rejection of the innovation. While GIS is the core innovation being considered, this framework allows for the invention of different GIS related innovations over time (reinvention), as technology and perceptions change and GIS responds to different problems. Both the diffusion/ adoption process and the product implementation process are components of the innovation development process.

"The innovation-development process consists of all the decisions and activities, and their impacts, that occur from recognition of a need or problem, through research, development, and commercialisation of an innovation, through diffusion and adoption of the innovation by users, to its consequences." (Rogers, 1995)

Rogers (1995) identifies six main steps in this process, as demonstrated in the following diagram:

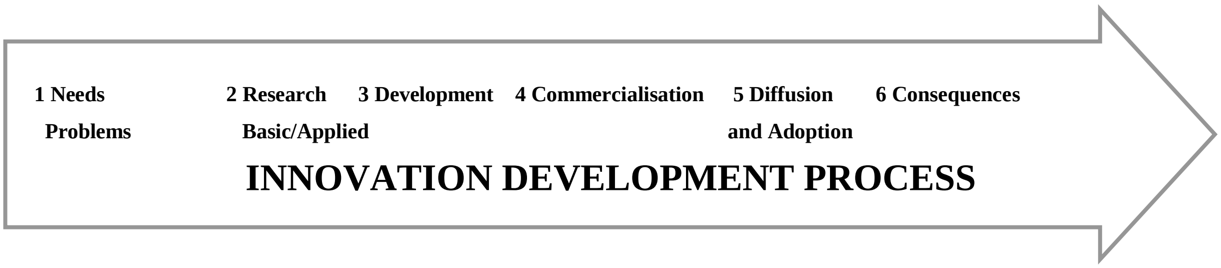


Fig 2.2 Innovation Development Process. (Adapted from Rogers (1995, p133))

These steps need to be explored so they can be used as a framework for the rest of the thesis. One of the critical questions to be answered during implementation is when the invention of a new innovation occurs; as distinct from the reinvention, diffusion and adoption of a current innovation.

2.3.1 *Recognition of a Problem or Need*

This is the phase that prompts the research, and is stimulated by either a scientific or political reaction to a problem. The identification of problems can either be random and identified when they have an impact that requires a response, or identified as part of a systematic review of a process. A third method of identification is the prediction of a future problem that is solved in anticipation, possibly for commercial purposes.

The identification of operational problems that require an innovation for the solution can also come from business process re-engineering that starts with systematic identification of current operational problems.

2.3.2 *Research*

Once a problem is identified, there are several ways it can progress to a solution. There are two building blocks used in the creation of an innovation that will solve a given problem: basic research and applied research. Basic research is the advancement of scientific research that does not necessarily aim to solve a practical problem. Basic research would never develop software, for example. Applied research starts with the basic research and applies it to practical problems to provide a path for a solution. This phase of the development of an innovation would take the solution of the problem to proof of concept stage.

The difference between an innovation and technology is explained in the previous section, and in many cases they are synonymous.

The research phase may be simply finding the right combination of applied research for a specific problem. Literature indicates that the research component is sometimes solved accidentally while attempting to solve another problem (serendipity), and that the solution is as likely to come from the end user as the research community.

This phase is very similar to the Information Systems (IS) process of converting a set of operational problems to a set of user needs which are then converted to a set of functional requirements, as detailed in later chapters. At this point it has thus been proven that meeting the functional requirements will solve the problem, however it is not clear how the functions will be performed in a technical sense.

The critical test of whether the innovation development process is occurring during implementation is whether research, development and commercialisation is required to solve the problem, or whether it is just a matter of adopting or reinventing a previously commercialised solution.

2.3.3 DEVELOPMENT

Development takes the Research stage to the point where it can actually meet the needs of the user. Often Research and Development (R&D) are undertaken together, however this is not always the case. For example, a tender may be let for a software company to develop a product from a set of functional requirements. A critical component of the development phase is continuous feedback from the end users to ensure that the final result meets the user requirements. The detail and accuracy of the functional requirements will dictate the importance of feedback. Development cycles can vary from where all of the possible end user feedback is contained in a specification, to where the product is built entirely from a combination of trial and error and user feedback.

2.3.4 COMMERCIALISATION

"Commercialisation is the production, manufacturing, packaging, marketing, and distribution of a product that embodies an innovation. It is the conversion of an idea from research into a product or service for sale in the marketplace" (Rogers, 1995)

This phase is self-explanatory, however the extent to which an innovation is commercialised depends on the size and number of the applicable social systems. If an innovation is built for a specific purpose or business unit, then it will require very little commercialisation. The quality of the commercialisation will impact on the diffusion of the innovation.

2.3.5 DIFFUSION AND ADOPTION

Diffusion and adoption are the movement of the innovation into the social system, as explained fully in the next section. One of the main decisions made in this stage is when to start the diffusion or communication process through the target community. Communication with the target social system prior to this phase may vary from no contact at all to very close contact. This is the point where the communication process commences on the whole target social system, not just a sample who have participated in the development of the innovation.

The adoption process differs from the diffusion process in that adoption is the process between a person hearing about an innovation and that person adopting the innovation. Diffusion is about the spread of an innovation from the source to the eventual adopter.

2.3.6 CONSEQUENCES

There are two possible outcomes from the innovation development process, either the initial problem is solved or it is not solved. The consequences are thus the impact of the solution on the problem. These are commonly a combination of tangible and intangible benefits, however tangible benefits are more easily quantified.

2.3.7 SUMMARY

These six phases are a higher-level structure within which an innovation is adopted or rejected. The extent to which any phase occurs can vary greatly, as can the order, and a test must be developed so that the person implementing the innovation clearly knows if the innovation development cycle is required. If the innovation exists, it may just require implementing or reinventing and then implementing.

2.4 INDIVIDUAL INNOVATION DECISION PROCESS

Arguably the most important innovation diffusion process that occurs is the individual innovation decision process, which is where an individual person within the social system decides to adopt the innovation. Unless this occurs within all of the other frameworks, then the innovation is not utilised.

2.4.1 DEFINITION

"The innovation-decision process is the process through which an individual (or other decision making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of the decision." (Rogers, 1995)

Rogers goes on to describe the process through the following diagram:

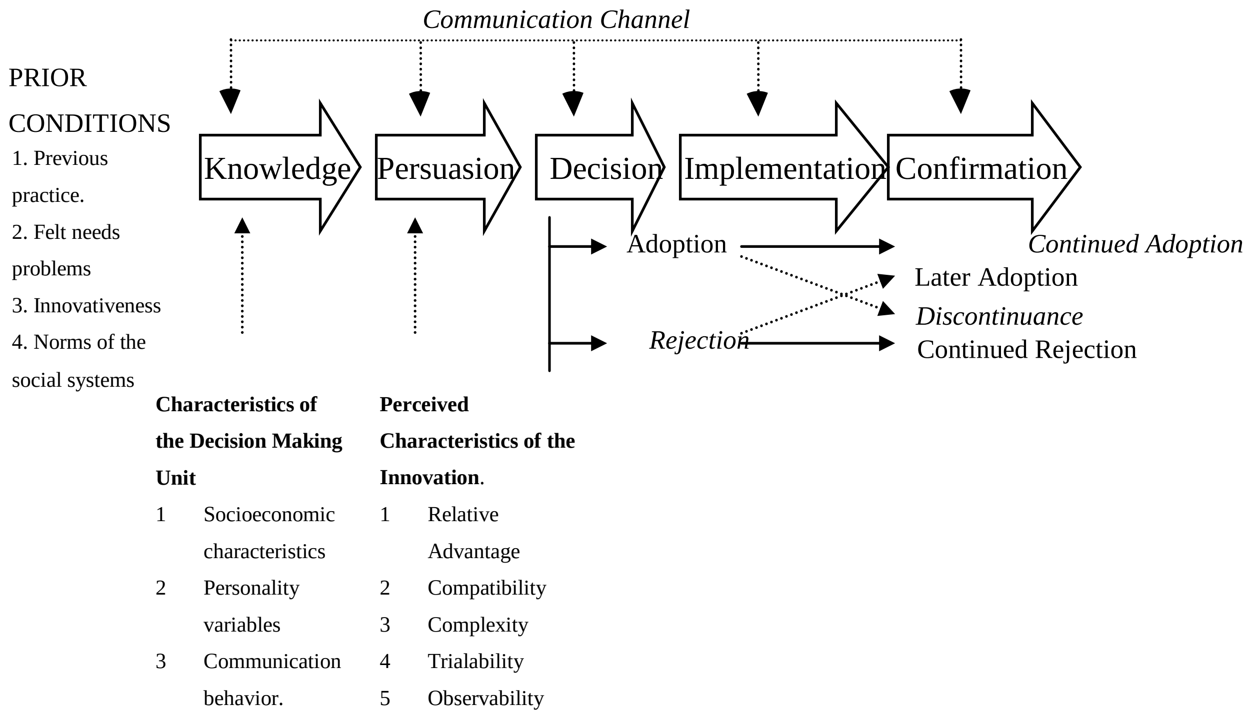


Figure 2.3 The Innovation-Decision Process. (Adapted from Rogers (1995, p163))

This figure shows the stages an individual goes through while making a decision on the adoption of the innovation, and these will be explored in the next sections. This process will later be adapted to the decision of an individual to adopt GIS.

2.4.2 DECISION PROCESS

The various stages that an individual goes through before adopting an innovation are now described as follows:

KNOWLEDGE

This is where an individual first learns that an innovation has been commercialised to a point where it may solve their particular problem. They may get this knowledge from either within the social system or outside channels, such as a change agent or mass media. The most likely source of the initial knowledge depends on an individual's personality, and thus position in the social system.

PERSUASION

Persuasion is the first proactive step taken to obtain further information about the innovation. The critical components of an innovation that an individual will look for are those described in 2.2.1 – relative advantage, compatibility, complexity, trialability and observability. At this point the communication channel also becomes important, as credibility of the source is necessary to move to the decision stage. The communication channel that an individual finds most effective is dependent on their position in the social structure (i.e., from early adopter to laggard, as described in 2.2.3). The necessary outcome of the persuasion stage is to reduce the uncertainty and to give the innovation credibility.

DECISION

The decision process is where the individual has enough information to make an informed decision regarding the adoption or rejection of the innovation. An organisational decision process may influence this decision, however an organisation cannot effectively force an individual to adopt an innovation.

IMPLEMENTATION

Implementation is where the decision to adopt is acted on by taking the practical steps required to implement the innovation. At this stage reinvention can occur, as the individual decides precisely how the innovation should be utilised in their particular case.

CONFIRMATION

This is the stage where the final decision to continue adoption, adopt later, discontinue adoption or to continue rejection occurs. If implementation has occurred, the options are to decide to continue to adopt or to discontinue the adoption, while if implementation has not occurred, the possible decisions are to adopt later or reject the innovation. This will be partially based on communication with other similar members of the social system.

2.4.3 SUMMARY

These stages occur for all end users regardless of the other higher-level dynamics occurring in the social system. The time for this to occur may vary from several years (for a complex innovation) to a couple of days (for a simple innovation). In its simplest form, the first four components (knowledge through to implementation) may occur during an effective training session, and the fifth (confirmation) during the first few days of effective use in the workplace.

2.5 THE ORGANISATIONAL INNOVATION PROCESS

2.5.1 OVERVIEW

The diffusion of an innovation starts at the identification of a problem and moves through the phases of invention of the innovation to finish at the adoption of an innovation by an individual. Rogers also identifies another important associated process that occurs within this. That is, the diffusion process resulting in the adoption of an innovation by an organisation.

2.5.2 THE STRUCTURE OF ORGANISATIONS

The first critical difference in organisational adoption (as opposed to individual adoption) is the concept of collective and authority based innovation decisions. Rogers (1995) identifies three types of innovation decisions:

Optional: Individual and independent adoption decisions.

Collective: Adoption decisions by consensus of the members of the system.

Authority: Relatively few individuals make the decision to adopt.

This introduces a more complex set of factors, which may impact on an individual's decision to adopt an innovation. To determine whether this is occurring, the characteristics of organisations themselves are investigated.

Rogers (1995) identifies the following five core components of an organisation:

1. **Predetermined Goals.** Organisations should have a formally specified aim and method for achieving their goals. This usually correlates to the definition of a relevant social system in this thesis, as the social system would be the employees or staff members under the umbrella of the formal aim and method for achieving the goals.

2. **Prescribed Roles.** Tasks will be formally distributed among the members according to their duties. Organisation charts and position descriptions define the formal social structure.

3. **Authority Structure.** There is a set authority structure, with a hierarchy that defines who is responsible to who. This is a direct contrast to the previously described random distribution in a social system, and will impact on implementation methodology.

4. **Rules and Regulation.** All decision processes and actions may be specified by a formal set of procedures, particularly if Quality Assurance is implemented. This can result in a high level of social control, and thus impact heavily on the normal communication processes in diffusion.

5. **Informal Patterns.** Regardless of the above formal structures, the people in the organisation will form their own social structure, which will conform with those discussed previously. This will result in the normal types of social communication also occurring.

This structure has the ability to impact on normal diffusion processes that would occur by individuals without these controls. This has to be investigated further so that the impact of two parallel sets of forces is allowed for.

2.5.3 THE ORGANISATION INNOVATION PROCESS

The most relevant diffusion setting that applies to Local Government is the process whereby an innovation is adopted by an organisation. Rogers (1995) combines the previous research by Gerald Zaltman and others into this aspect and defines the following two part, five stage process:

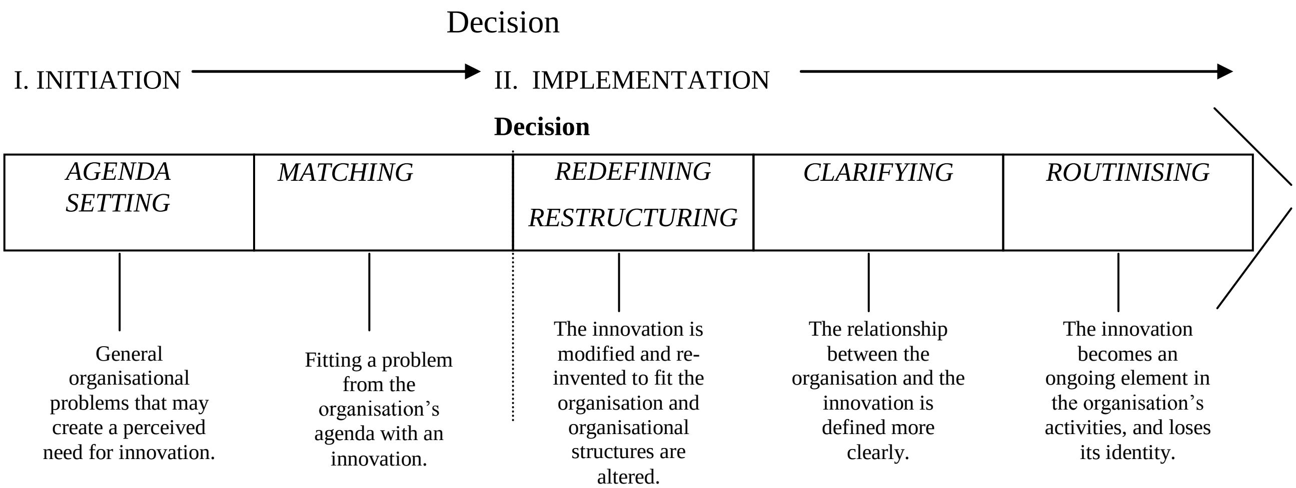


Figure 2.4 Five Stages in the Innovation Process in an Organisation. (Adapted from Rogers (1995, p392))

The decision by an organisation to adopt the innovation clearly splits the process into two parts, the initiation sub process and the implementation sub process. The five stages will be explained further.

1. AGENDA SETTING (INITIATION)

The two core dynamics that occur in organisations all of the time are the identification and prioritisation of problems and the search for solutions to these problems. As described earlier, this process is also the trigger for the creation of an innovation. Thus organisations are always either looking for available innovations or starting the creation process of new ones.

This process can be accelerated when the members of an organisation perceive a performance gap between their expectations and the reality. The phase of agenda setting can take several years, and alternately can occur in reverse where organisations look for useful solutions and then see if they have the problem.

2. MATCHING (INITIATION)

This is the stage when the problem is matched with an innovation that will solve the problem. This is followed by a decision by the organisation on the suitability of the match and thus either acceptance or rejection of the innovation as a general principle. The decision to accept the innovation in principle is when the process moves from initiation to implementation.

3. REDEFINING/RESTRUCTURING (IMPLEMENTATION)

Once the decision is made for the organisation to adopt the innovation, there are two processes that occur, redefining the innovation to fit the organisation better (reinvention), and restructuring the organisation to fit the innovation better. Both the innovation and the organisation will change during this process. Typical organisational changes are the creation of a unit within the organisation to take responsibility for the innovation, or a fundamental change can occur in the way the organisation operates. The introduction of internal email is an example of this.

One of the important dynamics that occurs when the innovation is computer related is the creation of a state of uncertainty. There are three types of uncertainty that need to be identified at this point:

1. *Technical uncertainty*, or the inability to precisely know how the new system will perform technically in terms of speed, capacity and reliability etc.
2. *Financial uncertainty*, or the degree to which the innovation will deliver financial benefits.
3. *Social uncertainty*, or the degree to which social uncertainty will be created during implementation.

Rogers (1995) then draws the important correlation between uncertainty and the adoption process: *"Some innovations are so radical, and create such a high degree of uncertainty,* *that they must be adopted through an innovation process that is relatively unstructured and almost completely unroutine."*

At this point the other core component in the adoption process is the change agent. The higher the level of uncertainty with the innovation, the greater the need for a change agent.

4. CLARIFYING

Once the innovation starts to be put into widespread use, the members of the organisation start to understand the innovation more clearly. This occurs partially with use, but more importantly through communicating with other members who are also using the innovation. Again Rogers (1995) makes an important observation: *"Too-rapid implementation of an innovation at the clarifying stage often leads to disastrous results."* By the end of this phase, the members have a much clearer understanding of the innovation being introduced.

5. ROUTINISING

This is the last phase of the introduction of the innovation, and is where the innovation becomes an accepted part of the normal activities of the organisation. It is no longer perceived as an innovation.

2.6 RELATIONSHIPS BETWEEN DIFFUSION COMPONENTS

This chapter has described the four components of diffusion (the innovation, communication, time and the social system), and the three main frameworks within which diffusion works. It is clear that the four diffusion components act in a co-ordinated way. In the case of this research the innovation is GIS, the social setting is Local Government, and the communication channels over time is the task of the implementation.

The relationship between the frameworks within which diffusion operates is not so clear. The three frameworks (the innovation development process, the diffusion of an innovation through an organisation, and the innovation–decision process) exist for each combination of commercialised innovation (e.g., GIS) and social system. The diffusion process itself is a dynamic that occurs across all three settings. While all dynamics occur together in a Local Government implementation, the current theoretical work does not combine the frameworks in a logical manner, but rather presents them as separate bodies of theory. While this thesis uses all components, the full integration of the three dynamics remains a subject for future research.

The various diffusion dynamics and principles described operate naturally in society over time. An understanding of them enables two courses of action, firstly to stop the naturally occurring diffusion process from affecting an implementation in a negative way, and secondly to run an implementation so that positive diffusion forces are used to maximum advantage. These positive components have to be setup and managed during the implementation.

2.7 SUMMARY

This chapter has described the various influences that make a person adopt an innovation, which will later be used to determine why a staff member of a Local Government would adopt GIS. While other sources of diffusion literature were read during the research, Rogers provides a suitable clear and structured basis for further research into predicting the diffusion forces in Local Government. Other research tends to apply diffusion research in a manner that is not suitable for this.

Diffusion forces cause many current GIS implementations to fail because they are unknowingly having a negative effect in the background, or the GIS implementation does not reach its full potential because diffusion forces are not proactively applied. This chapter has systematically described the various diffusion forces that can occur during an innovation, and by the end of this thesis most components of this chapter will have been applied to a Local Government GIS implementation. The task of this thesis is to put these principles and dynamics into a practical context so that they can be deliberately and effectively used during future GIS implementations.

3 IMPLEMENTATION THEORY

3.1 INTRODUCTION

"Implementation: All organisational activities working towards the adoption, management, and routinisation of an innovation." Laudon and Laudon (1998, 513)

The purpose of this chapter is to understand current implementation theory and practice, and then later in the thesis the new research will build from this.

There are four backgrounds that are relevant to this thesis: current Information Systems (IS) theory, current GIS implementation theory, current implementation practice (which is not always based on any theory), and emerging implementation theory. The emerging implementation theory starts to tie the previous three backgrounds together.

The IS theory concentrates on the implementation of Information Technology (IT), while the GIS implementation theory starts with some IS theory and adds GIS specific components. This chapter starts by examining briefly the relationship between IS and GIS, which gives some priority between the two older theoretical bodies of research used in this thesis.

3.2 THE RELATIONSHIP BETWEEN GIS AND IS

Because it is common practice in some literature to mix up the terms Information Systems (IS) and Information Technology (IT), the difference is now discussed. IS refers to the overall system that is being implemented, including the organisational and management components for example. IT refers to the physical technology component of IS, particularly the software, hardware and network components. Where the term IT is used from another source, it is taken as referring to IS unless otherwise stated.

There are a number of theories on which to base the proposed implementation methods. The question is whether to primarily base the new implementation methods on existing GIS implementation theory, or on the Information Technology (IT) industry, which uses Information Systems (IS) theory. This section will discuss the relationship between these theories to justify the direction of the thesis.

The real question is whether GIS is a subset of IS or a special type that runs approximately in parallel. If GIS is a subset of IS then the implementation theory currently being utilised in the IS industry becomes relevant. It can then be modified for the influence of diffusion and the introduction of a geographical component, accepting that some of the current GIS implementation theory may already do this. If we accept that GIS is not a direct subset of IS then this thesis has to extend the current GIS implementation theory, and the current GIS theory should set the majority of the theoretical background.

3.2.1 INDUSTRY VIEWS

Current industry discussion on the relationship between IS and GIS from a GIS editorial point of view is relevant. Practice adopted by industry influences both the previous and future nature of GIS. The perception that GIS is a part of IS will take priority over working within a theoretical framework as was the case in the past.

GEOWorld (Dec 1998) wrote an industry trends article under the heading "GIS melts into IT", where they asked their editorial panel a series of questions on the relationship between GIS and IT. The first question was: *" Given the rate of change of geographic technology, from being GIS-centred to being IT-centred (in a world of distributed technology), is GIS in danger of loosing its identity? In short, is it a good or bad thing that GIS is being assimilated into IT?"*

The twenty-three responses were graded to see if they agreed that GIS was in fact a part of IT, whether GIS will lose its identity within IT and also whether it is a good or bad thing. The results were as follows:

	Yes	%	No	%	??	%
Agree GIS is a part of IT.	22	95%	1	5%	0	-
Agree GIS is not losing its identity.	17	74%	0	0%	6	26%
Believe the assimilation is a good thing.	15	65%	2	9%	6	26%

Table 3.1 Table of opinions on GIS/IT relationships

Thus the current industry assumption is that GIS is a clearly identifiable part of IT (which from the questions and answers can be taken to mean IS), and that the two are no longer implemented as disparate systems.

Confirmation of the relevance of IT implementation management is shown in the 1998 *AGI Source Book* (Corbin, 1998), where sixty seven GIS consultants are listed as available to manage GIS implementation projects. There are fifty-seven consultants who use the “PRINCE” project management methodology, and fifty-three who use the “SSADM” methodology. A large number can use both. Both of these methodologies are IT industry standards for project management, and neither has been designed specifically for GIS.

3.2.2 CONCLUSION

From the two perspectives of where the industry considers GIS to be and what type of implementation methodology the industry considers appropriate to implement GIS, it would appear that GIS is considered to fit under the IS umbrella. This thesis will thus consider implementation from both the GIS and IS perspectives.

3.3 INFORMATION SYSTEMS DEVELOPMENT

The IS theory is treated as a body of research that is applicable to GIS implementation, but is not mandatory to use. For this reason the theory will be summarised, concentrating firstly on the aspects most commonly used by the GIS community, and then on the aspects that may have the most relevance to this thesis.

Laudon and Laudon (1998) are used extensively in this chapter as a reference. Their book is a good summary of the current theory and practice of Information Systems (IS) and the relationship of IS with the commonly used term Information Technology (IT). Laudon and Laudon (1998) describe the typical IT system development cycle as having the following steps: systems analysis, systems design, programming, testing, conversion, production and maintenance. These steps, as described below, are currently taught by Laudon and Laudon (1998) as the classically correct approach to implementing an Information System.

SYSTEMS ANALYSIS

Systems analysis is defined as the analysis of the problems that the organisation will try to solve with an Information System. Systems analysis consists of defining the problem, identifying its causes, specifying the solution, and identifying the information requirements that must be met by a system solution. This component also includes a feasibility study to address technical, economic and operational feasibility.

SYSTEMS DESIGN

Systems design details how the system will meet the information requirements as specified by the systems analysis. There are three objectives: consider alternative technology solutions, responsibility and management for the technical delivery of the system, and detail the implementation specification, including managerial, organisational and technological components.

PROGRAMMING

The programming stage encompasses the process of translating the system specifications prepared during the design stage into program code.

TESTING

Testing is the process that determines whether the system produces the desired results under known conditions.

CONVERSION

Conversion is the process of changing from the old system to the new. There are several strategies for this: parallel, direct cut over, pilot and phased.

PRODUCTION AND MAINTENANCE

Production and maintenance is when the new system is reviewed by users and technical specialists to determine how well it has met its original goals, followed by any appropriate changes to correct errors, meet new requirements or improve processing efficiency.

These steps are commonly used in isolation to implement GIS by the IS (IT) industry treating the spatial information as another type of relational database. By treating the spatial information as a database then a GIS implementation can be matched to the accepted skill and position hierarchy used by the IS (IT) industry, and outwardly GIS does look like any other software product. This type of implementation results in software and geographical data being available at the desktop, however the true results will be critically discredited later in the thesis.

3.4 INFORMATION SYSTEM THEORETICAL APPROACHES

The IS body of theory is substantially greater than the six IT steps in the previous chapter, and can contribute valuable background in a similar manner to diffusion theory. In the 600+ pages of IS theory and practice documented by Laudon and Laudon (1998), GIS is mentioned once as an application software available with word processors and spreadsheets. This may be the correct place for the software component of GIS, however the rest of the GIS theory may fit into the normal IS theory. With this qualification a summary of other relevant components of IS (IT) implementation theory that may be applicable to this thesis is now given. Some of these components are parts of the six core IT systems development steps described in 3.2, some are options to, and some are factors outside the six steps.

3.4.1 A SOCIOTECHNICAL SYSTEM PERSPECTIVE

Laudon and Laudon (1998) advocate a Sociotechnical System perspective to implementation, and observed the trend that rapidly decreasing software costs and growing power is not necessarily translating into greater profit or business benefit. They make the following critical observation:

"We stress the need to optimise the performance of the system as a whole. Both the technical and behavioural components need attention. This means that technology must be changed and designed in such a way as to fit organisational and individual needs. ***At times, the technology may have to be 'de-optimised' to accomplish this fit****. Organisations and individuals must also be changed …"*

If you start with the optimum technology and the existing social system, both will require changing until a middle ground that works is found. This will normally fail to be the best technical solution to the problem but rather the result of a mutual influence of the two factors on each other. Laudon and Laudon illustrated this with the following diagram:

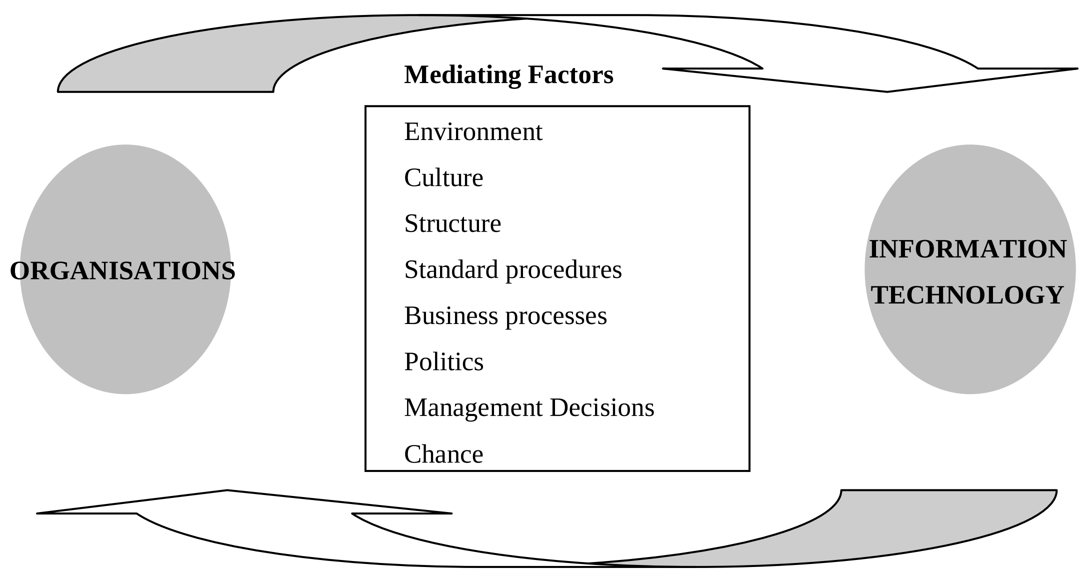


Figure 3.1 Mediating Factors between Organisations and Information Technology. (Adapted from Laudon and Laudon (1988, p75))

The point is also made that this takes time. This concept agrees with diffusion theory and is a critical component of GIS implementation. If the implementation of GIS requires the mediating of an organisation with the technology, further explanation of the eight mediating factors from the previous diagram is required.

ENVIRONMENT

Environment entails the external impacts on the organisation, particularly financial and political. Environments can change much faster than organisations, and can cause the failure of organisations. Changes in the external environment can greatly impact on IS implementations.

CULTURE

Organisational culture is a set of fundamental assumptions about what products the organisation produces, for whom and how and where they are produced. They are taken for granted, and rarely documented or discussed. These assumptions dictate all of the other components of an organisation.

STRUCTURE

There are several types of organisational structure possible, each requiring different approaches to implementation. Examples are divisional bureaucracy and machine bureaucracy. This will determine characteristics like how centralised authority is and how quickly the environment can change.

STANDARD PROCEDURES

Standard operating procedures are a reasonably precise set of rules, procedures and practices that develop over time to efficiently undertake the core tasks of the organisation. These are not easily changed.

BUSINESS PROCESSES

Business processes are the way in which organisations co-ordinate and organise work activities, information and knowledge to produce products or services. Standard operating procedures are a subset of these.

POLITICS

Organisational politics occur because of the different positions and thus perspectives of people towards the distribution of resources, rewards and punishments. These differences will generate conflict and, more importantly, resistance to change.

MANAGEMENT DECISIONS

Management decisions control the way all of the above factors mediate the reaction between the organisation and the new IS. Managers dictate timeframes and technical specifications.

CHANCE

The outcome may be influenced by either good or bad luck, put another way, perfect control is not possible when dealing with a social component.

3.4.2 ORGANISATIONAL IMPACT ON INFORMATION SYSTEM IMPLEMENTATIONS

Laudon and Laudon (1998, p105) give the following check list in order of importance when considering the organisational factors of an IS implementation:

- The *environment* in which the organisation must function.
- The *structure* of the organisation: hierarchy, specialisation, and standard operating procedures.
- The *culture* and *politics* of the organisation.
- The *type* of the organisation.
- The extent of support and understanding of *top management*.
- The *level* of organisation at which the system resides.
- The principal *interest groups* affected by the system.
- The kinds of *tasks*, *decisions*, and *business processes* that the information system is designed to assist.
- The *sentiments* and *attitudes* of workers in the organisation who will be using the information system.

- The *history of the organisation*: past investments in information technology, existing skills, important programs, and human resources.

This list is from an IS perspective and experience, and runs parallel with diffusion theory. It will make a useful contrast to the GIS version of these factors.

3.4.3 System Analysis Considerations

The previous sections describe some of the external factors that have to be considered. Laudon and Laudon (1988) also give more relevant detail on components of the first implementation step, system analysis.

TASK 1 ORGANISATIONAL INFORMATION REQUIREMENTS

The first implementation task is linking the Information System to the business plan or business needs by determining the organisational information requirements. There are two methodologies detailed for establishing organisational information requirements, enterprise analysis and critical success factors. These will be summarised.

Methodology 1 Enterprise Analysis (or Business Systems Planning)

"An analysis of the organisation wide information requirements by looking at the entire organisation in terms of organisational units, functions, processes, and data elements, helps identify the key entities and attributes in the organisation's data." (Laudon and Laudon, 1998).

The general principle is to take a wide sample of managers and identify their information needs through a series of questions on what they do and how they do it. These results are then aggregated and categorised across the organisation. This process is time consuming and expensive, and may not result in a questioning of the way business is done.

Methodology 2 Critical Success Factors

Critical Success factors (CSFs) come from the operational goals of the organisation, which are used to determine the information needs of the organisation. These are determined from a smaller higher management group than the enterprise analysis technique. This method initially makes no assumptions about the current processes or organisational aspects, and will take advantage of the emerging environment from a management point of view, as distinct from the existing productional perspective of the lower levels of management.

TASK 2 ORGANISATIONAL CHANGE DECISIONS

The other core decision required at the start of the process is the extent of organisational change that the implementation requires. There are four levels of change identified, each delivering higher return but requiring higher risk.

Level 1 **Automation** is the use of technology to speed up existing tasks, which has minimal organisational impact and minimal risk, but possibly highly visible returns.

Level 2 **Rationalisation** is the next level past Automation, where existing business processes are streamlined to allow better operating efficiency.

Level 3 **Business Re-engineering** includes automation and rationalisation, but also questions all existing roles and business processes in the organisation and then builds them again to take full advantage of the new IS being implemented.

The five steps in Business re-engineering are:

1. Develop the business vision and process objectives.
2. Identify the processes to be redesigned.
3. Understand and measure the performance of existing processes.
4. Identify the opportunities for applying information technology.
5. Build a prototype of the new process.

This has a large and risky impact on the organisation and all of the organisational factors discussed in the previous section need to be considered.

Level 4 **Paradigm Shift** is the most radical, where the core nature of the business and organisation is reconceptualised. This would be rarely done, and is not considered further in this thesis.

TIMING CONSIDERATIONS

One of the main considerations when determining the level of change is timing. It is possible to incrementally move down the list over time, and as the organisation is able to change, so can the information technology be changed. Further consideration of timing of change is duplicated in diffusion theory.

SUMMARY

Section 3.4.3 covered several core concepts that can be summarised as follows: There are two methodologies given for measuring the organisational information requirements, enterprise analysis and critical success factors. There are also four levels of organisational change possible, ranging from automation through rationalisation and business process re-engineering to paradigm shift.

These components match the traditional roles of business analyst and systems analyst in the IT industry, and these decisions are undertaken as part of the core systems analysis described in section 3.2.

3.4.4 PROTOTYPING

Prototyping is offered by Laudon and Laudon (1988) as an alternative approach to the standard IS implementation cycle, where an experimental system is rapidly and inexpensively built for users to evaluate. This is then used as the basis for the fine-tuning of the full system. It allows for an iterative process of design by repeatedly redesigning the system based on end user feedback. The steps are as follows:

1. Identify the user's basic needs.
2. Develop a working prototype, possibly using Computer Aided Software Engineering (CASE) tools.
3. End user uses the prototype with a limited dataset.
4. Revise and enhance the prototype based on user feedback.
5. Repeat steps 3 and 4 until design is ready for full implementation.
6. Use the finished prototype as a final specification for the required application, or use it as the final application itself.

The main reasons given for adopting prototyping are as follows:

- Overcomes the situation where precise requirements are difficult to specify in advance, particularly where the outcomes are decision orientated and the final user is unsure what they need.
- Enables the end user interface to be tested and fine tuned making the requirements easier to predict.
- Makes the organisation more involved in the implementation process, particularly the final users of the system.

The main risk in prototyping is that it lacks the rigor and discipline of traditional methods.

3.4.5 PURCHASE OF APPLICATION SOFTWARE PACKAGES

The third option described by Laudon and Laudon (1988) is the purchase of application software packages that have already been written. There are three circumstances where this is viewed as a favourable strategy:

1. Where functions are common to many organisations.
2. Where Information Systems resources are in short supply in-house.
3. Where desktop microcomputer applications are being developed for end users.

It is worth immediately noting that GIS in Local Government fits all three of these criteria. The advantages and disadvantages of software packages are described as follows:

Advantages:

- Software design and testing has already been done.
- Updates and enhancements are easily incorporated.
- Internal staff are not required for technical support.
- Takes advantage of the experience of other similar organisations.
- Software costs are fixed, increasing management support.
- Eliminates major sources of internal organisational resistance by introducing a third party.

Disadvantages:

- Possibly not capable of the sophistication required by the organisation.
- May only undertake the tasks required by the majority of the market.
- Customisation may cause cost and support requirements to increase dramatically.
- Very hard to mould fully to the organisation, thus forcing more organisational change than would be required utilising traditional IS methods.

DISCUSSION ON GIS SOFTWARE PACKAGES

Although not documented as part of this thesis, the State of Victoria (Australia) has a situation where 40% (30 of 78) of the Local Governments in the state have identical application GIS software (Latitude). This GIS software has no database ability of its own, but simply reads corporate data. Latitude users include the City of Port Phillip, which is used as a reference for this thesis. From the known histories of most of the other twenty-nine councils, the utilisation rate of the software varies from very high to not at all, with some councils taking several years and several implementations to succeed. This situation clearly indicates that choice of software may not be critical for GIS implementation success in Local Government, and that this component of the implementation methodology can be a minor part of this thesis. In particular this thesis will concentrate on the non-software system development aspects of GIS implementation.

3.4.6 Information System Perceptions of Success Factors

The IS theory summarised by Laudon and Laudon (1988) also addresses from an IT perspective two very relevant questions to this thesis: What is a successful implementation and why do implementations fail? It is stated that as many as 75% of large IT systems fail in that although they are in production, they are not delivering any benefits.

MEASURING SUCCESS

The true measure of success is very subjective, however the IS industry considers the following five criteria to be the most suitable, in order of importance:

1. **High levels of system use**, measured by user surveys or on line monitoring.
2. **User satisfaction,** measured by questionnaires including factors like accuracy, timeliness and relevance. In particular the opinions of managers and the ability of the system to deliver relevant information is important.
3. **Favourable attitudes,** about the system and the system staff.
4. **Achieved objectives,** compared to the original system goals.
5. **Financial payoff,** by either reducing costs or increasing output.

CAUSES OF IMPLEMENTATION SUCCESS AND FAILURE

At a higher level there is some consensus between the different implementation theories on the causes of success and failure. The core reasons from the IS theory are worth stating, even though in some cases they are identical to or derive from diffusion theory.

Laudon and Laudon (1998) give the failure to correctly manage the organisational impact (as previously described) as the main reason for failure. They then go on to further investigate particular instances where the environment, institutional features and innovation provided are similar, yet the implementation outcomes are successful in some instances and fail in others.

The main difference identified is the communication structure during the implementation process. This can result in a lack of support from either senior management or at the grass roots level. Implementation may fail if either support is missing. The diffusion theory change agent is seen as synonymous with the role of the systems analyst, although the IS view sees organisational change as a clinical process that can be defined in a similar manner to defining software. This is however further clarified with the concept of a user-designer communications gap.

The "user-designer communications gap" is defined as the difference in background, interests, and priorities that impede communication and problem solving among end users and information systems specialists (Laudon and Laudon, 1998). This communication gap is noted as a critical cause of implementation failure, as also identified in diffusion theory.

In summary Laudon and Laudon (1998) state that implementation outcome can be largely determined by the following factors:

- The role of users in the implementation process.
- The degree of management support for the implementation effort.
- The level of complexity and risk of the implementation project.
- The quality of management of the implementation process.

SUMMARY

The IS theory described above provides a set of implementation issues, techniques and measures that may be relevant to GIS implementation. These are referenced or used when appropriate, and some of them run in parallel to core diffusion theory.

3.5 CURRENT GIS IMPLEMENTATION THEORY

The parallel body of research to IS that is relevant in this research is the body of GIS implementation theory. While many would consider the work by the U.S. National Centre for Geographical Information and Analysis (NCGIA) a logical starting point for this component, the summary by Ferrari and Onsrud (1995) is considered to be of more relevance. This is a comparison of twenty-two other works and books on GIS implementation, and has an emphasis on the non-technical components. The work by the U.S. National Centre for Geographical Information and Analysis has the construction of a "GIS database" as the central implementation task, while this thesis later argues that this is not a necessary component at all. Most of their methodology assumes that GIS does not currently exist and concentrates on the technical aspects of implementation. The background included in this thesis emphasises the non-technical components.

3.5.1 SUMMARY OF CORE GIS IMPLEMENTATION STRATEGIES

In contrast to the IS section, the various GIS implementation theories will be critically analysed as they are summarised. This will emphasise the components that contribute towards this thesis and justify making other components redundant. The literature reviewed identifies five sources of literature that focus on the strategic planning of the implementation process as distinct from the technical design of the information system itself. It also identifies another three sources whose primary goal is to guide implementation. These will now be summarised and analysed.

THE DUAL TRACK IMPLEMENTATION OF SOMERS

Somers (cited in Ferrari and Onsrud, 1995) proposes a dual track development strategy for implementation of Local Government GIS, a short-term development of immediate applications and a parallel long-term development of the full GIS. The reasoning is to deliver early results at the expense of possible extra development costs and complexities. The advantages also include extra learning through iterative prototyping, extra flexibility and possibly the ability to start with existing application based software or data.

Analysis

This paper assumes that a core IS development process is essential, and particularly that the final result will be a large complex single multi-purpose multi-user GIS, that in particular requires high accuracy data. It is not necessarily true that this is the desired outcome in Local Government. The core contribution of this paper is the recognition of the need to deliver early results at the sacrifice of efficiency, and the need for flexibility during implementation.

ITERATIVE PROTOTYPING OF PEUQUET AND BACASTOW

Peuquet and Bacastow (cited in Ferrari and Onsrud, 1995) based their research in the US Army, and point out the following findings:

1. The classical project lifecycle does not work well because someone who has never used the technology cannot define the functional and organisational requirements.

2. That the organisation must commit to significant change prior to commencing the implementation process.
3. That the whole organisation must be involved in the development process.

The authors propose a series of iterative prototypes that both test the IS functional requirements and the organisational change requirements at the same time, emphasising the need for a balanced implementation team representing both technology and organisational interests. The advantages they see of the iterative approach are:

- Low level of risk as ideas are tested incrementally.
- Greater responsiveness to change as managers and users are involved in the whole process.
- Gradual familiarisation of the user with the technology.
- Refining of requirements and project flexibility.

Analysis

The concept of an iterative approach and all of the related advantages are transferable to Local Government and are relevant to this thesis. This work reinforces the discrediting of the traditional "project lifecycle" approach as discussed later. On the negative, commitment to GIS is not a commitment to significant change. In the long term, GIS may only need to deliver the routinisation of core tasks to be of benefit to some sections of Local Government.

FERRARI AND GARCIA

Ferrari and Garcia (cited in Ferrari and Onsrud, 1995) propose a three-phase implementation process – persuasion, familiarisation and globalisation – to overcome persuasion of managers and sustaining support due to the long-term nature of the results. The first phase is a *Sectorial Evolution Process (SEP)* where GIS is made a component of a proposal to resolve operational problems within the organisation. The concept may be technically tested but is not implemented and does not actually deliver any results in this phase. The second phase, familiarisation, is where small independent GIS applications based on the SEPs are implemented throughout the departments to deliver results and provoke organisational change. The third phase, globalisation, is where the isolated systems are integrated over a medium to long-term time frame into a corporate GIS.

Analysis

The overall concept is again one of incremental preparation of both the technology and the organisation, which is utilised in this thesis. The only criticism is that managers do not easily believe reports or pilots, and a direct move to phase two is preferable as suggested by Chan and Williamson (1999a).

HEDGES INCREMENTAL IMPLEMENTATION AND RE-ENGINEERING

Hedges (cited in Ferrari and Onsrud, 1995) questions the impact of initial departmental projects in the utility industry, while agreeing that enterprise wide implementations take too long to deliver results. The solution suggested is the incremental implementation of business process changes or process automations supported by small GIS modules over a period of time. Initially a simple higher-level organisational GIS infrastructure is also required.

Analysis

The incremental approach is suggested again. Hedges does not however see the ability to mechanise existing processes as a positive outcome, and requires organisational change to occur. Many benefits can occur before GIS requires organisational change.

OTHERS

There are several other authors who have proposed implementation strategies, and generally the lessons are to tie the results back to organisational outcomes, prototyping and initial interim low cost solutions.

DISCUSSION

There is a reasonable amount of commonality in these implementation strategies, particularly in the concept of incremental and evolving implementation. This typically uses short-term independent applications as an enabling technique for a long-term organisation wide implementation. The authors analysed also identify the task of moulding the technology with the organisation, as described previously, from an IS perspective. These core concepts will be developed further in this thesis. They all assume that business process re-engineering is necessary to obtain worthwhile benefits, without giving credit to the benefits of implementing simple process automation. They also all assume that in the long term an organisation needs to develop a complex "GIS database" and run the full project implementation lifecycle. These two assumptions are not necessarily correct, as will be discussed later in the thesis.

3.5.2 ISSUES OF GIS IMPLEMENTATION

Ferrari and Onsrud (1995) constructed the following set of common implementation issues that enabled the comparison of various GIS implementation works:

Overall Strategy
• Role of strategic planning or risk evaluation
• Implementation pace and scope
Information System Design
• Implementation plan
• GIS design model
• Role and position of pilot project
• Detailed design techniques
Project Enabling Strategies
• Top level persuasion/support
• Organisational conflicts/user resistance
• Funding strategies
• Communication channels/project marketing
• Training strategy and role
Project and System Management
• System location/co-ordination bodies
• GIS staffing, consultant and contractors
• Project Control
• Management of risks, IS function and strategy

Table 3.2 Implementation Considerations. (Adapted from Ferrari and Onsrud, 1995, p5))

As this list is in effect a checklist for GIS implementation, the main components are described and the various options and conclusions detailed by Ferrari and Onsrud are summarised against each as follows:

OVERALL STRATEGY

Overall strategy looks at the role of strategic planning, organisational risk evaluation and implementation pace and scope. Most of these issues are already covered in the summary of GIS implementation strategies.

The **role of strategic planning or risk evaluation** is identified with two alternative foci. First, business area analysis where business processes, and thus the economic impact that GIS implementation will affect, are addressed. The second given option is situational analysis where risk evaluation and readiness to implement GIS are addressed. This is suggested as the first phase in the implementation process.

Implementation pace and scope. The assumed scope of the implementations in the reviewed literature were organisation wide with two variations, small applications in the short term, moving to organisation wide in the long term, and small scale systems if there is a lack of departmental co-operation. There is emphasis put on the early delivery of results in most research, and little support for the traditional implementation model where the whole system is designed and built as a single process.

INFORMATION SYSTEM DESIGN

This looks at the issues related to the technical delivery of the GIS software, hardware and communication methods. This closely follows the IS methodology discussed previously.

Implementation plan is discussed in terms of its position and thus content. In reality the author of this thesis believes all projects should start with planning, and all projects should have an overall plan with supplementary detailed plans for various components.

The overall plan must be done at the start, and it should detail when and what detailed plans will be prepared along the way.

GIS design model contains discussion on when the user needs analysis should be undertaken and whether the user needs or the higher-level business needs should dictate the detailed functional design of the GIS. If the implementation is iterative, then design will be iterative and so will all of the other components. This discussion does not appear to contribute effectively to GIS implementation, as the only sustainable justification for the implementation of GIS is improved business process. It needs to be determined for each project whether this comes from the user's perspective or better meeting business goals.

The role and position of pilot project is identified as either helping to define system requirements or to test the design and cost estimates. In reality the further secondary roles of building better understanding and training, determining the impact on operations etc. are more important.

Detailed design techniques tend to follow the traditional IS systems implementation practices for software design and construction.

PROJECT ENABLING STRATEGIES

Project enabling strategies cover the organisational components of GIS implementation, particularly organisational support. Some of these components will be revisited in detail in the later part of this thesis.

Top-level persuasion/support. There are three approaches identified for obtaining and sustaining top-level management support: favourable cost-benefit, initial education/ awareness programs, and by providing short term results for low initial investment.

Organisational conflicts/user resistance were identified as able to be reduced through three main approaches: iterative prototyping or gradual introduction of the changes, proactive user involvement in the changes, and user centred or socio-technical emphasis in the design. There was also a suggestion of, in effect, bribing the users to use the product, through some sort of incentives.

There were three core **funding strategies** suggested: cost sharing between organisations, revenue from sales of GIS products, and distributing costs across users on either a user pays principle or proportional costing.

Communication channels/project marketing is always mentioned as an important element, but with very little provided in the way of detailed solutions.

Training Strategy and Role is broken up into the following components:

- Education of the leaders at the beginning of the implementation process;
- Training after system design and implementation;
- Familiarisation based on small independent applications;
- Ongoing training programs for new users;
- Complimentary educational programs, user associations etc.; and
- Different training programs for different users.

There is no mention of training format or the importance of who the trainer is, which is a core diffusion concept.

PROJECT AND SYSTEM MANAGEMENT

Project and system management issues relate to some of the organisational aspects of GIS, in particular how it is co-ordinated and where it is located.

Co-ordination Bodies were generally proposed at two levels, a technical or project team for implementation and planning activities, and a policy body or steering committee responsible for the main decisions or for conflict resolution. The importance of a project manager is generally emphasised.

System Location has been identified as either centrally controlled or distributed control by a board of representatives. This issue will be discussed fully later in the thesis.

GIS Staffing, Consultant and Contractors. There is general consensus that Local Government will require external professional assistance for implementation, and that contractors would be used for one off data conversion and other tasks.

Project Control, Management of Risks etc. are not identified as requiring special treatment because the implementation is GIS. Normal practice should be used.

DISCUSSION

This section gave a general overview of the components of a GIS implementation and a base structure for part of this thesis. Some components, particularly the IS section, may not be very relevant in the future, and some of the project and system management issues require further investigation and development.

3.6 CURRENT IMPLEMENTATION PATTERNS

One of the core assumptions made in this thesis is that the Local Government already owns GIS software. The ways this can occur will be discussed in the first part of this section. This moves the emphasis in the rest of this thesis from being the background theory in how to implement GIS software (the IT component of IS) to how to implement the other components of an IS and thus a GIS. That is, the emphasis is on the innovation, not the technology. This section will also give a perspective on how any existing GIS software may have already been installed, and thus how to identify if any improvements can be made.

A Local Government GIS implementation starts at the "decision to adopt" stage of organisational diffusion theory. The implementation process must however also cater for any previous GIS implementations. Until the organisation makes the decision to adopt, organisation diffusion theory and implementation methodology cannot be applied together.

The approach taken to implementing GIS varies widely with the background of the person undertaking the task, and their perception of GIS. The most common implementation patterns will be described and analysed in terms of their suitability for future GIS implementation.

Chan and Williamson (1999a) identified four patterns of GIS development of a corporate GIS: *opportunistic*, *systematic*, *opportunistic–infrastructure* and *opportunistic–business process*. One of the initial implementation tasks will be to identify which one has occurred and to what extent. The two extreme patterns, opportunistic and systematic, which also match *fiercely independent* and *classical corporate* as identified by Campbell and Masser (1995), will be discussed first.

3.6.1 Opportunistic Implementation

Chan and Williamson (1999a) identified that the opportunistic pattern of implementation results in isolated and uncoordinated GIS development that does not have higher-level management support. Typically the implementation occurs in a single department, and is known as *fiercely independent* by Campbell and Masser (1995), whose survey indicated that this approach occurred in up to 50% of the GIS systems being implemented.

One of the ways Masser (1993) described this occurring is that software vendors simply do the software component of the implementation and leave the client to do the rest. This takes advantage of the common perception of GIS as a software package that comes in a box in a similar manner to the Microsoft products. They are installed on a computer and some relevant compatible maps loaded that have been supplied usually either by the government or by the software supplier.

Chan and Williamson (1999a) identified that this pattern results in so much duplication and inefficiency that in due course senior management will demand better coordination and integration. This can be the point at which the methods developed in this thesis would apply.

3.6.2 Systematic GIS development

Systematic GIS development occurs when the organisation has made the decision to adopt and commences an implementation process with secure funding and support from all managers (Chan and Williamson, 1999a). Campbell and Masser (1995) called this pattern *classical corporate*, and both sets of research identified that these types of implementations were problematic. Campbell and Masser (1995) put the problems down to technology limitations, while Chan and Williamson (1999a) identified that the system does not survive the variations in commitment from the top, particularly when combined with disagreement among stakeholders. Their joint conclusion is that these types of implementations are unlikely to survive. The question of why this type of implementation does not survive will be revisited when diffusion research is discussed more fully later. While the suitability of a systematic approach is in question, the concepts must be understood fully as it is the basis of many existing systems.

3.6.3 Opportunistic–Infrastructure and Business process

Between the opportunistic and systematic approach are various hybrid approaches. Campbell and Masser (1995) identified the *theoretically pragmatic corporate* style of implementation in about 35% of local governments. This is described as a number of departments co-operating in the implementation of GIS without any formal higher-level control or co-ordination. Their observations were that these councils were experiencing a wide range of problems, in particular data and organisational issues.

Chan and Williamson (1999a) also identified a similar middle ground, and identified the characteristic of fluctuating support from senior management at different times. The argument is that as an organisation undergoes normal change, this fluctuating support is a reality in any organisation and the GIS must survive it. The systematic approach does not survive the periods of low support. The reason that this is called *opportunistic business process* and *opportunistic infrastructure* pattern is that both components are built, but in a more random manner as support from senior management come and goes.

3.6.4 INTEGRATED SOFTWARE INSTALLATION

One emerging pattern that has not been identified in the previous GIS research but is occurring frequently is the supply of GIS software as part of another application. The organisation may or may not have made a conscious decision to purchase the GIS software, or not even know they have it. The most common example of this is the MapInfo based GIS that is supplied with every copy of Microsoft Office. This pattern is being accelerated by Local Government IS suppliers who are starting to provide well-developed and well-integrated GIS software with other corporate products. Both of these can occur without the organisation or anyone in it making a decision to "adopt" GIS. Thus an implementation can commonly start with suitable software being available on every desktop. This type of implementation does not fail or succeed until an attempt is made to follow one of the other patterns. This software is usually installed without any of the normal GIS infrastructure and is commonly not used.

3.6.5 DISCUSSION

It is clear that a new implementation process has to be able to start in any one of the above situations, and the first task is to determine the type of previous pattern that has occurred. An implementation starting without any previous software or implementation attempts is becoming rare, so the other task is to measure the degree to which the components of a GIS exist.

3.7 SUMMARY

This chapter covered a diverse set of relevant theories that may apply to the implementation of GIS in Local Government. The content emphasis has been on the non-technical components, and the parts of the literature that do not relate to the specific building of a "GIS database". It also described a range of options for the current GIS status if GIS is already installed in a Local Government and provided some background theory for these options. These are relevant, as the implementation methodology developed in this thesis will both have to measure the current implementation status and then complete and/or remediate the current implementation.

4 LOCAL GOVERNMENT STRUCTURE

As the setting or social system on which this thesis is based is Local Government, then the next task is to give an overview of the relevant social system from the perspectives of function and structure. Because each Local Government can vary in both perspectives, a core part of any implementation process will be the precise re-measurement of both function and structure. This section will give a general overview, as well as a description of the external environment in which Local Government operates.

There are at least three social systems in Local Government, the State/Country, an individual Local Government and a Business Unit within a Local Government.

4.1 THE EXTERNAL ENVIRONMENT

The Victorian Public sector has been extensively reformed to ensure performance meets both Australian and international standards. The main impact of this has been that *"The focus should be on delivery of services to entitled clients – not on the production of the services themselves."* Vertican (1996). Local Government reform is one of the effects of the National Competition Policy introduced by the Federal Government.

In 1994 Victorian Local Government was reviewed not only to implement a client/ provider model, but also in terms of the whole physical structure of Local Government boundaries. The Impact Consulting Group (1994) were given the following terms of reference by the Victorian Government:

- Describe and quantify the benefits of amalgamating certain hypothetical council areas in terms of improving the efficiency and effectiveness (capacity) of Local Government in each area, with reference to any savings identified through amalgamation in terms of reduction in unit costs and service delivery in administration, capital works and recurrent expenditure;

- Assess the most effective way of organising services in each of the amalgamated council areas, whistle maintaining the existing standard of service and/or improving the standard of service where this is warranted;
- Configure the options for new management and service delivery systems for the areas, including staff structures, locations of depots, service delivery points, etc; and
- Make recommendations with respect to critical mass of new structures and service delivery capacity within the broad framework of current service levels.

The resultant seventy-eight reports substantially detail the current Local Government structure that evolved from the original 270+ councils in Victoria at that time. All positions have been recreated and councillors were replaced with appointed representatives for a period of eighteen months to undertake the restructure in all seventy-eight new councils.

In addition to this restructure, councils were forced to reduce costs by 10% and let at least 50% of their budget out to private tender to test competitiveness. Local Government now operates varying forms of a client/provider model where over 50% of council functions are either publicly tendered every three years and existing staff compete for their previous job, or have to prove efficiency in operation. A secondary impact of this is a new management structure that is well educated in management and financial theory, not necessarily from a Local Government background, and focused on business performance. Most Local Government management positions operate on three year, performance based contracts.

4.2 LOCAL GOVERNMENT STRUCTURE

The structure of Local Government determines the social setting or organisational context into which GIS is to be introduced. The definition of the client/provider split is very similar to the GIS definitions of infrastructure and business process, one performs the actual business delivery whilst the other has a supporting and guiding role.

There are usually between three and four second level business units, approximately of the following structure:

CORPORATE SUPPORT

This section would undertake the behind the scenes infrastructure that all business functions require, usually covering financial control, IT support and general business systems.

SERVICE DELIVERY

This section controls the actual delivery of service to the clients, utilising the infrastructure provided by the corporate functions. This section traditionally contains the service providers.

STRATEGIC PLANNING

Provides a strategic direction and technical/data support role for corporate decisions. Typically this is a client role.

The following diagram shows the usual relationships between the three levels in a Local Government.

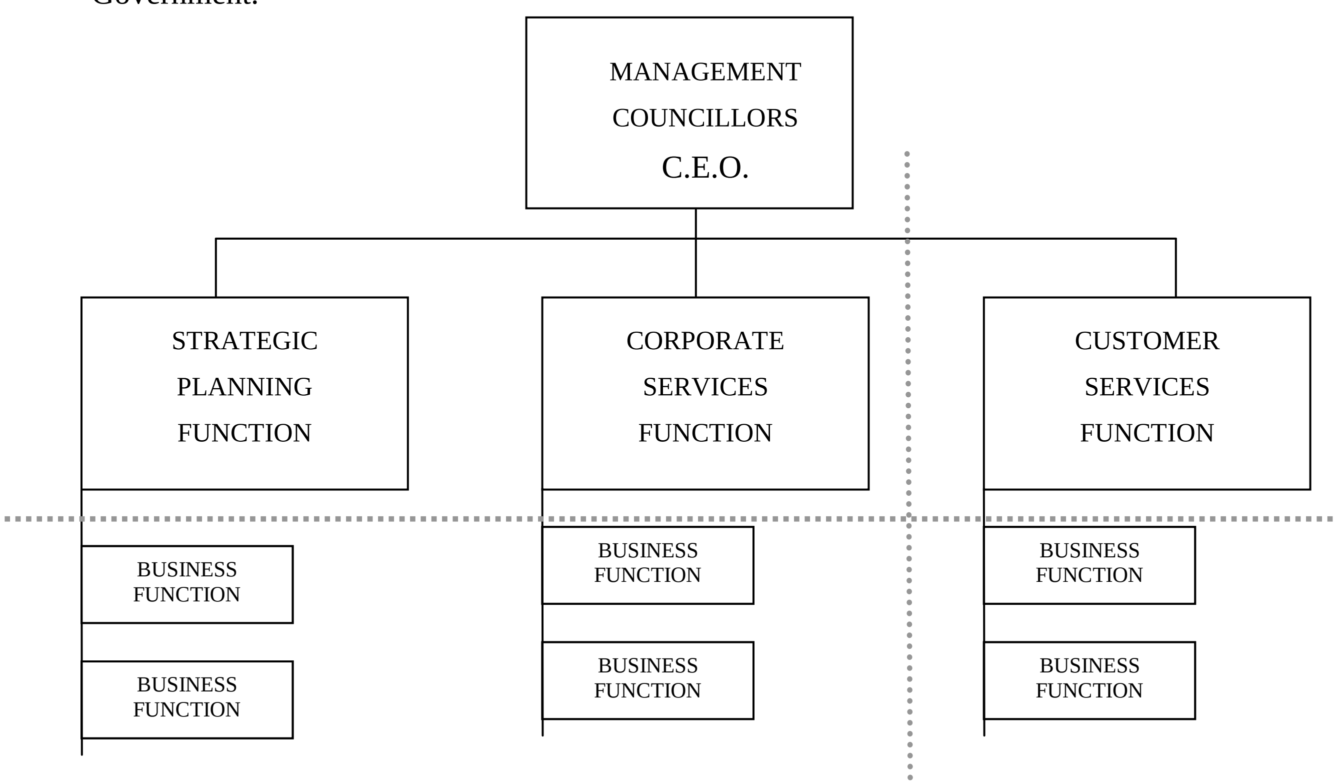


Figure 4.1 Typical Local Government Structure

What is actually on the respective client and provider side varies widely between councils and will have to be re-measured for each implementation, however the two lines shown ………… are the two most common configurations. The first configuration is where all possible business functions are on the provider side and the client simply manages the contracts. The second configuration is where the customer interface is on the provider side and the balance of the supporting business function is on the client side. The actual third level managers can be on either side or 50% each side at the same time. The structure of the social system becomes complex because of this "Purchaser/Provider Model", which results in more practical fragmentation of the organisation.

4.3 LOCAL GOVERNMENT FUNCTION

The functions that a Local Government performs normally correlate to the third level of management in a Local Government, and there is typically between ten and thirty, third level managers. A brief summary of the main functions (and thus organisational units or social systems) that are performed in Local Government and their typical position is now described:

Finance runs the overall financial control and allocates budget to respective second level managers who in turn manage the third level budgets. Income is from both property rates and State Government. All Local Governments have a finance role.

Valuations/Property determines the value of properties and thus in turn the income sources for Local Government. The property aspect commonly includes control of properties which local government owns, leases or manages for the State Government.

Rates collect the revenue for finance, based on the valuations of the properties.

Information Technology provides the IS for the whole organisation, including hardware, networking and software. This occurs with varying degrees of control and co-ordination.

Customer Service communicates with the public and performs the traditional "front desk" role. There are two models, one where a core unit takes all enquiries and one where each second or possibly third level provides their own customer service.

Records Management controls and co-ordinates the documents and files that relate to the whole organisational function. Again this can exist as a central unit or the function can be dispersed throughout the organisation.

Human Resources provides an internal employment and staff liaison role for both the client and sometimes the service providers.

Contract Management manages the interface between the client and the provider from a legal perspective and sometimes from a practical perspective.

Strategic Planning provides information like population growth planning, building and environmental controls, heritage studies etc. They may also have a high level input into most of the services such as roads, parking and open space.

Statutory Planning provides the legal control over the various building, subdivision and property development activities that Local Government is responsible for.

Environment Health provides the audit and regulation of the various food premises from a public health point of view.

Parking and Traffic Management controls parking tickets and infringement notices, as well as possibly some planning of issues such as disabled parking.

Events/Community Services co-ordinates the community events like sporting clubs, festivals etc.

Technical Services/Design is the traditional road and storm water planning design and maintenance control function. They may also provide the financial measurement of the physical assets owned by council.

Road/Asset Maintenance undertakes the physical maintenance of the roads and storm water under direction of Technical Services.

Parks and Gardens maintains the open space and gardens for the council. There is some swap over between this role and the above two roles in some councils.

Children's Services provides child immunisation and co-ordinates home care, infant welfare etc to the under five year olds.

Aged and Disability Services provides home help, meal on wheels and runs elderly citizens centres for the elderly.

(A notable exception in Victoria is that Local Government does not manage sewerage and water supply.)

This description covers the core functions. Differences in actual business unit configuration and percentage of resources allocated to each function will occur in each case, but these can be easily measured through budget and staff numbers and then allowed for during implementation.

4.4 LOCAL GOVERNMENT IT STRUCTURE

The status of the Information Systems can vary greatly from council to council. This does however become relevant from a GIS point of view because it is now common to heavily utilise the IT components, in particular the database management system, for the GIS implementation. The question is whether any deficiencies in the council database management system are the role of the GIS implementation, or should GIS implementation be deferred until the IT systems are complete? Traditional GIS implementation methodology had database development as a core task, however the question as to whether this is still appropriate will be discussed fully in later chapters. The typical IS structure described here is the basis of this thesis, and any work to take the council's system to this standard is considered to be an IT task.

The following City of Port Phillip IT diagram is typical of the current IT structures within Local Government.

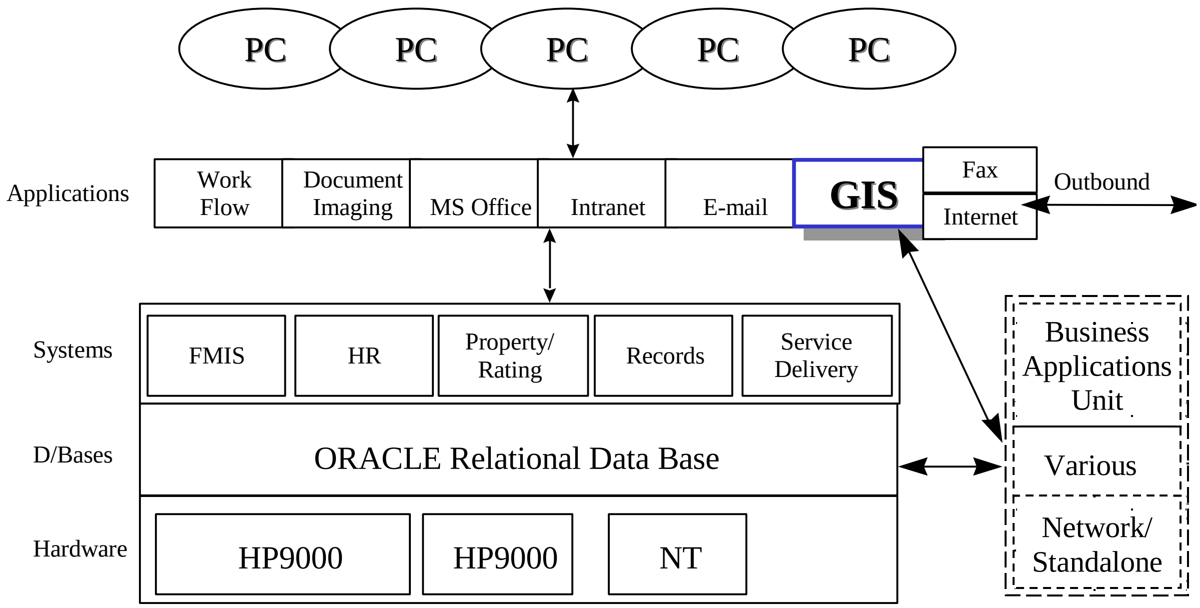


Figure 4.2 Information technology structure at the City of Port Phillip. (Adapted from Fitzgerald, Dooley, and Chan (1999))

The diagram shows that each business unit has desktop applications, business unit systems and data, and access to corporate data.

It can be assumed that Local Government has at least a networked environment with computers available at the desktop. The desktop will have electronic mail, word processing, possibly document management systems, and any applications specific to the business unit function. The corporate IT structure will consist of database management functionality including accessibility functions, and associated hardware.

Any business unit will utilise corporate applications and data, as well applications and data specific to the business unit. The data may or may not be kept with the corporate data depending on the site. These components will be checked as part of any implementation.

4.5 SUMMARY

While there are differences between each Local Government, they basically work under the same legal structure and perform the same duties to the public. Thus for the purposes of GIS implementation we can make some assumptions on both structure and function based on the averages of the whole state. This chapter described a typical Local Government from both a structural and functional perspective, which allows the research to assume some commonality and thus standardise some implementation tasks.

This chapter has defined one of the core components of diffusion theory, the social system. Local Government structure defines the social system on which diffusion acts while GIS is being implemented. By defining Local Government structure in functional terms, we both break the organisation into the social systems within which diffusion acts, and we form a framework for identifying the different GIS requirements within the organisation. This is the starting point for an implementation.

5 GEOGRAPHICAL INFORMATION SYSTEMS AND DIFFUSION

5.1 INTRODUCTION

The final set of theory that is required for this thesis is an understanding of GIS itself. Chan and Williamson (1999b) clearly identified that the diffusion and adoption of GIS is directly related to the various perceptions of a GIS. A manager, a GIS technician and an end user may all have different perceptions of a GIS. Thus this chapter will concentrate on the various perspectives of GIS, which in turn are the innovation characteristics of GIS. It is important to restate that this thesis is about the corporate wide implementation of GIS, and not just about GIS implementation in a single social system.

There are three perspectives of GIS identified by Chan and Williamson (1999b) that are derived from current research, and one new one from their own research. They are *identificational*, *technological and organisational*, and the new one is *productional*.

5.2 IDENTIFICATIONAL PERSPECTIVE OF GIS

GIS must have unique characteristics in the eyes of the end users that separate it from other Information Systems. This is a critical component of an innovation and a requirement of the diffusion processes. Chan and Williamson (1999b) cite several sources of research that identify this perspective. They then summarise the two unique characteristics of a GIS:

Data of entities and relationships managed within a spatial framework, which includes any system that provides the answer to the simple question of ‘what is at a given location?’ (through a map query).

Ability to perform spatial analyses including operations like simple queries that return answers to simple locational and conditional questions, through to complex modelling processes.

The most critical aspect of the *identificational* perspective is that it is initially necessary to raise the awareness of GIS in the organisation. By the time initial implementation commences the need for this perspective may be gone. This perspective also helps GIS compete against other solutions for the organisational problem, and underpins the other GIS perspectives.

5.3 TECHNOLOGICAL PERSPECTIVE OF GIS

This perspective of GIS is the most common, and concentrates on what the GIS is capable of doing technically. This perspective has two components, process based (which describes GIS in terms of how it does the task), and application based (which describes GIS in terms of what it can do for the business).

Castle (1993) defines these perspectives as structural (process) and functional (application). *Structural* GIS can be defined in terms of what it is made of and *functional* GIS can be defined in terms of what it can do. While the theory concentrates on the structural definitions, many people would find the functional definitions more relevant.

5.3.1 STRUCTURAL DEFINITIONS OF GIS

The following summary from Chan and Williamson (1995) is a good overview of some of the industry standard answers to the question "What is GIS?".

"Dangermond (1988) saw GIS as consisting of five basic elements: data, hardware, software, procedures and people.
Aronoff (1989) defined GIS as "a computer-based system that provides the following four sets of capabilities to handle georeferenced data: 1. Input; 2. Data Management (data storage and retrieval); 3. Manipulation and analysis; 4. Output", all within a suitable organisational framework.

Burrough (1990) considered that GIS has three components: hardware, software and the organisational context.

More recently, to provide a comprehensive conceptual framework for discussing the institutionalisation of GIS, Huxhold and Levison (1995) identified four elements of GIS: the GIS paradigm, data management principles, technology and organisational setting."

These definitions have a heavy emphasis on a structural rather than a functional perspective, and are self-explanatory.

5.3.2 FUNCTIONAL PERSPECTIVES OF GIS

While GIS implementation arguably consists of effectively building the structural components described in the previous section, we also have to look at GIS from a functionality point of view. Firstly because the technical aspects of implementation must relate to the functions GIS will perform, and secondly because an implementation manager must relate to the managers and end users in terms they will understand. The viewpoint of managers and stakeholders will be based on functionality not structure.

"A holistic understanding of GIS diffusion therefore requires understanding of how both managers and other stakeholders view GIS." (Chan and Williamson, 1999b)

The definition adopted by the *AGI Source Book* (Corbin, 1998) GIS dictionary appears to be the best functional definition:

"A Geographical Information System (GIS) is a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the earth."

Maguire (1991) further develops this with the belief that the current theory can be synthesised and presented as three distinct but overlapping views. These can be termed the *map*, *database* and *spatial* view.

The map view focuses on the cartographic aspects of GIS. The core functionality required and delivered is like a seamless and automatic map draw, where maps can be displayed and manipulated in various combinations and need not have any attributes or intelligence at all. Government mapping agencies typically use this type of GIS as an alternate means for producing the traditional hard copy products.

The database view treats the maps as an extension of the database where database records have correlating map objects that can find and display the database records. The primary purpose of the database is the storage of the graphical objects, and the database is seen as an integral part of a GIS.

The spatial analysis view emphasises the spatial analysis and modelling capabilities of GIS. The emphasis is on geographical relationships and queries that cannot be performed by traditional databases.

Maguire (1991) believes these three components can be parts of a single system while being quite different in purpose and structure.

In practice implementation needs a bit more detail than this. Castle (1993) identifies nine sets of functions that a GIS may be able to perform, however he also points out that a GIS may only be capable of performing some of these functions.

1. **Presentation and Thematic Mapping** is the presentation of data on a map by showing the relative position of the element or by showing the attribute data as a colour.
2. **Data Query** is the ability to view existing corporate data on a map in a manner that is more meaningful than existing methods, such as reports and spreadsheets. The critical difference between this view and the database view of Maguire is that the emphasis is on viewing existing corporate data, not specially captured data stored in the GIS database. The corporate data simply has a spatial attribute and the database management is done by the corporate database system.
3. **Spatial query** is the ability to use the map as a search tool for corporate data, where the query pulls a copy of the corporate data back to the mapping environment for viewing. This view differs from the *data query* in that instead of a

one to one relationship between the map element and the database record, there is a spatial query in between.

4. **Database Integration and Updating** is where each record has a spatial attribute (i.e., is geocoded). This attribute can be used to either update other components of the database or join databases. Again this is corporate database manipulation through a GIS interface.
5. **Routing and Minimum Path** is where an intelligent set of base data, usually road centrelines, allows for the calculation of travel times and shortest path determination between locations.
6. **Buffering** is where queries are performed based on relative position or proximity of objects from each other.
7. **Point-in-Polygoning** is the ability to analyse a set of data points based on a second set of data which is displayed as polygons or regions. Thus relationships can be transferred without the data having the same spatial attributes.
8. **Overlay** is an extension of point-in polygoning where both data sets have polygons as spatial attributes, and these polygons may or may not correlate. Castle (1993) identifies four types of this functionality ranging from where the polygons are identical to where attribute analysis occurs over non-correlating polygons.
9. **Distance, Adjacency and Proximity Analysis** is the ability to calculate these values or relationships between various map elements directly from the geometry**.**

These nine functions appear to be a good practical summary of the functionality options that are currently expected to be available from a GIS, and can be utilised as a subset of the three Maguire (1991) views. The Castle list is used later as a more detailed framework for discussion when the application of GIS in Local Government is addressed.

5.4 ORGANISATIONAL PERSPECTIVES

There is now a large body of research identifying that GIS implementation requires more than just the technical aspects, and there have been various models developed to cater for this. Chan and Williamson (1995) went on to distil the various theories on the organisational aspects of GIS into the following five components: *data*, *information* *technology, standards, expertise* and the *organisational setting*. The five components are more fully explained in the following table.

Components of a GIS	**Scope of Each Component**
Data	All accessible data, both geographical and attribute, required to meet the geographical information needs, identified or latent.
Information Technology	All computer hardware, software (including applications) and associated communication technology required to meet the geographical information needs, identified or latent.
Standards	All agreed practices required to facilitate the sharing of the other four components of a GIS.
People with expertise	All knowledge, skills, procedures, and systems, technical or otherwise, acquired by people involved, for the smooth functioning of the GIS.
Organisational Setting	All the operating environments, technical, political, or financial created by the interaction among stakeholders, in which the GIS is to function

Table 5.1 Components of a GIS. (Adapted from Chan and Williamson (1995))

If the aim of this thesis is to define a process for generically building the five components, then these components will make up part of the core implementation methodology. We will revisit their definition fully in the context of Local Government later in the thesis.

5.5 PRODUCTIONAL PERSPECTIVE OF GIS

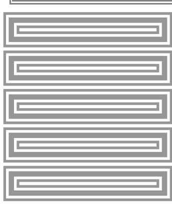
Chan and Williamson (1995) then further developed their components of a GIS into a productional perspective based on Information System structures. They identified two distinct components to a GIS implementation, *infrastructure* GIS and *business process* GIS. Derived from relevant IT/IS research, the separation is based on whether they provide the support role or deliver the actual benefits. In the *productional perspective* of GIS, the five components of the *organisational perspective* become the *infrastructure GIS* module.

5.5.1 *INFRASTRUCTURE GIS*

Infrastructure GIS is the core set of GIS components that have an influence or supporting role across one or more business process GISs. It is critical that each business process GIS is supported by all five infrastructure GIS components described above. These five components come from the *organisational perspective* of GIS.

During this thesis the infrastructure GIS component is represented like this:

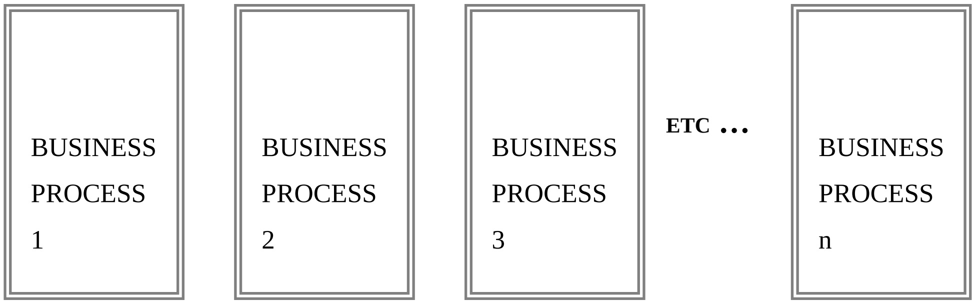
DATA
INFORMATION TECHNOLOGY
STANDARDS
PEOPLE WITH EXPERTISE
ORGANISATIONAL SETTING

or 

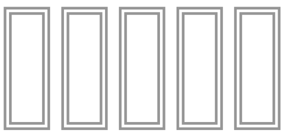
5.5.2 *BUSINESS PROCESS GIS*

Business Process GIS is usually the application of GIS directly related to a common business or task. The GIS must be an integral part of the business process to produce a defined product of the business. It may or may not have an infrastructure component for support, however in an organisation where there were several business process GIS installations without the infrastructure GIS component, there would be many duplicated or incompatible components.

This thesis will represent modules of business process GIS like this:



or



5.5.3 THE RELATIONSHIP BETWEEN INFRASTRUCTURE AND BUSINESS PROCESS GIS

Chan and Williamson then went on to identify that the relationship between *Infrastructure GIS* and *Business Process GIS* could go across many levels of business activity and organisation. For example one set of information technology may be suitable for an organisation, but each business unit may require different sets of data or different standards. These are often subsets of the main components for the whole organisation.

This concept may be extended over several levels of organisational definition. For example a GIS user in a Local Government may obtain infrastructure GIS data from the business unit Infrastructure GIS, the Local Government Infrastructure GIS and the state wide infrastructure GIS.

The organisational *Infrastructure GIS* support diagram for a *Business Process GIS* in an organisation may look like either of the following diagrams:

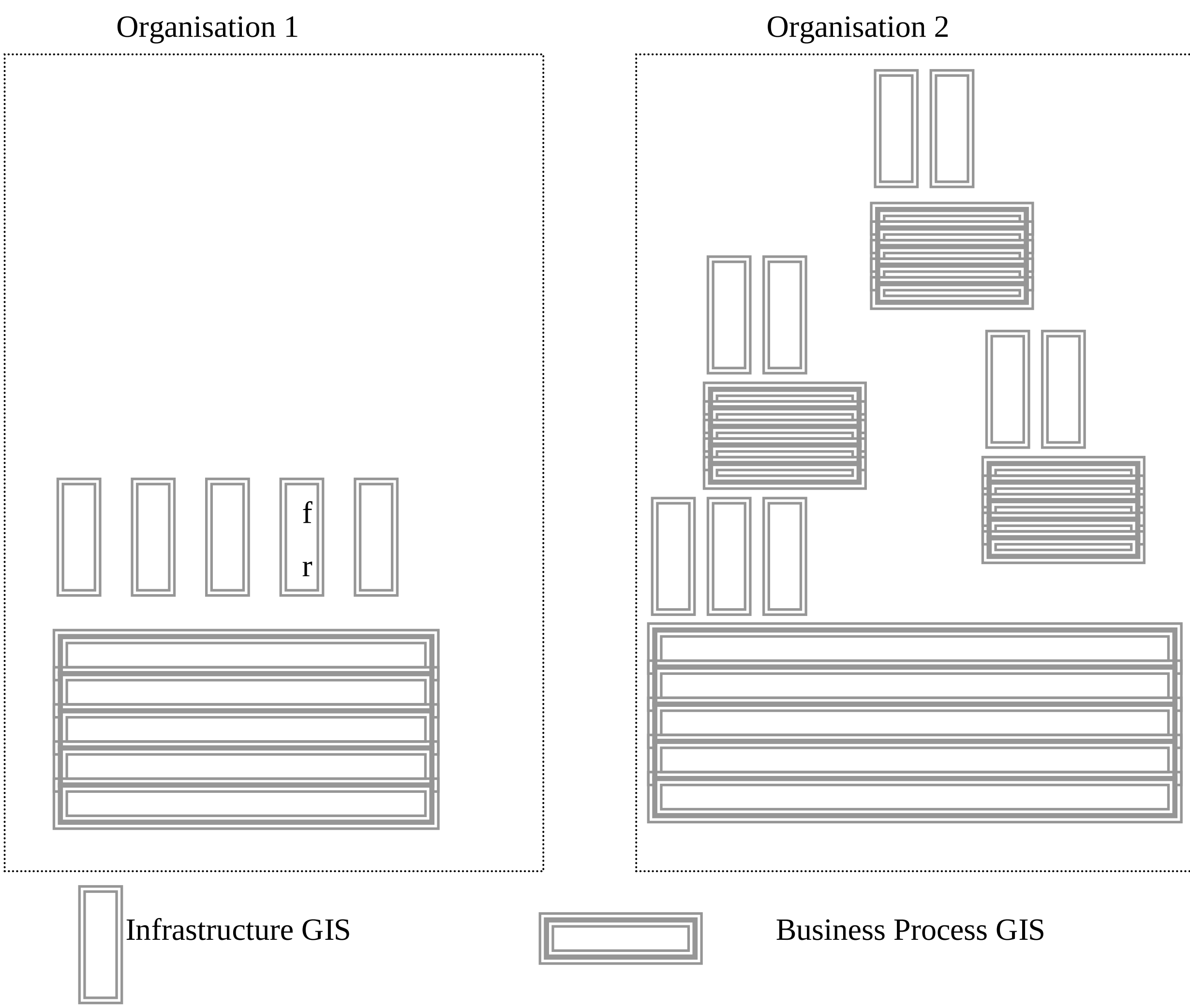


Fig 5.1 Options for *Infrastructure GIS* support for a *Business Process GIS*

In summary the required task is to identify and build the required business process GIS modules for the organisation, and to support that with an appropriate infrastructure GIS. The appropriate combinations have to be designed as part of any implementation.

5.6 EMERGING GIS IMPLEMENTATION TECHNIQUES

The discussion in 3.6.2 put doubt on the ability of structured IS based implementations to succeed in the long term, and described the body of theory developed by Chan and Williamson (1999a) suggesting a controlled opportunistic approach to the implementation of GIS. Based on the infrastructure and business process components in the previous section, these theories will be described further.

Chan and Williamson (1999a) suggest that the development of a corporate GIS is a long-term process, and advocate a three-stage approach based on the productional perspective described above. The three stages are summarised in the following diagram: (Fitzgerald, Dooley and Chan, 1999)

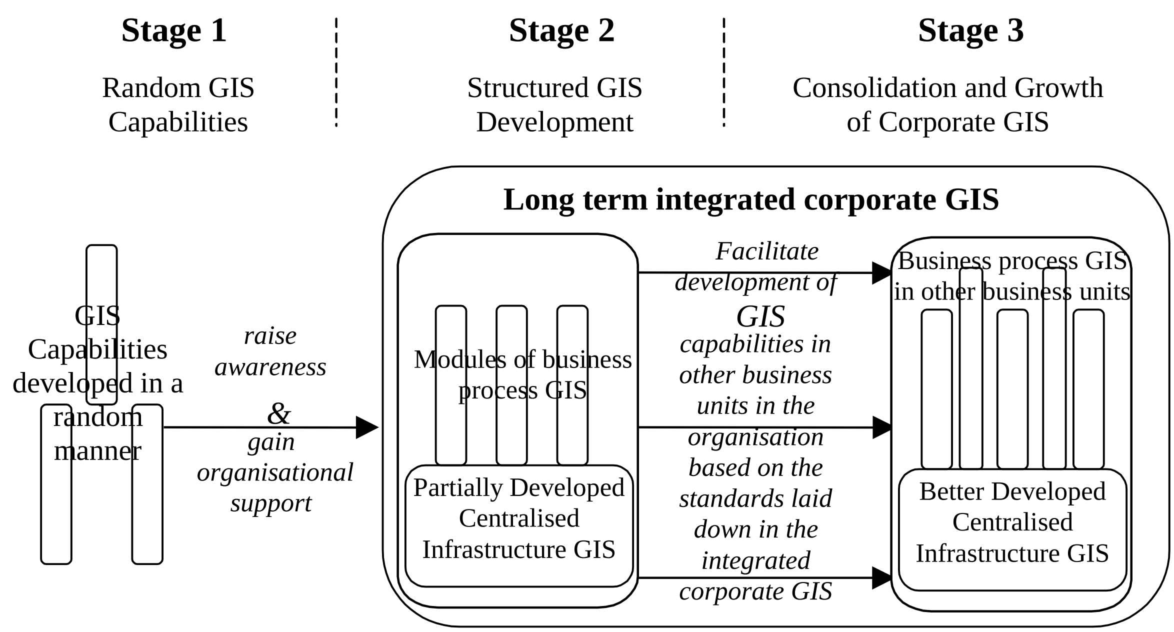


Figure 5.2. A 3-stage approach to GIS development. (Adapted from Fitzgerald, Dooley and Chan (1999))

Stage 1 is where strategically placed modules of business process GIS are placed throughout the organisation to generate direct business benefits and raise awareness of GIS within the organisation. The structure is inefficient and unsustainable in the long term, as it probably duplicates components of infrastructure GIS. In the short term it will serve the purpose of gaining organisational support.

Stage 2 is where there is sufficient support to build the basis of a corporate GIS infrastructure and deliver core functionality to the main users. This stage is the only one that utilises components of traditional GIS implementation theory. The aims and outcomes are defined and delivered in a planned way. At the end of this phase no one will have a full business process GIS and the infrastructure GIS components will only be partially complete. This stage will also setup the mechanisms for Stage 3.

Stage 3 is best summarised by Chan and Williams (1999a):
"*The first two stages describe the well documented approach of developing a centralised integrated corporate GIS. Instead of ensuring the continued growth of this centralised GIS, the third stage advocates the use of data, standards, expertise and the overall credibility of the centralised GIS to support the development of GIS modules in the business units. Eventually, the business units are encouraged to drive the development of their GIS modules. In return for the support of the centralised GIS, the business units are required to adopt established standard practices to ensure that their GIS modules are interoperable with the other modules in the organisation.*"

This methodology is also described in detail in Fitzgerald, Dooley and Chan, (attached, Appendix A), which describes how these stages occurred to deliver a successful implementation of GIS at the City of Port Phillip. The author undertook Stage 2 on this site between November 1997 and May 1998, and the site is now well into Stage 3 as described above. It is probable that Chan and the author influenced each other in both the practical implementation strategy at Port Phillip and in the parallel development of implementation theories detailed in Chan and Williamson (1999a).

5.7 SUMMARY

In this chapter we have identified that at the highest level the *productional perspective* of GIS can be generically split into two distinct types, *infrastructure* GIS and *business process* GIS. The business processes are typically described by the technical perspective of GIS in the early theory, and are dependent on the structure of the target social system. The infrastructure GIS is made up of five components, *data, information technology, standards, expertise* and are derived from the *organisational perspective* of GIS. This breakdown of GIS will be the high level framework for implementing GIS into Local Government.

While the social system may never need to understand the structural or infrastructure components, they along with the functional components are critical to successful implementation from the perspective of an implementation manager.

Within the business process component, the technical perspective looked at the various functions a GIS may perform, both as a high level grouping of three and then broke those down to a further nine. These are however very generic, and are yet to be related to Local Government in terms of their business processes. This is the task of the next chapter.

The chapter also tied together other parts of the theory to describe the current theoretical approach to GIS implementation. This is based on three stages, random capabilities, structured development and loosely structured consolidation and growth. These will be further utilised in the following chapters.

6 THE DEFINITION OF GIS IN LOCAL GOVERNMENT

The main aim of this chapter is to combine the previous theory with some experience of the author to develop a new framework that describes GIS in Local Government. The chapter starts with a summary of the current status of GIS in Local Government, and then defines GIS within the theoretical framework. The following chapter then concentrates on "how" to implement GIS in Local Government.

Primarily, the thesis will build on the works by Chan and Williamson using the *productional* perspective of GIS, and starts by detailing a framework definition of GIS within the *infrastructure* and *business process* GIS concepts discussed previously in the theory. This will be a higher-level generic definition of GIS for Local Government in Victoria, based on what is known to be common to all Local Governments. The differences between individual Local Governments can then be measured as part of the implementation process.

This chapter is derived from basic IS principles and the experience of the author, as priority over older GIS based literature review. Use of a literature review to technically define GIS would assume that the business processes are the same for all Local Governments in the world. As identified previously, it is not the responsibility of Victorian Local Government to administer sewerage and water assets. Thus previous literature that includes these aspects does not provide a valid basis for Local Government research in this instance. The absence of these functions moves the GIS emphasis away from high positional accuracy of physical assets to mapping and interfacing/integrating with corporate data/systems.

The five infrastructure components are expanded from the Chan and Williamson (1995) components, while the five new business process components are developed as part of this thesis, based on both theory and the experience of the author.

6.1 CURRENT GIS IMPLEMENTATION ENVIRONMENT IN LOCAL GOVERNMENT

It will be necessary to give an overview of the status of GIS in Local Government in order to define the typical starting point for implementation.

Informal surveys and onsite experience of the author indicate that about sixty of the seventy-eight councils in Victoria currently have some sort of GIS capability. Of those about thirty have Latitude, about ten have Easimaps and the other ten have either MapIt, ArcInfo, Genamap or another package. Up to fifty Local Governments have single MapInfo licences, either stand alone or in addition to other GIS software.

Latitude and Easimaps (existing in about 50% of the councils) are simple Windows based GIS software packages written specifically for Local Government. They are both non topological and run only in the Windows environment. Neither can be implemented using the traditional IT systems development approach because the vendor fixes their functionality. Neither are capable of full topological queries. The extent of the success of these implementations varies, with the author being involved in over 50% of them. Some Local Governments have only been successful on the second or third attempt at implementation. To date there have been very few successful implementations using State Government data, and it is usually necessary for an implementation to include the reconstruction of suitable base mapping. This is not the focus of this thesis, but is relevant in that it is one of the current major causes of implementation failure in the state.

The other ten sites using ArcInfo and other similar products have undertaken the traditional IT system development cycle, with varying degrees of success. There are also several sites with more than one software type.

Sites where more than 20% of the indoor staff is obtaining benefit from GIS would number less than ten and are mostly Latitude sites. A common benchmark aim is 60% to 70% of the indoor staff in all Local Governments obtaining benefit from GIS. This figure will be discussed further later in the thesis. As most Local Governments own GIS software and some data, then the core aim of this thesis is to be able to increase effective use of GIS either from the initial implementation or after the initial implementation. If GIS is already being fully effectively used, then this thesis should be capable of providing a methodology to prove this.

Because the core aim of this thesis is to raise the effective utilisation of GIS as distinct from initially implementing the technology, then this also makes a lot of the current GIS implementation theory irrelevant.

6.2 BUSINESS PROCESS GIS IN LOCAL GOVERNMENT

Because of the competitive nature of the Local Government Environment described earlier, GIS will not be considered by a manager unless its introduction directly relates to improved business process and thus performance. This may make GIS harder to justify from the perspective of long term gain or intangible advantages. On the other hand general performance incentives make the risk of GIS more attractive to a manager if short-term business benefits can be proven to come from implementation. This environmental factor is important to implementation techniques.

Because the emphasis of this thesis is on delivery of business benefits, the next step of the thesis is to critically look at definitions of GIS from a business process perspective, and apply them to Local Government. This will set the high level definitions of what is being implemented to deliver business benefit to Local Government. The clarification of the structural GIS components follows in the *infrastructure* GIS section of the chapter.

The thesis now answers the generic question, "How can GIS deliver business benefit to a local government business unit?"

6.2.1 Business Process GIS Framework

When defining *business process* GIS for local government, it is first necessary to develop a framework from the previous theory. This framework will contain the high level definition of the components, and thus the implementation framework for the fine-tuning of the *business process* GIS for an individual business unit during implementation.

When the theory in Chapter 3 is examined, the various IS methodologies (based on systems analysis) can be summarised into the following sequential components:

- What operational problems can GIS solve?
- What is the GIS functionality that is required to solve the problem?
- What are the technical requirements to deliver the functionality?
- What are the data requirements to deliver the functionality?

These questions will be revisited in detail as part of the implementation methodology in Chapter 7. The next sections will move through the traditional views and define them within the four-part framework above. The previous perspectives and views can be cross-matched with different parts in this framework, however the components are primarily divided on the question, **"What operational problems can GIS solve?"** This new breakdown is driven by the diffusion consideration that the implementation process should be both communicated and performed in a structure that the managers and the users can relate to.

The headings of the five new business process components come primarily from the experience of the author from doing over twenty Local Government user needs analysis reports within the above framework. Section 6.2 combines this with the previous theory to detail the five new business process components for Local Government that are developed by this thesis. The component being discussed is emphasised in the heading using the framework from the diagrams from Section 5.5.2.

6.2.2 *SIMPLE DESKTOP MAPPING*

OVERVIEW OF BUSINESS PROCESS GIS COMPONENT 1

The greatest benefit of GIS to Local Government is the availability of mapping information at the desktop and the ability to make simple A4 prints. (The ability to make complex prints up to A0 is available if required.) The emphasis in delivering this functionality is the word ‘simple’, as to be effective the mapping need only contain the following information:

- Road reserves and property boundaries;
- Road names, house numbers, reserve and main feature names; and
- Possibly aerial photos if available.

Common examples of this functionality are:

- Cut and paste a map into a report to help explain part of the report;
- Attach the map to a customer request to clarify location; and
- Look at a map on the screen while discussing an issue with a customer.

About 80% of all indoor staff would eventually benefit from this functionality, and it moves the role of map production from a specialist field to a common task performed by most people. It also moves mapping to people who would not traditionally be trained in reading maps. This perspective does not require either a GIS database or a corporate database, but simply consists of maps.

OPERATIONAL PROBLEM SOLVED

The users of this functionality previously have not had access to desktop mapping as part of their daily workflow. This impedes their daily workflow because they cannot communicate place or location effectively. The place communication requirement may be either to them or from them. About 80% of all Local Government tasks have a place or location attribute.

REQUIRED GIS FUNCTIONALITY

This problem is resolved by providing the ability to look at a meaningful map while receiving advice or instruction, and the ability to create a meaningful map when giving advice or instruction.

THEORETICAL BASIS

The simple desktop mapping perspective of GIS correlates to one of Maguire et al's core three views of GIS and is widely documented and used in literature.

TECHNICAL REQUIREMENTS

To be able to look at a relevant map on the desktop.

To be able to navigate around the area of interest or to a new area of interest.

To be able to simply print the map.

To be able to include the map in a report.

To do so without substantially interrupting the current workflow (e.g., within 10 to 15 seconds).

DATA REQUIREMENTS

The data requirements are broken down into three components:

1. Screen navigation aids.
2. Parcel/occupancy shape and surrounding detail.
3. Cartographic detail, road names etc.

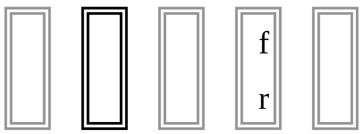
COMMENT

This business process GIS component corresponds to part of the Maguire map view as described previously. In particular it performs the previously described cartographic aspects of GIS, where maps can be displayed and manipulated in various combinations and need not have any attributes or intelligence at all. The data and technical requirements would be a minimum, and would be added to for each specific implementation. While the data and technical requirements can be found in the theory, they have been prioritised from the experience of the author. This is the GIS functionality most commonly utilised by Local Government.

SIGNIFICANCE

This component is the least controversial both in terms of accepted need and implementation detail or ability. It will not be given great detail for the rest of this thesis, but continues to be of vital importance.

6.2.3 Spatial Analysis



OVERVIEW OF BUSINESS PROCESS GIS COMPONENT 2

In simple terms Spatial Analysis means obtaining information about data in relation to where it is placed on a map. These queries are usually split into two levels of complexity, simple and complex. The reason for this split is that GIS software capability is also split along this line, the complex spatial analysis usually being more expensive to purchase and implement.

OPERATIONAL PROBLEM SOLVED

Queries need to be performed to analyse data in relation to other elements in the same data set or other data sets with regard to their geographical relationship. The emphasis is on geographical relationships and it is this form of query that cannot be performed by traditional databases.

REQUIRED GIS FUNCTIONALITY

Functionality of current GIS systems can be divided into two categories: queries which geographically select map elements, and queries that make new map shapes based on spatial relationships. These are often referred to as simple and complex.

SIMPLE QUERIES

Simple place queries tend to be the analysis of a property in relation to layers that sit over it. Examples include find properties in certain town planning zones and that are flood prone, or all of the properties within a set distance from a new planning permit. They can also be an analysis of the relationship between layers, calculated per property. The simplest example of this is finding the adjoining neighbours for a planning permit. Simple spatial analysis will be commonly utilised by council staff.

The commonly available simple spatial queries are:

- Find adjacent map elements.
- Find map elements within a radial distance.
- Find map elements under a line.
- Find map elements under a shape or polygon.

These queries may be combined with non-spatial criteria at the same time. They are usually available from either a temporary point, an existing map object, or from a whole map layer.

COMPLEX QUERIES

These queries are not property based, and are absolute calculations of relationships between layers. An example of this is identifying potential residential development land by selecting a combination of ideal criteria like slope, soil type, aspect, distance from services etc.

There is usually a substantial cost and time penalty for initially implementing a GIS that can perform large complex spatial queries. In technical terms, GIS that can perform complex queries have a relationship based data structure. A common cause of implementation failure is to concentrate on providing complex spatial analysis. There is commonly no demonstrated need for corporate wide complex spatial analysis in Local Government.

THEORETICAL BASIS

This view is also one of Maguire et al’s core three views and is widely documented and used in literature. Section 5.3.2 of this thesis, particularly the Castle components, also provides the theoretical basis for this view.

TECHNICAL REQUIREMENTS

Any technical requirements past the ability to perform the four simple queries listed above would be detailed during implementation.

DATA REQUIREMENTS

Where adjacency queries are required, then the graphical data should be regions or polygons with no overlaps or slithers.

Otherwise all data requirements would be detailed during implementation when the required queries are listed.

COMMENT

The ability to perform complex queries may alone dictate choice of software and thus the cost of the whole implementation (it could double). These queries have to be separately justified during an implementation, as currently only a small percentage of Victorian Local Governments have the need or ability to perform complex spatial queries. Currently Latitude and Easimaps sites cannot perform complex spatial queries.

SIGNIFICANCE

Simple spatial queries are performed commonly in Local Government, complex queries are not. The most common spatial query is finding the details of the next-door neighbours to a property. Implementation should possibly investigate the option of utilising a bureau service to perform complex queries if they occur infrequently.

6.2.4 *THE GEOGRAPHICAL DATA STORAGE VIEW OF GIS*

OVERVIEW OF BUSINESS PROCESS GIS COMPONENT 3

This is the next business benefit that GIS will deliver to Local Government. In effect the GIS is a digital version of the existing plan drawers and filing cabinets that have made up the traditional mapping section of Local Government. This would usually be within an engineering section. While the drive for "efficiencies" in the Local Government environment has seen the demise of the plan room or drafting section, in practice the need has not gone away. Implementation of GIS usually shows a large pent-up demand for even simple maps of council services and activities.

The main advantages of GIS over traditional means are:

- The GIS can automate production of maps at various scales, depicting many themes, singularly or in combination.
- Using a GIS, maps need never be out of date, nor is basic map data ever drawn more than once, thus saving time and effort.

It is common for the complex map production role to be replaced by part of the GIS support role.

OPERATIONAL PROBLEM SOLVED

The organisation manages substantial volumes of mapping data, traditionally through a series of indexed plan drawers, and needs to store, maintain and distribute these in an efficient and cost effective manner. Currently users have to go to another building or plan room to view the data.

REQUIRED GIS FUNCTIONALITY

The GIS needs to be able to store and retrieve these mapsheets so they are presented to the user in an efficient and seamless manner. The GIS will also have to replace or utilise the current maintenance procedures. (This will vary, depending on the current maintenance procedures.)

THEORETICAL BASIS

This comes from one interpretation or part of the database view as described by Maguire et al and others. See discussion on this in the following section.

TECHNICAL REQUIREMENTS

The maps will be stored in a digital indexed format.
The stored mapsheet information can be retrieved, distributed and displayed.
The various layers can be displayed and printed or analysed together.

DATA REQUIREMENTS

The elements will be indexed at least by attribute, layer and mapsheet. The data inputs are determined site by site on an as required basis.
The timing of the loading of the various map layers is independent of the rest of the GIS implementation, as it can be done as soon as the software is on the desktop. All that is required is software and a base map. This means that layers can be loaded as available if the data currently exists. In an implementation across many sections this does not often have initial priority, but can occur soon after.

COMMENT

This is another part or interpretation of the map view perspective of GIS, where the core functionality required and delivered is like a seamless and automatic map draw, where maps can be displayed and manipulated in various combinations. Both the data and technical requirements would be scoped in substantially more detail than the simple requirements above. Making new map layers and making data with high absolute positional accuracy is a common emphasis in a GIS implementation. This can delay overall implementation by years and can be very expensive.

The current literature appears to be ambiguous in what the term "GIS database" means. Is it a database containing data that comes from the GIS, where the database records are geographical features and the associated attributes necessary for the functioning of the GIS and the associated spatial analysis component? Alternately does the GIS database duplicate or hold original corporate data that is not primarily geographic in nature, but has a geographic attribute? Some literature intends it to do both. For this reason the term GIS database has been avoided as a term for describing a core component of Local Government GIS.

SIGNIFICANCE

This component is often given similar importance in Local Government to State Government, where it is the primary GIS function in organisations such as the Department of Natural Resources and Environment (e.g., storage of contours and water courses across a whole state). The importance and cost benefit of delivering this in local government may be marginal, and efficient technical delivery of this component during an implementation does not appear to correlate to a successful implementation in the eyes of the organisation. The data capture costs and the associated time delays are contrary to the diffusion principle of the early delivery of results. The recommended strategy is to implement GIS without either of these but to allow for them to occur as justified and funded in the future.

6.2.5 Discussion on the Database View of GIS

This is not used as one of the core components of the thesis, but is discussed here because of its historic prominence in GIS theory. **The database view** treats the maps as an extension of the database where database records have correlating map objects that can find and display the database records. The primary purpose of the database is the storage of the graphical objects. This view is technology and IS infrastructure dependent. It was developed before it was possible to easily merge spatial databases with corporate databases. It also assumes that graphical data requires the power of a relational database to be quickly available at the desktop and to be able to quickly perform spatial queries.

These assumptions relate to the assumption that full topology is necessary for successful GIS implementation and flow through to the typical implementation techniques in GIS literature. The author would question the relevance or validity of all of these assumptions and makes the following points:

- Local Government data sets are not large by some overseas standards, proven by the fact that the City of Port Phillip GIS runs quickly and easily on a laptop computer and is about 50 Mb in total (including software, maps and the property database).
- The requirement for full topology has been negated in these datasets by the ability of the current computers to regenerate spatial relationships each time a query is run with no visible loss of performance.
- There are other techniques available to obtain the necessary performance without requiring either topology, database power, or for the map elements to be stored in a database at all.
- This view assumes that a GIS implementation provides its own IS infrastructure and does not use that existing for other Local Government functions.

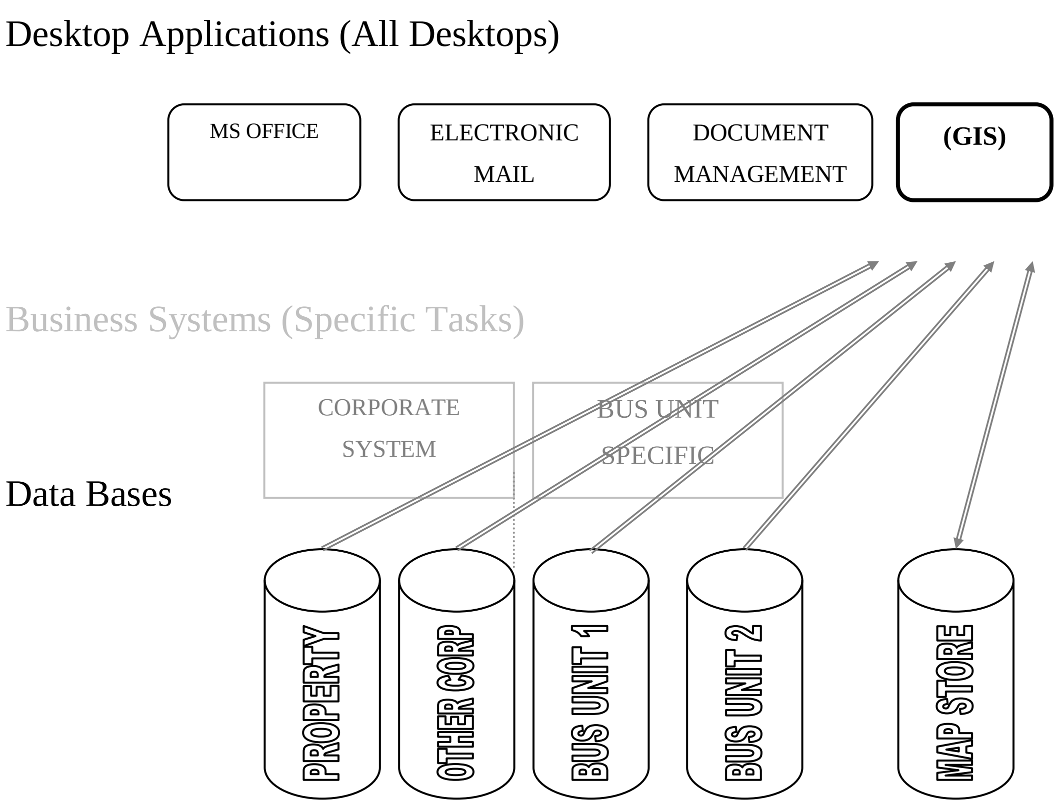
For this reason the database view of GIS is not disputed in relevance, however it is now spread out through all of the other components. Changing technology has negated the need to build a specific GIS database to duplicate the other existing corporate databases or to deliver acceptable functionality and performance.

For the purposes of this thesis, the technical details of how the maps are stored, retrieved or displayed are not critical, and are usually the responsibility of the software provider. From the point of view of managing an implementation, content and performance of the technical system are all that needs to be specified.

6.2.6 Viewing of Corporate Data (Interfacing)

OVERVIEW OF BUSINESS PROCESS GIS COMPONENT 4

The GIS will provide another way of accessing and viewing corporate data. This can be used either to obtain data grouped by a geographical region or by other search criteria. Often the Windows based GIS systems are more user friendly than the core corporate systems when compared performing the same query, particularly for a function like mail merge. The following generic diagram shows the typical role of GIS:



The arrows indicate the flow of information.

Figure 6.1 The role of GIS when viewing corporate data.

The first task of a GIS implementation is to index the corporate databases against a map. Initially this is done by mapping the property numbers, and eventually extends to mapping all geographically based databases.

OPERATIONAL PROBLEM SOLVED

Corporate data cannot be accessed or interpreted efficiently by current methods. Common problems include the numerous passwords and screens that must be entered and viewed, poor textual searching or indexing of data, inability of current systems to retrieve data in a useable format, and inability to visualise corporate data on a map.

The main workflow benefits this process allows are:

- GIS allows another quick way of searching and retrieving existing data. This is usually an option in addition to traditional methods, however it does not completely replace them.
- Viewing corporate data by either a colour on a map or even the value written on a map is a powerful way of interpreting data.
- GIS allows access to corporate data from other parts of council where required without requiring specific training in the system the data is kept in. The data access methods through a GIS are the same regardless of the data source and format. An example of this is where some infrequent users find the property system hard to start or use, but will use the GIS to access the property data, possibly in a simplified format.

REQUIRED GIS FUNCTIONALITY

To be able to retrieve and visualise corporate data using the map objects as a searching index and display background. The corporate data may be displayed as map text, a screen browser or a colour related to value. Optionally the data may then be exported to a third application. Screen navigation may occur by entering property attributes like owner's name, street address or property number, which are also kept as map layers to use as navigation aids. Again, the whole process should occur in about five seconds, with retrieval of several thousand answers occurring in less than a minute.

THEORETICAL BASIS

This also comes from one interpretation or part of the database view as described by Maguire and others. See discussion in 6.2.5.

TECHNICAL REQUIREMENTS

The GIS requires a link to the corporate data that is either live or utilises ODBC technology. The precise details will be specified and scoped for every corporate database being utilised.

DATA REQUIREMENTS

Ideally the corporate data should be read and retrieved directly. If this is not possible, a copy may be temporarily brought into the GIS environment or an interim environment for analysis.

The map elements must have the same structural rules as the corporate dataset being accessed. There must be one element per corporate database record at the level the database is being extracted, and a common linkage between the graphical element and the textural database.

COMMENT

If we assume that the role of GIS is to improve core business process and function, then the nature of GIS is dictated by the nature of the core business. In turn, the technical function and characteristics of the GIS are dictated by the technical characteristics of the core business process. This means that the GIS must use and visualise on a map the core business or corporate data, not a set of specially built GIS data.

The previous three views of GIS are the traditional ones considered relevant to Local Government, however all of these have started from the point of view that GIS is implemented as an isolated and self-contained system. If we look at GIS from the perspective of being part of the corporate IS, then a fourth view becomes the natural one to initially implement.

SIGNIFICANCE

A core contribution of this thesis is the emphasis of a fourth primary view of GIS, being the visualisation and manipulation on a map (or the geographic enabling) of existing corporate data. The logic provided above and the experience of the author indicates that this will be the primary view of GIS in Local Government in the future.

The critical difference between this view of GIS and the traditional database view is that the database view assumes that the database is an integral part of the GIS (Maguire et al). This view does not require the GIS to have a database at all, but rather the ability to "map" the existing corporate database.

6.2.7 ACCESS TO CORPORATE SYSTEMS (INTEGRATION)

f r

OVERVIEW OF BUSINESS PROCESS GIS COMPONENT 5

Related to Viewing of Corporate Data is the use of GIS to access and start corporate systems on records that correlate to the property selected on a map. In Local Governments where this functionality is available it is extensively used. The required functionality allows a property to be selected on the map, and the normal work environment (e.g., the property system or electronic document management system) to be activated on the correct record ready for performance of normal tasks. This functionality allows GIS to become a part of the current workflow, as distinct from the concept that staff become "GIS Operators".

The following generic diagram shows this integration:

The integration links are shown ⟺

Desktop Applications (All Desktops)

Business Systems (Specific Tasks)

Data Bases

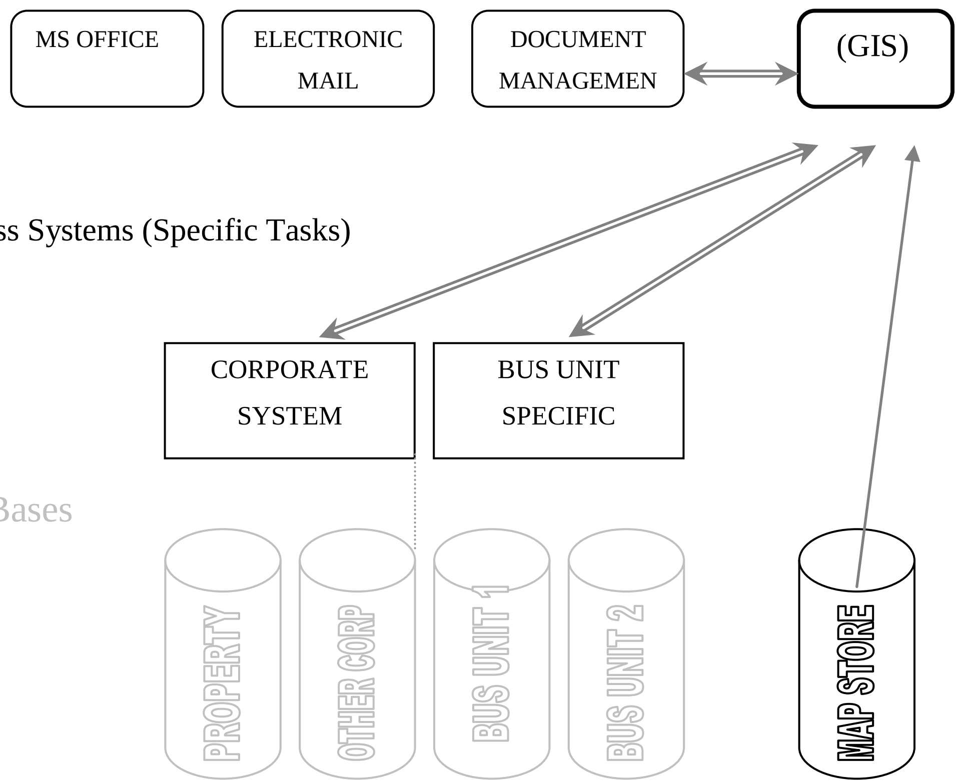


Fig 6.2 The role of GIS when integrating with corporate systems.

OPERATIONAL PROBLEM SOLVED

The operational problem is starting the corporate systems on the correct record or validating that the correct record is being used for data entry. The functionality is also an extra visual check that the action is being undertaken against the correct record.

This functionality may only save minutes or seconds per use, but used many times per day over the whole council would be a valuable source of time saving. Network monitoring in councils where this functionality is available shows that the GIS software is used as often as any other software package in the building except word processing and the rating system (City of Knox, Melbourne), and that up to 70% of all staff use the GIS.

REQUIRED GIS FUNCTIONALITY

The functionality that GIS provides is where the GIS is used to find a map object representing a corporate record, the GIS then starts another corporate software application on the required record. A variation of this is where the GIS is started by another application and goes to the map position of the record being processed by the other application. The two workflows can occur to different applications (i.e., property and records system). This functionality also allows the printing of an associated map or the checking that the other application is processing the correct record.

THEORETICAL BASIS

This view or use of GIS has not been found in literature and has come from the experience of the author. This would have to be proven by case study, which is outside the scope of this thesis.

TECHNICAL REQUIREMENTS

This will be specified site-by-site and application-by-application. A lot of the commonly used Local Government applications and GIS software have already developed this link. The availability of this functionality is a major determinant in the selection of GIS software. In order of priority the GIS should at least be integrated with the property system, the customer request system and the document tracking system. Other systems can be integrated on an as needs basis.

DATA REQUIREMENTS

Again this will be developed site by site, and be derived from the corporate data business rules. The data requirements are usually the same as the data-interfacing component.

COMMENT

This functionality is essential if GIS is to become part of the corporate culture as well as part of the corporate IS environment. The new user perspective introduced by this section assumes that GIS is part of the IS environment, and that they are not disparate systems. The following diagram showing where GIS fits into the City of Port Phillip IS structure illustrates this concept. Note the GIS does not have its own database.

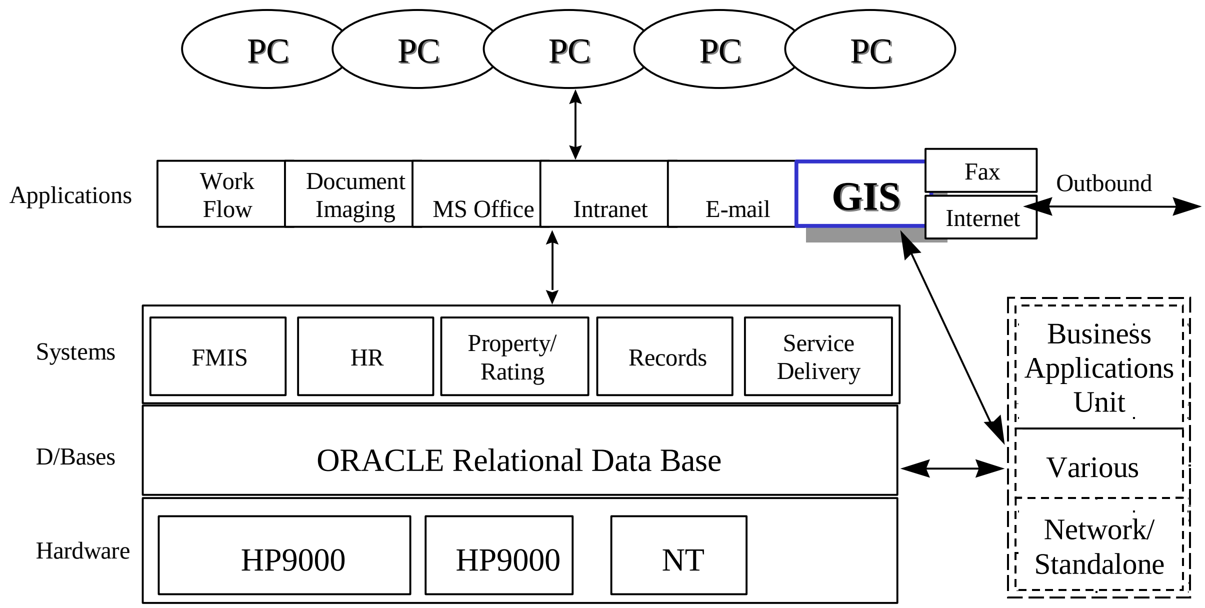


Figure 6.3 The place of GIS in the information technology structure at the City of Port Phillip. (Adapted from Fitzgerald et al (1999))

SIGNIFICANCE

This is arguably the most common use of GIS on a mature site where high overall GIS usage exists. The core concept is that GIS is inserted properly into the normal workflow, rather than staff becoming temporary GIS operators to do their work. The GIS should not duplicate any corporate functions when this functionality is available.

6.2.8 BUSINESS PROCESS GIS PRIORITIES

By changing the priority of GIS implementation from being a stand alone system to being part of IS, the traditional priority given by GIS literature changes for Local Government business process GIS components, as shown in the following table:

Business Process GIS Components	Traditional priority	New priority
Map View	High	High
Geographic Data Storage View	High	Low
Spatial Analysis View (Simple/Complex)	High/High	High/Low
Data Interface View	Low	High
System Integration View	Not Considered	High

Table 6.1 Business process GIS priorities for a typical Local Government

These components grow in definition and complexity as a GIS implementation proceeds. It is the experience of the author that most *Business Process* GIS requirements in Local Government fit within this framework of five components.

The following table gives the author's experience of the use of the five components of business process GIS by typical business units:

BUSINESS PROCESS	MAP VIEW	ANALYSIS		PLAN STORAGE	DATA INTERFACE	SYSTEM INTEGRATION
		Complex	Simple			
Finance	Y	N	N	N	Y	Y
Valuations	Y	N	Y	Y	Y	Y
Council Property	Y	N	Y	Y	Y	Y
Rates	Y	N	Y	Y	Y	Y
Information Technology	N	N	N	N	N	N
Customer Service	Y	N	Y	Y	Y	Y
Records Management	N	N	Y	N	Y	Y
Human Resources	N	N	N	N	N	N
Contract Management	Y	N	Y	Y	Y	Y
Strategic Planning	Y	Y	Y	Y	Y	Y
Statutory Planning	Y	N	Y	Y	Y	Y
Environment Health	Y	Y	Y	Y	Y	Y
Parking and Traffic	Y	N	Y	Y	Y	Y
Events/Community Services	Y	N	Y	Y	Y	Y
Technical Services/Design	Y	?	Y	Y	Y	Y
Road/Asset Maintenance	Y	N	Y	Y	Y	Y
Parks and Gardens	Y	?	Y	Y	Y	Y
Children's Services	Y	N	Y	Y	Y	Y
Aged & Disability	Y	N	Y	Y	Y	Y

Table 6.2 Business process GIS requirements of typical Local Government business units.

This table shows the corporate functions that require the three traditional and two newer GIS components. An implementation will eventually need to check all answers, however this table would be a suitable generic starting point, from the experience of the author.

6.2.9 *Summary of Business Process GIS*

This section has described all five GIS Business Process components and their relevance to Local Government. The genetic framework for determining the business process outcomes of the GIS implementation described has also been found by the author to work in any Local Government social system. The second half of this Chapter now describes the supporting GIS infrastructure, while the next Chapter describes how to deliver these outcomes whilst utilising diffusion principles.

6.3 ***INFRASTRUCTURE GIS IN LOCAL GOVERNMENT***

The previous section gave a framework for defining what is to be delivered to the desktop as business process GIS. The next question is what infrastructure GIS do we have to put in place for the delivery, co-ordination and support of the various business process GIS implementations across the organisation. The components are well defined by Chan and Williamson in various papers, the purpose of this section is to give them some detail and practical content.

6.3.1 *Data*

"All accessible data, both geographical and attribute, required to meet the geographical information needs, identified or latent." (Chan and Williamson, 1995)
This component is the most complex and possibly the most well developed outside IT. The contents of this section are based on the theory in previous chapters and the work by the author at the City of Port Phillip. The work done at Port Phillip in data structures and hierarchies for Local Government is extensive, and would require a thesis of its own to fully document and prove. Parts of this work are described in Fitzgerald, Dooley and Chan (1999), attached as Appendix A.

In order to provide an effective data infrastructure, all data is categorised in three types as utilised at the City of Port Phillip:

CORE DATA:

Funded, created and maintained by the GIS Unit for use by the entire organisation as required. For example, the base map (private and public land and road reserves), road names and street address numbers.

SHARED DATA:

Created and maintained by a specific unit, but viewed via GIS by the wider organisation. For example, street trees or planning scheme zones.

UNIT SPECIFIC DATA:

Data that is created and maintained by one unit and will not be viewed by the wider organisation because other units have no (practical GIS) use for the data or the data is confidential. The GIS Unit will not fund the collection or maintenance of this data but will provide technical assistance.

The core differences between the data types are the ownership, maintenance responsibilities, access rights and collection funding arrangements. These become critical in phase three of the implementation where the GIS role moves from one of control to loose co-ordination and facilitation.

DATABASE LINKAGE LAYERS

The core task in defining GIS requirements for Local Government is to start with the corporate activities that have a geographical attribute, and to aggregate these into common groups for use in a GIS (i.e., use on a map). The common groupings of corporate data may have already done this. These groupings will lead the definition of GIS data requirements and show the components that will require the corporate data view of GIS.

The activities of Local Government can be broken down into five distinct groups by simply asking, where do the activities of the business occur? The four types of geographical areas that most business units primarily administer are **private property**, **roads and related assets, open or public space** and those whose analysis operates at **higher level regions** like census or contract areas. The first three of the four geographical regions are mutually exclusive. (A GIS that links to databases through points and not regions loses a lot of its effectiveness.) There is also a fifth option, those whose activities do not have a geographical component. Most business process/business units can be clearly assigned one of these four core geographical bases for activities and thus their corporate and GIS data requirements.

In order for Local Government to see a large amount of its business process in a GIS the only requirements are a set of graphical objects that match their corporate records. This can be made for each of the three mutually exclusive geographical types: private property, roads and assets, and public space; which together make a complete geographical coverage of a Local Government area. By definition, to represent these mutually exclusive geographical types, the graphical objects must be regions or polygons whose extent represents the area of influence of the business process.

6.3.2 Information Technology

"All computer hardware, software (including applications) and associated communication technology required to meet the geographical information needs, identified or latent." (Chan and Williamson, 1995)

A brief description of the IT components required to be considered are as follows:

HARDWARE

It is becoming rare that a Local Government GIS implementation requires new hardware. Operational GIS data and software rarely exceeds 50 to 100 Mb, with the whole maintenance data set rarely exceeding 2 Gb. Hard drives of this size cost a few hundred dollars. Server capacity utilised by GIS should be minor in a similar manner. The exception to this rule is where imagery is put on the desktop. This must be independently scoped, due to its large file sizes (up to 8Mb files to a possible total of many Gb).

SOFTWARE

This component will be discussed fully in the implementation chapters, however the software to be considered is the actual desktop GIS software, as well as interfacing and integration applications. The immediate core requirement is that the GIS software be fully compatible with the current IT systems, whatever they may be.

COMMUNICATIONS

Traditionally this means network considerations for the communication of information between the server and the desktop. While there is much current discussion about Internet applications, the Internet is only another method of communicating between the server and the desktop. Currently Internet GIS applications are not as efficient as existing networked systems within a Local Government building or even over wide area networks. They also make the server do all of the processing, which is proving to be the weakest technical link.

The business requirements of the end user relate to performance, which is dictated by network or communication speed. They do not care what the technology to deliver it is.

COMMENT

The IT components are becoming the least critical of the GIS infrastructure components. Software development no longer concentrates on more power or speed, hardware is mostly not a consideration, and communication is close to the point where all staff and most constituents of a Local Government can retrieve GIS information within seconds.
As identified in Chapter 3, however, the limiting factor is the socialisation of the technology, not the technology itself. Thus the results of this thesis should be technology independent.

6.3.3 STANDARDS

"All agreed practices required to facilitate the sharing of the other four components of a GIS." (Chan and Williamson, 1995)

As implementation processes are developed they are documented as standards. The main initial requirements for standards are as follows:

- Data model and data dictionaries.
- Associated data structure and components.
- User control.
- IT protocols.
- Layer/data lists and controls.

6.3.4 PEOPLE WITH EXPERTISE

"All knowledge, skills, procedures, and systems, technical or otherwise, acquired by people involved, for the smooth functioning of the GIS." (Chan and Williamson, 1995)

The framework developed for this component is represented by the following diagram:

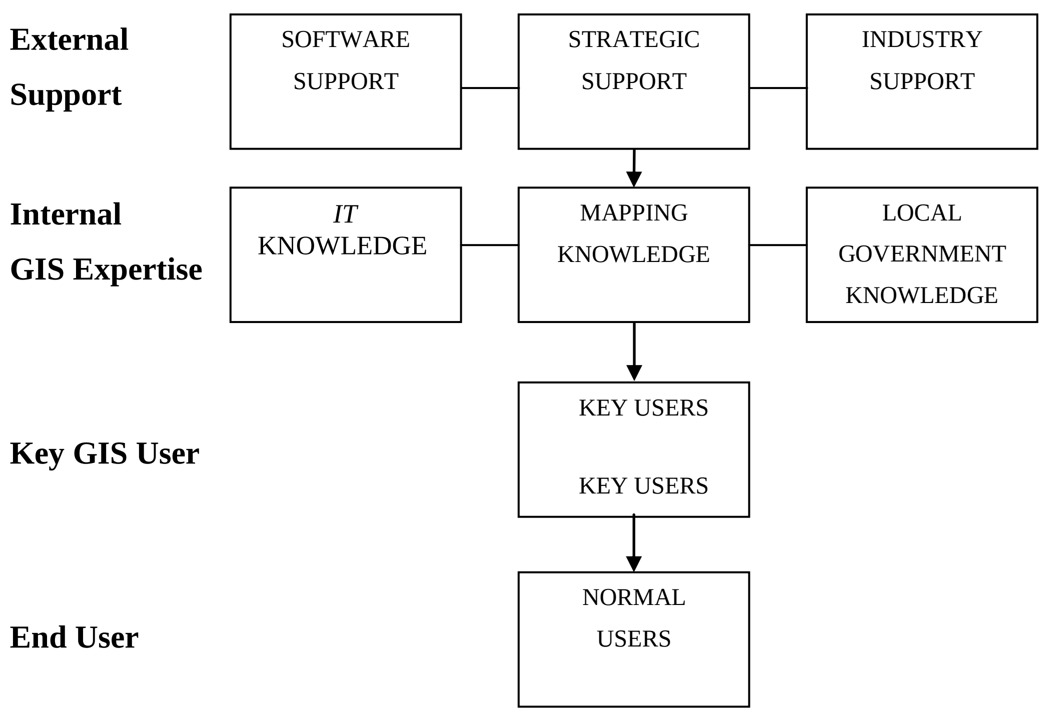


Figure 6.4 GIS knowledge and people framework.

This diagram has been tested practically by the author on several sites. The GIS knowledge is spread through this four level hierarchy, as follows:

EXTERNAL SUPPORT

There are certain components of expertise that are not worth keeping within a Local Government. Software expertise should, where possible, lever off the experience of the rest of the industry rather than run a parallel set of research and development. Local Governments should, where possible, use software suppliers that have at least ten other Local Governments utilising their GIS products. Local Governments should also continue to initially use their change agent, and continue to get strategic consultancy advice in the long term. Software vendors cannot give unbiased strategic advice unless it falls within their product range. The third area of external support is the Local Government GIS community, particularly with regard to data issues and relationships with State Government.

INTERNAL GIS EXPERTISE

The GIS section of a Local Government should be small but requires a wide range of expertise. With this support model, indicative sizing would be one GIS person for 60 users, however it is possible for three GIS officers to support up to 500 users.

The core knowledge requirements in the GIS section in order of priority are:

- Knowledge of how local government works.
- Knowledge of mapping, digital data and projection principles.
- IT support knowledge.
- GIS theoretical knowledge.

KEY GIS USER

Each business unit has a “Key” or “Power” GIS user identified. Their role is to be the first line of technical support for the rest of the users in the business unit, and to initially train the users. These people are given more extensive training than the rest of the users and it is their role to keep the GIS relevant to the business needs of the business unit. To some extent, only the key users liaise with the GIS section.

END USERS

End users are precisely as the term suggests. They make up the rest of the staff in the business units who will use GIS. A rule of thumb is that 70% of Local Government staff will use GIS.

6.3.5 ORGANISATIONAL SETTING

"All the operating environments, technical, political, or financial created by the interaction among stakeholders, in which the GIS is to function" (Chan and Williamson, 1995)

The preferred management structure for GIS within a Local Government organisation is as follows:

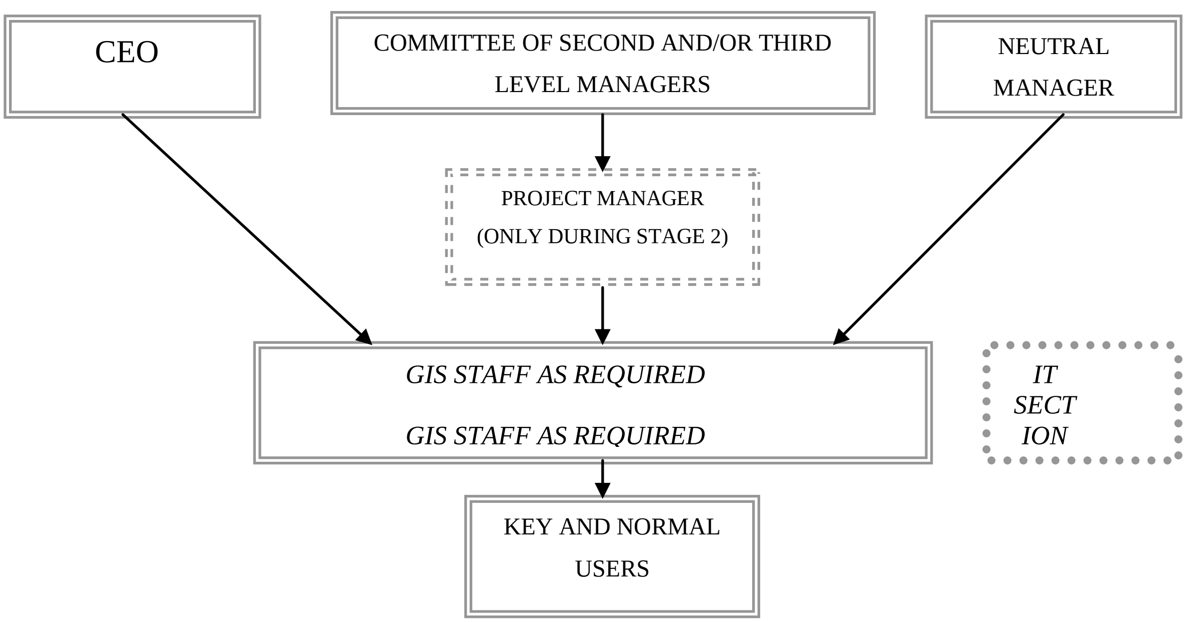


Figure 6.5 Management structure for GIS

Ideally the GIS section should be as neutral as possible, and thus, if possible, it should not be a part of any other business unit. It will however require the following controls and mechanisms:

ULTIMATE CONTROL

The Chief Executive Officer (CEO) of a Local Government has ultimate control over all activities including GIS. Ideally however, GIS should sit directly under the CEO in a similar manner to that of special projects, human resources or economic development. The CEO may delegate the practical responsibility.

DAY TO DAY ACTIVITIES

Someone has to supervise the daily activities of the GIS section with regard to issues such as employment, timesheets, staff performance reviews, leave, budget, office issues etc.

GIS IMPLEMENTATION DIRECTION

Ideally a committee should strategically control the GIS section. This committee should as a minimum be comprised of the group of people who made the decision to adopt on behalf of the organisation. Their key role is keeping the GIS relevant to the overall business needs of the organisation. They manage the infrastructure GIS component so that the demands of the various business units are balanced and put in the perspective of the organisational Key Performance Indicators (KPIs) and business plan. This helps remove the GIS from internal party politics.

Other structures do work, but usually with more difficulty.

6.4 SUMMARY

This chapter has put a Local Government perspective on the current theoretical framework that defines GIS. A summary of the framework within which GIS will be implemented is shown in the following diagram:

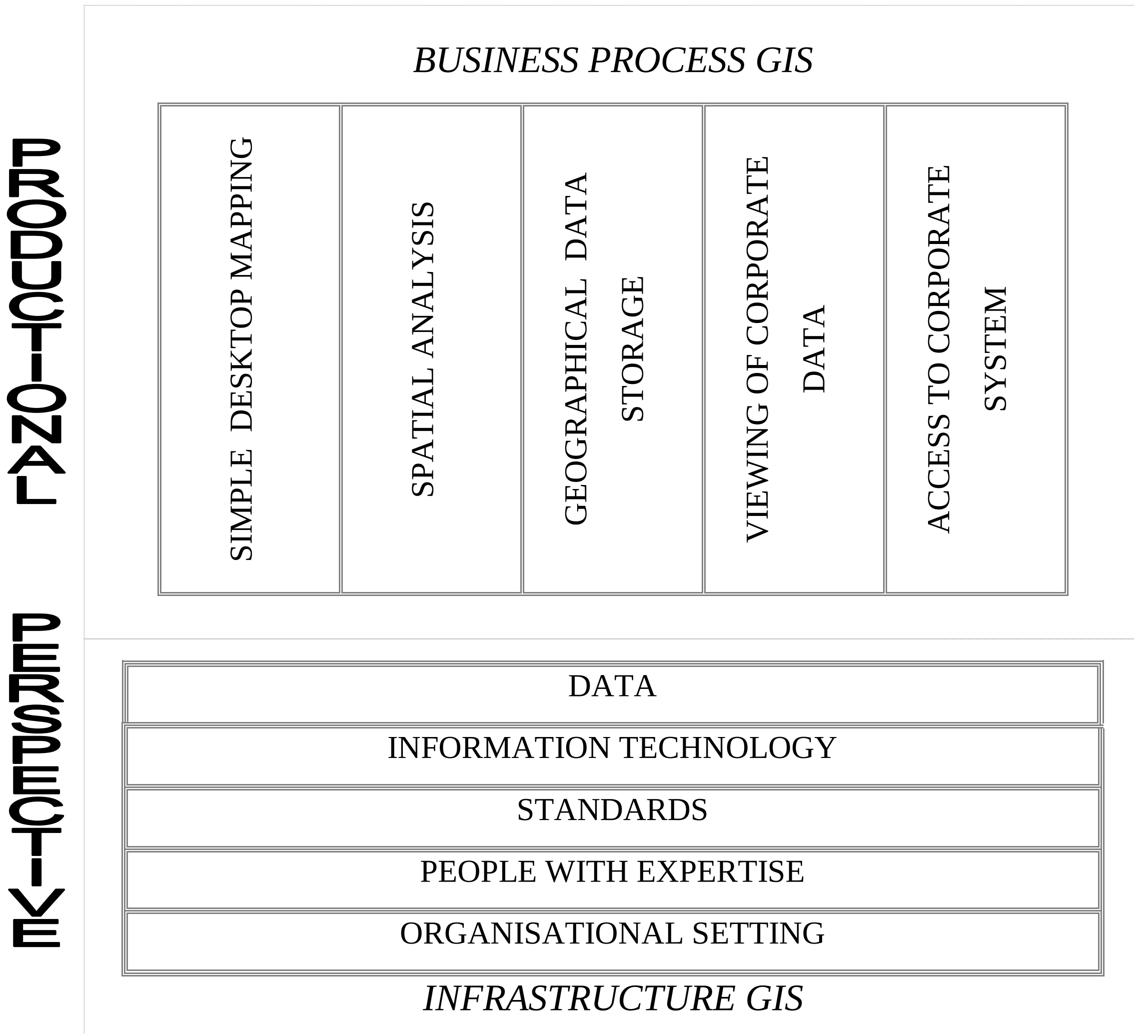


Figure 6.6 Overall productional perspective framework for Local Government.

This diagram can be applied to any level of social system within Local Government. This template can be used during implementation to precisely define the GIS innovation for each Local Government business process (and social system), and to build the GIS infrastructure components necessary to provide this.

DIFFUSION DISCUSSION

This chapter has performed the critical diffusion task of redefining GIS in terms of the Local Government problems it will solve. This is essential for the matching stage of the organisational innovation process to occur, where the innovation is matched with the problem prior to the organisation's decision to adopt (as described in 2.5.3). It is unlikely that the people in a Local Government organisation would adopt any of the traditional GIS perspectives because they cannot relate them to the problems they need to solve.

7 THE IMPLEMENTATION OF GIS IN LOCAL GOVERNMENT

7.1 INTRODUCTION

The hypothesis of this thesis is:

"That in order for a Local Government GIS implementation to be successful, it is necessary to develop an implementation process that allows for the influence of diffusion."

This chapter proves the hypothesis to be justified by describing an implementation process that contains a substantial number of components that allow for diffusion to be identified and managed.

The previous chapter gave a framework within which to define GIS in a Local Government setting. The task now is to add some communication over time (implementation dynamics) which actually add the innovation to the social setting (or add the GIS framework to the Local Government environment).

It is the opinion of the author that the answer to how to implement GIS in Local Government has not been clearly laid out in any of the theory discussed so far, but rather lies in a combination of them all.

The implementation of GIS will fit within the following generic questions:

1. Where are you now?
2. Where do you wish to go?
3. How do you get there?

These can be converted to the following implementation steps using the framework from Chapter 6, as follows:

1. Measure the current status.
2. Determine the required GIS business process outcomes.
3. Determine the required GIS infrastructure to deliver the business process outcomes.
4. Implement the requirements determined in 1 to 3.

This chapter will start with some more detailed discussion on the relative importance of the various theoretical backgrounds, and then detail the four steps outlined above. Diffusion forces occur at all steps, and thus diffusion will be a focus of the chapter, rather than this chapter concentrating on covering all of the mechanical implementation steps in detail.

7.2 RELEVANCE OF THE THEORETICAL BACKGROUNDS

7.2.1 The Importance of the IT Component of GIS

In the previous chapter the emphasis of GIS implementation moved from a stand-alone system delivering primarily only the first three traditional business process GIS functions, to being a part of the corporate system. GIS now primarily undertakes corporate data interfacing and corporate system integration, with less emphasis on the traditional roles of complex spatial analysis and map storage functions. In re-defining GIS, it has naturally moved into mainstream IT. Theoretically, then, we should be able to implement GIS using the general IS frameworks, without needing all of the IT components for technical delivery.

The technical composition of the IT component of GIS is rapidly becoming identical to most other IT components. For example maps are becoming simply a corporate database record with a geographical attribute. As stated in the introduction, "*An emphasis in the perspective of this thesis is the innovation of GIS as the mapping of current corporate data, as distinct from the efficient managing of current spatial data. Most current Local Government GIS research refers to the latter only.*"

Laudon and Laudon (1998) list GIS software with word processors, spreadsheet packages and other application package software. It is already occurring that powerful GIS software is coming preloaded on a high percentage of Local Government computers, and implementation methodology will not require the building of GIS software or user interfaces from first principles. Additionally the database design component may consist of simply adding geographical identifiers to existing corporate data infrastructures. This confirms that the thesis can be based on modified IS implementation methodology with the emphasis on the management and organisational components. This is used in preference to previous GIS implementation methodology that concentrated on GIS system design. Put another way, the area of interest is implementing GIS the innovation, not GIS the technology. Campbell (1995, p11) clearly makes this point.

7.2.2 *Discussion on Relevance of GIS Based Theory*

The approach of most of the GIS implementation theory studies detailed has been to start with the typical IS implementation theory from a technical perspective and then address the factors that have to be added to make GIS work. In fact the IS software/system implementation theory should not be central to GIS implementation theory. The technology component is an optional component of an implementation methodology that otherwise allows for the innovation characteristics of GIS by applying diffusion theory. A lot of the factors identified by GIS implementation theory are caused by innovation characteristics, and a lot of the answers correlate to diffusion theory, but the core technical IS framework used in the GIS research to implement the technology is not necessarily relevant.

The following general observations are made by the author of this thesis with respect to the various GIS implementation studies and comparisons:

1. There is no attempt to allow for variations caused by the differences in the application or perception of GIS when studying implementation. It is usually assumed that each stakeholder has the same definition of GIS. For example, the implementation of GIS into an organisation that administers physical assets is very different to an

organisation whose primary role is land administration, even within the same Local Government.

2. Direct comparisons are made between implementation studies of vastly differing organisations, for example, Local Governments can have between twenty and many thousands of computers and thus potential GIS users. Current implementation methodologies are not necessarily scalable.
3. No provision is made for previous opportunistic or failed systematic GIS implementations, while research is dictating that GIS implementation is unlikely to succeed unless either of these have already occurred (Chan and Williamson, 1999a).
4. The timings revolve around the software/systems development cycle, which may not be required in future implementations. Investigation into the order or importance of timing of the other components is deficient.

These studies are however still very relevant to this thesis in that they raise non-technical issues that have to be addressed during GIS implementation.

7.3 HIGH LEVEL GIS IMPLEMENTATION PROCESSES

The emerging implementation works by Chan and Williamson will be used at the higher level to manage the GIS implementation process. This implementation theory is detailed in Chapter 5.6 and is summarised in the following diagram:

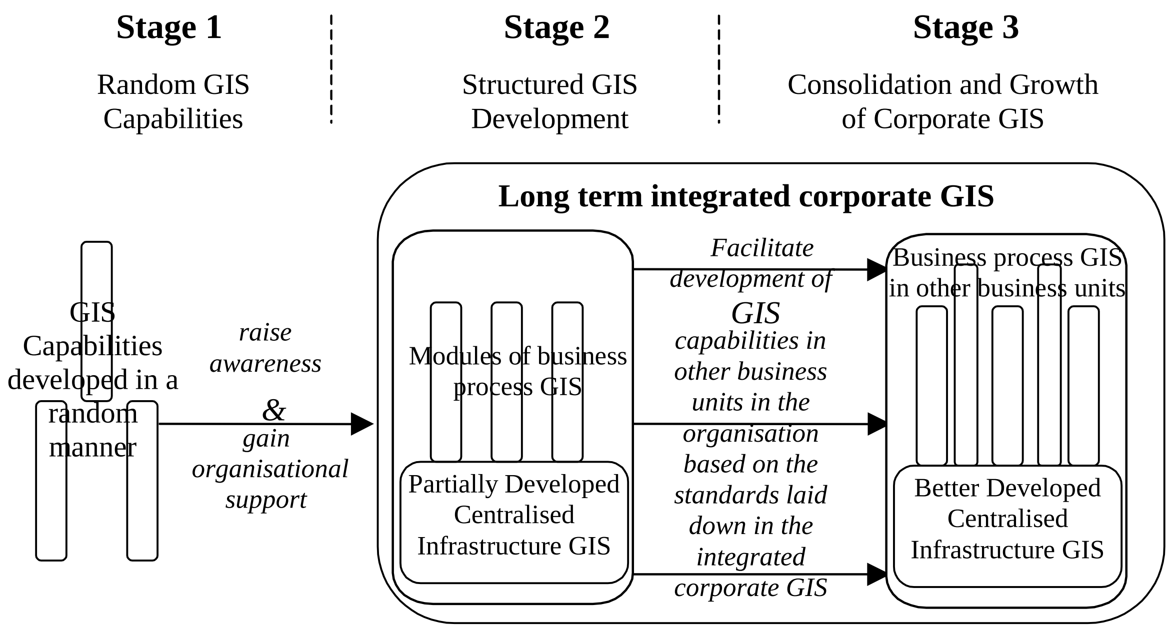


Figure 7.1 A 3-stage approach to GIS development. (Fitzgerald et al, 1999)

Almost all Local Governments are going to be somewhere between stages one and three. The following is a very common scenario:

A mature GIS sits in the engineering section, which fully provides the map storage perspective and some of the mapping perspectives. Viewing software is available at the desktop but is not being used. There is no integration or interfacing available and the users do not know it is possible.

This would be a typical target for the processes developed in this thesis, however the target range is from no GIS capabilities, to a fully mature site where the framework from this thesis will only undertake fine-tuning.

Clearly the main implementation tasks are to measure the current status, identify the desired result and plan the processes to achieve these. The process is a type of gap analysis.

Stages 1 and 3 occur naturally within the organisation, while Stage 2, which includes the setup for Stage 3, is done as a dedicated implementation project. Stage 2 is the subject of the remainder of this thesis.

7.3.1 THE IMPLEMENTATION PROCESS

As stated in the introduction, the four steps to implement GIS are as follows:

1. Measure the current status.
2. Determine the required GIS business process outcomes.
3. Determine the required GIS infrastructure to deliver the business process outcomes.
4. Implement the requirements determined in points 1 to 3.

Steps 1 to 3 are done as a report, with the facts being collected and documented as part of a User Needs Analysis. This is the first step of Stage 2 of the Chan and Williamson three stage process described above. There are several very important roles of the user needs analysis from a diffusion perspective that are not contained in the typical IS methodology.

7.3.2 THE USER NEEDS ANALYSIS

A user needs analysis should be officially undertaken to gather the information required to do the implementation as detailed in the rest of this chapter. An experienced operator will know most of the answers before it is started, which overcomes the problem of the user not being able to communicate their needs until they have used, or understand, a GIS. The interviews, which are conducted as a needs gathering process, have some other important aims:

CHANGE AGENT.

The person who undertakes the user needs analysis must be the change agent as defined by Rogers and described in Chapter 2.2.2. The change agent performs a critical role in the diffusion process, and the first five of the seven key roles of a change agent defined by Rogers are now revisited:

Develop a need for change: The user needs should point out current problems and explain how GIS is a viable option for solving them. More importantly the change agent must convince the client that he has the ability to solve the problems.

Obtain the clients trust: The credibility of the GIS in the eyes of the client is directly related to the credibility of the change agent.

Diagnose problems: The change agent must relate the innovation to the client in terms the client understands. Part of this process involves redefining the current perceptions of GIS from the productional perspective. This moves the GIS implementation framework into terms the client will understand.

Create an intent to change: The result of doing the above three steps correctly is that the client is positively motivated to change to the new innovation.

To translate an intent to action: The change agent also has to convince opinion leaders and near peers to influence the client's decision to adopt. The user needs must cover these people as well.

(The remaining last two roles are to prevent discontinuance and achieve a terminal relationship, and are done after implementation.)

OPINION LEADERS

These people must be identified and made an integral part of the user needs. *Opinion leaders are defined as those individuals from whom others seek information and advice* (Rogers, 1962, pp17). Typically opinion leaders are the people who influence the decisions of others within the social system. In analysing the relationship between change agents and opinion leaders, Rogers (1995) makes the following generalisation:

"Change agent success in securing the adoption of innovations by clients is positively related to the extent that he or she works through opinion leaders."

INFORMAL SOCIAL PATTERNS

Informal patterns of communication must be allowed for, as the diffusion process will travel through these faster than through the formal patterns. For example, managers do not always take advice directly from the people who technically answer to them, but rather can take advice from another staff member who they are in social contact with, or know from previous employment.

CREATING A SENSE OF INVOLVEMENT.

All of the research indicates that unless the social system feels involved in the implementation process, then the implementation is unlikely to succeed. The involvement in the user needs may be more important from a perception point of view than from a practical input point of view.

GENERIC STRUCTURE

Apart from the above considerations, the user needs analysis is an information gathering exercise. In fitting the user requirements to the GIS framework, the following questions are a suggested sequence. These fit the IT principles detailed earlier in the thesis.

- What are the business processes of the business unit?
- What are the operational problems in undertaking these processes?
- Which of these problems have a spatial component?
- Which could be solved by GIS technology using a component of the productional perspective?
- What are the technical and data requirements (infrastructure components) to solve the problem?
- Is it economical or practical to use GIS?
- Where does the solution fit within the framework of five business process GIS components?
- Would any of these components that do not apparently solve business problems be of benefit to the business?

Most or all of the results will fit into the framework developed in this thesis. The requirements of any that do not, will have to be worked through from IS first principles.

7.4 MEASUREMENT OF CURRENT GIS STATUS

BUSINESS PROCESS GIS STATUS

In a given business unit, the current measurement is simply the number of indoor staff using this functionality, not the number of people the functionality is available to. If the site appears to have GIS being commonly used at the desktop, then the first implementation task is to conduct a user survey of the frequency of GIS use, both overall and for each business process component. This will also determine whether the various business process GIS components are innovations or not. The author is currently collecting statistics on this to allow benchmarking between implementations, however this is not part of the thesis and is in the early stages. Indicative figures are that on a mature site 80% of all indoor staff use the GIS, 40% daily or more, 20% weekly and 20% occasionally.

The following are results from user surveys at the City of Cairns and the City of Port Phillip, and are of potential GIS users who have been given the software:

How often do you use GIS?	City of Port Phillip		Cairns City Council	
	Number of Users	%	Number of Users	%
Daily	42	58	92	54
Weekly	4	5	38	22
Occasionally	15	21	32	19
Never	4	5	9	5
No response	8	11	0	
Total	73	100	171	100

Table 7.1 Indicative frequency of GIS usage.

While these figures have not necessarily been rigorously collected, they are indicative of the usage rates achievable.

The task in future is to break down the user survey not only into how often GIS is used, but also how often each of the five business process components is used. Lower use numbers can be either because one is not available or does not work well or, alternatively, one of the many other causes of implementation failure.

INFRASTRUCTURE GIS STATUS

The status of the infrastructure component of the GIS has to be documented. Section 6.3 details the required components, and is thus a checklist for detailing both the current status and the future requirements.

The aim of Stage 2 is to ensure there is enough GIS infrastructure to support the initial roll-out, and the means for it to grow to completion during Stage 3. The following diagrams are from the paper by Fitzgerald, Dooley and Chan (1999), which show the percentages of Infrastructure GIS at the end of Stage 2 and twelve months into Stage 3 for the City of Port Phillip Implementation. The diagrams also show the extent of GIS implementation among the various business units at those stages.

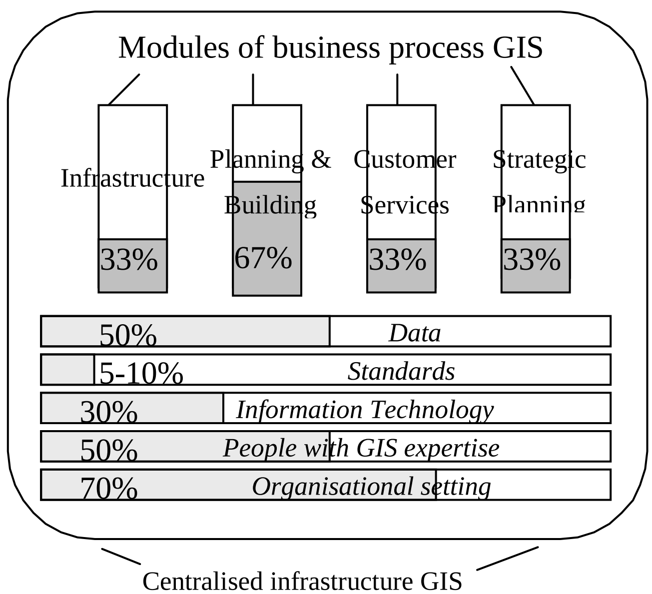


Figure 7.2 City of Port Phillip GIS development at the end of Stage 2. (Adapted from Fitzgerald et al (1999))

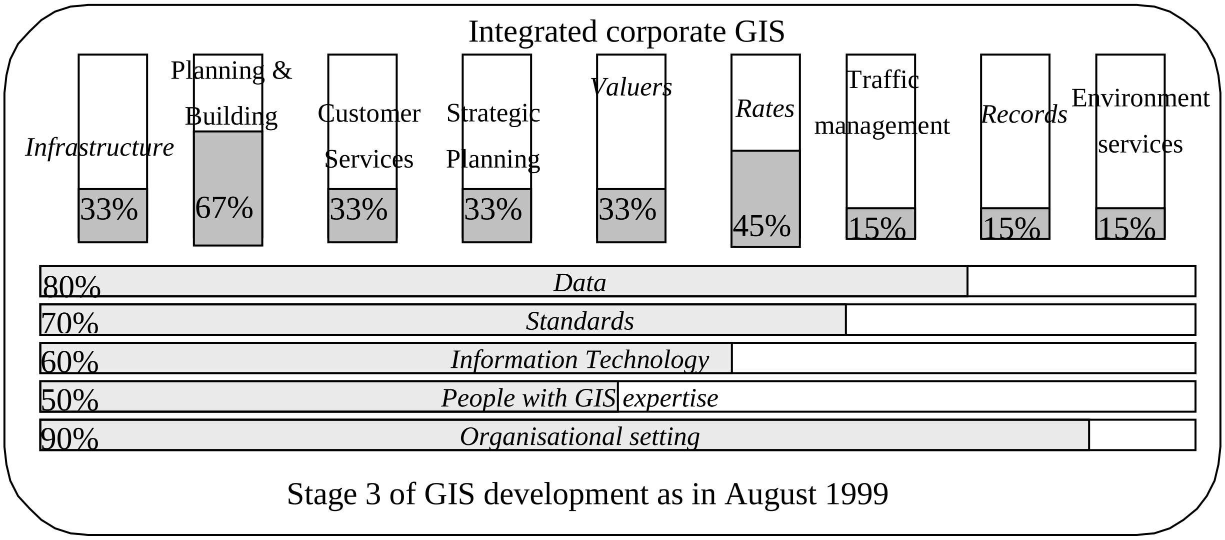


Figure 7.3 City of Port Phillip GIS development 12 months into Stage 3. (Adapted from Fitzgerald et al (1999))

From these diagrams it can be seen that the question is what is an appropriate amount of Infrastructure GIS at what part of the implementation. In April 1998 there were sixty-five users, by August 1999 there were 120, and the infrastructure was still a long way from complete, yet the site achieved high usage. (At May 2001 the number of users is about 200 and the infrastructure is still not complete.)

AIM OF THE IMPLEMENTATION

One of the decisions to make during implementation is how many business units to consider during the initial implementation (Stage 2), and how many to leave for Stage 3. The reality is that the most efficient number, as a minimum, is to obtain support from a majority of second level managers, which is where the organisational decision to adopt will officially occur. Thus the decision is not just how many business units, but where they are in relation to management. If the support is secure, i.e., the implementation is in Stage 2, then implementation should be as wide as the resources will allow. It is important to give all business units one or two business process GIS modules before completing implementation in one unit. The diagrams in the previous section show an appropriate distribution in the case of the City of Port Phillip.

There are two ways to determine the approximate final level of GIS usage. One is to be guided by more mature sites (as per the user surveys), and the other is to ask. The problem with asking is that until they have seen and understood the innovation then potential end users will not be able to give meaningful feedback on what their future requirements are.

The first way relates to the previous section, where we assume in the short term that their future requirements are similar to those of a similar business unit on another mature site. This gives approximate initial software numbers.

A third way is to do a minimal implementation of only the users that have an obvious and immediate need for the technology, and let the business unit determine their own future requirements. This method is preferred and conducted through the use of a “Key User” or “Power User”.

This discussion really is about what constitutes Stage 2 and Stage 3 of the Chan and Williamson diagram, or how much of the implementation should be structured and how much should occur naturally using the GIS infrastructure.

The business process GIS implementation steps described here will be the same for any business unit, with all components being investigated to determine whether or not they are required.

7.5 DETERMINATION OF BUSINESS PROCESS REQUIREMENTS AND DIFFUSION IMPACTS

7.5.1 DIFFUSION IMPACTS

There are several diffusion impacts that are critical to the delivery of GIS business process components. Rogers (1995) defines five characteristics of an innovation that will have a major impact on the rate of adoption that can be related directly to the nature of the business process GIS component (innovation).

RELATIVE ADVANTAGE

One of the core dimensions that users will judge relative advantage against is time taken to complete the task. The innovation must fit into the current work flow, which means, for example, that a user must be able to start the GIS and undertake the task while on the phone. Time is perceived to be a more important relative advantage than the true advantage of better performance or more accurate information.

COMPATIBILITY

If the GIS does not have the same "look and feel", and appear to be compatible with the other systems used on a daily basis, then the rate of adoption will be slower. Practical examples are that if the current operating system is Windows based, then the GIS should use standard Windows print dialogue boxes, screen navigation tools, etc. It should feel like a part of the trusted system.

COMPLEXITY

From the experience of the author, acceptable GIS complexity for a first time user would mean that initial training should take about one hour. The user should be able to perform the task on the first attempt, and a set of instructions should fit on one page.

DIVISIBILITY

A user should be able to try each of the processes by themselves without having to do any setup or other tasks first if they do not wish to. This isolates all of the tasks into small separate components that can be individually tried by a user.

COMMUNICABILITY

People will use GIS if they see their peers using it. Because the innovation occurs at the desktop then this will naturally occur in a successful implementation.

The thesis now discusses the diffusion impacts on the delivery of business process GIS for each of the five components, where each component has different diffusion forces occurring during implementation.

7.5.2 SIMPLE DESKTOP MAPPING

IMPLEMENTATION CONSIDERATIONS

In order to meet the trialability/divisibility criteria, this task should be the first one given to a new user. It is one of the easiest to deliver and provides the most beneficial result.

DIFFUSION IMPACTS.

The following specific diffusion forces will operate on this business process GIS.

Mapping Characteristics

The contents of the screen mapping should be as close as possible to the hard copy mapping currently being used throughout the organisation. This is a typical need to socialise the technology or to minimise changes to the current culture. Particular care should be taken of the cartographic content (as people still judge the quality of the maps by the presentation of the text). A core implementation task will be to make the text cartographically acceptable, something that no longer has priority in the various State Government mapping agencies. An example is the Department of Infrastructure planning maps which no longer contain crown descriptions. In some cases councils paid to have them entered again privately.

If topographic mapping is in common use, then the GIS can be run with the topographic mapping visible and the cadastral base as an invisible set of intelligence for the other GIS functions.

Screen Colours

One of the most subtle requirements of desktop mapping is choice of colours. Experience has shown that if a linework/background combination of black/white is used then there will be substantial end user resistance to use of the GIS outside the traditional mapping areas. The perception is simple, that the contents of the screen contain one of those complicated drawings that only engineers could understand. The immediate conclusion by a potential GIS user is that they would not be qualified or experienced enough to understand one of those systems and they simply refuse to use the GIS. This paragraph contains enough potential research by itself to be outside the scope of this thesis, however it is a valid implementation consideration.

Intuitive Screen Navigation

In a related matter to colours (and for similar reasons), the end user must be able to find their way around the screen without any formal training in map reading or an understanding of map scale. Again this is based on practical experience, and is worthy of more formal research outside this thesis.

The concept of intuitive screen navigation is that at any time on the screen there are three or four objects with which the user would identify. For example, many end users would not identify with objects on a cadastral map. One way of delivering this functionality is to have photography on the screen at all times, however this cannot be at the sacrifice of system performance. An alternate method is to make the prominent features on the screen the geographical features people see from a car, commonly water features, parks, churches, schools and public buildings. This layer must be constructed prior to implementation, and again choice of colour or, more importantly, intensity will be important. The screen should generally be pale and non-threatening.

7.5.3 Spatial Analysis View of GIS

IMPLEMENTATION CONSIDERATIONS

As stated previously, the request for complex queries has to be treated carefully. Do the business processes really require the complex queries to function or does the staff member think they would be handy? Does more than one person do the complex queries, and does this warrant a whole system upgrade in price and complexity? Are the complex queries run frequently, or would it be more economical to get them run by an external bureau? The requirement for complex queries may alone determine the technical requirements of the software choice.

TIMING DEPENDENCIES

This component should be made available after simple mapping, and with or after data interfacing. Some types will be the most complex for the end users to perform and done the least often, while the neighbourhood query will be used the most often on all sites. On average this function is used about every two hours in the City of Port Phillip.

DIFFUSION IMPACTS

The insistence by a part of an organisation that complex spatial analysis is required has the effect of dramatically slowing down all aspects of the diffusion process. The higher the requirements the higher the risk of stalling the GIS implementation regardless of the money spent. By insisting on complex spatial analysis, the training times for a GIS administrator can go from one week to two years to learn the software alone. The training times for an end user can go from four hours to two weeks. These differences are dramatic and impact heavily on the diffusion process.

One common scenario is that GIS software is evaluated for Local Government suitability based on the ability of the software to perform complex spatial analysis. The resultant short list can exclude the GIS products that do four out of the five core tasks well but only do simple spatial analysis. These implementations rarely succeed in the long term.

7.5.4 THE GEOGRAPHICAL DATA STORAGE VIEW OF GIS

IMPLEMENTATION CONSIDERATIONS

The delivery of this functionality has no dependencies on any of the other four components, i.e., the other four can be delivered without this component and this component does not need any of the other four to function, with the possible exception of some base mapping. This means that the requirement for this functionality at the desktop should be put through a traditional cost-benefit form of analysis, and not be considered with the other business process GIS components. In order for engineering or planning type mapping layers to be funded from the corporate implementation budget, then the benefit would have to pass across a high percentage of the business units. The mechanics for determining if map drawer contents are core layers are covered in the committee section of the organisational component of the infrastructure GIS.

What is important to consider during implementation is that the GIS infrastructure must enable a business unit to capture their own map layers and obtain this functionality if needed without duplicating any of the other infrastructure GIS components.

DIFFUSION IMPACTS

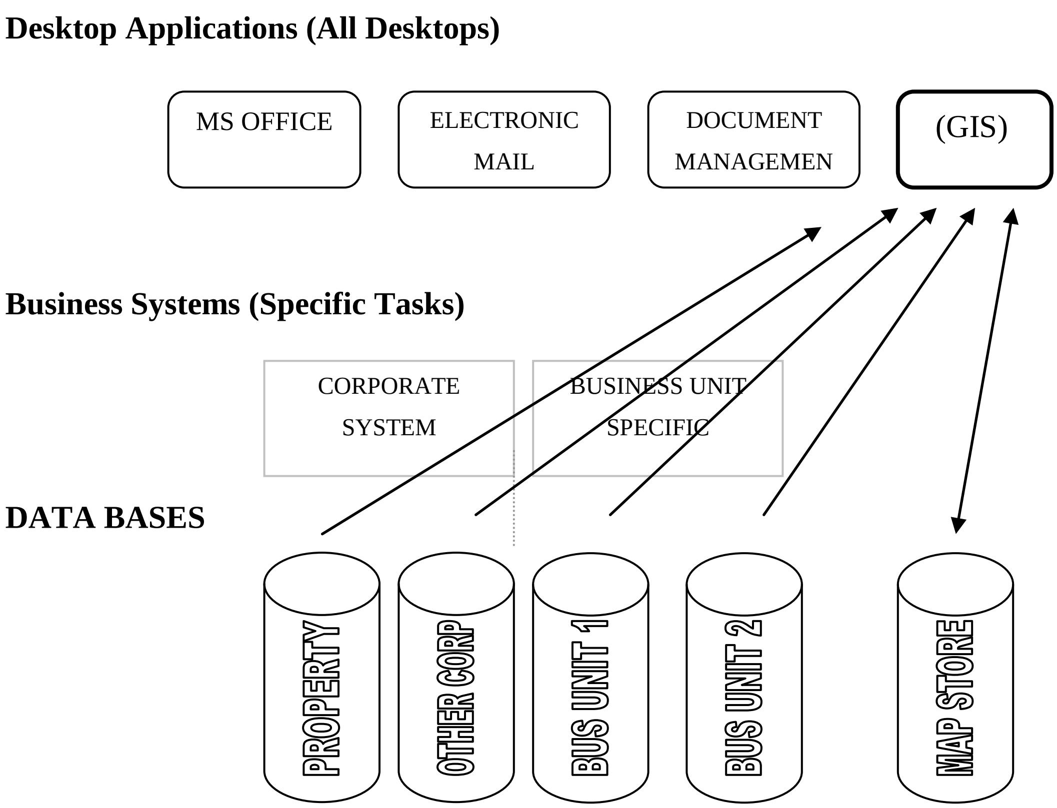
Delivery of this functionality can be both time consuming and expensive, and rarely justifies being taken from a corporate budget. Most existing hard copy mapping is only used by either engineers or town planners. The common implementation mistake is to use the corporate GIS budget for this task alone. At the end of the expenditure there are no benefits at all to about 70% of the staff and no visible operational benefits to senior management because the system has only replaced an existing system. A large part of the existing GIS implementation research concludes by identifying this fact without any real practical definition of the options detailed in this thesis for quick delivery of visible business benefits.

7.5.5 VIEWING OF CORPORATE DATA

IMPLEMENTATION CONSIDERATIONS

Measurement of Current Status.

In order to measure the current status of data integration within a business unit, it is necessary to draw the corporate information diagram for that business unit. The typical setup is as follows:



The arrows indicate the flow of information.

Figure 7.4 Template for specifying corporate data viewing requirements.

The determination of future requirements is simply the completion of the above diagram for each business unit, covering all data interfacing connections and technically specifying how they will work.

IT CONSIDERATIONS

This functionality requires systems that have common communication protocols, for example, Windows Dynamic Data Exchange (DDE). It also assumes a networked environment.

DATA CONSIDERATIONS

The requirements are the screen navigation tools and base mapping from the map view component, and a base set of corporate polygons to be specified in the data component of the infrastructure.

TIMING DEPENDENCIES

This should be the first functionality implemented along with the map view. The highest priority and largest task of the implementation will be to make the core set of corporate polygons.

DIFFUSION IMPACTS

All five characteristics of an innovation will again have a major impact on the rate of adoption. As well as the generic impacts, the following considerations apply:

Relative Advantage

This innovation is capable of substantially improving the current work flow, partially due to the fact that a good GIS user interface will be easier to use than the normal corporate ones. This functionality commonly is used for non-spatial queries. Again speed is essential, but achievable with the correct setup. Powerful databases such as Oracle are proving to be slower in practice than the previous systems.

Compatibility

This functionality will not be possible unless the systems are compatible.

Complexity

It is common to find staff using this functionality because they find the corporate systems too complex.

Divisibility

A user should be able to try this functionality by itself without having to do any setup if they do not wish to. Queries should be preset for the relevant business unit and data.

7.5.6 *ACCESS TO CORPORATE SYSTEMS (INTEGRATION)*

IMPLEMENTATION CONSIDERATIONS

Measurement of Current Status.

The diagram required to specify this functionality is similar to the previous one as follows:

The integration links are shown ⟺

Desktop Applications (All Desktops)

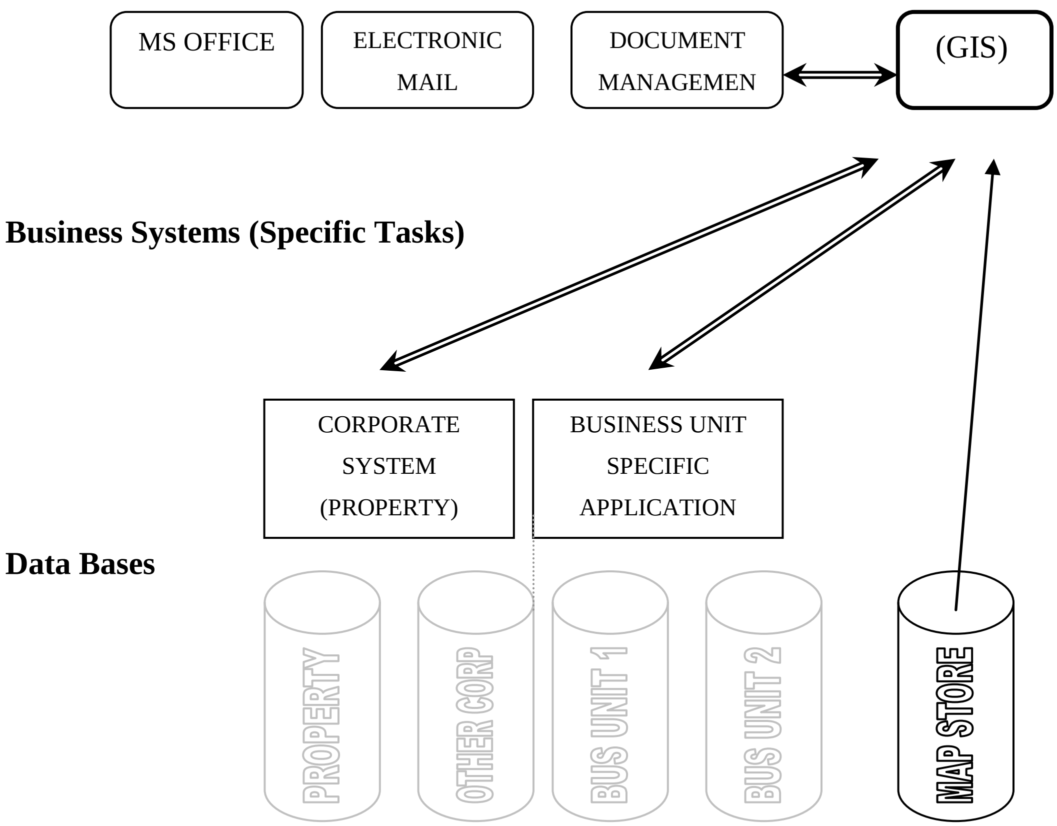


Figure 7.5 Template for specifying requirements for GIS access to corporate systems.

Again, the future requirements are the completion of the above diagram and the specification of how the integration will work.

IT CONSIDERATIONS

This functionality requires systems that have common communication protocols, for example, Windows Dynamic Data Exchange (DDE). It also assumes a networked environment. Achieving this functionality will be more costly and time consuming than interfacing. Choice of GIS software will be impacted heavily by the availability of existing integration software.

DATA CONSIDERATIONS

The requirements are identical to those of interfacing.

TIMING DEPENDENCIES

This functionality would not initially be rolled out unless the integration between the chosen GIS and the other applications is already done. Otherwise it can wait for up to several years, as the map view and the interfacing view will give the GIS enough momentum to survive.

DIFFUSION IMPACTS

Delivery of this must again meet all of the previously described Rogers' criteria. This level of integration completes the merging of GIS with IS and will speed up the diffusion process considerably.

7.6 INFRASTRUCTURE GIS AND DIFFUSION IMPACTS

The five components of Infrastructure GIS have specific diffusion considerations for implementation. The emphasis in this section is on standards, and in particular people and organisational issues. The components of IT and data have been indirectly covered while specifying business process performance and content, and are the two components that current practice and theory has documented well.

7.6.1 Data

DIFFUSION IMPACTS

People do not naturally have a mapping culture. We are taught to read and write at school, but are only taught to read a map if it is a core part of our profession. A GIS implementation will deliver mapping to people who turn the road map around every time they go around a corner. The screen must at all times have features visible that the average person can identify with, as discussed previously.

As discussed in the previous section, the data structure must reflect the characteristics of the data being mapped, and thus the business processes being undertaken outside the GIS. Again, fit with current culture and practices is an important diffusion principal.

7.6.2 Information Technology

DIFFUSION IMPACTS

Treating GIS as simply another IT implementation usually fails. There are two main differences between GIS and IT, the unique characteristics of a mapping culture and the digital structure of map data.

Quick delivery of a map to a GIS screen, and of text to a spreadsheet, are two different concepts. IT principles usually do not achieve the speed necessary to regenerate the screen within five seconds at any zoom, and a slow screen regeneration time will be fatal to an implementation. Specific research is required to deliver GIS data to a user in acceptable times as discussed elsewhere.

7.6.3 Standards

IMPLEMENTATION CONSIDERATIONS

The initial system can be implemented with a set of standards provided by a consultant, and the proper organisational standards can be put in place after implementation.

DIFFUSION IMPACTS

By not waiting for proper standards to be developed, the implementation will achieve the core diffusion aim of early delivery of tangible results. Practical experience has shown that standards can be finished many months after the initial Stage 2 implementation.

7.6.4 People with Expertise

IMPLEMENTATION CONSIDERATIONS

The current GIS staff and users have to be fitted against this model in the previous chapter for practical skills and the roles discussed in the diffusion considerations.

All of the roles described in the initial description of the people component have to be filled for the effective implementation of GIS if there are to be more than sixty users. The minimum is all of the external support sources, assuming the consultant is a suitable change agent, at least one GIS officer, one key user per business unit (may be part-time), and the users. The question is, can one person do all of the tasks on a small site? Diffusion theory tells us that an external change agent is essential; after that the personality of the GIS officer becomes critical if they are to hold the key user role as well.

Diffusion theory states that you will never get all people in a social system (business unit) to adopt an innovation in the initial stages. Laggards, by definition, may take years to change their ways. Effective transfer of GIS knowledge through an organisation will take years to complete; the core implementation task is to set up the processes to allow this to occur.

TIMING DEPENDENCIES

Ideally GIS should be implemented in a business unit in the following order:

1. Install a preliminary GIS environment with the key user.
2. Give the key user several days training and editing rights to the environment.

3. With the GIS officer spend up to six months fine-tuning the environment so that it precisely meets the needs of the business unit.
4. Implement this environment with the rest of the staff in the business unit.

As an option, implement a safe generic environment with the rest of the staff at the same time as the key user is initially trained.

Continue to have the key user one generation ahead of the rest of the users, to allow a slow transfer of ownership to the business unit as the implementation enters Stage 3. Business units are encouraged to drive the development of their own GIS modules by encouraging experimentation and feedback. Allow different business units to enter Stage 3 at different times.
This system will drive most of the scheduling considerations for implementation.

DIFFUSION IMPACTS

This people model comes straight from diffusion theory, where the external consultant is the change agent and the key user is the early adopter and opinion leader. It is designed to overcome the following diffusion problems:

- 84% of the GIS users in a Business Unit (social system) are early majority, late majority or laggards. They will usually only change their ways if the lead comes from within the social system, which is the role of the key user.
- The key user must have the early adopter characteristics as defined in Section 2.2.3. This is a critical role in the innovation diffusion process, and the wrong key user will cause the implementation to fail within that business unit. A very good GIS officer may also be capable of filling the early adopter role from outside the Business Unit if they are from a Local Government background. They must also have early adopter characteristics and be known to the other members of the Business Unit.
- The key user has the role of making sure that the GIS innovation is relevant to the business unit. This person will have enough knowledge of both GIS and the business unit to make sure that what is implemented has the five characteristics identified by Rogers as having a major impact on the diffusion process. *The five characteristics of*

innovations utilised are: (1) relative advantage, (2) compatibility, (3) complexity, (4) divisibility, (5) communicability. (Rogers, 1962)

- The external consultant must perform the role of the change agent. If a project manager does not have change agent characteristics then a separate change agent will be necessary. Implementation will probably fail without an effective change agent, and the GIS officer cannot be the change agent. The role of the change agent is clearly defined as part of the user needs requirements in Section 7.3.2.
- The change agent must identify and utilise the informal social system to enhance the diffusion process through the organisation as a whole as well as through individual Business Units.

7.6.5 Organisational Setting

IMPLEMENTATION CONSIDERATIONS

One of the interesting questions will be, where is the committee? If it does not already exist then how has the organisation made the decision to adopt, and if this is not readily evident then is an organisational implementation really occurring? The one change that can be made to the diagram is that the CEO can be replaced by a second level manager, and the committee can be made up of third level managers. The committee must be representative of the whole organisation.

The roles and responsibilities have to be clearly set up, particularly for the committee. Considerations like budget procedures and resource allocation of the GIS section will be important ongoing considerations.

A structure suitable for the future needs to be set up, preferably along the lines shown in Figure 6.5. This component must however be flexible enough to cater for the subtle variations in each organisation.

The Relationship With IS

If GIS is part of IS then the IS strategy should include GIS at a high level. If the IS consultant does not understand GIS, then GIS will not be in the IS plan. GIS may cause a rewrite of the IS strategy in the long term, but in the short term it should only educate both the IS consultant and the organisation by being implemented in parallel with the IS strategy.

TIMING DEPENDENCIES

The organisational structure must be in place as the first users are implemented. Depending on the history the users may wish a far greater say along the way as well.

DIFFUSION IMPACTS

The committee will perform the organisational innovation process as defined by Rogers, and described in section 2.5.3. The three-step implementation process developed by Chan and Williamson and being used in this thesis also fits into this process identified by Rogers. The committee was probably responsible for making the organisational decision to adopt, which is the end of Rogers' Stage 2 (matching). The remaining steps the committee has to control are:

Redefining/Restructuring (Implementation)

This equates to Stages 2 and 3 of the implementation where the GIS (innovation) is restructured until it fits the organisation. This takes a substantial amount of time, and cannot be accelerated or pre-empted by any clinical IS based process during initial implementation. It must also be performed by the organisation and cannot be conducted by an external consultant. This is a higher-level repeat of the role of the key user in fitting the innovation with the business process.

Clarifying

This is the stage where the use of the innovation is becoming widespread and the users are starting to confirm with each other that the innovation fits the organisation. This is part of Stage 3 of the implementation where the official implementation has finished and the organisation has taken ownership.

Routinising

This is where all components of GIS are an accepted part of the workflow in all relevant Business Units. This may take five to seven years from the decision by the organisation to adopt. At this point the committee may no longer be needed and GIS will be as familiar as word processing.

Rogers also identifies the need for an innovation champion at the organisational level. Possibly this could be a small group within the organisation.

7.7 SUMMARY

This chapter is based on the assumption that a Phase 2 implementation of a corporate GIS in Local Government consists of writing an implementation strategy and then following the strategy. The previous chapter provided the structure for the strategy and this chapter provided some of the diffusion considerations required for GIS implementation to be successful.

As a standard, GIS implementation strategy will aggregate the correlating components from Chapters 6 and 7 for the productional perspective of GIS. This chapter will form part of the framework for the actual implementation. The framework described includes a report that should scope the implementation to the end of Stage 2, and does not have long-term detail. During Stage 3 the GIS infrastructure will automatically generate ongoing direction at the appropriate time, and therefore does not need to be described in this thesis. This process has been tested by the author, and has become a standard implementation procedure. Appendix A is a detailed example of how this works.

From the content of this chapter there is no doubt that diffusion has a major influence on all aspects of a GIS implementation process.

8 CONCLUSION AND RECOMMENDATIONS

Previous research into diffusion into Local Government has been more a case of measuring current GIS penetration after implementation has occurred, not predicting what will happen and how to cater for it.

The thesis looks at the process of adoption from the decision to adopt GIS technology on a corporate basis to the point where the implementation has delivered effective use. The emphasis is thus on the processes that occur over time within an organisation, not the comparative adoption between organisations at a point in time, or the typical profile of an organisation that would adopt GIS.

8.1 SUMMARY OF THE GIS IMPLEMENTATION FRAMEWORK

There are two clear new areas of research in this thesis, the development of a new framework for the definition of GIS within the Local Government environment, and the application of this framework including diffusion. The new work is a combination of Chapters 2 to 5 and ten years of consulting experience undertaking Local Government GIS implementations. This new framework for the definition and implementation of GIS is summarised in the next two sections:

8.1.1 *The Definition of GIS in Local Government*

In order to define how to effectively implement GIS it has been necessary firstly to redefine GIS itself, particularly the aspect of corporate systems integration, which is not discussed in the current theory. A detailed framework within which GIS can be clearly quantified has been built from the productional perspective as developed by Chan and Williamson (1995), and summarised in the following diagram.

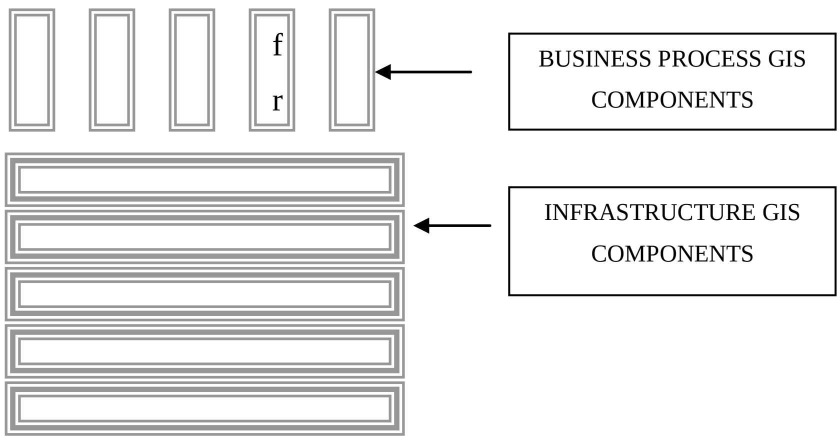


Figure 8.1 Productional perspective summary diagram.
This diagram is produced in Detail in Figure 6.6.

While the Infrastructure GIS components are well documented, particularly from a State Government perspective, the Business Process GIS components have been developed for Local Government as part of this thesis. Associated with diffusion theory is the need to define an innovation in terms of the problems it will solve. This caused the need to move the current definitions of GIS from technical and functional perspectives to a set of new definitions within the productional perspective described above. Many of the current GIS implementation problems in Local Government come from a lack of a structured framework within which to define GIS, and this structured framework constitutes a major part of the new work in Chapter 6.

8.1.2 THE IMPLEMENTATION OF GIS IN LOCAL GOVERNMENT

Chapter 7 does not give a precise set of technical steps for implementing GIS, but rather a high level process for delivering GIS as defined by applying the framework developed in Chapter 6. In simple form, the process is to apply the framework to define GIS for the Local Government, undertake "gap analysis" to determine the current status, and define the necessary steps to complete the implementation.

A CONTROLLED OPPORTUNISTIC APPROACH

The only effective way to implement GIS is a controlled opportunistic approach as suggested by Chan and Williamson (1999a). This has been put into practice by the author at the City of Port Phillip and several other sites. A GIS implementation project as detailed in Chapter 7 can only be Stage 2 of the whole process.

This approach has three stages, which are summarised in the following diagram, (Fitzgerald, Dooley and Chan, 1999)

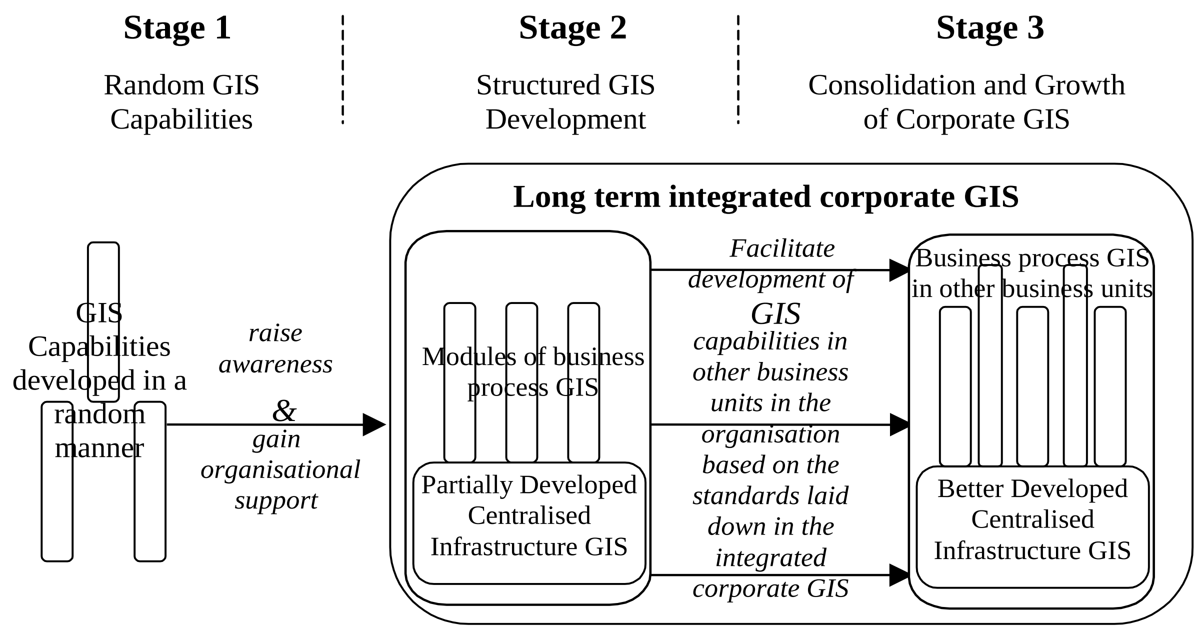


Figure 8.2 A 3-stage approach to GIS development. (Fitzgerald et al, 1999)

Stage one will occur naturally, and is part of the organisational diffusion process Most Local Governments are at least somewhere in Stage 1. Stage 3 also occurs naturally from the Infrastructure GIS setup in Stage 2. Thus this thesis concentrates on Stage 2, which is the move to a true corporate GIS.

GIS IMPLEMENTATION STEPS

The implementation of GIS will fit within the following generic questions:

1. Where are you now?
2. Where do you wish to go?
3. How do you get there?

Most of the current implementation theory from both GIS and IS is based on these questions, except stated in a more complicated way. These steps convert to GIS implementation in Local Government as follows:

1. Measure the current status.
2. Determine the required GIS business process outcomes.
3. Determine the required GIS infrastructure to deliver the business process outcomes.
4. Implement the requirements determined in 1 to 3.

Steps 1 to 3 are determined through a user needs analysis and report, which then becomes the implementation plan. Chapter 7 describes a structure for the non-technical contents of a report, with emphasis on the diffusion impacts.

8.2 DIFFUSION DYNAMICS

The thesis has documented a substantial number of critical diffusion dynamics that are occurring during a GIS implementation in Local Government. If the implementation allows for these dynamics then it will be successful. If the implementation ignores them then they will either work against or stop an effective implementation. This has also been the practical experience of the author in about thirty Local Government GIS implementations. The main ones are summarised here:

COMMUNICATION CHANNELS

Diffusion theory discusses effective communication channels extensively, and it is necessary to put almost all of the theory in Chapter 2 in place for an effective implementation. This means that the same person who manages the project on a day-to-day basis must do the user needs analysis and must communicate with the end users of the GIS during Stage 2 of the implementation. The core characteristics of this person are that they must:

- be external to the organisation to be an effective change agent;
- have a high level of *Homophily* with the end users*;*
- have a reasonable level of technical competence; and
- be able to identify and manage the internal communication channels, including the opinion leaders.

These characteristics are directly from diffusion theory.

The following diagram applies to all local government GIS implementations.

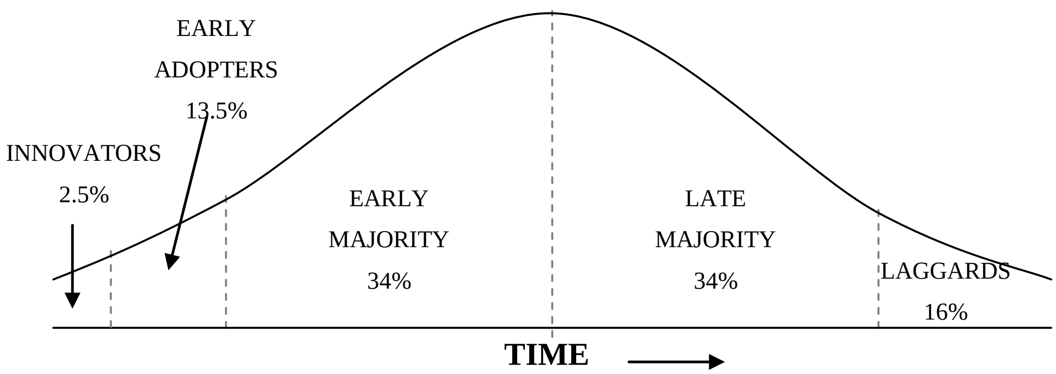


Figure 8.3 The categorisation of adopters over time. (Adapted from Rogers (1995, p262))

The project manager must grade all business units by these categories and accept that the the following diffusion dynamics will occur:

- 50% of staff members will not immediately use the technology.
- The project manager must identify and work closely with the early adopters, whilst not confusing them with the innovators.
- Full implementation and effective use will continue for several years before laggards use GIS. This will be well into Stage 3 and past the official implementation (Stage 2).

SOCIALISATION OF THE TECHNOLOGY

Both IS and diffusion theory give clear guidelines for the socialisation of the technology, and state the importance of deliberately undertaking this task. Technical design and capacity of GIS software now far exceeds the requirements of a Local Government at an affordable price. It is arguable that the only software selection criteria should be proof that the software works on another comparable site, and has a high utilisation rate. This means that it has been sufficiently socialised on that site.

SCOPE OF IMPLEMENTATION

As described in the thesis, there are many situations where identical software is successful in one Local Government and not in another. Software must be useable, and the recommended test of this is by demonstration on comparable sites. Map data needs to be accurate but GIS can be successfully implemented with aerial photos, corporate polygons and some descriptive text only. The scope of GIS implementation must extend to people, standards and the organisational dynamics. These are the components where most of the diffusion forces operate. This thesis concentrated on defining and detailing these components.

8.3 FURTHER RESEARCH

There are many areas discussed in this thesis that did not receive the focus they deserved. The main ones are discussed below.

THE GIS DATABASE

The clarification of the relationship between GIS and databases requires further research. Does a GIS need a database? Precisely what is the current research referring to when it uses this term? The business process perspectives developed in this thesis that relate to databases, integration and interfacing have not been done justice, and have partially been developed from the experience of the author. This area is worthy of further investigation.

SOCIALISATION OF THE TECHNOLOGY

The issue of how best to optimise the technical aspects of GIS to fit the social setting has been briefly described in relation to several components, but requires more research. Issues like screen colours and intuitive screen navigation have been discussed mainly from the experience of the author, and are worthy of more rigorous research. This should extend to examining the graphical user interface, with particular emphasis on issues such as button symbols. While these concepts fit into diffusion theory, they also move into the larger area of software design. These issues have not been researched comprehensively from a GIS perspective.

CORE MAP STRUCTURE

There is extensive research required to determine the core mapping requirements of a Local Government. The required characteristics of GIS base mapping are determined by the business rules of the corporate data being mapped. What is the relationship between these and the data being provided by State Governments, and how are the two best merged and derived from each other? The opinion of the author is that many GIS implementations fail because GIS is implemented with State Government data that is incompatible with the Local Government business processes.

RELATIONSHIPS WITH IS

The issue of the relationship between IS and GIS within a Local Government organisation is highlighted when both strategies are being prepared, often at the same time. In reality GIS is a subset of an IS report, and IT is a subset of a GIS report. Whose strategy should include what components? Should either committee answer to each other? Is one a subset of the other, or does GIS have a clearly complimentary role to IT? An associated question is, should GIS include the role of data co-ordination and quality checking, regardless of whether the data will be displayed on the GIS? The experience of the author is that compatible skill sets make this a logical progression within Local Government. Does GIS manage data and IS manage technology?

RELATIONSHIPS BETWEEN DIFFUSION DYNAMICS

There are several sets of diffusion forces that operate on a person when deciding to adopt GIS. The two main ones are the organisational diffusion forces and the individual innovation decision process. The third process is the definition of and development of the GIS innovation itself. While the thesis has attempted to allow for all of these occurring during an implementation, precisely how they affect and interact with each other is not documented or researched at all, even by Rogers.

CYCLICAL REINVENTION

Because the critical component of an innovation is the "relative advantage" aspect, the definition of the GIS innovation may occur several times within Local Government. GIS must be continually reinvented by starting with the definition of the target social system to which the innovation will give relative advantage. This cyclical reinvention of GIS is an important part of the implementation process that has not been investigated fully in this thesis.

8.4 CONCLUSION

The main conclusion of the thesis is that diffusion forces have a major effect on GIS implementation in Local Government. This fully supports the hypothesis, *"That in order for a Local Government GIS implementation to be successful, it is necessary to develop an implementation process that allows for the influence of diffusion."*

The thesis has clearly identified and quantified some of these influences. Since diffusion forces work on the innovation characteristics of GIS, it has been necessary to redefine GIS from a productional perspective. This is the perspective which defines GIS as an innovation, and thus introduces the diffusion forces. This allows the diffusion effects to be put into the implementation process, which is the main outcome of this thesis.

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Appendix A