The Dynamics of Diffusion of Corporate GIS

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Abstract

The hypothesis of this research is 'Diffusion of GIS in an organisation is affected by the qualities of GIS as seen in the context of the structure of the organisation'. A review of the GIS diffusion literature establishes the theoretical background of the research. It is argued that the qualities of a corporate GIS reflect the GIS qualities mentioned in the hypothesis. These qualities are identified and applied to Rogers' model of *organisational innovation process* to give a model of diffusion of a corporate GIS, which serves as a working model for the hypothesis. The model describes how the qualities of a corporate GIS can affect GIS diffusion, and predict four sets of relationships as follows.

- A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with *an infrastructure GIS* supporting the development of one or more *business process GIS*.
- Diffusion of a corporate GIS takes place in the *dispersed* scenario.
- Diffusion takes place when the purposes served by a module are focused and well defined.
- Reinvention of a corporate GIS can be monitored by the outcome of diffusion of the modules of GIS in the *focused* scenario.

These relationships are confirmed by the outcomes of a survey of the State Government of Victoria and a subsequent case study that involves the Department of Natural Resource and Environment of the government. As a result, the hypothesis is validated.

The case study also reveals that modules of infrastructure and business process GIS can be created in three sequences. A corporate GIS can be developed through any combination of the three sequences over time. However, it is the linkages (or cooperation) developed between the GIS modules that make a corporate GIS an integral entity.

Together, the outcomes of the case study have two significant implications for GIS management. Firstly, initial development of a jurisdictional Spatial Data Infrastructure can be achieved effectively and efficiently through automating the jurisdictional mapping function with GIS. Afterward the updating and upgrading of the Infrastructure are best achieved through arrangements established to use data collected directly by other business functions.

Secondly, a single GIS that serves all business functions of an organisation is neither practical nor sustainable in the long term. In order to maximise the benefits from GIS investments, GIS diffusion in an organisation must be maximised. This requires a new breed of GIS/information managers. These managers do not develop GIS modules directly. Instead, they are coordinators who have access to resources and expertise to encourage and support the development of GIS modules by managers of the business functions in the organisation. More importantly, they encourage these business managers to cooperate and share GIS capabilities with one another to develop an integrated corporate GIS to minimise cost. To function properly, these managers need to know the state of development of GIS in the organisation. The *reach-range-routine* framework developed for the survey in the research is a tool for such a purpose.

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 less than 100,000 words in length, exclusive of tables, maps, bibliographies, appendices and footnotes.*

(Tai On Chan)

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Acronyms and Abbreviations

Acronyms	Full Terms
ASDI	Australian Spatial Data Infrastructure
AUSLIG	Australian Land information Group
Business process module/s	Module/s of business process GIS
CAD	Computer-aid-design
CLA	Crown Land and Assets
CLMB	Catchment and Land Management Branch
CLPR	Centre for Land Protection Research
CSMA	(Division of)Catchment Management and Sustainable Agriculture
DAEM	Department of Agriculture, Energy and Minerals
DCDB	Digital cadastral databases
DCFL	Department of Conservation, Forests, and Lands
DCNR	Department of Conservation and Natural Resources
DNRE	Department of Natural Resource and Environment
DTDB	Digital topographic databases
ESU	Environment Science Unit
FI	Forest Information (Section)
FPA	Forest Planning and Assessment (Section)
FRI	Forest Resource Inventory (Section)
GDV	Geographic Data Victoria
GEDIS	Geological Exploration Development Information System
GIS	Geographic Information System/s
GISci	Geographic Information Science
GPAC	Geospatial Policy and Coordination
Infrastructure module/s	Module/s of infrastructure GIS
IRIS	Industry and Resources Information Service
IT	Information technology
LIMS	Land Information Management System
LIS	Land information system
LMRI	(Division of) Land Management and Resource Information
LTO	Land Titles Office
MAFRI	Marine and Freshwater Resources Institute
MWC	Melbourne Water Corporation
NRGISCC	Natural Resource GIS Coordinating Committee
NRS	Natural Resource Systems
NSDI	National Spatial Data Infrastructure
OGDC	Office of Geographic Data Co-ordination
OLRIM	Office of Land Resource Information Management
Organisational GIS process	Organisational innovation process of GIS
OSG	Office of the Surveyor General
OVG	Office of Valuer General
PC	Personal computer/s

PFF	(Division of) Parks, Flora and Fauna
PRIMS	Parks and Reserves Information Management System
SAB	Sustainable Agriculture Branch
SDC	State Data Centre
SDMB	State digital map base
SDRN	State digital road network
The head of IT	The head of the Biometry and Computing Division
The Shepparton Plan	The Shepparton Irrigation Region Land and Water Salinity Management Plan
UK	United Kingdom
URSA-NET	Urban and Regional Spatial Analysis Network for Education and Training
USA	United States of America
VFRI	Victorian Fisheries Research Institute

Chapter 1
Introduction

1.1 Background

Geographic Information System (GIS) is ‘a system for capturing, storing, checking, integrating, manipulating, analysing and displaying data which are spatially referenced to the Earth. This is normally considered to involve a spatially referenced computer *database* and appropriate applications software’ (Department of the Environment 1987, p. 132). GIS is also a multi-million dollar industry. Payne, as cited in Craglia and Masser (1996), estimates the European GIS market in 1993 to be worth around 4 billion ECU. Governments in the European Union and federal agencies in the USA spend billions of dollars each year on geographic information and on collecting and managing domestic geospatial data (Craglia and Masser 1996). In Australia, Price Waterhouse (1995) reports a benefit to cost ratio of four for data usage and a benefit in the order of A$4.5 billion during the period 1989-94. Tomlinson Associates Ltd. (1991, p. 3) also reports that ‘Current expectations of benefit-cost in well planned and well implemented systems are 2.5:1 fully discounted over ten years’. With the billions invested in geographic data and information and their management, governments all over the world stand to gain many billions in return, provided that the systems involved are well planned and implemented.

Generally, Campbell and Masser (1995, p. 4) see diffusion as ‘the fundamental process that is responsible for the transfer of innovation from the workshops of their inventors to becoming a daily part of the lives of a large section of society’. GIS, as a computerised system that manages geographic/spatial data, is still a technological innovation in many government departments and agencies. Unless the technology is adopted and properly implemented, and utilised, the billions of dollars of benefits promised will never be realised. This is why Craglia and Masser (1996, p. 1) stress that ‘it is necessary to study the diffusion of this technology and its impacts on society as a whole’. Underpinning the statement is a research agenda developed by a group of international experts for diffusion and use of geographic information technologies (Masser and Onsrud 1993b).

In Australia, the development of GIS/LIS in the State of Victoria illustrates the range of problems of diffusion and use of geographic information technology a government can face. In Victoria the value of and the need for an integrated GIS/LIS was recognised as early as mid-1970s. However, it was only until 1991 when the State Government of

Victoria recognised the importance of a rigorous government wide GIS strategy and commissioned a group of international consultants to undertake a comprehensive GIS planning study. Williamson (1992) and Chan and Williamson (1995c) document much of the background that led to this study.

The study took 18 months to complete. The consultants recommended an investment of A$56 million over a period of six years to develop 270 datasets which would generate 61 information products for use by 39 state agencies. In return, the consultant predicted a fully discounted benefit of up to A$312 million (Tomlinson Associates Ltd. 1993c), albeit the returns were subject to achieving many technical, institutional and administrative reforms (Chan and Williamson 1995b). The government accepted the findings of the consultants, and a new office, which was created to manage the study, was put in charge of formulating and implementing the State's detailed GIS strategy.

Since the study, the State government recognised that there was a need to examine the technical and institutional issues of developing a government-wide GIS. An agreement was made that the Department of Geomatics (formerly Surveying and Land Information) at the University of Melbourne and the State government would cooperate to research into issues concerning GIS implementation, including GIS diffusion. With the agreement, state officials were willing to spend time with the researcher to discuss the history and issues of the development of GIS in the government. This allowed the researcher to identify the key research questions and to obtain feedback on various ideas developed to address the questions.

1.2 Research Questions and the Hypothesis

Based on the experience of GIS development in the State Government of Victoria, the extent of adoption and utilisation technology is still growing. Significant achievements have been made. However, the achievements come only after significant effort and struggle by the managers involved in the development process. Many of these managers did not stay long enough to reap the fruit of success. GIS diffusion in the State Government of Victoria does progress but only very slowly. The path of diffusion is long and winding, and strewn with problems and uncertainties. These observations lead to two broad questions:

- How does GIS diffusion take place in an organisation?
- Why does GIS diffusion progress in the way observed?

These two questions are not new and can be examined from different points of views. One line of research focuses on the nature of GIS diffusion. Rogers (1983, p. 5) defines diffusion as ‘the process by which an innovation is communicated through certain channels over time among the members of a social system’. Based on this conceptualisation, Campbell and Masser (1995, p. 5) see that ‘the speed and extent of the diffusion of an innovation is linked to social and political processes rather than simply the inherent technical worth of the product’. Campbell (1996a) also establishes the social interactionist nature of the process for GIS, arguing that neither useful technology nor rational management strategy can guarantee successful GIS diffusion.

Campbell takes an interactionist approach to studying diffusion and concentrates on the perceptions and behaviours of individuals in the organisation. A similar approach is adopted by Budic (1993). However, Campbell (1996b) recognises that among other things, diffusion of GIS is affected by the nature of GIS, the structure of an organisation, and the interplay of the two. She notes that ‘the precise nature of the relationship between technology and the multi-levelled contexts in which it is located is unclear’ and identifies the need for ‘An analysis of perspectives on the nature of GIS technology with particular emphasis on the extent to which each organization reinvents a particular form of technology’ (Campbell 1996b, p. 40).

Campbell’s comments provide a focus for the research, and highlight the need for a better understanding of the nature of GIS in the study of diffusion and use of GIS. The focus is summarised in the following hypothesis of the research:

> *Diffusion of GIS in an organisation is affected by the qualities of GIS as seen in the context of the structure of the organisation.*

1.3 The Objectives

Having defined the research questions and hypothesis, three main objectives of research are identified:

1. To understand the elements of GIS diffusion.
2. To identify and test the qualities of GIS that can improve the understanding of GIS diffusion.
3. To develop principles to support better GIS management.

1.4 The Scope

The scope of the research is defined by several factors. The word ‘corporate’ can mean a wide range of organisations. In this thesis, ‘corporate’ refers to a multi-divisional organisation that has a staff of 1000 or more, and has tens and hundreds of regional offices that scatter across a state or country. GIS refers to different things to different people. The subject being studied in the research is GIS in an organisation (or corporate/organisation wide GIS), which generally refers to the collection of GIS and related capabilities and arrangements in the organisation. Only permanent organisational GIS is dealt with here, not transient project-based GIS.

There are many approaches to studying diffusion (see chapter 3). This research adopts the ‘process’ approach, in which diffusion is viewed as a set of sequential stages of events that take place in an organisation. The emphasis is on how GIS, with its qualities as seen in the context of the organisation, affects the diffusion process. The details of how and why an individual user adopts and reinvents GIS will not be studied.

1.5 Summary of the Research Methodology

Over the period of the research, a number of activities have been undertaken to meet the objectives listed in section 1.3. These activities can broadly be grouped into five main areas: literature review, exposure to GIS implementation and diffusion activities and research world wide, model generation, model validation, and data analysis. The relationships between the research activities and research objectives identified are shown in table 1.1.

Table 1.1 Relationships between research activities and objectives.

Objectives	Research Activities
1. to understand the elements in the process of diffusion	literature review and exposure to GIS implementation and diffusion activities
2. to develop/test a model	model generation, validation and data analysis
3. to develop management principles	data analysis

1.5.1 Literature Review

To establish the theoretical background for the hypothesis, a literature review was conducted. Based on the scope of the hypothesis and the disciplines identified by Masser and Onsrud (1993a), the review covered literature from a number of disciplines. They include GIS and diffusion, innovation diffusion, information technology and information systems management, sociology, psychology, organisation theory, and public administration.

1.5.2 Exposure to GIS Implementation and Diffusion World Wide

While literature review is important, it is no substitute for discussions with managers and researchers to understand what the current issues are and how the issues are being tackled elsewhere. It is also important to gain critical first hand feedback from leaders and peers around the world about concepts that the author is developing.

To gain the exposure, the author attended a total of eight conferences and met with a wide range of researchers and managers to discuss various aspects of diffusion. Appendix 1 lists the conferences attended and the experts met. In particular, a study trip was organised to allow the author to spend one week each at the Department of Town and Regional Planning, University of Sheffield, UK and at the National Center for Geographic Information and Analysis, Department of Surveying Engineering, University of Maine, USA. The purpose was to widen the author's perspective on GIS diffusion. Some of the people met, such as Professor Ian Masser and Professor Harlan Onsrud, are world leaders in GIS diffusion research. Discussions with these people help the understanding of current issues of GIS diffusion and state-of-the-art position of the research worldwide.

1.5.3 Model Generation

Once the theoretical background pertinent to the research is established, the key elements of GIS diffusion and their relationships are identified. In particular, the role played by GIS in the diffusion process is elucidated. By this time, the first objective is met.

After reviewing the current definitions of GIS, new qualities of a GIS in an organisation, that is a corporate GIS, is described. Based on these new qualities, a model for the diffusion of a corporate GIS is developed. The model is refined continuously as the author's exposure to GIS diffusion widens.

1.5.4 Model Validation

In the past, government organisations often led the adoption and development of GIS in a country. These organisations have long been the targets of diffusion studies worldwide. In Australia, the state governments play an important and direct role in the overall livelihood of the Australian people. They are also an untapped source of insight into GIS diffusion. The State government of Victoria, with its well-documented history of GIS development and its support of research in GIS, is a desirable candidate for GIS diffusion study.

In the research, the states of development of GIS in the eight State departments in Victoria were assessed through a questionnaire survey. The context and the reasons for the state of development in each department were determined by a follow-up semi-structured interview. This pieced together the extent of diffusion of GIS in the State government as a whole and provided a first level of data to match against the model of diffusion of a corporate GIS. Based on the states of development of GIS in the eight departments, the department with the most advanced GIS was chosen for a more in-depth case study, from which patterns of GIS diffusion were identified for the ultimate validation of the model.

1.5.5 Data Analysis

The data collected are essentially a series of events that have contributed to the development of GIS in various organisational units in the department studied. The main data analysis techniques are to arrange the events of GIS development in a chronological order, to derive the actual patterns of GIS diffusion, and to match the patterns with those predicted by the model. If the patterns match with one another, the model is validated. As a result, the second objective of the thesis is also fulfilled. A minor job of data analysis concerns the questionnaire survey. It is expected that simple arithmetic manipulations of the data are sufficient. No statistical analysis is required.

Once the model of diffusion of a corporate GIS is validated, the implications of outcome of the case study on GIS management are also discussed, fulfilling the third and final objective of this thesis.

1.6 Assumptions Made

The strategy used to achieve the objectives as described above is devised based on the following assumptions.

- Among a group of organisations, the one with the best-developed GIS is more likely to provide useful data for the GIS diffusion research in this project. In general, a department in an advanced state of GIS development tends to have longer and more diverse experience in GIS diffusion. A case study of such a department is likely to uncover a wider range of patterns of GIS diffusion for model testing purpose.
- The respondents can recall the key events that contribute to the diffusion of GIS. This is made feasible by the case study methodology adopted to collect data from different sources, and to interview a number of people who are known to be involved in the development of a particular group of GIS capabilities. By prompting

or challenging respondents with information collected elsewhere, the respondents are helped to recall the key events in better perspective.

- All managers work in their own ways towards the overall good of the organisation and its units.
- All decisions by managers regarding GIS are rational.
- The outcomes of diffusion reflect the current needs of the organisational units.
- A dedicated GIS is one of many ways of meeting the program objectives of an organisational unit.
- The process of diffusion is an on-going process in the organisation studied.

1.7 Structure of the Thesis

This thesis is made up of three parts: 1) overview and context, 2) theoretical background and model development, and 3) model testing and conclusions. The first part comprises Chapters one and two. Chapter one gives an overview of the research and thesis while Chapter two sets the scene, providing the political and historical context of the State government of Victoria in which GIS diffusion progresses.

The second part is made up of Chapters three and four. Chapter three reviews the past research on GIS diffusion and identifies a focus for this research. Chapter four reviews past definitions of GIS, and identifies new qualities of GIS as seen in the context of the organisational structure, that is, qualities of a corporate GIS. Based on the new qualities, a model of the process of diffusion of a corporate GIS is developed.

The last part includes Chapters five to eight. Chapter five provides an account of the methodology used to collect data from the State Government of Victoria to test the model of diffusion of a corporate GIS. Chapter six reports the results of a GIS development profile survey conducted to select a department in the State Government of Victoria for a detailed case study. Chapter seven reports the outcomes of the case study and discusses how the model of diffusion of a corporate GIS is corroborated. The implications of the outcomes on GIS management are also discussed. Chapter eight is the concluding chapter with recommendations for future research.

1.8 Chapter Summary

This chapter begins by providing a background of the importance of GIS diffusion research. The research questions are then described, and the hypothesis of research is articulated as follows.

Diffusion of GIS in an organisation is affected by the qualities of GIS as seen in the context of the structure of the organisation.

Based on the hypothesis, the objectives of the thesis are identified:

1. To understand the elements of GIS diffusion.
2. To identify and test the qualities of GIS that can improve the understanding of GIS diffusion.
3. To develop principles to support better GIS management.

The scope of the research is also described. This is followed by a brief account of the research methodology, which comprises literature review, exposure to GIS implementation and diffusion activities, model generation, model validation, and data analysis. The assumptions made for the research are described. A section on the structure of the thesis sums up the chapter and provides pointers to the various chapters that follow.

Chapter 2

The State Government of Victoria in Australia

2.1 Overview

The study of diffusion of corporate GIS in this thesis is based on the experience of the State Government of Victoria. To set the scene for subsequent discussion, this chapter starts by providing some background information about the State Government of Victoria and the Australian system of government (unless stated otherwise, the materials are drawn from (Byrt and Crean 1982)). It then briefly describes the major events and factors that had shaped GIS diffusion in Victoria since early 1980s. It ends by highlighting the value of using the State Government of Victoria as the subject of study.

2.2 The Australian Government

2.2.1 The Australian system of government

The Australian system of government is federal, parliamentary and democratic. Figure 2.1 is a diagrammatic representation of the system. The Australian government is three-headed comprising the central government as Commonwealth or federal and the other two branches as state and local, respectively. Under a federal system, there is a formal division of powers between federal and state governments. The federal government has delegated some powers to the Northern Territory Administration and set up an elected advisory body in the Australian Capital Territory. The state governments delegate powers to local government bodies – city, shire and county councils. However, these powers may be increased, reduced or abolished at the discretion of the appropriate state government. The people are the source of power in both the Commonwealth and the states. They elect the parliaments and any elected bodies in the local government areas or territories. In both the Commonwealth and the states, government is carried out through an elected parliament. The Commonwealth parliament has two houses: the House of Representatives and the Senate. The lower and upper house in each state are normally designated the Legislative Assembly and the Legislative Council respectively.

An administration, the executive branch of government, is formed from the party or coalition of parties that have been elected into power. In the Commonwealth, the head of the ministry is the Prime Minister, and in a state, the premier. The King or Queen of Britain is the titular head of the government. He or she is represented by the governor general in the Commonwealth and by a governor in each state.

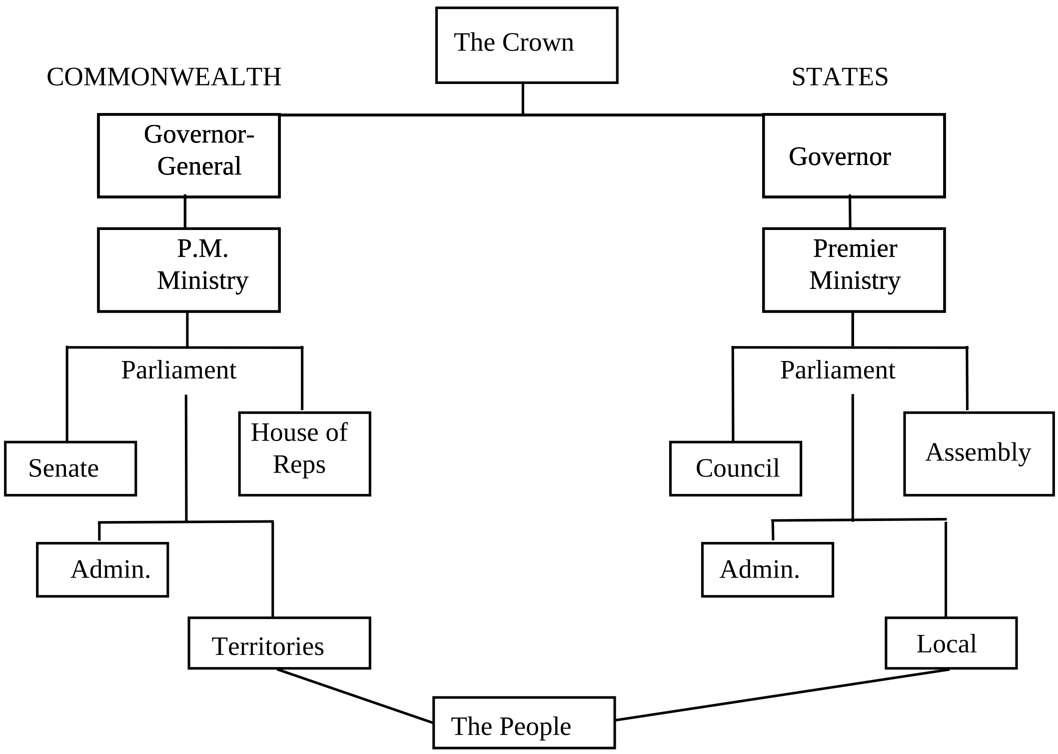


Figure 2.1 The Government of Australia (Byrt and Crean 1982, p.11)

2.2.2 The role of state governments

The Commonwealth Parliament is responsible for defence, external relations, the government of territories, and the control of migration, external trade and of trade between the states. The states are responsible for the making and administration of common law and statute law, both civil (commercial, industrial and social) and criminal. They also have direct responsibility for long-term economic development and conservation of natural resources. The states must initiate, plan and carry out most of the detailed programs for extending harbours and highways, encouraging industrial and mining development, building dams and controlling floods, providing water, power and light, conserving soil and forests. Apart from these, the states also have to shoulder some of the most expensive activities undertaken by governments, such as, education, public transport, social services, public health, law and order.

In contrast, local government in Australia is given the more trivial housekeeping tasks such as local roads, sanitation, garbage disposal, street lighting, building control, and protection of food supplies. Some may also look after items such as water supply and sewerage, gas and electricity supply, recreational, welfare and cultural activities. In any case, the local council is the creation of the state government, dependent for its power on state legislation and ordinances. The states direct and control local authorities in a fairly detailed way, usually through a department of local government.

In Australia, expenditures of federal, state and local authorities in the early 1970s were in the ratio of 48:44:8. The equivalent figures for America and Canada were 60:14:26 and 40:32:28 respectively (Spann 1979, p. 215-6). In 1993, the Australian ratio became 57:39:4 (Australian Bureau of Statistics 1993). These figures suggest that local government in Australia is much less powerful, politically and economically than its counterparts in North America. The above figures also suggest that the Commonwealth has a financial dominance over the other two areas of government. This comes as no surprise, as by the introduction of uniform income tax in 1942 the Commonwealth claimed the lion's share of all government revenues.

Despite this, in order to make up for shortfalls in certain strategic services such as health or education, the Commonwealth will have to work through the states, giving them incentives or the necessary financial means to provide the necessary services. In this way, the states come to rely on the Commonwealth for up to 60 per cent or more of their revenues (Spann 1979, p. 75-8). However, this just reinforces the states' importance as the key service provider to the people in Australia.

Further, because of the Commonwealth administration's responsibilities, it is regarded to be remote from the people, relatively abstract, and centralised in Canberra. On the other hand, the state and local governments are responsible for activities that more closely concern the daily lives of citizens and are thus more directly in touch with the economic and social activities of the community. With local government playing a subordinate role, state government in Australia generally has the most direct and immediate impact on the livelihood of the citizens.

Based on their different responsibilities, the Commonwealth and state governments are responsible for different components of the Australian Spatial Data Infrastructure (ASDI) that underpin the use of GIS in the nation. For example the Commonwealth government through its Commonwealth organisation Australian Land information Group (AUSLIG) is responsible for medium to small scale topographic mapping (scales 1:50,000 and smaller) and the national geodetic network (it shares some of these responsibilities with the Department of Defence). On the other hand, land administration, resources conservation and cadastral matters are a state responsibility. As such states are responsible for medium to large scale topographic and cadastral mapping (1:25,000 and larger) and any products derived from that (such as the road networks and the national census tract datasets) (ANZLIC 1996, Mooney and Grant 1997).

Small-scale topographic maps suit the needs of the Commonwealth and certain national private companies in terms of national and regional strategic planning and decision making. The majority of social and economic activities in Australia will rely on the larger scale mapping products—both paper-based and digital—managed by state governments. In digital form, the topographic, cadastral, road network and the digital planning zones and controls data are seen to be the more important (core) data sets managed by the states. There are many other datasets that the states manage that are needed by a wide spectrum of communities both locally and nationally (see appendix 2). Therefore, the success of diffusion of GIS in state governments not only affects government's performance in service delivery, but also underpins the availability of key datasets needed by many activities in Australia, both public and private.

2.3 State Government of Victoria

Australia began as a penal colony of Britain. The discovery of gold in Victoria shortly after 1851 provided the colony with money for investment. In ten years, gold transformed Victoria from a minor pastoral settlement to one of the most important entities in Australian politics and economic life (Byrt and Crean 1982, p. 4-5).

2.3.1 Political and economic context

Over the past 18 years, the Labour party that is socialistic in its ideals controlled the government in the first 13 years. In the period, the economic situation of the state and the financial position of the State Government were declining. By the latter half of the 1980s, and in line with the national trend of micro-economic reform (INDECS 1990, p. 276), the Victorian Labour government first introduced the concept of cost recovery into the government machinery. The coalition of the Liberal and National party that hold a more conservative and capitalistic philosophy was elected into office in 1992. The new government started a rigorous program of financial austerity and micro-economic reform. They were re-elected into office for a second term in 1996.

In the context of nation wide and statewide micro-economic reform, changes to the management of the Australian public sector were introduced. In the State of Victoria, public sector reform has focused on "delivering better, more responsive and more effective services at lower cost" (Vertigan 1996, p. 7 of 19). This focus has helped shape the current management model—the purchaser and provider model (also called funder and provider model recently)—adopted for Victorian public sector.

In this management model, Parliament oversees the State Government that defines the outcomes (states or conditions) that it seeks to create or influence in its policy. The main responsibility of each State department is “the delivery of outputs which satisfy performance standards and targets established in the budget in terms of quality, quantity, cost and timeliness” (Vertigan 1996, p. 11 of 19). The head and the policy makers in each department serve as the purchaser and define the outputs. There are internal and external providers. Internal providers are located inside government; they comprise traditional departmental staff (to be gradually converted to service agencies), state owned enterprises and government business enterprises that are part of government but managed in a commercial manner independent of any department. External providers are made up of private sector or community agencies outside government. Irrespective of the nature of the providers, the purchaser enters into service agreements with individual providers to deliver the outputs that satisfy performance standards and targets as agreed by government (Vertigan 1996).

An important element of the reform had been the restructuring of organisations to sharpen their focus on core business or service delivery objectives, and improve cost attribution, so that management decisions take account of the full costs of service delivery (Vertigan 1996). Some of the micro-economic measures adopted over the past decade include downsizing of State Government, reducing recurrent annual budgets, and applying commercial accounting and rate of return requirements to scrutinise capital investments.

Concurrent with the Victorian reform was the commissioning of an independent Committee of Inquiry by the Federal government in 1992 to develop a National Competition Policy to “consolidate the many reforms undertaken by governments over the last decade” (Hilmer, *et al.* 1993). The report by the committee was published in 1993 with all State governments agreeing to implement the policy in 1995. The Victorian State Government was committed to the policy that was considered complementary to its own micro-economic reform objectives. It published its own policy statement on competition in 1996 in support of the introduction of the competitive neutrality principles to both government owned businesses and predominantly tax-funded general government services. The principle of competitive neutrality aims to ensure that government businesses and services do not enjoy any net competitive advantage through immunity from taxes, regulations, debt charges, and in general, full cost attribution (Department of Premier and Cabinet 1996).

Apart from the broad political and economic environment, there were other local initiatives that had an impact on GIS development. One such initiative was the Victoria 21 initiative, which was launched in 1995 to boost the economic and cultural future of Victoria through the development of integrated information technology, telecommunication and new interactive multimedia services throughout the public and private sectors of Victoria (Office of Communications and Multimedia undated). This initiative, of which GIS was an integral element, was driven by the Premier of the state.

The micro-economic reform policy, the Victoria 21 initiative, and the recent commitment to a competitive neutrality policy of the Victorian Government together constitute the context of public administration in Victoria. It is within this context that GIS diffusion has taken place in the State Government over the past decade or so.

2.3.2 Geographic data management responsibility

Historically in Victoria, the Departments of Lands and the Surveyor General's office controlled the alienation of Crown (that is, government) land. In more recent decades, the Department of Lands in general administered Crown lands and estate with the support of the Surveyor General. The Office of Surveyor General carried out Crown land surveys (Williamson and Enemark 1996). The Surveyor General was also responsible for the government mapping function. Typical duties included producing topographic maps in conjunction with the Army, compiling cadastral overlays for topographic maps particularly over the last 30 or 40 years, and the creation of digital topographic databases (DTDB) and digital cadastral databases (DCDB) over the last 10 to 20 years.

Traditionally until the mid-1980s, the Office of Surveyor General had maintained a consistent set of topographic base maps. However, there was significant duplication in maintaining the cadastral base maps, with as many as 20-30 different base map series being maintained in each state. These series of cadastral maps were derived from the index maps which were copied from approximate valuation maps, and were maintained by the Land Titles Office to track land subdivisions. These maps had a low spatial integrity and were used by many other authorities such as local government and utilities. The integrity of the cadastral system was based on the individual accurate cadastral surveys and plans kept in the Land Titles Office, and those relating to Crown land kept in the Department of Lands or Office of the Surveyor General. The relatively simple position of the topographic maps, and the complex position of the cadastral maps are made more complex in more recent years by the introduction of new players in the creation and management of digital map bases, both cadastral and topographic.

First, most computerised cadastral maps in urban areas were initially prepared by utility authorities (previously part of the state government) responsible for water, sewerage and drainage in response to their requirement for digital data to manage their assets and services. For example, Melbourne Water Corporation originally captured and managed the state's metropolitan cadastral map. This represented a large portion of the land parcels in the Victoria (Wan and Williamson 1995).

Second, there is a national trend towards establishment of Chief Information Officers in each state to centrally coordinate information/GIS policy. This had created a further group of stakeholder in the digital spatial databases development process.

Third, since the mid-1980s, there has been a steady drive by agencies in the natural resources sector to develop GIS to meet their business needs. This results in a strong demand for digital mapping data, topographic data in particular. On the one hand, these agencies digitise the topographic data they need immediately. On the other, they try to put pressure on the traditional mapping authority, the Surveyor General, to produce digital map data in GIS formats which they can use with minimal conversion.

Australian state governments such as that of Victoria play a key role in the development of the ASDI, both as a user and a supplier of medium to large scale spatial data, which have significant impact on the delivery of essential services to the citizens. The political and economic changes in Australia in general, and in the State of Victoria in particular, has significant impact on the distribution of geographic data management responsibilities and on GIS diffusion in the State. This is illustrated by the brief history of GIS development of the State Government of Victoria documented in the next subsection.

2.4 Development of GIS in Victoria

The development GIS in Victoria has been a turbulent process. The process can be studied in terms of three epochs named after the lead agencies in GIS coordination in the respective era: LANDATA (not an acronym), OGDC (Office of Geographic Data Co-ordination), and GPAC/GDV (Geospatial Policy and Coordination Victoria/Geographic Data Victoria).

2.4.1 LANDATA Era (Early 1980s - 1991)

In the early and mid-seventies, many government agencies were looking into the development of computerised mapping and land information systems (Bryant 1977, Cramer 1977, Department of Crown Lands and Survey of Victoria 1977, Kelly 1977, Seabrook 1977). By the latter half of 1970s, through a task group headed by the Surveyor General, the Victorian government was already aware of the significant duplication in the maintenance of computerised land information (Anonymous 1977). Due to the scale of the problem, it was only after a series of studies (Eddington 1979, Eddington 1981, Eddington 1982, Miller 1991) that in 1984, the State Government finally agreed to a proposal to establish an agency called LANDATA. LANDATA was created in the Department of Crown Lands and Survey to coordinate the development of computerised mapping and land information systems (GIS/LIS) in three major areas: legal/financial, mapping and natural resources (Rakkar, *et al.* 1984).

Though innovative, the LANDATA initiative was ahead of its time. It was under-resourced by government that viewed the agency primarily as a mechanism to achieve land administration reform (Chan and Williamson 1995c). The problems (technical, political and organisational) it faced were also under-estimated. Though the four key agencies responsible for land information management were combined into a functional group under one department (Russell 1986), they all worked towards different agenda. Of the three main activity areas, only the mapping program of developing the DCDB was successful. Progress in the development of the textual land information system (the textual cadastre) in the legal/fiscal area was limited. The natural resources sector was not getting the data they needed. LANDATA's overall achievements were insufficient to satisfy the cost recovery requirements introduced by government. After a series of reviews, LANDATA was reduced to a public inquiry service of land ownership information in the Land Titles Office by the early 1990s. By this time there was virtually no government GIS strategy.

In 1991, frustrated by not having the right digital map bases to support their GIS initiatives, a group of nine agencies from the natural resources sector pooled their resources to hire a group of international consultants to review the State's GIS policy. Much of the background that led to this initiative is described in (Williamson 1992).

The consultants produced a report (Tomlinson Associates Ltd. 1991) which adopted an economic rationalist approach. They highlighted the need to initiate GIS planning using rigorous modern methods. The approach of the report matched the philosophy of the government and the report was accepted. The Office of Geographic Data Co-ordination (OGDC) was established under the Department of Finance in late 1991 to oversee a government wide GIS planning study to be undertaken by the same consultants.

2.4.2 OGDC Era (1991-1996)

The GIS planning study took 18 months to complete. In the process there was a change of government from Labor to Liberal. The final report was produced in 1993. It recommended an investment of A$56 million over a period of six years in return for a fully discounted benefit of up to A$312 million (Tomlinson Associates Ltd. 1993c). The methodology adopted for the user needs and cost-benefit analyses in the report was in tune with the Liberal government's general philosophy of economic rationalism. The report was accepted albeit the returns were subject to achieving many technical, institutional and administrative reforms (Chan and Williamson 1995b). OGDC was put in charge of formulating and implementing the State's detailed GIS strategy.

Based on a schedule of development of datasets prescribed by the consultant, OGDC managed to consolidate a set of core databases under its charge to form the State Digital Map Base (SDMB), taking over the mapping function of the Office of Surveyor General in the process. SDMB comprised the digital topographic, cadastral, and road network databases. This was a significant achievement, as historically, the databases were managed by different agencies. Another major achievement was the successful contracting out of the management of the Victoria metropolitan DCDB to a private company on 1st July 1995.

These achievements came at a price to OGDC. Being located primarily within the Department of Finance from 1991 to 1995, OGDC was placed at the forefront of micro-economic reform. As a model for other government agencies and without a corresponding increase in management resources, OGDC was required by government to downsize and prepare for the privatisation of the mapping section that it took over from the Surveyor General. It was also expected to remain small, to contract out its business operations as far as possible, to manage the SDMB in a commercial manner and to be self-sufficient as soon as possible. All these detracted OGDC from its duties as a GIS authority and coordinator.

Another outcome of the government's economic rationalism policy during this period was the utilisation of universities and other research bodies to a far greater extent for its research needs. One result has been a major six-year contract of research between OGDC and the Centre for Geographic Information Systems and Modelling within the Department of Geomatics at the University of Melbourne, which commenced in 1996.

2.4.3 Land Victoria/GPAC Era (1996-1997) – Current Development

By April 1996, immediately after its re-election, the government of Victoria decided to reform its land administration and natural resources programs. OGDC, together with the Land Titles Office, the Office of Surveyor General and the Office of Valuer General, were put under a line department, the Department of Natural Resources and Environment (DNRE). This decision was in line with the trend started by the State of New South Wales (Watkins 1994).

To complete the transition to the purchaser-provider model, OGDC was split into two offices: Geospatial Policy And Coordination Victoria (GPAC), the purchaser, and

Geographic Data Victoria (GDV), the provider. Following this restructuring exercise, DNRE was prepared to inject resources to nurture the growth of GPAC and GDV, the State's GIS administration machinery, allowing it to tackle its job in all fronts. Concurrently, a major business process re-engineering study was conducted resulting in the creation of Land Victoria on 1st September 1997. Land Victoria incorporated the State's GIS/LIS agencies with DNRE's in-house GIS management resources into a new division that is dedicated to the management of GIS/LIS in the State.

Table 2.1 Changes in the spatial information industry in Victoria, 1985-1997.

	Public Sector	Private Sector	Academic Sector (The University of Melbourne)
staff in 1985	> 1,500	"cottage industry" with about 100 small private firms	staff of 4 (with only one having a PhD), had a few graduate students, took in about 20 surveying undergraduates each year
role in 1985	large capital expenditures, and undertook extensive applied research and development	little capital expenditure, and undertook little or no research and development	had a lot of second hand equipment donated by government, undertook little research and attracted little external funding
staff in 1997	<250	>1,500, still having many small firms, currently had a growing number of larger firms employing over 30 persons	staff of about 15 (with vast majority having PhDs), had over 60 graduate students, took in 40-50 undergraduates into a range of programs
role in 1997	Undertook minimal research and development, played a coordinating, strategic and policy development role, managed many contracts to the private and academic sectors	Played a broader role with many investing in research and development and some exporting overseas	Generated about one third of its budget from external sources through contracts, consultancies etc, and had a close working relationship with both the government and private sectors

2.4.4 Changes In The Spatial Information Industry In Victoria

The spatial information industry in Victoria is made up of three integrated sectors, namely, government, private and academic. Their relationship is so intertwined that changes caused by economic rationalism in one sector have resulted in changes in the others. Table 2.1 summarises the dramatic changes over the past decade as documented by Marwick (1997).

In short, in 1985, the development of spatial information industry was driven and powered by the public sector, which dominated the industry in terms of staff and financial resources. In 1997, the situation was reversed. The private sector provided the main impetus to the industry, which was supported by active participation of the academic sector in research and development. The public sector reverted to the role that it did best—leading, coordinating, and regulating.

2.5 The State Government of Victoria and GIS Diffusion Research

2.5.1 The importance of GIS diffusion research at a state government level

State governments account for a major slice of government expenditure in Australia. They also play a key role both in delivering social and economic services of direct and immediate concern to the Australian community at large, and in supplying the key spatial data necessary to support decisions concerning these services. The spatial data together with the enabling technology of GIS underpin the efficient and effective delivery of these services, both in tangible and intangible ways. Knowledge of GIS diffusion at a state government level, which examines the adoption and utilisation of GIS at this level, would have significant impact on the delivery of these crucial services to the Australian community. However, study of diffusion of GIS at a state government level is currently fairly limited, particularly in Australia.

Further, the GIS planning study for the State Government of Victoria (Tomlinson Associates Ltd. 1993c) has predicted a return of A$312 million, fully discounted over 7 years, for an investment of A$56 million in developing key spatial datasets and products. These benefits for Victoria, together with the important role played by the state government in serving the citizens of Australia, help justify this study of GIS diffusion at a state government level.

2.5.2 The value of GIS diffusion research in the State Government of Victoria

The State Government of Victoria has a long and turbulent, but relatively well-documented history of GIS development, which can be traced back to the mid-1970s. State agencies and departments in Victoria had been early adopters of GIS. They have played different roles in the development of the technology over the years, ranging from research, system development and management, outsourcing contract management, to coordination, and policy development and implementation. These organisations have unique, valuable, and extended experience of GIS diffusion that cannot be found in other types of organisation. Together with the willingness of the Victorian Government to cooperate with academia to look into the technical and institutional issues of GIS diffusion, the State Government of Victoria is a good source of data for this research into the diffusion of GIS in an organisation.

Governments are being reinvented (Osborne and Gaebler 1992) as in the case of the State Government of Victoria described above. The distinction between public and private organisations is diminishing all the time. Therefore, the extended experience of GIS diffusion of the State Government organisations in Victoria in the last two decades also has the potential to contribute to the knowledge of GIS diffusion in organisations in general.

2.6 Chapter Summary

This chapter starts by describing the political and the functional relationships among the three levels of government in Australia, that is, federal, state and local. It is argued that the activities of the state government in Australia generally have the most direct and immediate impact on the livelihood of the citizens. It is also pointed out that the state governments are also key spatial data providers in addition to being data users in Australia. The states are responsible for the medium to large scale (scales 1:25,000 and larger) topographic and cadastral mapping, including the production of road centre-line maps. These sets of data constitute the key part of the Australian Spatial Data Infrastructure, and support many political and socio-economical activities in Australia, both in the public and private sectors. Therefore, improved understanding of diffusion of GIS in state governments will benefit the livelihood of the people in Australia directly.

The Chapter also briefly documents the long and turbulent history of GIS development in the State Government of Victoria, which is representative of the trend of GIS development in Australia. The extended experience of GIS development in the State Government of Victoria, together with its willingness to cooperate with the academic sector make it a valuable source of data for this research into the diffusion of GIS in an organisation. The history of GIS development in Victoria and the background information of the Australian Government described in this chapter also help to set the scene for the discussion to be followed in the thesis.

Chapter 3
Current GIS Diffusion Research

3.1 Introduction

GIS diffusion is a recent branch of GIS research. Its grounding is the sub-disciplines of innovation and socio-technical systems in the disciplines of organisation behaviour/ organisation theory and information systems (Onsrud, *et al.* 1995). In general, the sub-discipline of innovation studies the diffusion of new idea or practices (an innovation) among people or other adoption units in a social system (Rogers 1995). Socio-technical systems research examines the design and implementation of new technology in the form of technical systems that meet the requirements of the members of a social system such as an organisation (Eason 1988).

3.1.1 Definitions of diffusion

Gattiker (1990, p. 22) views diffusion as 'the degree to which an innovation has become integrated into an economy'. Spence (1994, p. 83) describes diffusion as 'the spread of a new idea from its source to the ultimate users'. Campbell and Masser (1995, p. 4) see diffusion as 'the fundamental process that is responsible for the transfer of innovation from the workshops of their inventors to becoming a daily part of the lives of a large section of society'. These definitions package different concepts inherent in diffusion in such a way as to help the authors make their points. Gattiker emphasises the relation between innovation and an economy. Spence pictures a unidirectional movement of diffusion that has a source and many end users. The innovation concerned refers to new ideas. Campbell and Masser view diffusion as a process of transfer of innovation, which, like Spence's view, is unidirectional in nature. Instead of viewing the target of diffusion as an economy, their target is people in a section of society. Their definition gives an impression of innovation more akin to an invention. Together, these definitions capture many different aspects of diffusion. Individually, they tend to impart a biased view of diffusion and are generally not appropriate as a definition to guide research.

Rogers has followed and documented the development of diffusion research over many years (Rogers 1962, 1971, 1983, 1995). Ten major diffusion research traditions are identified, ranging from anthropology, through education, public health and medical sociology, communication to general economics. Based on the understanding of this multi-disciplinary research area, Rogers provides a more generic definition of diffusion:

> *Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.*
>
> (Rogers 1962, p. 5)

3.1.2 The paradigm of diffusion

People from different disciplines have used this definition (or its variations) over the years (Goodman 1993, Pinto and Onsrud 1993, Zaltman, *et al.* 1973) and underpins the intellectual paradigm of innovation diffusion (Rogers 1993). The definition also gives rise to four elements of diffusion: namely, *innovation*, *communication channels*, *time*, and the *social system* (Rogers 1995). The four elements represent the foci of research activities in the past five decades.

A significant body of knowledge has accumulated around the diffusion paradigm over the past five decades, particularly in relation to the elements of *time* and *communication channels*. The bulk of research concerns the innovativeness of and the earliness of knowing about an innovation by members of a social system, and the rate of adoption of innovations in different social systems. However, study into the structure of social system of diffusion is relatively limited (Rogers 1995).

On the other hand, researchers of socio-technical systems have put much effort into examining technological innovations and social systems, and their relation (Goodman and Sproull 1990, Luftman 1996, Nord and Tucker 1987, Pennings and Buitendam 1987, Tushman and Moore 1988). An integrated set of principles of system design and implementation has been developed to make technical systems acceptable to users in an organisation (Eason 1988, Eason 1993a). But limited effort is spent on the *time* element. Goodman (1993, p. 49) points out one of the limitations of current research: 'we do not have good theories and/or studies tracing the evaluation and interrelationship of these criteria over time'. Goodman is referring to success criteria in his discussion, but neglect of the *time* element in technology implementation research appears to be a general issue. Clearly, within the broad framework of the diffusion paradigm, the sub-disciplines of innovation and socio-technical systems can complement each other.

In the sections that follow, the GIS diffusion literature is reviewed to document major achievements of GIS diffusion research to date, with the diffusion paradigm as the organising framework. In the light of the experience of the two grounding sub-disciplines, the limitations of current GIS diffusion research are identified. The implications of these limitations are discussed and a theme for this research is chosen.

3.2 Innovation

> *Innovation is the sap that flows in the organization tree, and the effective management of technological innovation is what makes an organization grow and flourish.*
>
> (Gattiker 1990, p. 27)

3.2.1 Innovation and technology

The emphasis on technology, particularly computer/information technology in the literature in recent decades, leads to the often interchangeable use of the terms *technology* and *innovation*. It is useful to clarify the two terms before proceeding further. Some authors equate research and development with innovation (Link and Tassey 1987). However, other researchers argue that it is not true (Gattiker 1990, Hitt, *et al.* 1988). According to Gattiker (1990, p. 17), 'An innovation may be a new way of thinking or an invention that is the product of this way of thinking'. Though useful, this concept appears restrictive when compared with the definition by Rogers:

> *...an idea, practice, or object that is perceived as new by an individual or other unit of adoption...Newness may be expressed in terms of knowledge, persuasion, or a decision to adopt.*
>
> (Rogers 1995, p. 11)

Based on Rogers' definition, newness is the characteristic of innovation. Newness is a concept that includes the perception of an adopter (an individual or organisation) and a time element—something can be considered new by an adopter at different stages of diffusion.

On the other hand, newness is not a characteristic of technology. Technology is seen as 'knowledge of cause-and-effect relationships embedded in machines and methods. The knowledge may be certain or probabilistic' (Sproull and Goodman 1990, p.255). The term should be distinguished from technical system, which is defined as 'a specific combination of machines, equipment, and methods used to produce some valued outcome...Every technical system embodies a technology' (Berniker as quoted in Weick (1990, p. 3). Based on these definitions, technology is seen as the knowledge while technical system is a mechanism through which the knowledge is applied to achieve specific end/s. When either a technology or a technical system is perceived as new, each becomes an innovation.

3.2.2 GIS as an innovation

Based on the definitions of GIS put forward by many researchers, GIS often is viewed as a technical system (Aronoff 1989, Burrough 1986, Cowen 1988, Department of the Environment 1987). However, after 25 years of development, (Goodchild 1992) argues that GIS should be treated as geographic information science (GISci). GISci is defined as:

> *...the set of fundamental scientific issues arising from, stimulated by, or surrounding the use of digital computers to handle, process, analyze, store, or access geographic information.*
>
> (Goodchild 1995a, p. 1)

Based on Goodchild's argument, GIS is a body of knowledge of managing and manipulating geographic information by computers. *Science* is the status that better reflects the effort and achievement of the GIS community. In this sense, GIS is no doubt a technology. When the GIS technology is deployed in the form of a combination of machines, equipment and methods in a place like a cartographic office to produce maps, GIS also assumes the role of a technical system. In the past, such a technical system referred to spatial analysis methods and equipment that involved studying spatial patterns by overlaying transparencies of map layers on a light box. To those offices that still use the manual technology, the present day computer-based GIS certainly represents an innovation.

3.2.3 Types of innovation

Over the years, many ways have been used to classify technological innovations. Gattiker (1990) classifies them according to their types (primary or derivative), diffusion (low or high level in an organisation), and relationship to its users (incremental or radical). Some classify the innovations in terms of the state of the system, the initial focus or the outcome or effect of the innovations (Zaltman, *et al.* 1973).

When distinguishing 'process innovations' from 'product innovations' Rosegger (1986) points out that in industrial practice, a new product usually requires some changes and adaptation in the process technology. It is often difficult to distinguish a process innovation from a product innovation (or vice versa). The two innovations should be seen as representing 'a continuum rather than a dichotomy' (Gattiker 1990, p. 20). Both types of innovation are needed to describe the outcome of innovation and the associated organisational change. The same argument can be applied to the different types of innovations mentioned above. The process of diffusion is such that an innovation will cause change to product, process, people, and organisational structure.

It may be difficult to identify a pure type of innovation. The classification represents convenient grouping of innovation for ease of research. Innovation can assume the identify of any one type or combination of types of innovation in the process of its diffusion over time.

3.2.4 Types of GIS

So far, little work, if any at all, has been done on classifying GIS as an innovation. However, it is recognised that introduction of GIS involves the interaction of people, technology, and organisational structure (Benwell 1993). The business process will require compatible re-engineering in order for GIS to be fully successful. This suggests that like the innovations described above, the identity of GIS will change as diffusion progresses. As a tool to aid GIS diffusion research, it will be useful to have a way of classifying GIS to track its identify over time.

3.2.5 Uncertainty of innovation and implementation strategies

An innovation usually offers a certain degree of benefit to someone who adopts it. Often it can help to reduce uncertainty of an existing practice. However, this advantage is not always very clear cut to the intended adopters. They are seldom certain that an innovation is better than the practice that it might replace. So while potentially able to reduce uncertainty because of its information base, a technological innovation creates a different kind of uncertainty, an uncertainty about its expected consequences in the mind of potential adopters (Rogers 1995).

The more radical the innovation is, the more uncertain users are towards the innovation. Depending on the contextual requirements, the perception of the users/adopters and the extent of planning and preparation affordable, different innovations may require different implementation strategies. For example, Eason (1988, p. 159) identifies five broad strategies of implementing new information systems, which range from the ‘big bang’ to ‘incremental evolution’ depending on the radicalness of the strategy.

3.2.6 Uncertainty of GIS and implementation strategies

Recognising that introduction of GIS to an organisation creates similar uncertainty as other innovations described above, GIS researchers have suggested many implementation strategies. Somers (1994) suggests a dual-track development strategy. After a preliminary requirement analysis and core design, the strategy follows two tracks simultaneously. By the first track, one collects short term data and implements immediate applications, while by the second track, one continues the detailed analysis and design. Peuquet and Bacastow (1991) suggest an iterative prototyping strategy. After defining a preliminary set of requirements, a working model is developed and implemented, provoking experimental organisational changes. Both the functional and the organisational requirements are derived and tested through iterations. Hedges as quoted in (Ferrari and Onsrud 1995) suggests an incremental approach to implement asset management and facility management projects in support of process re-engineering. Anderson (1992) suggests a proactive approach in which GIS is implemented in five phases, namely, participation, context evaluation, vision creation, change and implementation. The five phases are non-linear and proceed concurrently, and if necessary repeatedly.

3.2.7 Characteristics of innovation

In the past, it had been assumed that all innovations were equivalent units of analysis. The assumption is oversimplified, as people perceive different innovations differently based on many characteristics (Rogers 1995). Rosegger (1986, p. 187) identifies five major categories of factors that affect the rate at which a technological innovation has become integrated into an economy. They include origin of the innovation, effects on other inputs, relationship of the innovation to the existing production structure, change in the innovation and complementariness among innovations.

Rogers (1995, p. 15) summarises five generic characteristics of innovations, as perceived by individuals, that over the years are found to explain most of the variations in the rates of adoption of innovations. These characteristics are *relative advantage*, *compatibility*, *complexity*, *trialability*, and *observability*. Innovations that are perceived to have less complexity but greater relative advantage, compatibility, trialability and observability, will be adopted more rapidly. In general, the factors identified by Rosegger are a subset of the five characteristics summarised by Rogers.

3.2.8 Characteristics of GIS

Two studies conducted in recent years have shed some light on the characteristics of GIS as an innovation that affect its diffusion. The studies are part of a major initiative to determine the success factors for GIS diffusion. The first was undertaken by Budic (1993) who studied GIS diffusion in local governments in four southeastern states in USA. Budic finds two characteristics of GIS that significantly affect GIS adoption by individual people: *perceived relative advantage* and *exposure to GIS technology*.

The second study was conducted by Onsrud and Pinto (1993) who conducted a large scale questionnaire survey that covers 256 local governments in six different countries/regions, to identify the factors that best predict adoption/utilisation success. Eleven groups of factor are found to account for 62 percent of the total variance of adoption/utilisation success. Four groups of factors, namely, *utility*, *ease of use*, *history of failure* and *cost* are found to be significant predictors, with utility being the single most important group. It is interesting to note that the significant predictors are essentially characteristics of the innovation. These predictors, together with the GIS characteristics identified by Budic, fall within the scope of the five perceived characteristics of innovations summarised by Rogers. It seems that at least in the local governments sampled, perceived GIS characteristics are better predictors of success than other factors. In their conclusion, (Onsrud and Pinto 1993) point out that more work is required to determine the predictors of success, including the characteristics of GIS, in the adoption of GIS within local government.

3.2.9 Limitations of the research concerning innovation

When conducting innovation diffusion research, an important conceptual and methodological issue is to identify the scope of a technological innovation (Rogers 1995). In order to make work simpler, past research tended to adopt an implicit assumption that each innovation was independent of other innovations. Rogers (1995, p. 15) finds this assumption dubious and points out that 'In reality, a set of innovation diffusing at about the same time in a system are interdependent'.

Using the examples of 'miracle rice and wheat', Rogers (1995, p. 15) further notes that technological innovations may appear in the form of a *technology cluster*, which 'consists of one or more distinguishable elements of technology that are perceived as being closely interrelated'. In fact, Gattiker (1990) and Rosegger (1986) both notice that in industry, some innovations work complementarily to one another. The practical problem here is to determine which is the subject of analysis, the technology cluster as a whole or a specific combination of the elements in the cluster.

In the 1970s, diffusion scholars recognised that innovation changes in the course of diffusion. This is echoed by Rosegger (1986) who finds that innovation changes as it gets incorporated into an economy. This leads to the study of the concept of *reinvention* which is defined as 'the degree to which an innovation is changed or modified by a user in the process of its adoption and implementation' (Rogers 1995, p. 17). The two concepts of reinvention and technology cluster together create a problem of defining the identity of an innovation in diffusion studies.

To complicate the issue further, Goodman (1993) observes that technology, particularly information technology, can achieve the same result through different configurations or technical systems. The unique aspects about each technical system is defined by 'the interaction or adaptation among the technological system and organisational characteristics' (Goodman 1993, p. 50). Also, the meaning of technology is interpreted differently by different individuals and groups within the organisation depending upon the organisational context. This suggest that in addition to objective characteristics, technology also has socially-defined characteristics. To clearly define the identity of an innovation/technology is not a simple task. Therefore, Goodman (1993, p. 50) points out that though there are many accounts of implementation success or failure in the literature, 'there are very few accounts of the technology under observation', and that the knowledge of many forms of new technology is actually incomplete.

3.2.10 Limitations of the research concerning GIS as an innovation

Currently, GIS researchers also recognise the problem of defining the identity of GIS as an innovation. The concept of GIS as a technology cluster has been touch upon recently (Chan and Williamson 1995a), but the impact of the concept on diffusion has not been explored. In a presentation to the GIS community, Rogers emphasises the ability of an innovation to undergo reinvention. Rogers also predicts that the changing technology for GIS and the lack of user-friendliness may slow the rate of adoption of GIS, while the reinventability of GIS may speed the rate of adoption (Rogers 1993).

Based on findings of 12 case studies of local government in Britain, Campbell and Masser (1995) confirm the presence of reinvention, and a multitude of objective and social configurations of GIS. They find that GIS is not 'a particular configuration of equipment' (p. 108). Instead, each local government 'had chosen a different configuration of equipment, filled it with different data and wrapped it up in different organizational structures' (p. 109). Their findings suggest that 'the meaning of a technology such as GIS was continuously being reinvented at both the organizational and individual scales' (p. 109). As reinvention is not their primary research subject, the detail of the phenomenon is not investigated. Still Campbell (1996b, p. 40) notes that 'the precise nature of the relationship between technology and the multi-levelled contexts in which it is located is unclear' and identifies the need for 'An analysis of perspectives on the nature of GIS technology with particular emphasis on the extent to which each organization reinvents a particular form of technology'.

Establishing the identity of GIS early on is crucial for GIS diffusion research. It allows researchers to keep track of the technology in the course of diffusion, and to relate any findings back to the particular configuration of GIS in study. It also ensures that findings from different research initiatives are comparable for GIS that have matching configurations.

3.2.11 Section Summary—GIS as an Innovation

This section briefly describes the current knowledge of the different aspects of an innovation. GIS diffusion researchers recognise that the knowledge is also applicable to GIS in general. They also found that like other innovations, GIS diffusion research has to tackle the problem of identity of GIS. The problem has three different dimensions. Firstly, GIS may comprise a cluster of related technologies/knowledge. Secondly, the identity of GIS may change in the course of diffusion through reinvention. Thirdly, GIS may have different configurations and socially constructed meanings depending on the needs and perceptions of different individuals or units of adopter within an organisation/social system.

Establishing the identity of GIS as an innovation is fundamental to GIS diffusion research. This allows tracking of GIS in its course of diffusion, and relating any findings back to the particular entity of GIS in study. This also ensures that results from different research initiatives are comparable based on a clearer specification of GIS.

3.3 Communication Channels

> *A communication channel is the means by which messages get from one individual to another.*
>
> (Rogers 1995, p. 18)

Research into the element of communication channel of the diffusion paradigm emphasises on the types of channel, including *mass media* and *interpersonal channels*, *cosmopolite* and *localite* channels. Study of the people at both ends of the channels concerns *opinion leaders* and their followers. The network of channels formed among these people is called a *diffusion/communication network*. Two main groups of linkages in the network can be identified depending on whether they are *homophilous*/*heterophilous*, and *strong ties*/*weak ties*. The description of the different aspects of communication channels in the subsections below is based on the account by Rogers (1995)

3.3.1 Types of communication channels

In diffusion, there are two main categories of communication channels. One is characterised by its nature as in mass media and interpersonal channels. The other is characterised by its source of origin as in cosmopolite and localite channels. In general, mass media such as newspaper, radio and television are more effective in making potential adopters aware of an innovation. It can also lead to changes in weakly held attitudes. Like mass media, cosmopolite channels, which are communication channels from outside the social system of study, are more effective in raising awareness of an innovation. On the other hand, interpersonal channels are better for persuading an individual to form or change a strongly held attitude toward a new idea. Localite channels, which refer to channels from within the social system, like interpersonal channels, are more important at the persuasion stage.

3.3.2 GIS and types of communication channels

Croswell (1989) stresses the importance of keeping stakeholders informed through periodic presentations by the GIS manager and newsletters even after the system is operational. Koller as quoted in Ferrari and Onsrud (1995), points out that to successfully implement a GIS, there is a need to open informal lines of communication between participating departments, and to spend managerial effort in interdepartmental persuasion and interpersonal communication. Engelken (1994) advises that a GIS project manager should establish and maintain personal linkages at all levels of the organisation, and that communication can make the difference between technical or business success for the project. There are also discussion into the types and means of establishing communication channels to facilitate sharing of geographic information (Obermeyer 1995, Tosta 1995, Ventura 1995).

In the survey by Onsrud and Pinto (1993), though not a key factor, *existence of (formal and informal) communication channels* was found to have certain significance in accounting for GIS diffusion. It ranks seven out of the eleven groups of factors that account for 62% of the variation in adoption success in local government. The result may be more meaningful if the nature and pattern of utilisation of the communication channels are known. This comment is based on the observation by Budic (1993, p. 155) that although interpersonal channels are more effective than general communication in facilitating GIS adoption, ‘negative messages or conflicting personal relationships’ can make communication with GIS users a negative predictor of success.

There is a recent study in Greece that specifically examines communication channels in the diffusion of GIS (Assimakopoulos 1996, Assimakopoulos 1997). In the study, GIS diffusion is found to be achieved through both mass media and interpersonal contacts.

3.3.3 Diffusion networks

The gist of the diffusion process is the modelling and imitation by potential adopters of their near-peers' experiences who have previously adopted an innovation. The pattern of interpersonal linkages of these near-peers is a diffusion network. The persuasion process will be more effective if the individuals in this diffusion network are homophilous, that is, similar in socioeconomic status, education, or other important ways. The opposite will apply to heterophilous individuals who have different background. At the focus/foci of the network are opinion leaders who are different from and are highly respected by other members (followers) in the network. They are found to possess many key characteristics such as greater exposure to mass media and contact to change agents, greater social participation (extensive communication network), higher socioeconomic status, more innovative but also more sensitive to the social norms. Often when an opinion leader decides to adopt an innovation, the followers will rapidly take up the innovation. At this stage, the critical mass is said to be reached.

However, homophily is not the only key to successful diffusion. Executives often discover new ideas and information through weak tie systems (Granovetter 1973) which is characterised by infrequent and sparse interaction among heterophilous people, who have barely overlapping areas of knowledge and information. To develop their weak ties, executives engage in multinational scanning (Keegan 1974), cultivate social contacts (Dalton 1959, Domhoff 1974), join the boards of other organisations (Allen 1974, Pfeffer 1972). Once a while, they try to break away from their strong tie systems represented by their immediate homophilous network of peer groups and competitors. For example, they participate in brainstorming sessions, go on retreats and hold open–door days (March and Sproull 1990). This is why in order for diffusion to be effective, there should be at least some degree of heterophily between any two participants. Heterophily actually aids rapid diffusion.

3.3.4 GIS and Diffusion networks

Assimakopoulos (1996) identifies the important role in GIS diffusion as played by a network of organisation in Greece called URSA-NET (Urban and Regional Spatial Analysis Network for Education and Training). This network is instrumental in organising conferences and seminars to establish contacts between European Union and Greece GIS experts. By studying key people who are influential in the development of GIS in Greece, he investigated and mapped the big picture of GIS diffusion on a national scale. He produces a cognitive map—the social/communication network—of the team-based Greek GIS community in 1993–94. The concepts of homophily/ heterophily, and strong tie/weak tie have been applied to describe the linkages of this social network. Opinion leaders in the community are also identified quantitatively by using the *Ucinet IV social network analysis* computer software and a *25x25 GIS sociomatrix* of 25 individuals in the community (Assimakopoulos 1997). The outcomes of the study pave the way for more in-depth studies into this aspect in future.

3.3.5 Limitations of research concerning communication channels of GIS

Currently, basic concepts of communication channels research have started to be applied to GIS diffusion research. More work is still needed to better establish the role of communication channels in GIS diffusion. In the process, the application of the basic concepts to GIS diffusion can be improved by paying more attention to identifying the targets and the channels of the communication process (Goodman 1993).

Further, researchers have also identified specialised communication processes that will significantly affect the successful implementation of new technologies. For example, Goodman (1993) identifies *socialisation* and *congruent and integrative rewards* as two such processes. Weill and Broadbent (1995) also identify *maxims* and *deals* as two major means of communication in developing IT (information technology) infrastructure in an organisation. Researchers can gain more insights into GIS diffusion by applying the basic concepts of communication channels research to these specialised processes in addition.

3.3.6 Section Summary—communication channels of GIS

In general, research into the communication channels in GIS diffusion involves applying established concepts concerning *diffusion networks* and *types of communication channels* to GIS diffusion studies. The work is still superficial and not part of main stream GIS diffusion research. However, the outcome is encouraging and paves the way for more in-depth and diverse studies in the future.

3.4 Time

Rogers (1995) views diffusion as a process. According to the Collins Paperback English Dictionary, *process* refers to, among other things ‘progress or course of time’, and, ‘a series of actions which produce a change or development’. To discuss the process of diffusion is to discuss ‘progress or course of time’ in diffusion. It involves a series of actions that produce a change or development—an outcome of diffusion in this case. Table 3.1 shows three different processes or series of actions studied under the time element of diffusion. These processes are *innovation-decision process, organisational innovation process*, and *varying rate of adoption among members*. Associated with these processes are three different outcomes of adoption: adoption by an individual or unit of adoption, a social system (such as an organisation), and cumulative adoption by members of a social system.

Table 3.1 Processes of innovation diffusion and the associated outcomes.

Processes	Outcomes
1. Innovation-decision process	Adoption/Rejection by an individual or unit of adoption
2. Organisational innovation process	Adoption and implementation by an organisation
3. Varying rate of adoption among members	Cumulative adoption by members of a social system

The concept of a process also forms the basis of the staged approach diffusion research. The staged approach views the process of diffusion of innovation 'as a set of stages or phases ordered along the temporal dimensions of their anticipated sequence' (Zaltman, *et al.* 1973, p. 52). Evidence for the existence of stages comes from the studies of the innovation-decision process of farmers in Iowa (Rogers 1995). The description of the three diffusion processes in this section is based on the work of Rogers (1995).

3.4.1 Innovation-decision process

The first process of innovation diffusion is the innovation-decision process or the innovation diffusion process for the individuals (person or other unit of adoption). It 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 this decision.*
>
> (Rogers 1995, p. 20)

It includes five stages, namely, *knowledge*, *persuasion*, *decision*, *implementation* and *confirmation* as shown in Figure 3.1. Communication channels that provide information and feedbacks from one stage to the others link all these stages together.

At the knowledge stage, an individual obtains information that indicates that the innovation may be a solution to certain problems. *Prior conditions* and *characteristics of the individual* will affect the outcome of the knowledge stage. Prior conditions include factors such as *previous practice*, *felt needs/problems*, *innovativeness* and *norms* of the social systems. Innovativeness is the degree to which an individual is relatively earlier in adopting new ideas than others in a social system. Innovativeness is often affected by the characteristics of the individual, which include the socioeconomic characteristics, personality variables and communication behaviour.

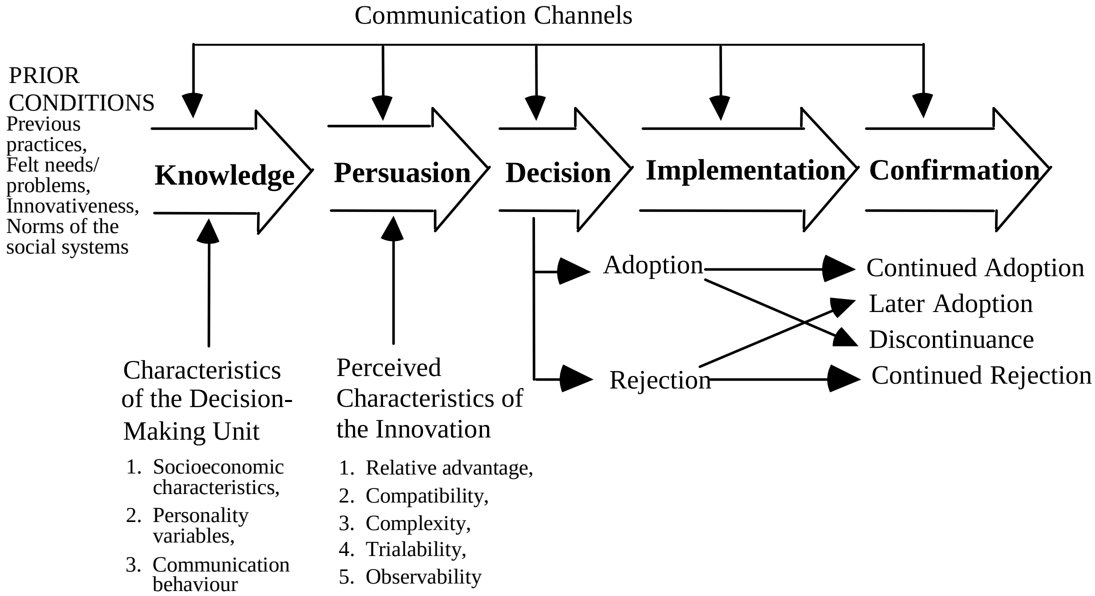


Figure 3.1 The Innovation-Decision Process (adapted from Rogers (1995, p.163))

At the persuasion stage, further information is collected. This time, the information is needed to reduce the individual's uncertainty of the innovation in bringing about the desired outcome. Interpersonal network and subjective judgement/experience from peers or competitors provides the channels. The outcome of this stage will be affected by the five perceived characteristics of innovation described in subsection 3.2.7.

At the decision stage, the individual goes through a series of deliberation to make a choice of adopting or rejecting the innovation in question. The decision is then carried out in the implementation stage in which the innovation is actually used to produce any benefits intended. Experience gained from the implementation stage, together with other information that comes in through various communication channels help the individual to confirm or change his or her decision during the subsequent confirmation stage. In this stage, the original decision may be continued, changed from adoption to discontinuance, or changed from rejection to later adoption. Provided that the technology is already available, the decision by an individual to adopt the technology will usually lead to success of implementation, that is, actual utilisation of the technology. The individual's satisfaction towards the technology is also a good indicator of its benefit.

3.4.2 GIS and Innovation-Decision Process

Probably due to the difficulty of probing into the mental process of individuals, minimal work has been done on the innovation-decision process in GIS diffusion. Nevertheless, there are some studies that touch on innovativeness of GIS adopters in the innovation-decision process. In these studies, some identify personality variables and other socio-economic characteristics of the adopters as important ((Budic 1993), Ventura *et al*. in (Ferrari and Onsrud 1995)). One identifies personal capabilities of managers as one of the critical elements (Engelken 1994). These characteristics are summarised in table 3.2. In general, these findings are by-products of some studies conducted to uncover success factors of GIS implementation.

Table 3.2 Personal factors affecting GIS adoption/implementation success.

Budic (1993)	**Ventura *et al*. in (Ferrari and Onsrud 1995)**	**Engelken (1994)**
Compatibility with previous experience	Level of education	Right person at the helm of the project with: –intellectual energy
Communication behaviour	Exposure to & experience with computing & LIS	
Attitude towards work-related change	Motivation	–personal energy–communication

3.4.3 Organisational innovation process

The second process in innovation diffusion is the organisational innovation process. It is a staged approach to describing the process of innovation diffusion in an organisation. In general, it is made up of two main stages, namely, *initiation* and *implementation*. *Initiation* is concerned with all the activities, including information gathering, conceptualising and planning, that culminate to the decision to adopt an innovation by the decision makers in an organisation. ‘Implementation refers to the steps taken after the adoption decision that lead to utilisation of an innovation prior to its ultimate institutionalization’ (Goodman 1993, p. 46). In an earlier model of the process (Zaltman, *et al.* 1973), the *initiation* stage has three sub-stages, namely, *knowledge–awareness*, *formation of attitude toward the innovation*, and *decision*. The *implementation* stage is made up of the sub-stages of *initial implementation* and *continued-sustained implementation*.

In Rogers' (1995, p. 392) more recent and sophisticated model as shown in Figure 3.2, the decision to adopt is treated as the watershed between the *initiation* and *implementation* stage. The two sub-stages of *initiation* are *agenda-setting* and *matching*, and the three sub-stages of *implementation* are *redefining/restructuring*, *clarifying* and *routinizing*.

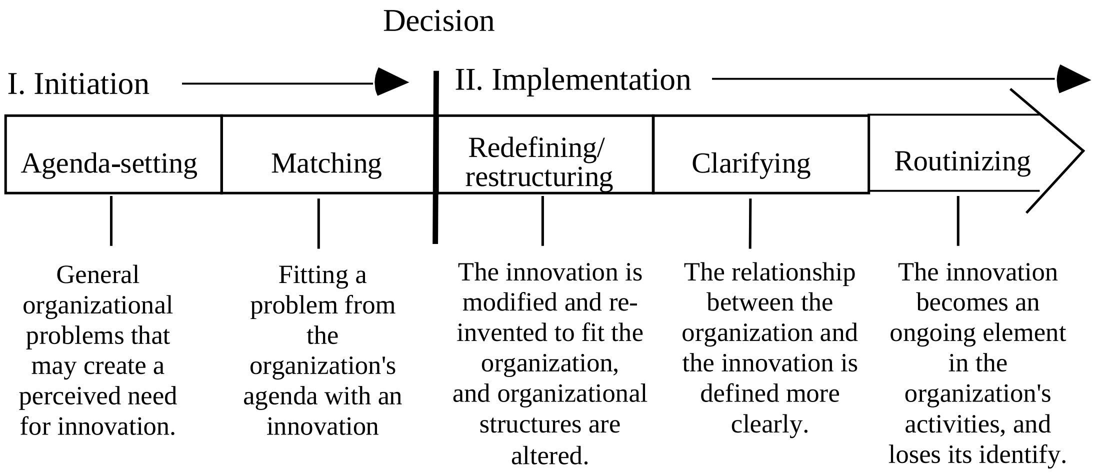


Figure 3.2 The organisational innovation process (Rogers 1995, p. 392)

In the *agenda-setting* sub-stage an organisational problem that may create the perceived need of an innovation is defined. Those involved in defining the problem are normally a powerful group of persons in the organisation. Sometimes, the knowledge of an innovation may precede the definition of a problem (Wildemuth 1992). *Matching* takes place when a problem from the organisation's agenda is fit with an innovation. In this stage, planning and design of the innovation are carried out.

In the *redefining/restructuring* sub-stage of *implementation* both the innovation and the organisation are changed to suit each other's needs. It is a mutual adaptation process to derive maximum utility out of the innovation. It is often at this stage when the innovation is adapted to suit the organisation structure and reinvention takes place. It is comparable to a social construction process. The more flexible an innovation is, the better is the chance for the process to succeed.

Clarifying is a sub-stage in which the innovation is put into more widespread use. The meaning of the innovation is agreed, accepted, and imbedded into the organisation through a process of interaction among the members—another social construction process. *Routinizing* is the last sub-stage when the innovation process is complete. The innovation is incorporated into the organisation and its meaning is so well known and built into the organisational structure that it loses its identity.

The *innovativeness* of an organisation is found to be affected by individual (leader) characteristics (such as attitude toward change), and internal and external characteristics of organisational structure. Internal characteristics include *centralization*, *complexity*, *formalisation*, *interconnectedness*, *organizational slack*, and *size*. External characteristic refers to *system openness*.

3.4.4 GIS and Organisational Innovation Process

In the GIS community, organisational innovation process of GIS (organisational GIS process) is not a common term. The process is more commonly called GIS development or implementation in an organisation. On recognising the significance of non-technical factors to the successful implementation of GIS (Croswell 1989, Foley 1988, Saarinen 1987, Somers 1989) in the late 1980s, GIS diffusion researchers had examined many such factors (Ferrari and Onsrud 1995). Within the diffusion paradigm the work of these researchers is seen to focus on both the elements of *time* and *social system.* The work that concerns *social system* is described in section 3.5 below. The work that has a bearing on the *time* element is primarily concerned with the organisational GIS process, and is described in this section.

The bulk of research that is related to the organisational GIS process is based on theories or practices from the disciplines of socio-technical systems/information systems, or simply from anecdotal implementation experiences of the researchers. A small part is based on or related to the diffusion paradigm. Depending on the theoretical base, this area of GIS diffusion research can be classified according to three views, namely, *diffusion theory*, *managerial rationalist*, and *evolutionist*.

The diffusion theory view (Table 3.3) examines the patterns of interaction between GIS and the organisation (including its members) over time through a sequence of stages. This view includes the six stage conceptualisation of diffusion by Campbell and Masser (1995), the four parsimonious stages by Azad (1993), and the three stages proposed by Anderson (1996). These models are based on or closely related to the organisational innovation process, and generally describe diffusion in terms of two key stages: *initiation* and *implementation*, with selective incorporation of other stages/sub-stages.

Rogers' model of the organisational innovation process (see Figure 3.2) is comprehensive, has a strong theoretical base, and is fairly well known to the GIS community. It also takes into account the issue of *reinvention,* which has been confirmed by Campbell (1996a) to exist in GIS diffusion. Therefore, it is included in Table 3.3 for reference and comparison purposes.

Table 3.3 Diffusion theory view of describing the organisational GIS process.

Rogers (1995)	Campbell and Masser (1995)	Azad (1993)	Anderson (1996)
Initiation		Initiation	Initiation
Agenda-setting	Awareness raising		
Matching			
Decision	Adoption	Adoption	
Implementation	Implementation	Implementation	Acquisition
Redefining/ Restructuring	Utilization		
Clarifying			
Routinizing	Routinizing	Routinization	Incorporation
(Outcome assessment)	Outcome assessment		

The next view is the managerial rationalist view. It is derived from an approach of technology implementation called managerial rationalism which assumes that organisations are rational systems and ‘that behavior of staff can be controlled and predicted using rational management techniques’ (Campbell 1996a, p. 102). Adopters of this approach believe that the process of GIS diffusion/development is linear, and that rational formulation of management strategies is the key to realise the potential benefits of GIS.

Table 3.4 lists out three examples of the managerial rationalist view. One is Eason’s (1993b) user-centred model of system development. Others include the general stages of implementation prescribed by Aronoff (1989), and the more detailed stepwise prescription of Antenucci *et al.* (1991). The latter two models are strategic steps developed from the experience of the researchers concerned, which supposedly would lead to successful GIS implementation. Apart from the three examples, there are many other prescribed strategies/steps that have not been detailed here (Clarke 1991, Effenberg 1994, Onsrud and Pinto 1993, Somers 1996, Vastag, *et al.* 1994). Also included in Table 3.4 for comparison is the classical system development methodology for designing and implementing large information systems (Laudon and Laudon 1994).

Table 3.4 Managerial rationalist view of organisational GIS process.

Laudon and Laudon (1994)	Eason (1993)	Aronoff (1989)	Antenucci, *et al.* (1991)
System analysis	Systems integration	Awareness	Concept -requirement analysis -feasibility evaluation
System design	User-centred design structures	Development of system require'ts	Design -implementation plan -system design -database design
Programming Testing	User-centred design processes	System evaluation	Development -system acquisition -database acquisition -organization, staffing & training -operational procedure preparation -site preparation
Conversion	User-centred system implementation	Development of an implementation plan	Operation -system installation -pilot project -data conversion -applications development -conversion to automated operation
Production & maintenance		System acquisition & start-up Operation	Audit -system review -system expansion

The third and last view is the evolutionist view. It originates from the influential computer development model described and improved by Nolan (1973, 1979). The term *evolutionist* is used by King and Kraemer (1984) to describe and evaluate the Nolan model:

> *The evolutionist perspective assesses history as a developmental, progressive, and directional set of changes that increase in their complexity or perfection with the passage of time. Such theories embody a clear concept of the direction of change and the destination of change.*
>
> (King and Kraemer 1984, p. 473)

Nolan's model is a model of computing growth in an organisation based on the organisation's level of expenditure on computer. The more recent 1979 version of the model comprises the steps of *initiation, expansion/contagion, formalization/control, integration, data administration,* and *maturity*. The model describes a *direction of change* (see definition by King and Kraemer) that is characterised by the availability of resources and emphasis of management control, and a *destination of change* that is indicated by a steady and leveled-off expenditure curve.

Table 3.5 Evolutionist view of organisational GIS process.

Crain and MacDonald 1984)	**Graafland (1996)**	**Marr and Benwell (1996)**	**Tulloch, *et al.* (1996)**
		Paper based systems	No modernization
	Initiation	Move towards GIS	System initiation
			Database development
Inventory	Local control		Recordkeeping
Analysis	Infrastructure development	Fully integrated GIS	Analysis
Management	Integration	Corporate data integration	Democratization

Nolan's approach is first adapted by Crain and MacDonald (1984), and more recently by Marr and Benwell (1996), Graafland (1996), and Tulloch, *et al.* (1996). In an attempt to model GIS development in different settings, they all tried to specify the *direction* and/or *destination of change*.

As illustrated in Table 3.5, Crain and MacDonald model GIS development according to the *direction of change* over the 15 years of evolution of the Canada Land Data System. The *destination* of the system moves from the simple *inventory* stage through *analysis* to the most advanced and complex *management* stage. The models of Graafland, and Marr and Benwell describe two different *directions of change* towards a common *destination of change* in local governments in the Netherland and New Zealand respectively. The common destination is having GIS as an integral part of the corporate information system.

Tullock *et al*. (1995) models the initial *direction of change* of multi-purpose land information systems in USA in terms of a database development process. Then the focus of the *direction* is shifted to the services provided by the system, which moves from *recordkeeping* through *analysis* to the *destination* of *democratization.* In the *destination* stage, 'data are manipulated to guide public policy decision-making by public officials and citizens' (Tulloch, *et al.* 1996, p. 489).

3.4.5 Varied Rate of Adoption

The third process in innovation diffusion is the varied rate of adoption of the innovation by members of the social system. By studying the distribution of adoption of an innovation over time by members of a social system, two distinct patterns are observed. One is an S-shape curve representing the pattern of cumulative increase of adopters. The other is a bell-shaped curve that approaches a normal distribution curve, representing the pattern of distribution of new adopters. The two curves represent the two sides of the coin of distribution of adopters over time.

In general, for each S-shaped curve, there is an initial gestation period when the adoption is limited and slow. Once a critical mass of adoption is reached, a rapid and dramatic increase in adoption ensues, and is followed by a period of saturation in which the rate of adoption levels off. The S-shaped curve for each innovation is unique. The curves may display a gentle or a steep slope, representing a slow or drastic change in the rate of adoption respectively.

Based on the bell-shaped distribution curve of new adopters and established statistical principles, five ideal types of adopters can be identified based on their relative positions along the curve and the percentage of the total population. In order of earliness of adoption, the five types of adopters are *innovators* (2.5%), *early adopters* (13.5%), *early majority* (34%), *late majority* (34%), and *laggards* (16%). The innovators are the first to adopt an innovation while the laggards are the latest. Though these adopter types are statistically derived, each has been associated with a unique combination of socioeconomic status, personality variables and communication behaviour patterns.

3.4.6 GIS and Varied Rate of Adoption

Application of the theories of the varying rate of adoption by members of a social system to GIS diffusion is only a recent development. Through research involving local government, researchers are reporting that cumulative GIS adoption in European local government follows an S-shaped curve (Graafland 1996, Junius *et al.* 1996, Masser and Campbell 1996). The countries involved are still in the phase of rapid expansion and have not yet reach saturation.

3.4.7 Limitations of Time Related GIS Diffusion Research

The key limitation of time related GIS diffusion research in general concerns the scope of the research. So far, most effort is concentrated on the organisation innovation process of GIS. Relatively little work is done in connection with the remaining two processes of diffusion, that is, the innovation decision process, and the varied rate of adoption of GIS. Based on the experience of innovation and socio-technical systems research (Goodman 1993, Rogers 1993), research in the organisation innovation process of GIS is found to suffer from an important drawback, namely, *pro-innovation bias*.

> *The pro-innovation bias is the implication in diffusion research that an innovation should be diffused and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should neither be re-invented nor rejected.*
>
> (Rogers 1995, p. 100)

The pro-innovation bias suggests that the process of diffusion is linear and deterministic, following a specific path/direction. The cause for any form of failure is not perceived as the inappropriateness of the innovation, but some problems with the people and organisational factors involved. This deterministic approach distorts the way outcomes of GIS diffusion research are interpreted, and at best, would slow down the understanding of the diffusion process.

The presence of pro-innovation bias in past GIS diffusion research is confirmed indirectly by recent research findings. These findings suggest that diffusion of GIS in an organisation is a social interactionist process, that reinvention does take place in the process, and that the outcome of diffusion cannot be certain (Campbell 1996a, Campbell 1996b, Campbell and Masser 1995). The bias is particularly evident in the managerial rationalist view and the evolutionist view of the organisational GIS process described earlier in this section.

In the managerial rationalist view, many of the models are put forward as recipes for successful GIS implementation. These models are developed implicitly or explicitly from the system development methodology and enriched by personal experiences of working on one or more cases/projects. Though useful to the often over-worked managers as a guideline to implementation, there is no guarantee that application of the models will lead to success. These models also provide little insight into why and how GIS diffusion actually takes place in an organisation.

In the evolutionist view, the organisational GIS process is described in term of a pre-determined direction of development (series of stages) to achieve a pre-determined destination (state of development). The underlying assumption is that people need the GIS and GIS development will progress from one prescribed stage to another until the pre-determined state of development is reached. The evolutionist view is clearly affected by pro-innovation bias, albeit a different form.

The models in the evolutionist view have an additional limitation. These models are originally proposed for systems developed in a specific environment to achieve a specific destination/purpose. These specific aspects of the models may be made out-of-date by the changing technical, economical, social, and political environments over time, and thus reducing/nullifying the value of the models. The risk of becoming outdated is well illustrated by the need for Nolan to add two extra stages to his 1973 model on the advent of database management technology (Nolan 1979).

The approaches of and the purposes served by the models in the evolutionist and managerial rationalist views suggest that the pro-innovation bias is not simply a bias that has been overlooked. In these views it appears to be a philosophy of model design. Obviously they have a value in helping people understanding GIS diffusion/ development in specific circumstances. However, their value to aid understanding of GIS diffusion in general is limited.

What is left of the three views is the diffusion theory view. Models developed in this view aim at describing the generic sequential events that take place in GIS diffusion. Unlike the other two views, pro-innovation bias is not built into the models. By acknowledging the bias and taking appropriate precautions to avoid it in the design of studies, its impact can be minimised. Therefore, the diffusion theory view represents a potentially good approach to describe the process of GIS diffusion.

In this view the model by Campbell and Masser is developed primarily to illustrate the 'umbrella' concept of GIS diffusion (Campbell and Masser 1995, p. 5) but not to describe the process of GIS diffusion in an organisation. Azad's model is still at an early stage of development with little detail for the diffusion process in general and reinvention in particular. The model by Anderson is well developed with extensive details. It also has an in-built iterative process to accommodate reinvention. However, the model is complicated and has not been subjected to rigorous testing. Also it does not make allowance for failure of diffusion and for determining when diffusion of GIS is considered complete. 'Complete' here refers to the termination of diffusion on both the occasions of failure or successful completion of the process. Therefore, though Anderson's model is potentially a good model of the organisational innovation process of GIS, this thesis still adopts the generic model for innovations developed by Rogers (Figure 3.2) to support discussion on GIS diffusion later on. Rogers' model has the merit of being simple, well-known, comprehensive and has a sound theoretical base.

The weakness of Anderson's model is not unique to the model but constitutes a general limitation of time related GIS diffusion research. Zaltman *et al*. identify this limitation when they point out that instead of having a clear 'beginning' and 'end',

> *...the process of innovation is probably "circular" in that each solution or outcome of the process "feeds back" into the adoption unit in the form of new problems (perceptions) which require attention.*
>
> (Zaltman, *et al.* 1973, p. 70)

Zaltman *et al*. do not elaborate on what that 'solution or outcome' is and when it can leave the process and be fed back into the process as new problems. However, their observation does point towards the inclusion of a feedback loop in the organisational innovation process. In case the first pass of diffusion is a failure, this loop provides an exit to allow diffusion to start all over again. This loop also helps to alleviate the impact of pro-innovation bias by accepting that failure of diffusion is possible. This modification to the model of the organisational innovation process still leaves one issue outstanding—when is diffusion considered complete?

The last stage of Rogers' model of the organisational innovation process is *routinizing*. By routinizing, the innovation is taken to lose its identity as an innovation and the process is considered complete. This implies that an innovation such as GIS has to be quite clearly defined at the beginning. However, as discussed in the section 3.2, it is not always possible to clearly identify a GIS innovation on account of reinvention, technology cluster, and the objective and social meanings of innovation. As a result, the issue raised in section 3.2 concerning the element of innovation—establishing the identity of GIS—is also relevant to time element related diffusion research.

3.4.8 Section Summary—GIS and Time

Time related diffusion research could broadly be grouped into studies that concern three processes of diffusion: *innovation-decision process, organisational innovation process,* and *varying rate of adoption among members*. Researchers of GIS diffusion have done minimal work on the innovation-decision process apart from the early investigation of the impact of personal factors on innovativeness. Some useful work has begun in the study of the pattern of varying rate of GIS adoption, primarily among local government agencies in the European context. The bulk of research into the time element of the diffusion paradigm concerns three views of organisational innovation process of GIS, that is, diffusion theory view, managerial rationalist view and evolutionist view.

The diffusion theory view is the approach that attempts to describe the generic relation between GIS and the organisation over time during implementation. The managerial rationalist view is geared toward successful development of GIS in organisations. The evolutionist view has an in-built direction and destination of GIS development and is suitable to describe GIS development under specific circumstances.

Pro-innovation bias, which is a limitation of innovation and socio-technical systems research in the past, is also an issue in work concerning organisational innovation process of GIS. But models in the diffusion theory view are considered less susceptible to the bias. The model by Anderson in particular is considered potentially very valuable in the understanding of GIS diffusion in organisations. However, the model does not make allowance for failure of diffusion and for determining when diffusion of GIS is considered complete. It is argued that the inclusion of a feedback loop in future models of the organisational innovation process of GIS could cater for the situation of diffusion failure. By accepting that failure is possible, the loop also help alleviate the impact of pro-innovation bias. It is also pointed out that to help decide when GIS diffusion is complete, prior establishment of the identity of a GIS is critical.

3.5 Social System

> *Social systems should be understood here in a broad sense as ensembles of interrelated elements, including institutions, modes of production, forms of life, patterns of distribution, sets of values and beliefs, and theorized systems, from dyads to the world system.*
>
> (Therborn 1994, p. 283)

The quote from Therborn above gives a theoretical definition of social systems. In a functionalised way, (Rogers 1995, p. 23) defines a social system as ‘a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal’. The units may include individuals, informal groups, organisations, or any sub-systems. Innovation diffusion is also found to be affected by different aspects of the social system. These aspects include special individuals such as opinion leaders, change agents and their aides, types of innovation-decisions involved, the consequences of the innovation, and the structure, the norms and culture of the social system. The description of the different aspects of the social system element in this section is based on a summary by Rogers (1995).

3.5.1 Special Individuals and Types of Innovation-Decision

Special individuals here refer to *change agents* (or *champions)* and *opinion leaders*. A change agent is someone who works with members of a social system to change their innovation-decision in the direction favoured by the change agency. This agency may be inside or outside the social system. The rate of diffusion is affected by the effort put in by the change agent and the associated strategy. A special kind of change agent that holds a senior position in the organisation is called a *champion*. A champion is someone who is seen to have the charisma to 'transform a seemingly apathetic environment into an innovative and progressive organisation' (Campbell and Masser 1995, p. 139). Such a person is seen as instrumental in gaining approval for the purchase of GIS technology and in supporting the implementation process throughout.

The change agent often works through opinion leaders in the system. These leaders are role models to the members in the system. Their status is gained and maintained by these individuals' technical competence, social accessibility, and conformity to the system's norms. If the change agent can convince the opinion leaders to adopt an innovation, there is a good chance that other members will follow. Sometimes, these opinion leaders may represent the change agencies outside the social system.

Depending on who makes an innovation-decision and how the decision is made in a social system, four types of decisions can be identified. They are *optional*, *collective*, *authority* and *contingent innovation-decisions*. The first three types of decision are made by individual members, all the members, and a few social and technical elites of a social system respectively. Contingent innovation-decisions are decisions by individuals that can only be made after a prior innovation-decision, either a collective or authority innovation-decision. In this aspect, the characteristics of the unit or collection of units making the decision will affect the decision process.

3.5.2 GIS, and Special Individuals and Types of Innovation-Decision

As already reported in subsection 3.3.4, study of opinion leader has started (Assimakopoulos 1997). The role of change agent in general has also been examined, albeit briefly by Ventura (1995). However, the role of champion has been well documented (Bundock 1996; Azad and Wiggin 1993; Obermeyer 1995). Some researcher have even queried the importance of a champion in sustaining the diffusion of GIS in an organisation (Onsrud and Pinto 1993; Campbell and Masser 1995).

Ventura's research (1995) also brings into light the impact contingent innovation-decision has on GIS diffusion. Ventura finds that the decision to participate in a sharing initiative is contingent upon a prior decision to adopt GIS. Even under a perceived low risk and high benefit situation, if an organisation has not decided to adopt GIS in the first place, it is difficult to expect it to embrace the concept of geographic information sharing. This observation highlights that contingent innovation-decision like adoption of GIS by an organisation can affect GIS diffusion.

3.5.3 Consequences of an innovation

The consequences of an innovation to a social system and its members will directly determine if the innovation will continued to be adopted. Three groups of consequences can be identified depending on whether they are *desirable*, *direct* and *anticipated*. Positive consequences will generally encourage continued adoption and vice versa.

3.5.4 Consequences of a GIS innovation

In general, researchers study the consequences of GIS innovation by first looking at benefits of GIS (Onsrud, *et al.* 1989a). They identify different types of benefit associated with the GIS implementation process and describe how these benefits can be assessed. For example Budic (1994) identifies *operational efficiency, operational effectiveness*, *program effectiveness*, and *contribution to well-being* as the four categories of benefit of GIS to an organisation. Pinto and Onsrud (1995) suggest viewing outcomes in terms of *efficiency*, *effectiveness*, and *enhanced decision making,* while Dueker and Vrana (1995) suggest *efficiency*, *effectiveness*, and *enterprise*.

These benefits are called differently but are often *desirable, direct* and *anticipated* in nature. They are relatively easy to determine and are use for primarily for justifying GIS (Chan 1994) and for monitoring the success of innovation (GIS) implementation (Goodman 1993). Normally, after having assessed these more obvious consequences, *indirect*, *undesirable*, and *unanticipated consequences* are tackled.

3.5.5 Structure, Norms and Culture of social system

The structure of a social system is a cocktail of many different patterned arrangements of units, such as the social structure, communication structure and authority/hierarchical structure. It governs what, how and why information flows to and from a unit of the social system and therefore affects the rate of diffusion. Rogers observes that few studies are made to examine the relation between the structure of a social system and diffusion. This observation is accounted for by the trickiness of untangling the effects of a system’s structure on diffusion independent from the effects of the characteristics of individuals that make up the system. Still, some impact of organisational structure on diffusion is discussed briefly in relation to *innovativeness* of an organisation in subsection 3.4.3.

The norms and culture are the established behavioural patterns that are acceptable to other members of the social system. It dictates the way members will react to a change such as the introduction of an innovation. Whether or not the qualities of an innovation match the norms or culture of a social system will directly affect its adoption.

3.5.6 Structure, Norms and Culture of social system and GIS

In line with the observation of Rogers for diffusion studies in general, little work has been done solely regarding the relation between the structure of a social system and GIS diffusion. Often, a range of factors that also cover the structure, the norms and culture of social systems (usually refer to collectively as organisational factors in the literature) in GIS diffusion are studied together. Identified by individual researchers or groups of researchers as important in successful GIS implementation, Table 3.6 illustrates four different mixes of factors:

- Organisational factors (Croswell 1989)
- Perceived GIS characteristics and organisational factors (Onsrud and Pinto 1993)
- Technical and economic factors in addition to organisational and personal factors (Ventura et al. as quoted in Ferrari and Onsrud (1995)),
- External environment of the organisation and management (Budic 1993) in addition to organisational and personal factors,

The above examples are taken from the North American context. Concurrently with their North American counterparts, European researchers are also examining different types of factors/problems that are affecting GIS diffusion in local government. Table 3.7 summarises the findings of four individual/groups of researchers.

Firstly, Masser and Craglia (1996) compare GIS diffusion in five European countries, namely (in alphabetical order), Britain, Denmark, Germany, Italy, Portugal. These countries have been studied using similar approaches based on the methodology developed in the Department of Town and Regional Planning at the Sheffield University in Britain. Data-oriented, technical and organisational factors are identified. Data-oriented factors concern availability, cost, compatibility, and quality of data. The technical factors are primarily about lack of hardware and software compatibility, lack of user friendliness and hardware reliability. These factors are perceived as more important by smaller municipalities/local government authorities. By far, the most important issues are organisational in nature, particular among large municipalities/local government authorities. The organisational factors are generally similar to those identified in America. They include lack of skilled staff, motivation, and awareness, poor coordination, bureaucratic inertia. In general, few personal factors are reported apart from the personal communication network studied by Assimakopoulos (1996) in Greece.

Table 3.6 Factors studied in GIS implementation research.

(Croswell 1989)	(Onsrud and Pinto 1993)	Ventura et al. in (Ferrari and Onsrud 1995)	(Budic 1993)
Success guidelines:	**Success factors in local government:**	**Organizational keys for MPLIS:**	**Success factors:**
Evaluate organisation risks	Access to learning Ease of use Effects of use	Management support Committees to support MPLIS Cost sharing System location	Personal factors -perceived relative advantage -compatibility with previous experience -attitude towards work-related change
Get management commitment	Cost	Economic factors	-exposure to GIS technology
Assign GIS manager early in project	Utility	-define and document costs and benefits	-communication behaviour
Involve users in design	Benefits to extended users	Technical factors -form & quality of existing records	GIS management -provision of incentives for users
Formulate goal-oriented plan and schedule	Communication channels	-suitability of existing hardware/software	-GIS training -commitment -securing financial resources
Develop a project organization that encourages cooperation and consensus	Compatibility & past success History of past failures	Personal factors -level of education -exposure to & experience with computing & LIS -motivation	-initiate team of manager-technician Organization environment -political support -governmental mandates
Allocate sufficient staff time	Proximity to other users	Personnel factors -competent staff -retain staff	-provision of external funding -size of jurisdiction -rate of growth of jurisdiction
Keep participants informed	Fallback options		Organizational internal context -organizational conflict
Provide education & training at all stages			-organizational change/ stability -motivation to incorporate GIS -resources

Table 3.7 Factors examined in GIS diffusion research in European local government.

Masser and Craglia (1996, p. 225)	Masser (1993); Masser and Campbell (1996)	Campbell (1994)	Graafland (1996)
Perceived problems of GIS diffusion in Europe:	**Predictor of GIS adoption in local government:**	**Success factors in local government:**	**Factors affecting GIS introduction:**
Technical: -lack of user-friendliness	Type of local authority	Simple applications fundamental to the work of potential users	Size of municipality
-lack of SW/HW compatibility	Population size	Users directed implementation	External factors:
-lack of HW reliability	Location in the core or periphery	Awareness of the limitations of the organisation	-supply of hardware/software
Organizational: -lack of qualified/ skilled staff		A high degree of stability/an ability to cope with change	-legislation -de facto standards set by other agencies
-insufficient motivation of staff			**Factors affecting Experience (perceive) GIS:**
-lack of awareness			Level of cost
-poor coordination			Education
-bureaucratic inertia			Complexity
Data:			Organisation (coordination)
-availability			Degree of automation
-cost			
-incompatibility			Automation activities/ time spending
-quality			
Other: -vendors attitudes and limited support			Attitude of personnel, management and the organisation

Secondly, using a different approach, and through conducting 12 case studies, Campbell (1994) identifies four success factors for GIS implementation in British local government. These factors are organisational in nature that concerns the strategic adopted to implement the technology. The factors comprise *simple applications for users*, *users directed implementation*, *awareness of organisational limitations*, and *high organisational stability/ability to cope with change*.

Thirdly, apart from the three sets of factors studied in the Sheffield methodology, three contextual factors that account for more than half the variance of GIS adoption in local government in Britain are also identified (Masser 1993, Masser and Campbell 1996). These factors are *population size*, *type of local government*, and *location in the core or periphery*. Fourthly, Graafland (1996) identifies two major groups of factor: factors affecting GIS introduction and factors affecting experience (perceive) GIS.

In addition to the four sets of factor, European researchers also identify other contextual factors as important in contributing to GIS diffusion. These include: *local government reform* (Ciancarella *et al.* 1996), *local government autonomy and practices* (Junius *et al.* 1996), *coordination by an external authority in producing digital data*, *external sources of funding*, *growing awareness and use of GIS* in society in general (Arnaud *et al.* 1996), and *legislation* (Bartnicka *et al.* 1996).

In fact the contextual factors identified by European GIS diffusion researchers are only the tip of the iceberg. Work is being done world wide to examine the impact of key contextual factors that affect GIS diffusion. These factors concern economic (Coopers & Lybrand 1996, King 1995, Price Waterhouse 1995), policy (Johnson 1995, Lopez 1995, Rhind 1994, Tosta 1994, Williamson *et al.* 1997), and legal issues (Epstein *et al.* 1996, Johnson and Onsrud 1995, Onsrud and Reis 1995, Rhind 1996). The legal issues cover liability, copyright and privacy issues that have all been debated enthusiastically in recent years.

Researchers have also started looking into issues of sharing of geographic information. Many factors/strategies affecting geographic information sharing are found to be common to those of general GIS implementation (Bamberger 1995, Craig 1995, Dueker and Vrana 1995, Obermeyer 1995, Ventura 1995). Good examples include *organisational structure* and *independence/autonomy*, *corporate culture*, *political support/environment*, *turf battles/ distrust*, *organisation inertia*/*resistance to change*, *different requirements of participants, roles of champions*.

Owing to the unique technical and institutional requirements of geographic information sharing, which stress intra- and inter-organisational communication and cooperation (Pinto and Onsrud 1995), there are factors unique to the process. Examples of these factors include *superordinate goals*, *quality of relationships*, *resource scarcity* (Pinto and Onsrud 1995), *role of change agent*, *lines of authority* and *communication* between key actors, *form of overarching body* for data sharing (Ventura 1995), *complexity*, *interdependency*, and *ambiguity* of the sharing system (Meredith 1995). Kevany (1995) identifies and defines nine categories of 30 factors that affect geographic information sharing. The nine categories comprise *sharing classes*, *project environment*, *need for* *shared data*, *opportunity to share data*, *willingness to share data*, *incentive to share data*, *impediments to sharing*, *technical capability for sharing*, and *resources for sharing*. Treating sharing as an inter-organisation relation issue, Azad and Wiggins (1995) identify six reasons for sharing, namely, *necessity*, *asymmetry*, *reciprocity*, *efficiency*, *stability*, and *legitimacy*. They also identify three types of sharing and three stages of sharing.

Owing to the countries' different political culture, legal framework, organisation of the state's bodies, international obligations and history, the individual country's dynamic of GIS development varies (Rhind 1994). Comparative study of GIS diffusion in different countries has been made. In Europe the key distinguishing factors are found to be *level of availability of digital data*, the *level of local government* and the *professions* (such as surveying, planning) *driving GIS development* (Masser and Craglia 1996). Major initiatives such as the ones conducted in North America and Europe lay the groundwork for future research into how the structures, norms and cultures of social systems impact on GIS diffusion.

All in all, a similar range of factors have been found to have impact on the development of GIS in both European and American countries—leaders in GIS research. Research findings of GIS diffusion described above cover factors that not only concern the organisation itself, but the environment created by the larger social system in which the organisation is located. The research activities also examine the technical and data issues of GIS as well as its perceived characteristics. Personal factors or characteristics of individuals who are responsible for GIS implementation are also found to be important. For ease of discussion below, these four groups of factors are called *internal organisational context*, *external context*, *GIS characteristics*, and *personal characteristics* respectively.

3.5.7 Limitations of Social System Related GIS Diffusion Research

A dominant approach to research into the relation between technology and organisation is the contingency theory (Gattiker 1990, Scott 1990). The theory 'emphasizes the interdependence of organizations and their environment' (Lawrence and Lorsch as quoted in Scott (1990, p. 110)). Researchers have been trying to match measures (variables) of technology and organisation structure statistically to account for success or failure of the introduction of technology into an organisation. The results have not been consistent (Scott 1990). Campbell and Masser (1995) observe the same outcome in GIS diffusion research, which leads them to put forward the social interactionist perspective of GIS diffusion. The key assumption of the perspective is that GIS gain meaning only 'as individual staff members in a particular cultural and organizational context interact with them' (Campbell 1996a, p. 104) and as a result, 'an appreciation of the context is fundamental if considerable resources are not to be wasted' (p. 105).

In a similar attempt to tackle the issue, (Scott 1990) argues for the need to study technology–organisation relationships at different levels of organisation and in different configurations of organisation. He further argues for the introduction of political, ideological, cultural, and institutional factors into the causal arena. These confirm the need to better describe the organisational context, both internal and external. According to Goodman (1993), the organisational context comprises among other things, the capabilities of people, culture, organisation strategy, reward systems, technological delivery systems and processes. To determine this context, the first step is to define the appropriate social system in question.

In addition to the issue of describing the social system or organisational context in question, there is also the issue of taking into consideration the time element of diffusion in studies concerning the social system element. In their comparative study of GIS diffusion in European countries, Masser and Craglia (1996) point out that their study is mainly concerned with GIS adoption. They expect the factors affecting GIS implementation to be different from those of GIS adoption. In the initiatives by North American researchers to examine factors and research frameworks concerning geographic information sharing, the sharing process is recognised as a special issue (Goodchild 1995b). The process is also considered an integral part but more advanced stage of GIS implementation (Ventura 1995), and thought to involve a different set of success factors (see subsection 3.5.6). The findings by European and North American researchers suggest that there is a different set of success factors for each stage of the organisational innovation process of GIS. As a result, a better understanding of GIS diffusion will require integrated studies involving the elements of time and social system of GIS diffusion. A good example is to examine success factors in the context of the sequential stages of the organisational innovation process of GIS.

Actually some GIS researchers have already recognised the need for an integrated research framework to study the time and social system elements of GIS diffusion. Azad (1993) proposes a meta-framework, which is a matrix comprising organisational context (social system) and theoretical stages of innovation (time). The items to be studied in the organisational context are *task*, *technology*, *structure*, *people,* and *environment*. The stages of innovation are *initiation*, *adoption*, *implementation*, and *routinization*.

Anderson (1996) recognises that the content and process models described by Onsrud and Pinto (1993) are two different routes of achieving the goal of successful GIS implementation. Anderson suggests that five issues of GIS development—*people*, *organisation*, *goals*, *change*, and *technology*—interact with each other in three stages of technology transfer—*initiation*, *acquisition*, and *incorporation*. The five issues are tackled in five inter-related phases of activities named respectively as *participation*, *context evaluation*, *vision creation*, *change*, and *technology implementation*. The five phases of activities and three stages of technology transfer constitute the *GIS development process matrix* which is a framework proposed for considering a broad array of critical GIS technology-transfer issues by studying the time and social system elements of diffusion in an integrated manner.

3.5.8 Section Summary—GIS and Social System

Studies to examine the roles of special individuals, the nature of GIS decisions, and the nature of different benefits in diffusion have begun. However, more work is needed to improve the understanding of GIS diffusion in these areas.

The thrust of GIS diffusion research into the element of social system concentrates on the aspects of structure, norms and culture of the organisation. Factors in these aspects are often studied in conjunction with factors relating to other elements of diffusion. All together four different categories of factors have been identified/studied. They are *GIS characteristics*, *personal characteristics*, *internal organisational context*, and *external context*. Though some important individual relationships have been established, there is still significant variability in the relationships identified. Few relationships are generalisable across the range of GIS environments. The social interactionist perspective of GIS development can account for this. The need to define the organisational context more clearly is identified as an aid to the study of GIS diffusion.

Different stages of GIS diffusion are affected by a different set of success factors. This points to the need to conduct integrated studies involving the elements of time and social system in GIS diffusion research. Two separate research frameworks have already been proposed to address the need.

3.6 GIS Diffusion Research in Perspective

The diffusion paradigm developed from innovation research can help reduce uncertainty (Rogers 1995) when planning research into the uptake and utilisation of programmable, and multi-purpose innovations such as GIS. The paradigm provides a theoretical framework for examining the various aspects of adoption and implementation of GIS. This framework, supplemented by the experience of socio-technical systems research, can be used to assess the current achievement of GIS diffusion research.

3.6.1 Elements of GIS diffusion

Much of the past effort of GIS diffusion research had been to derive formulae or strategies of success. The work mainly surrounded certain aspects of the elements of time and social system of the diffusion paradigm. In recent years, studies into the elements of innovation and communication channels also have begun. Important groundwork has been laid. Currently GIS diffusion research has expanded into each of the four elements of the diffusion paradigm. The time is ripe to say that, based on Rogers's definition of innovation diffusion, GIS diffusion is *the process by which an innovation of GIS is communicated through certain channels over time among the members of a social system*. It can also be concluded that the four elements of the diffusion paradigm also constitute the elements of GIS diffusion. This conclusion thus fulfils the first objective set in Chapter 1 for this thesis—to understand what elements are involved in the process of GIS diffusion.

3.6.2 Current approach of GIS diffusion research

While progress is being made in research concerning the four elements of GIS diffusion, the bulk of achievement is in the time and social system elements. From time related GIS diffusion research, it is recognised that GIS diffusion in an organisation is a multi-stage process. However, there is still no agreement on a model of the process for GIS. Researchers have recognised that there are two basic stages of diffusion: adoption (initiation) and implementation (Masser and Craglia 1996, Onsrud, *et al.* 1989b, Onsrud and Pinto 1991). There appears to be a lowest common multiple for a staged model of GIS diffusion in an organisation. Pending the development of a more formal model, it can be assumed that a working staged model is made up of two stages, namely, *initiation*, and *implementation*, which are separated by the *decision* to adopt GIS.

From social system related GIS diffusion research, it is also recognised that each stage of GIS diffusion in an organisation is affected by a certain combination of four categories of factors, namely, GIS characteristics, personal characteristics, internal organisational context, and external context. Figure 3.3 summarises the current approach of GIS diffusion research, highlighting the trend to study the impact of the four groups of factors on the success of individual stages of GIS diffusion in an organisation.

3.6.3 Approach of GIS diffusion research in future

Based on the limitations of research into the four elements of GIS diffusion discussed in the preceding sections, two main types of limitations can be identified. One is the need for more research effort in certain areas. The other type is the limitations inherent in the approach to research. If the latter limitations are tackled properly in future design of GIS diffusion research, significant insight into GIS diffusion is expected. Therefore this subsection looks at how these limitations can be addressed.

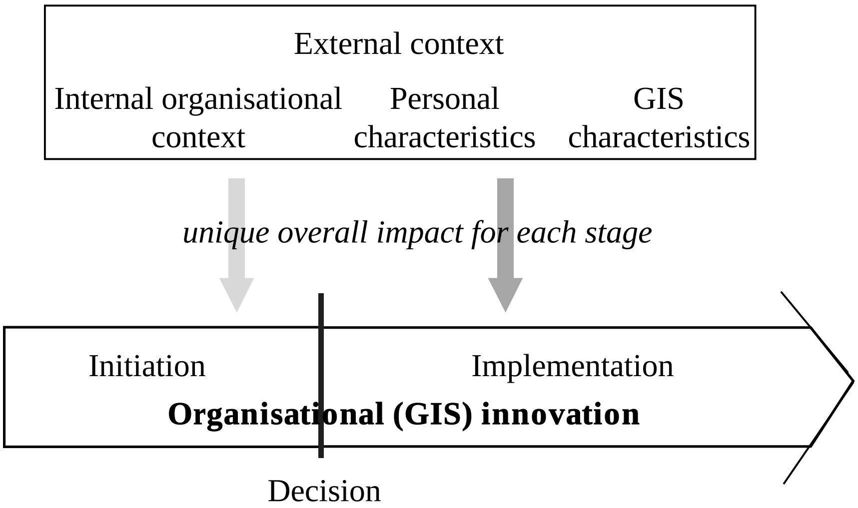


Figure 3.3 Current approach of GIS diffusion research

The limitation of the research into the element of innovation is the vague and changing identity of GIS in the course of its diffusion in an organisation. A way is needed to better establish the identity of GIS in the context of the organisation, and to accommodate the fact that GIS undergoes reinvention in the process of diffusion.

Pro-innovation bias is the primary limitation of research into the time element. To address this limitation, one must be acknowledge that failure is a normal part of GIS diffusion process. One way of acknowledging failure in the process is to introduce a feedback loop to the future models of organisation innovation process of GIS. This allows GIS that has failed in its diffusion to exit from the process. A secondary issue that stems from this solution is to find a means to clearly identify the GIS at the beginning of the diffusion process—a limitation under the innovation element. The means is needed to help determine the completion of the diffusion—success or failure.

One important limitation of research into the element of social system is the inconsistency of the results of the research. There are two possible causes of this problem. One is the insufficient definition of the organisational context in which diffusion takes place. The solution is to properly define the boundary of the organisation in study. The other cause of the problem is change of the organisational context over time. The solution is to integrate study of the elements of time and social system. To address the limitations of GIS diffusion research, the current approach will have to be modified as illustrated by the integrated research framework in Figure 3.4.

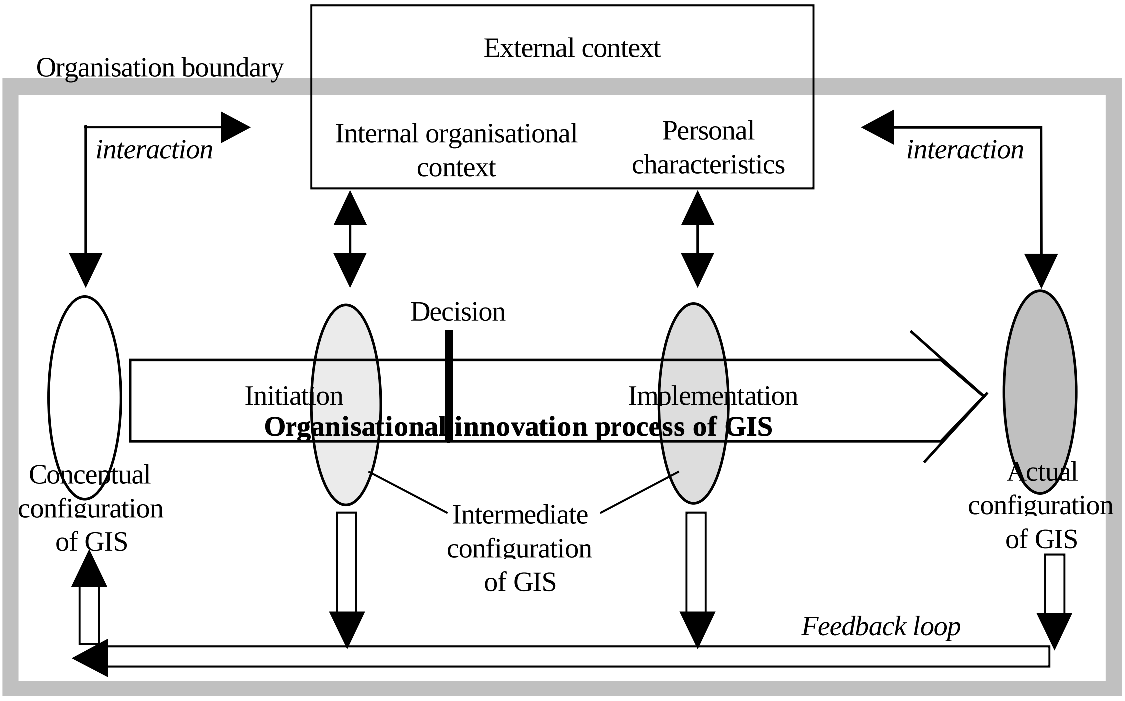


Figure 3.4 An integrated framework for GIS diffusion research

In Figure 3.4, GIS is not merely viewed as a set of uniform characteristics as perceived by the stakeholders. Instead, it is a dynamic entity that is central to the diffusion process. This entity assumes multiple identities or configurations as diffusion progresses over time, as represented by the simplified staged model of GIS diffusion. The characteristics of this entity change as it passes from the initial conceptual configuration, through one or more intermediate configurations, to an actual physical configuration of GIS that serves the needs of the organisation. Whether diffusion has failed or successfully completed, there is a feedback loop to allow the process to start all over again. Each configuration or identity of GIS now represents an entity that has its unique set of characteristics. Each configuration can affect and be affected by (interact with) other factors.

The introduction of the series of GIS configurations is accompanied by the introduction of an organisational boundary that demarcates the internal and external organisational context and thus the internal and external contextual factors. This is necessary, as the configuration of a GIS in one organisational context may be different from that in another context. For example, the GIS for a natural resources management department in a state government may be quite different from that for a surveying or engineering department. Likewise, the GIS for two natural resources management department in different state governments may also be different. Any factors outside that boundary are external contextual factors. The boundary also distinguishes an organisation from its parent establishment, for example, a department in the institution of a state government, or an office in the state government department. Admittedly, the boundary may be arbitrary in nature, but it helps to focus attention on the organisational context in study and thus help define the GIS in question.

3.6.4 The hypothesis

This chapter provides an overview of GIS diffusion research. Based on the limitations of the research identified, a new approach to conducting GIS diffusion research is described. The new approach involves a more complicated identity of GIS that is specific to the organisation in study, that changes over time in the course of diffusion, and that supports future integrated GIS diffusion research involving two elements of GIS diffusion, namely, time and social system.

The dynamic organisation-specific GIS plays a central and interactive role in GIS diffusion research. The inherent qualities of this GIS will significantly affect the outcome of diffusion. Therefore it is crucial to be able to clearly define the identity of this GIS. This will allow managers and researchers to better determine the causal relationships in GIS diffusion, to decide when the diffusion process starts and ends, and to relate causal relationships back to a particular identity/configuration of GIS to facilitate comparison of findings over time and from different research initiatives.

At this point, the chapter has established the theoretical background in support of the hypothesis of this thesis:

> *Diffusion of GIS in an organisation is affected by the qualities of GIS as seen in the context of the structure of the organisation.*

The next step is to determine the qualities of the organisation-specific GIS and how these qualities will affect diffusion of the GIS.

3.7 Chapter Summary

This chapter relates GIS diffusion research back to its grounding disciplines, namely, innovation research and socio-technical systems research in the disciplines of organisational behaviour and information systems. The chapter then provides an overview of the four elements of the diffusion paradigm of innovation research, that is *innovation, communication channels, time* and *social system.* This overview is supplemented by the experience of socio-technical systems research. Concurrently, the chapter also briefly describes the findings of GIS diffusion research with respect to the four elements.

Under the element of innovation, studies into the impact of the characteristics of GIS on the rate of its adoption have begun. More work is still required. The vague and changing identity of GIS is found to be an issue. A better way to identify GIS is needed. Under the element of communication channels, though research is generally superficial and not part of main stream GIS diffusion research, systematic study of the different aspects of the communication channels in terms of GIS diffusion has been started.

Under the time element, researchers have started investigating the impact of personal factors on GIS adoption decisions. Apart from that, minimal work has been done on the innovation-decision process. Some useful work has begun in the study of the patterns of varying rate of GIS adoption, primarily among local government agencies in Europe. The bulk of research into the time element of GIS diffusion concerns the organisational innovation process of GIS. The outcome of research is grouped into three views of describing the staged development of GIS. The three views are: *diffusion theory*, *managerial rationalist*, and *evolutionist*. The value of the managerial rationalist view and the evolutionist view in the study of the organisational innovation process of GIS is severely restricted by their strong *pro-innovation bias*. Being less affected by the bias, models under the diffusion theory view have the potential to evolve into a generic model for the organisational innovation process of GIS. To address the problem of pro-innovation bias, acknowledging the existence of diffusion failure and providing a feedback loop to allow failed diffusion to start again are suggested. To help decide when diffusion has completed or failed, a better way to identify GIS is considered necessary.

Under the element of social system, work has started to examine the impact of special individuals, the types of GIS innovation-decision, and the types of consequences on GIS diffusion in an organisation. However, the emphasis of research is on the structure, norms and culture aspects of the element of social system. This research has identified four different categories of factors affecting GIS diffusion. They are *GIS characteristics*, *personal characteristics*, *internal organisational context*, and *external context*. Many causal relationships have been identified for GIS diffusion but few are generalisable across the range of GIS environments. According to the social interactionist perspective of technology/GIS development, the solution rests with better definition of the organisational context. The first step is to clearly describe the organisation in study. The need for integration of research into the time and social system elements is also recognised.

Based on the scope of GIS diffusion research to date, the chapter concludes that the elements of diffusion paradigm are also applicable to GIS diffusion. GIS diffusion can be defined as *the process by which an innovation of GIS is communicated through certain channels over time among the members of a social system*. By identifying the elements of GIS diffusion, the first objective of this thesis is fulfilled.

To address the limitations of current GIS diffusion research and to accommodate the trend of GIS research, an integrated framework of GIS diffusion research based on a well-defined organisational boundary is suggested. The research framework suggests that GIS, as a dynamic entity, is central to GIS diffusion research. It is necessary to find a better way to identify GIS over time and within a pre-defined organisational context. At this point, the chapter has provided the necessary theoretical background in support of the hypothesis of this thesis and paves the way for further discussion ahead.

Chapter 4
GIS in an Organisation

4.1 Introduction

Chapter three has established the theoretical background in support of the hypothesis this project sets out to prove. This chapter takes the project one step further by defining what a GIS in an organisation is made up of, and describing how the qualities of the GIS can affect its diffusion. This helps to fulfil the second objective of this thesis—'to identify and test the qualities of GIS that can improve the understanding of GIS diffusion'.

4.2 Definitions of GIS and GIS Diffusion Studies

4.2.1 Significance of definition of GIS

Managers undertake significant planning and justification when trying to introduce GIS into an organisation (Aronoff 1989, Onsrud and Pinto 1993, Somers 1996). This starts in the *initiation* stage in which managers inform senior managers and other stakeholders about the concepts and benefits of GIS, and try to persuade them the technology is needed. Since many stakeholders are not experts in GIS, their perceptions of GIS are often based on their interpretation of the managers' definition of GIS. These perceptions of the characteristics of GIS will later affect the stakeholders' decisions regarding GIS adoption as found by Onsrud and Pinto (1993) and shown in Figure 3.1.

During the *implementation* stage, managers implement strategies to develop a GIS that is broadly in line with their definition of GIS (see for example Tomlinson Associates Ltd. (1993c)). The characteristics of GIS as perceived by the stakeholders, which may be different to those of the GIS managers, can lead the stakeholders' to oppose GIS implementation strategies (Campbell 1996a, Goodman 1993). Since both strategies of managers and characteristics of GIS as perceived by stakeholders originate from a definition of GIS, definitions play a fundamental role in GIS diffusion in any organisation. A holistic understanding of GIS diffusion therefore requires understanding of how both managers and other stakeholders view GIS.

As an initial step to achieve this understanding, it is necessary to identify the quality of GIS that is neutral to and yet can be related to by both parties. One such quality is the role a GIS plays in the business process that an organisation undertakes. Based on this quality, it will be possible to design studies to compare how the two parties view GIS in future. This chapter explores how such a quality can be identified.

4.2.2 Conditions governing identity of GIS in diffusion

Based on Rogers' organisational innovation process, two theories that underpin GIS diffusion in organisations deserve attention. First is the *performance gap* theory which requires that GIS, as an innovation, addresses a performance gap which is identified in the organisation in the form of actual problems or potential areas of improvement. The gap may be identified prior to or after the organisation becomes aware of GIS. Second is the *reinvention* theory, which suggests that in the process of being accepted, the identity of GIS changes together with the organisation during the *redefining/restructuring* sub-stage of implementation. These two theories (Rogers 1995) establish some conditions that govern the identity or definition of GIS and are critical to GIS diffusion research.

By requiring GIS to address a set of problems identified during the *initiation* stage in diffusion, a specific identity is given to the GIS. The stakeholders of the GIS project are also broadly defined by virtue of their relationship with the problems. The different interests that these stakeholders represent underpin their interaction, which in turn drives the diffusion (Goodman 1993). Though GIS undergoes reinvention in the *redefining/restructuring* sub-stage, on completion of its diffusion, it should still address the same set of pre-defined problems established during the *initiation* stage. In the process of reinvention, any excessive change to the problems being addressed will alter the identity of GIS and the combination of stakeholders. The resulting change in the dynamics of interaction between the stakeholders suggests that the initial set of assumptions adopted when designing the diffusion study may no longer be valid. This necessitates a re-design of the study. Otherwise, many causal relationships of diffusion, which are predicted or identified on the basis of the initial assumptions, will be open to challenge.

4.2.3 Scenarios of GIS Diffusion

Apart from laying down conditions for GIS diffusion research, the *performance gap* theory also provides the theoretical base to identify scenarios of GIS diffusion according to the nature of problems being addressed. The theory requires that GIS as an innovation should address one or more problems recognised by the organisation. These problems can be well defined and focused on specific business functions or they can be broad and fussy and have a strategic significance that has an impact across the organisation. Based on the nature of the problems addressed, two contrasting scenarios are identified and described below using the experience of GIS development in the State

Government of Victoria in Australia. These scenarios represent homogeneous diffusion environments that facilitate prediction and interpretation of the outcomes of GIS diffusion research.

The first scenario is called a *focused* scenario in which a GIS is developed to address a set of highly focused problems. The problems are so well defined that operationally the composition and technical capabilities of the technology can be specified early on. A School Assets Management System that was developed in the early nineties in the Department of Education in Victoria is a good example (Ward undated). It was an independent GIS in the Directorate of Schools developed to facilitate management of state schools in areas such as assets and security management, and management of cleaning contracts.

The second scenario is called a *dispersed* scenario in which the problems addressed are often strategic in nature and have wide implications. A *corporate/enterprise* GIS is a typical example of GIS in this scenario. Common problems addressed by a corporate GIS include elimination of duplication, acceleration of development and promotion of data sharing (Levinsohn 1997). These problems have such general and wide impact, and the resource implication is often so great that there is significant uncertainty about the long-term composition and technical capabilities of the required GIS.

An example of the corporate GIS in a *dispersed* scenario is the GIS proposed for the State Government of Victoria in 1993. The key problems addressed in a strategy developed by a group of consultants for the government (Tomlinson Associates Ltd. 1993c) were data sharing and cost reduction (Williamson, *et al.* 1998). This strategy was meant for the whole of government, yet it covered only those sectors of government that already had an interest in GIS. Even the departments in these targeted sectors had different needs for GIS, and varied experiences of GIS utilisation. The scale and complexity of the issues involved were great, and the resources implied were significant. This resulted in great uncertainty in the final identity and capabilities of the required GIS.

Instead of describing an independent government wide system, the strategy identified the GIS as a collection of 61 information products and associated datasets for the departments studied. It identified a list of strategic elements to support development of the information products. Success was conditional upon a list of 'Requirements for Going Forward' that specified the organisational setting required (Tomlinson Associates Ltd. 1993c, p. 5) as well as many other technical and institutional issues. The uncertainty of implementation was so great that the GIS was disaggregated into two main parts. The State GIS coordinating agency concentrated on developing a core set of shared spatial digital data called the State Digital Map Base. The departments involved were left to develop their individual GIS under the loose coordination of the agency.

This section has set the scene for GIS diffusion research and described the role of GIS definition in the research. The next section reviews the different perspectives on the nature of GIS as described by managers in the literature. These perspectives underpin the different identities of GIS portrayed by managers when they try to introduce GIS into an organisation over time and under different conditions.

4.3 Definitions of GIS

Maguire (1991) reviews the definitions of geographic information systems used by managers (or their collaborators). In the process he also identifies the unique characteristics of GIS. He concludes that a composite approach in which all the ideas about GIS are summarised in a series of views is the only satisfactory way to define GIS. Maguire has actually described three perspectives on the nature of GIS that underpin various definitions of GIS, namely, *identificational*, *technological*, and *organisational* perspectives.

4.3.1 Identificational Perspective of GIS

The *identificational* perspective describes the unique features of GIS that distinguish GIS from other types of information systems. This perspective gives GIS its special identity to justify separate attention needed from people during GIS implementation. The characteristics of GIS are ‘the general focus on spatial entities and relationships, together with specific attention to spatial analytical and modelling operations’ (Maguire 1991, p. 17). These characteristics are echoed by Obermeyer and Pinto (1994) who specify spatial referencing as an organising framework for the data. Huxhold and Levinsohn (1995) expand the framework to include geo-coding, geo-referencing and topology. In short, the unique features of GIS are:

1. Data of entities and relationships managed within a spatial framework; and
2. Ability to perform spatial analyses.

Here spatial analyses include operations that range from simple querying functions that return data to answer simple locational and conditional questions, to complex modelling processes (Rhind 1990 quoted in (Maguire 1991)). With data about entities and their relationships managed within a spatial framework, any computerised system that provides an answer to a simple question of ‘what is at location X?’ is a GIS.

4.3.2 Technological perspective of GIS

Maguire (1991) broadly identifies two perspectives on the nature of GIS, namely, the *technological* and *organisational* perspectives. Cowen's (1988) four approaches of defining GIS are good illustrations of the *technological* perspective. The first approach is a process-oriented approach that emphasises the capabilities of GIS to handle information (such as storage, retrieval, manipulation, and display of geographic data). The second is an application approach which groups information systems according to the problems they seek to address (such as soil, land, and planning information system). The third is a toolbox approach that emphasises the generic aspects of GIS as a toolbox to manipulate spatial data. The fourth is a database approach that regards GIS as a database system.

Within this perspective, Maguire (1991) identifies three views of GIS with each view focusing on one functional aspect of GIS. The *map* view provides inventory function such as data querying. The *database* view is concerned with simple analysis, such as overlaying, buffering. The *spatial analysis* view focuses on more complex analytical functions such as modelling and decision making.

Embracing all the above views and approaches, the *technological* perspective describes GIS as a certain form of technology (database, application, or toolbox) that provides specific functional capabilities (map, database, and spatial analysis). While the *identificational* perspective deal with specialised concepts such as geo-referencing and topology, the *technological* perspective portrays GIS as a tangible operational system that people can related to from their daily experiences.

4.3.3 Organisational Perspective of GIS

Carter (1989, p. 3) defines GIS as 'an institutional entity, reflecting an organizational structure that integrates technology with a database, expertise and continuing financial support over time'. Maguire (1991) regards Carter's definition as being representative of the *organisational* perspective but does not elaborate on its meaning.

By examining Carter's definition, two characteristics of the *organisational* perspective can be identified. First, GIS is described in terms of its generic elements, or building blocks—an approach also used by other researchers (Dangermond 1988, Dickinson and Calkins 1988). What distinguishes Carter's perspective from these researchers' is the second characteristic—inclusion of the organisational or institutional implementation environment in the definition.

Following the recognition of the importance of a National Spatial Data Infrastructure (NSDI) by the Government of United States of America (Executive Order of the White House 1994), the *organisational* perspective has gained popularity (Chan and Williamson 1995a, Huxhold and Levinsohn 1995), particularly in describing NSDI (ANZLIC 1996, Federal Geographic Data Committee Undated).

The five elements of *organisational* perspective suggested by Chan and Williamson (1995) include *data, information technology, standards, people with GIS expertise* and *organisational setting*. The scope of these elements as detailed in Table 4.1, covers most of the elements suggested by other researchers and is a useful illustration of the organisational perspective of GIS.

Table 4.1 Elements of a GIS (Source: Chan and Williamson (1995)).

Elements of a GIS	Scope of Each Element
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 the 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 GIS 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.

4.3.4 Section summary—definition of GIS

Three perspectives on the nature of GIS that underpin existing definitions of GIS have been identified in the literature. The *identificational* perspective establishes the uniqueness of GIS. The *technological* perspective describes GIS as a tangible operational system providing specific functional capabilities. The *organisational* perspective highlights the multi-element nature of GIS, emphasising the organisational environment as an integral element.

4.4 Perspectives on the nature of GIS and GIS Diffusion

With the three perspectives on the nature of GIS described in the previous section, this section explores their value in identifying GIS and tracking its reinvention in the course of its diffusion. For ease of discussion, Rogers' model of the organisation innovation process (Figure 3.2) is used here to represent the process of GIS diffusion in an organisation (see section 3.4.7 for justifications). The utility of each perspective in each stage and sub-stage of the process is discussed.

4.4.1 In the Initiation Stage

In either one of the two scenarios of GIS diffusion described in subsection 4.2.3, the *identificational* perspective is most important in the *agenda-setting* sub-stage of the *initiation* stage of diffusion. In this sub-stage, the general organisational problems that may create a need for innovation are identified. The primary function of the *identificational* perspective in this case is to raise the general awareness of GIS and succinctly inform people, especially senior management, what GIS is about. It distinguishes GIS from other information systems or technologies that are competing to be the innovative solution. It also underpins other perspectives of describing GIS.

Next in the *initiation* stage is the *matching* sub-stage in which GIS as an innovation will have to be fit with a set of problems. It is at this stage that the technology is packaged into a certain configuration (Goodman 1993) and marketed to the stakeholders. Without such a configuration as a basis for interaction among stakeholders, like embarking on a marketing campaign without a product in mind, there will be no diffusion in the organisation. The *identificational* perspective, while describing the uniqueness of GIS, fails to portray such a working GIS configuration.

In a *focused* scenario, the problems to be addressed are focused and well defined, allowing specification of the composition and functionalities of the GIS. In this scenario, the problems may concern improvement of specific business functions in the organisation for example. In this case, the *technological* perspective, which describes GIS as a certain form of computerised information system that provides specific spatial data handling and analytical capabilities to address the problems, provides a good working configuration. In another case, the problems may concern the development of a multi-participant GIS such as a set of shared GIS capabilities for departments within a local authority. In such circumstances, the *organisational* perspective that describes the GIS elements to be shared offers an alternative working configuration for the participants.

However in a *dispersed* scenario, the problems are so broad and vaguely defined that there is uncertainty regarding the final composition and functionalities of the GIS. As both the *technological* perspective and *organisational* perspective portray a definite target configuration for the GIS, they are not compatible with the uncertainty in the identity of GIS in this scenario.

4.4.2 In the Implementation Stage

In the *implementation* stage of diffusion, it has been argued that the pre-defined problems must be addressed on completion of diffusion (subsection 4.2.2). If the problems addressed are substantially changed during the *redefining/restructuring* sub-stage, the GIS diffusion study should be refocussed or even started again to take into consideration the changes that have taken place. In a *focused* scenario, as in the case of the School Assets Management System, the *technological* perspective is a useful yardstick to assess the change. This perspective identifies the GIS as an information system that supports assets and security management. Subsequent to reinvention, the scope of applications may change; the final configuration of data, hardware, and software may be different from that originally conceived. On condition that after passing the *routinization* sub-stage of implementation, the GIS is used by the Directorate of Schools to manage assets and security issues, its diffusion is considered complete. If there was pressure for the GIS to be modified to additionally manage pupil intake for example, the stakeholders involved would be changed and the identity of the GIS would also be substantially changed. Study of the GIS diffusion in this case should be re-designed or even started afresh to account for the changes.

The *technological* perspective only allows changes to or reinvention of the GIS to be monitored in terms of its technical capabilities. As such, it is not sensitive enough to track the change of detailed composition in the reinvention of GIS. In this respect, the *organisational* perspective is more versatile. On the one hand, by monitoring the extent of development of the elements, it can show progress of development of shared GIS capabilities, such as spatial data infrastructures. On the other hand, by monitoring incremental changes to the elements over time, reinvention of a GIS can be monitored. Therefore, the *technological* and *organisational* perspectives complement each other in monitoring progress of diffusion in the *implementation* stage in a *focused* scenario. This is in line with the use of both perspectives together to give a composite definition of GIS (Burrough 1990, Maguire 1991).

In a dispersed scenario, the position is more complicated. The case of the whole-of-government GIS intended for the State Government of Victoria serves as a good illustration of the issues involved. The Victorian system was originally visualised as a government wide system. The scope of the project was very wide and the issues involved were complicated. Despite having spent about A$ 1 million in GIS planning, the government wide GIS had to be disaggregated into separate departmental initiatives and a statewide spatial data infrastructure development program.

In this circumstance, while the vision may be a corporate GIS which is typical of a *dispersed* scenario, it will be quite misleading to treat the GIS in its diffusion as a single static entity. The development of that single entity may take years, if not decades. The combination of stakeholders and the problems that the GIS set out to address may change drastically during development and implementation (Juhl 1997). In this case the *technological* perspective which specifically relates technical capabilities of the GIS to the pre-defined problems of the organisation will be unsuitable.

In the course of developing a corporate GIS, some initiatives will be successful and some will fail. New initiatives may be added while old ones may be discontinued as the organisation is restructured to meet changing needs of government and society. In these circumstances, the *organisational* perspective which views GIS in terms of its integral elements, will not be able to distinguish one initiative from another, or to keep track of the changing combination of initiatives. There is no way for this perspective to monitor the progress of diffusion of the individual initiatives of the corporate GIS; to indicate when diffusion has been completed or when diffusion study should be re-designed or terminated.

Instead of being homogeneous, the corporate GIS is an evolving heterogeneous entity that tries to address different problems of the organisation at different points in time. It is argued above that neither the *technological* perspective nor the *organisational* perspective is suitable to describe the corporate GIS and to monitor the progress of its diffusion. A new perspective to describe GIS, and a corporate GIS in particular, is needed to overcome the difficulties in studying diffusion of GIS in a *dispersed* scenario.

4.5 A New Perspective On The Nature Of GIS

4.5.1 GIS in an organisation

To describe a corporate GIS, it is necessary to understand the relation between GIS and an organisation. Chan and Williamson (1996b) view GIS as part of the organisational capabilities (renamed in the 1996 paper as production infrastructure), which are used in a production process to generate the product mix required of the organisation. Figure 4.1 describes such an organisation in terms of a mechanism of production that is made up of both a formal and an informal structure, and shows the role of GIS in such a context.

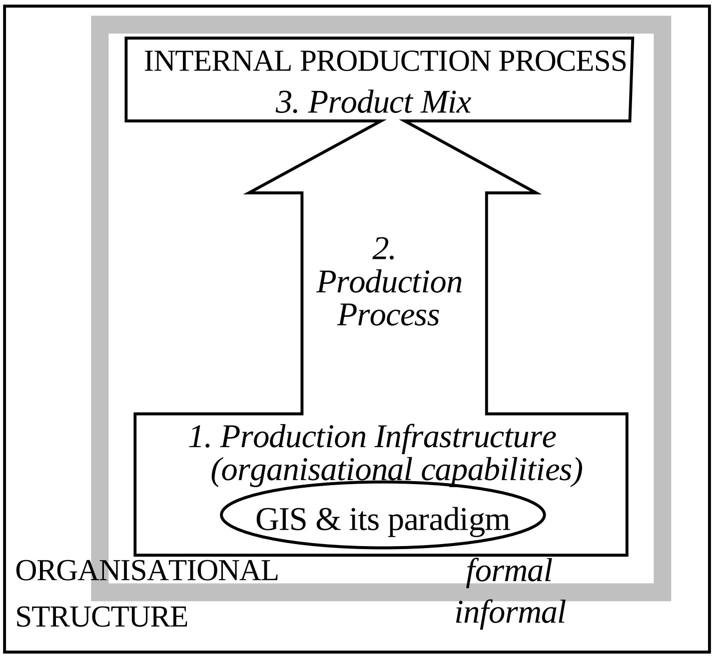


Figure 4.1 **Relation between GIS and the organisation (adapted from Chan and Williamson (1997))**

According to Broom *et al.* (1981), a hierarchical structure and the division of labour are the key elements in a formal structure of an organisation. Among the five main types of organisational structures identified by Mintzberg (1979), a basic combination of hierarchical structure and division of labour can be identified. This basic combination separates an organisation into central administration and the different business functions. Applying this primary level of division of labour and hierarchy of authority to the model in Figure 4.1, a new relation between GIS and the organisation is derived.

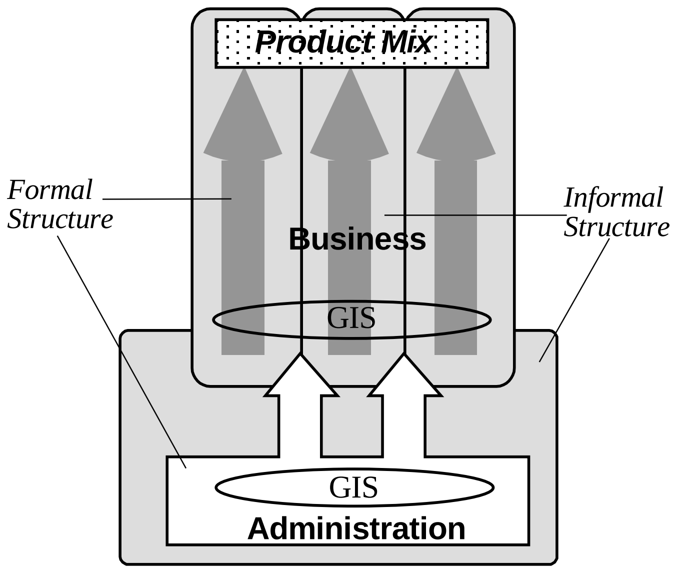


Figure 4.2 GIS in an Organisation

Figure 4.2 describes the new relation in which the formal structure of an organisation is divided into two functional parts. The first is the *Business* component, which includes all the business functions directly, involved in the production of the product mix required of the organisation. The second is the *Administration* component which includes the central administration and the staff departments which provide coordination and support functions to the *Business* component. The formal structure includes people and associated rules, regulations, procedures, power/authority, and communication channels that allow organisational functions to be carried out and changes to be made. Each formal structure achieves its functions by making use of organisational capabilities, which include GIS. Associated with each functional component is the informal structure of organisation (Handy 1993) which dictates the norms and values that have not been decreed.

4.5.2 The two roles of GIS in an organisation

Based on the corresponding concepts developed for information technology (Weill, *et al.* 1996), Chan and Williamson (1995) suggest that there are two types of GIS. The first one is a *business process GIS*, which is an integral part of each organisational business process that is directly involved in producing the product, mix. The other one is an *infrastructure GIS,* which supports existing *business process GIS* or facilitates the development of new ones.

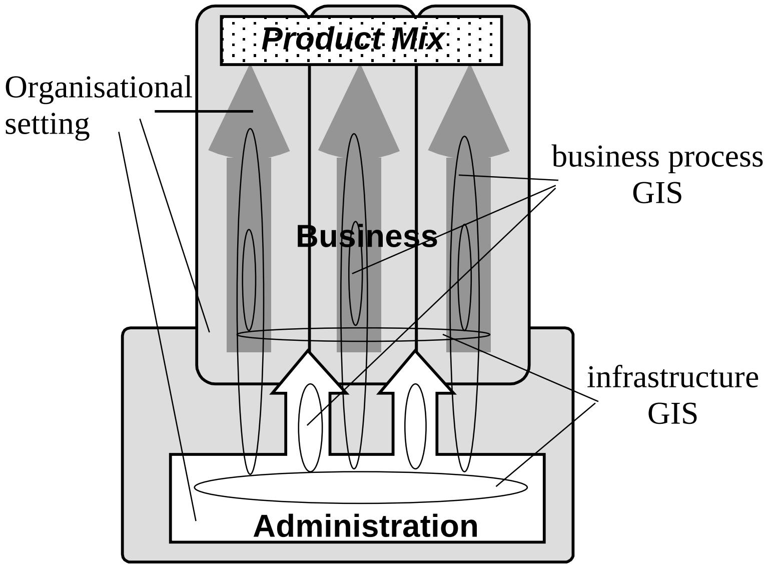


Figure 4.3 GIS in an organisation—the corporate GIS

A model of corporate GIS is developed by replacing 'GIS' in Figure 4.2 with *business process GIS* and *infrastructure GIS*. Figure 4.3 describes the model in which each functional component of an organisation is a potential location for GIS. The GIS in turn can assume any combination of the two roles of infrastructure and business process. Therefore it is possible to identify four basic modules of a corporate GIS: *infrastructure* and *business process GIS* in *Administration*, and *infrastructure* and *business process GIS* in *Business*. There can be a *business process GIS* for each of the business functions and staff departments, all of which are supported by *infrastructure GIS* of the respective functional component. It should be noted that owing to the coordinating and supportive role of *Administration*, its *infrastructure GIS* also supports *business process GIS* in *Business*.

The model forms the basis of the *productional* perspective which describes a corporate GIS as an integral part of the wider internal capabilities that support the organisation's effort to produce a set of products (or services) required by external stakeholders. The corporate GIS is seen as a dynamic heterogeneous collection of individual GIS modules in the organisation. Each module assumes the role of either an infrastructure or a business process in its particular functional component. The collection of modules is dynamic because as the formal structure of the organisation evolves, so do the collection of GIS modules. Defunct modules can be taken out of the organisation, new modules can be added, and existing modules may be modified.

However, the corporate GIS is more than just a collection of modules of GIS. By definition, each *infrastructure GIS* will eventually support all the *business process GIS* in each functional part of the organisation. Although the necessity of implementation or convenience may initially lead to the independent development of the two types of GIS, theoretically, they will be linked in due course. This relationship that links all the modules together in an organisation, identifies the corporate GIS as an independent entity worthy of being studied separately.

4.5.3 The Model of Diffusion of a Corporate GIS

Chapter one describes the hypothesis of this thesis as 'Diffusion of GIS in an organisation is affected, among other things, by the qualities of GIS as seen in the context of the structure of the organisation'. This chapter identifies such qualities through the *productional* perspective of a corporate GIS (Figure 4.3). The perspective identifies a corporate GIS as an evolving heterogeneous entity that is made up of inter-related modules of GIS, playing the role of either a business process or an infrastructure in the production processes of the organisation. Using the organisational innovation process as the backbone, Figure 4.4 describes the way diffusion of a corporate GIS progresses.

Instead of a unidirectional process as implied in the organisational innovation process, the diffusion of a corporate GIS is a cyclical process in a *dispersed* scenario. In the *agenda-setting* sub-stage, the *identificational* perspective is crucial to help justify GIS against other technologies. In the *matching* sub-stage, the *productional* perspective portrays a high level identity of the corporate GIS showing inter-related modules of GIS playing the roles of an infrastructure or a business process. At this point, the corporate GIS can be disaggregated and have the diffusion of its integral modules separately studied. Some modules, both *infrastructure* and *business process GIS,* may be conceived to address problems that are focused and clearly defined. Instead of remaining in a *dispersed* scenario like the corporate GIS, these modules can now progress to the next stage of diffusion in a *focused* scenario. As a result, the environment of diffusion of each module is made more homogeneous. This facilitates the tracking of identity of each GIS module in a diffusion study, and makes the prediction and interpretation of the outcomes easier and more meaningful. Previous discussion in this chapter suggests that in such a scenario, the progress of diffusion of *infrastructure* and *business process GIS* can be tracked by the *organisational* and *technological* perspectives respectively. The *organisational* perspective can also help monitor reinvention of each module in terms of its composition during implementation. For ease of discussion, this group of modules, the diffusion of which can be examined separately from the corporate GIS, is referred to as *focused* modules.

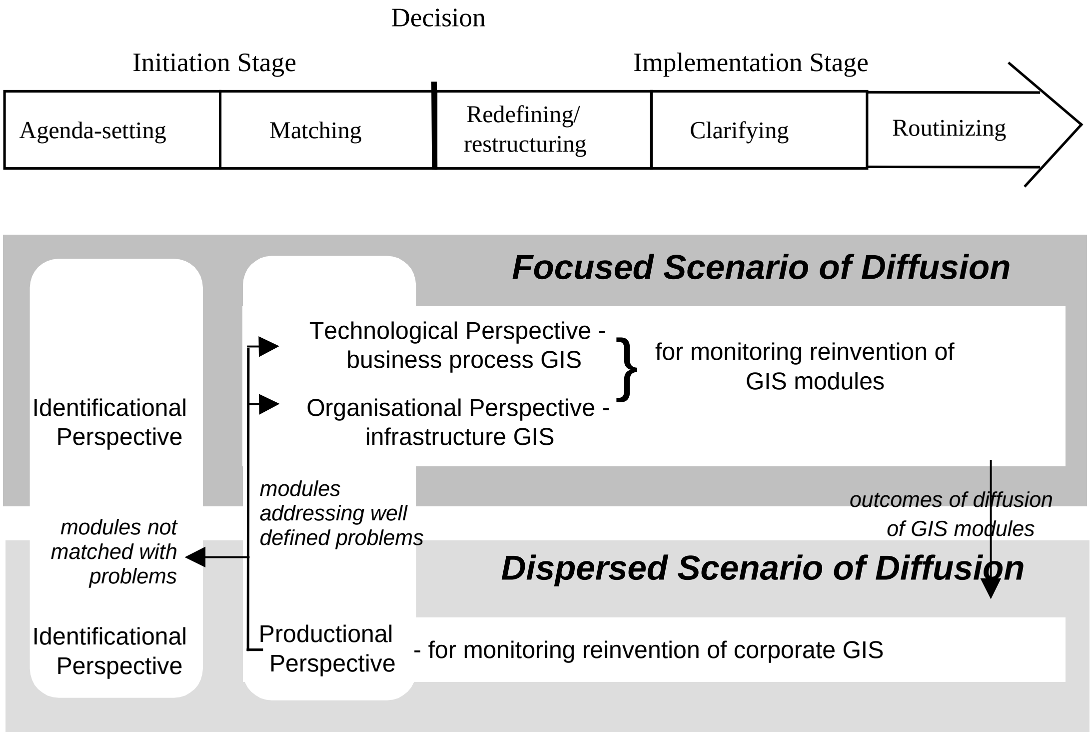


Figure 4.4 Roles of the four perspectives on the nature of GIS in describing a corporate GIS in the study of its diffusion

Coexisting with the *focused* modules are the remaining modules of the corporate GIS which are conceived to address problems that have not yet been clearly defined by the stakeholders, or even problems that may only be identified in the future. This latter group of modules remains in a *dispersed* scenario of diffusion. Instead of proceeding into the more advance stage of diffusion with the other modules, these modules will return to the *agenda-setting* sub-stage pending clarification of the problems they intend to address. These modules are called *dispersed* modules. When the *dispersed* modules and the problems they address become better configured for one another, they move forward to the *matching* sub-stage again. Some of them may become *focused* modules and progress to the next stage of diffusion in a *focused* scenario like their other counterparts.

The perspective also provides a framework (Figure 4.4) that organises the individual modules into a corporate GIS, which remains in the *dispersed* scenario as an independent entity. The progress of diffusion of the corporate GIS can be measured within the framework of the perspective by the number of *focused* modules that have completed diffusion. By using the same framework to monitor the status and number of the *dispersed* modules and the progress of diffusion of the *focused* modules, reinvention of the corporate GIS can be tracked. In addition, viewing the corporate GIS as an independent entity, the framework also serves as a tool to examine inter-relationships of the modules, and the impact that one GIS module has on the diffusion of other modules.

The development of a model of diffusion of a corporate GIS in Figure 4.4 is a first step towards the fulfilment of the second objective of this thesis—'to **identify** and test the qualities of GIS that can improve the understanding of GIS diffusion'. The next step—the step of testing—is described in Chapter five.

4.6 Chapter Summary

GIS diffusion in an organisation is affected by the nature of GIS. In the literature, three perspectives on the nature of GIS have been identified, namely, *identificational, technological* and *organisational*. The *identificational* perspective describes the uniqueness of GIS. The *technological* perspective describes the tangible form and functional capabilities of GIS. The *organisational* perspective emphasises the multi-element nature of GIS, bringing to the fore the organisational environment that affects the introduction of the technology.

Individual perspectives on the nature of GIS, when used alone or together, form different definitions of GIS which are used by GIS managers to give GIS an identity when introducing the technology into an organisation. As diffusion progresses, the identity of GIS also changes. The paper argues that excessive change to the identity may affect prediction or interpretation of outcomes of a diffusion study. Therefore, it is important to be able to track the changing identity of GIS.

However the environment of diffusion is not homogeneous. Based on Rogers' organisational innovation process and depending on the nature of the pre-defined problems in the organisation that GIS is to address, two contrasting scenarios of diffusion can be identified. The problems in a *focused* scenario are focused and well defined while those in a *dispersed* scenario are broad and strategic in nature with potentially great impact and resource requirement.

This Chapter has reviewed the ways that the changing identity of GIS in the two scenarios of diffusion can be tracked and described. It concludes that while current perspectives on the nature of GIS adequately describe the changing identity of GIS in a *focused* scenario of diffusion, they do not allow satisfactory monitoring of diffusion of a corporate GIS, which is a typically found in a *dispersed* scenario.

As a result, the *productional* perspective is developed. It views a corporate GIS as making up of modules that play the roles of either an infrastructure or a business process. The *productional* perspective of GIS is applied to Rogers' model of organisation innovation process to give a model of diffusion of a corporate GIS. In this model, diffusion of the GIS modules that address well defined problems takes place in a *focused* scenario. Those modules that do not address well-defined problems will remain in the *dispersed* scenario. Diffusion will only take place in the *focused* scenario when these modules match up with some well-defined problems. The model allows the diffusion of a complex heterogeneous GIS, such as a corporate GIS, to be studied and monitored holistically. In general the model highlights how the *productional* perspective of (corporate) GIS can affect GIS diffusion and forms a working model for the hypothesis of this thesis.

Chapter 5
Methodology

5.1 Introduction

Chapter four develops a model of diffusion of corporate GIS. The model is made up two parts. The first part is Rogers' model of the organisational innovation process that is used to represent the GIS diffusion in an organisation. The model serves only as a backdrop and no attempt is made to test the applicability of the model to GIS. The second part describes how diffusion of a corporate GIS will take place in the light of the *productional* perspective of GIS. If the model reflects the way events actually unfold in the diffusion of a corporate GIS, the following relationships predicted by the model will be observed.

- A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with a module of infrastructure GIS supporting the development of one or more modules of business process GIS.
- Diffusion takes place when the purposes served by a module are focused and well defined.
- Diffusion of a corporate GIS takes place in the dispersed scenario.
- Reinvention of a corporate GIS can be monitored by the outcome of diffusion of the modules of GIS in the focused scenario.

A field study is required to test the model. The objective of the field study is to collect data to answer the two research questions identified in Chapter 1:

- How does GIS diffusion take place in an organisation?
- Why does GIS diffusion progress in the way observed?

In the course of discussion with managers involved in the development of State Government GIS capabilities in the State Governments of Victoria and New South Wales in Australia, it was found that managers did not understand the term diffusion but they did understand the outcomes of diffusion, that is the development of GIS over time. Therefore, the field study initially aims at collecting data to compile a detailed description of the development of GIS in an organisation. The descriptive record of GIS development is then analysed to identify the patterns of events taken place and relationships formed. The model is validated when the predicted relationships listed above match with those observed. This Chapter describes in detail the methodology of and the rationales behind the field study.

5.2 Nature of the Field Study

In the past, a field study was identified as *exploratory*, *descriptive* or *explanatory* depending on its purpose. Different strategies including survey, archival analysis, history, case study and experiment, were matched to each type of field study. However, Yin (1994, p. 3) finds that 'Each strategy can be used for all three purposes'. He suggests a pluralistic view for gross matching of research strategies to the requirements of a field study based on three conditions. These three conditions are *form of research question*, *control over behavioural events*, and *focus on contemporary events*. Table 5.1 shows the matrix used by Yin (1994, p. 6) to match the different research strategies with the conditions.

Table 5.1 Relevant situations for different research strategies (Source: (Yin 1994, p. 6))

Strategy	Form of research question	Requires control over behavioural events?	Focuses on contemporary events?
experiment	how, why	Yes	yes
survey	who, what, where, how many, how much	No	yes
archival analysis	who, what, where, how many, how much	No	yes/no
history	how, why	No	no
case study	how, why	No	yes

The first condition used to select an appropriate research strategy is the form of research question. Based on the objectives of the field study in this research, the research questions to be answered are 'how' and 'why' questions which narrow the choice of research strategy down to three, namely, experiment, history, and case study.

At the same time, the questions are descriptive and exploratory in nature. Unlike explanatory studies, the field study does not have to prove or disprove any causal relationship under specific conditions. Therefore under the second condition, the study requires no control over behavioural events. This further narrows the choice of a research strategy to history and case study.

As the field study is concerned with both past and present events that constitute diffusion of a corporate GIS, it has a focus on contemporary events—the last condition. This suggests case study as the most appropriate research strategy for the field study.

The field study is conducted to explore if the *productional* perspective of GIS is a realistic way of describing the changing identity of a corporate GIS in the course of diffusion. The perspective has not been discussed before in the literature. This suggests that the study is *revelatory* in nature and satisfies one of the three conditions that justify the use of the single case study design (Yin 1994). Further, being not an explanatory type of study, there is no need to use multiple case studies in the study design for *literal* and *theoretical replications* (Yin 1994).

Based on the qualities of GIS described in the *productional* perspective, GIS is made up of many modular entities that exist in different business functions in an organisation. If the field study were simply a single case study, the unit of analysis would have to be the organisation selected. As a result, the focus would be on GIS capabilities that span across functional and administrative boundaries in the department. The GIS capabilities that serve individual business units would be excluded. But these capabilities are also an integral part of the corporate GIS. To take them into consideration, it is necessary to study the business units as *embedded* units of analysis. By examining the outcomes from these embedded units from an organisation wide perspective, the changing identity of a corporate GIS can be understood more holistically. Therefore the design of the case study is *single (embedded) case study*.

5.3 Candidate of the Study

Chapter one and Chapter two have established the case to study GIS diffusion at the state government level in Australia in general, and in the State Government of Victoria in particular. However, the Victoria government as a whole is very large and complex. Undertaking a case study of GIS diffusion at such a level of analysis can be an unwieldy exercise. The exploratory/revelatory nature of the research, the planned in-depth documentation of GIS development in the target organisation and the resources available together do not justify using the State Government as the case study.

On the other end of the scale, study involving an office, a section or even a division in a government department would narrow the size of organisation excessively. This would reduce the number and diversity of the business units, and unduly limit the range of patterns of relationship that are likely to emerge. Therefore, a suitable compromise is a State government department. Such a department in Victoria at the time of study normally had a rich diversity of staff and business units. It also had significant resource and operational autonomy to control the development of its GIS.

As there were eight State departments in Victoria, the compromise leads to the issue of choosing the right department. In general, a department in an advanced state of GIS development tends to have longer and more diverse experience in GIS diffusion. A case study of such a department is likely to uncover a wider range of patterns of GIS diffusion for model testing purpose. Based on this assumption, in order to choose a department for the case study, a way is needed to assess the states of development of GIS of the eight state government departments.

5.3.1 Assessment of state of development of a GIS in an organisation

There are two ways to select the department to be studied. First is to seek advice/opinion from local or national experts. Second is to conduct a survey to assess the state of development of GIS in all the eight State government departments. Although the first way is easier, it tends to be indirect and subjective. It may be difficult to find experts who know all the departments well enough to make an assessment that suits the need of the field study. To ensure that the assessment is relevant, a set of criteria is needed.

Keen (1991) has suggested a *reach* and *range* framework to define the functionalities of the corporate information technology (IT) platform. *Reach* is ‘the locations a platform is capable of linking’, and *range* refers to ‘the degree to which information can be directly and automatically shared across systems and services’ and so, defining the richness of IT services that can be shared across platform (Keen 1991, p. 179-180).

Based on this framework, Chan and Williamson (1996a) suggest that development of GIS and IT are related. They argue that IT platform provides the *reach*, determining the extent GIS is linked in the organisation, and the *range*, determining supporting services that allow GIS capabilities to be freely shared among the business units. At the same time, GIS capabilities enrich the *range* of the IT platform by providing two generic capabilities. One is spatial data management capability in addition to the traditional database management capability across organisation. The other is a common geographic data framework to support consistent geo-coding, geo-referencing, and spatial analyses involving all databases that are linked by the IT platform.

In relation to the IT platform, Chan and Williamson (1996a) also identify different contingencies of GIS development based on the *reach* and *range* framework, as illustrated in Figure 5.1. In the matrix, *range* occupies the x-axis, representing the extent to which geographic information can be directly and automatically shared across systems and services. There are two scenarios of GIS *range—discrete* and *integrated*. *Reach* occupies the y-axis, representing the extent GIS is available to members of the organisation. There are two scenarios of GIS *reach—local* and *corporate*. Strictly speaking, the x- and y-axis are both continua of the *range* and *reach* scenarios, representing an infinite combination of contingencies. However, for illustration purpose, four contingencies of GIS development are highlighted in Figure 5.1.

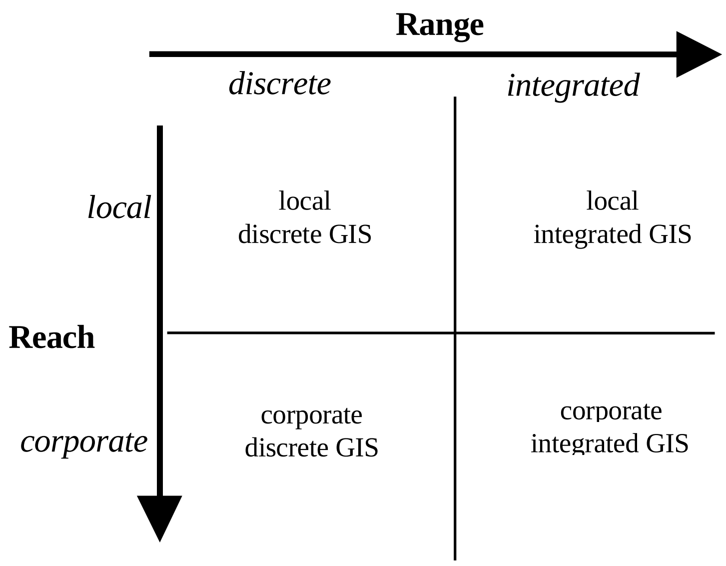


Figure 5.1 Four contingencies of GIS development in an organisation based on the reach and range matrix (Source: (Chan and Williamson 1996a))

- local discrete – GIS exists as stand-alone systems in one or a couple of business units;
- corporate discrete – GIS exists as stand-alone systems in many business units corporate-wide;
- local integrated – GIS exists as a system integrated with the local IT system of a business unit;
- corporate integrated – GIS exists as a system fully integrated with the corporate IT, infrastructure and business process.

The matrix can be a useful planning tool. It allows an organisation to map the states of IT/GIS development, and to plan the path needed to bring IT and GIS from their current state of *reach* and *range* to the planned state according to the strategic goals. Though the above concepts concerning IT/GIS development are derived from the commercial sector, Chan and Williamson (1996a) have shown that the concepts also apply to the government organisations in practice.

Though potentially useful in assessing the state of development of a corporate GIS, the framework has overlooked the role played by people. In the end, it is the people or the users who put the GIS into productive use, reaping the benefits promised in the process. Therefore, assessment of the state of development of GIS in a state government department will have to include a third criteria—*routine*—which assesses the extent GIS is designed/customised for use by all members of the organisation. Table 5.2 summarises the definitions of the three criteria of *reach, range* and *routine.*

Table 5.2 Definitions of *reach, range* and *routine.*

	Definitions
Reach	the extent GIS is available to members of the organisation
Range	the extent to which geographic information can be directly and automatically shared across systems and services
Routine	the extent GIS is designed/customised for use by all members of the organisation

After deciding on the criteria, it is necessary to identify the parameters that provide a measure of *reach*, *range*, and *routine* to facilitate comparison. Table 5.3 shows a list of parameters for each of the criteria. Based on the more commonly used parameters in the literature that fall within the definitions of the criteria, a key parameter is identified for each criterion. These key parameters are highlighted in bold print in the table. The other parameters (in normal print) are derived from the five elements of GIS under the *organisational* perspective of GIS, and from experience.

Table 5.3 Parameters for *reach, range,* and *routine.*

Reach	**Range**	**Routine**
Own or have direct and automatic access to hardware and software (HW/SW)	**GIS data are shared directly and automatically with the rest of the organisation**	**GIS is customised for use by all staff**
have staff with GIS expertise	have staff with GIS expertise that also service other offices	have GIS modified to suit business process
have GIS databases	adoption of departmental standards	have business process re-engineered for GIS
planning to adopt GIS	have cooperation with other offices to develop GIS capabilities	

By using the *reach* and *range* framework, Chan and Williamson (1996) develop a two-dimensional matrix to assess the state of development of GIS in an organisation. By using a *reach-range-routine* framework in this case, a three-dimensional matrix can be developed, with eight niches to represent the states of development of GIS in organisations as shown in Figure 5.2. In the figure, the most advanced state of development of GIS is represented by the niche that houses a grey circle. This niche represents the best achievements in terms of *reach, range* and *routine*.

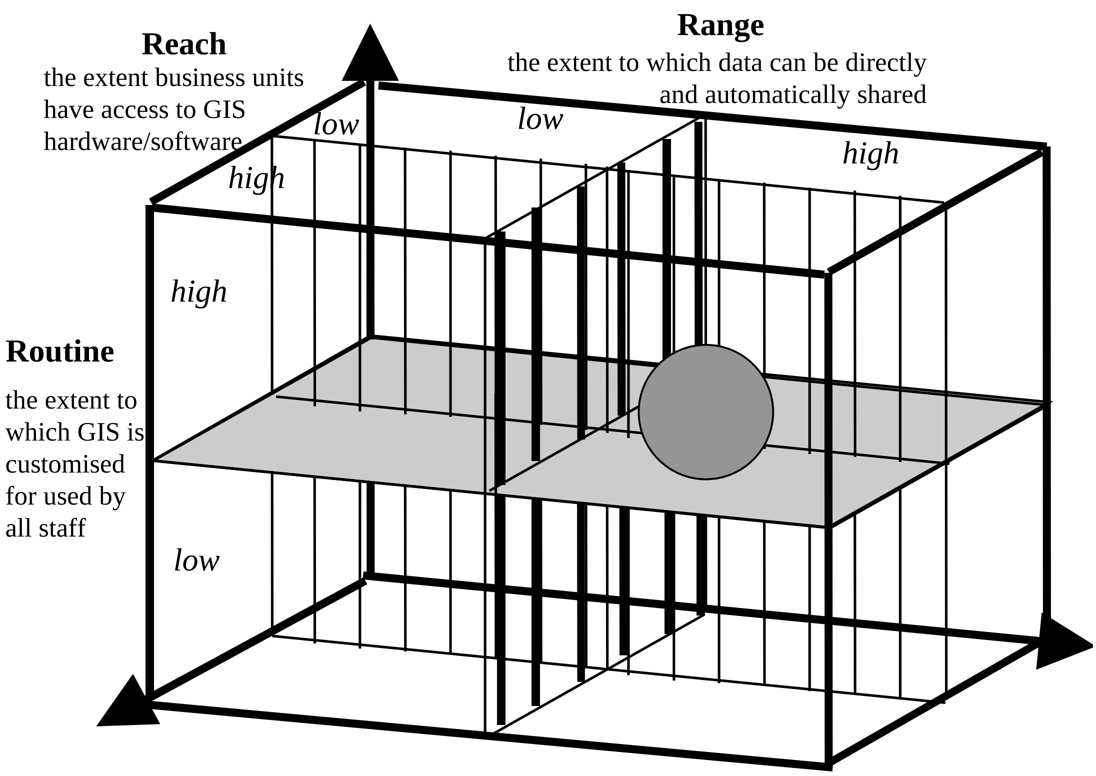


Figure 5.2 Three-dimensional reach-range-routine matrix to assess the states of development of GIS in organisations.

If the three criteria are measured in terms of the values of the corresponding key parameters, then the niche occupied by each State Government department shows the relative state of GIS development of each department. The department that occupies the niche marked by the grey circle is the department with the best-developed GIS. This method generates a quick but rough assessment of the state of GIS development. A more detailed assessment can be made by including other parameters in Table 5.3. The department that has the best score under most of the parameters is considered to have the best developed GIS.

If a well-developed GIS serve only a small part of the department, that department will not be useful to the research. It is necessary to select a department with the best developed GIS that has an impact on a wide range of business operations. Therefore, these parameters are assessed in terms of the percentage of offices and business units that these parameters are applicable in the department.

With the criteria established and the associated parameters identified, the author can exercise greater control over the selection procedure. Though subjective selection by local experts appears easier, the outcome may offend certain stakeholders unknowingly. To avoid this pitfall and to introduce more rigour and objectivity into the selection procedure, a survey is used to choose a department for the case study.

5.4 GIS Development Profile Survey

5.4.1 Planning the survey—opportunities and constraints

The purpose of the survey is to ascertain the state of development of GIS in each State Government department through the assessment of the parameters listed in Table 5.3. Normally, the survey instrument may either be a questionnaire or an interview schedule (Atherton and Klemmack 1982). Sometime, variations of the two instruments, such as a postal questionnaire survey or a interview by telephone, may also be used.

At first, it was planned to conduct a postal survey. However, it was learnt later that the State Government of Victoria had recently been restructured into eight very large departments. This implied a major reshuffling of GIS capabilities within government. The officer/s who had a realistic overview of GIS development in each department and could answer all the questions would probably be in middle or senior management. There was a real risk that these officers were busy adapting to the new management structure, and attending to their day-to-day businesses. They might not have the incentive to fill in the questionnaires that were delivered by post.

There was also the concern that some of the terms used in the questionnaire were not common. The officers might be reluctant to answer questions involving terms that they were not familiar with. Alternatively, they might delay reply or delegate the work to other less appropriate officers. In either case, the outcome of the survey would not be complete, casting doubts on the overall validity of the survey.

In view of the shortcomings of a postal survey, it was decided to actively seek out the contact officer of each department and arrange a meeting to help the officer fill in the questionnaire. Once this strategy was chosen, it opened up new opportunities of data collection. More questions could then be included to gather additional data regarding the organisational settings and GIS strategies of the departments. A session of semi-structure interview could be introduced at the end of the survey to further explore details concerning crucial stakeholders and events in the course of GIS diffusion in each department. This information which was difficult to collect in a questionnaire survey, could supplement results of the survey to provide a broad picture of GIS diffusion in the

State government as a whole. In this way, the survey not only provides a means to select a state government department for the case study planned, it also provided data to validate the model of diffusion of corporate GIS at a broad level.

5.4.2 The questionnaire

Based on a previous survey on the development of GIS in the State Government (Tomlinson Associates Ltd. 1993a, 1993b, 1993d), not all departments had GIS. Therefore, two questionnaire were designed (Appendix 3). One was for those departments with a GIS, and the other without. The former comprised five sections the heading of which are generally self-explanatory and are listed below:

- record of the interview;
- general information of the department (Questions 1–7);
- the current organisational setting and GIS management practices (Questions 8–16, and 41–43);
- internal and external stakeholders (Questions 17–21);
- progress of diffusion of departmental GIS (Questions 22–40, and 44).

The section of 'record of the interview' is for recording the code number of the department and the date of interview, which are not counted as questions. Altogether, there are 44 questions. The questions that falls within the scope of the remaining four sections are indicated in brackets at the end of each bullet above.

Just over half of the questions (the last section) are concerned with the state of development of GIS. The remaining are used to collect three categories of data about the departments and the stakeholders. The first category includes questions on general information of the organisation such as staff size, budget size, number of offices/business units, departmental IT strategy and IT platform. The second is concerned with questions on organisational setting and GIS management practices. It includes reasons for having or not having GIS, length of experience with GIS, departmental GIS strategy, role of senior management in GIS development, individual GIS strategies and capabilities of offices/business units, and approach to GIS management. The third is concerned with questions on the stakeholders. It includes the types of internal and external stakeholders involved, their perceived impact on GIS development, and the GIS needs of internal stakeholders. Data in these aspects provide the necessary background in support of the states of development of GIS observed on the basis of the *reach-range-routine* criteria.

A shorter version of the questionnaire was designed for departments that did not have a GIS. A total of 17 questions were asked. They were meant to provide information of why the department did not adopt a GIS. The sections of 'record of the interview' and 'general information of the department' are common to both questionnaires.

- record of the interview;
- general information of the department (7);
- the current organisational setting and GIS management practices (6);
- stakeholders, internal and external (4).

That version had only 17 questions grouped into three sections. The numbering of the 17 questions correspond to the 21 questions of first three sections of the full questionnaire. Questions 11, 15, 16, and 18 were left out, as they are irrelevant. It was intended that the questions with the same number in both questionnaire would address the same issues or issues of a similar nature. In that regard, questions 1–7, 9, and 20–21 are exactly the same as the corresponding questions of the full questionnaire. Owing to the different emphases of the two questionnaires, it was inevitable that questions that addressed certain issues were worded slightly differently as in the case of questions 8, 10, 12–14, 17, and 19.

Table 5.4 Definitions of GIS used in the GIS Development Profile Survey.

Terms	Definitions
Departmental GIS	Capabilities that include geospatial data, people with GIS expertise (technical or management), information technology (hardware, software and applications), GIS and related standards.
Business Process GIS	The set of GIS capabilities used in a set of procedures (business functions) established to carry out one or more mandatory functions of a department. It is normally the responsibility of a specific business unit, such as the survey unit or planning unit.
Shared GIS	The set of GIS capabilities served as an infrastructure on which new or additional GIS capabilities needed for existing or new business processes can be developed.

When meeting with respondents to help them fill in the questionnaires, the pre-defined answers for each question were printed on separate paper in a larger font size to make it easier for respondents to select the appropriate answers. While most of the respondents knew what was a GIS, some of the more cautious ones used to ask for a definition of GIS prior to answering. Definitions of each of the three types of GIS mentioned in the questionnaires were prepared prior to the interviews. They were kept at hand together with pre-defined answers for use during a survey session. Table 5.4 lists out the three definitions used during the interviews.

5.4.3 The survey protocol

This government wide survey fell within the jurisdiction of the State GIS coordinating office, Geospatial Policy and Coordination Victoria (GPAC). The support of GPAC was critical as it could provide contacts and boost the credibility of the survey. To this end, the proposed questionnaires together with a copy of the Departmental GIS Development Profile Survey Protocol (see Appendix 4) which provided a broad overview of the purposes and procedures to be followed (including confidentiality policy) were sent to GPAC. GPAC was very supportive and facilitated the survey by seeking high level endorsement from the Secretary (Head) of its parent department, the Department of Natural Resources and Environment. The Secretary sent letters (Appendix 5) to his counterparts in each and every departments requesting their support in the survey. The letter was followed up by telephone inquiries to the Secretaries' offices to ascertain the details of the departmental representatives assigned to respond to the survey. Appointments were made to meet with the officers. This strategy ensured that there was a 100% response rate and a realistic profile of GIS development of each department could be constructed. Appendix 6 is a list of respondents/interviewees met during the Departmental GIS Profile Survey.

5.4.4 The interview questions

Once each departmental representative was contacted and one of the two questionnaires was completed on site, an immediate semi-structured interview would follow. The aims of the interview were to ascertain the main stakeholders, their interactions/behaviours over time that result in the current state of GIS development observed, and the reasons for the interactions/behaviours. The questions prepared for the semi-structured interviews with the officers are listed in Appendix 7. The appendix shows two lists of questions with prompts in Italics and in brackets immediately following each question. The questions were not asked in sequence but rather served as a set of reminders when the flow of the interview stopped for one reason or another. The highlighted questions were the more important ones and were asked first.

5.5 GIS Diffusion Case Study

The main instrument of the field study is a single (embedded) case study. The primary objective of the case study is to describe the development of a corporate GIS. Once a department is chosen, the data to be collected are:

- the purposes, composition, distribution, and current state of development of the departmental GIS in terms of the existing perspectives on the nature of GIS;
- the stakeholders of each identifiable GIS in each business units;
- the events that have taken place in the course of development of each identifiable GIS and their relations with those events of other GIS.

5.5.1 The original strategy

In the past, State Government departments had undergone many major structural changes. The most recent change took place in April 1996, a short time before the field study was conducted. Therefore, in the department selected, there might be recently transferred programs that were still adjusting to the new management hierarchy. Whatever GIS these programs had were probably developed in other departments over the years and in effect constituted a GIS belonging to a different department. Therefore, it was originally planned to study those programs that had been with the department for a long time as highlighted in the case study protocol at Appendix 8. This was to ensure that the GIS developed had a long and traceable lineage in the department and had developed within a relatively consistent organisational setting. It was thought that this would make the organisational setting more homogeneous and thus the interpretation of outcomes easier. It was also planned to drill further into the hierarchy and assess the perception of individual stakeholders to gain an in-depth understanding of diffusion of GIS.

Based on the experience of research involving GIS (Campbell 1990) and information systems (Kling 1987), researchers have advocated for the use of the web model of research involving case studies. The model suggests that once the focus of study has been established, the boundary of research are not pre-defined but based on informed judgements following a period of study. This together with the embedded nature of the study, allowed four levels of contacts to be identified in the department:

- primary - the departmental contact officer;
- secondary - the head and/or GIS manager of each departmental program;
- tertiary - the manager or the GIS coordinator of each office implementing a program;
- fourth level - the stakeholders identified by each level of contacts.

The objectives of the case study, the approaches described above and other issues such as access procedures, details of the proposed interviews, confidentiality issue are detailed in the case study protocol (Appendix 8). As in the GIS development profile survey, the support of State GIS coordinating office (GPAC) was maintained by sending to it a copy of the case study protocol prior to getting in touch with the department selected for the case study directly.

5.5.2 The refocussed strategy

In the protocol there was a provision for a pre-test, which served as a final means of refining the design of the case study methodology before major interviews were conducted. Appendix 9 lists out a set of questions used to remind the interviewer the types of data that need to be collected during the interviews of the case study.

During the first meeting with the departmental contact person, no candidate was suggested for the pre-test and talks with departmental program managers were discouraged. The reason was that these senior managers had been subject to repeated interviews of a similar nature in the months prior to the case study when the department was conducting a series of studies and reviews. The contact person also pointed out that with the close working relation between new and old members of the department in the past, it would be undesirable to exclude the former from the study as planned.

The working objective of this project is to study how the qualities of a corporate GIS affect GIS diffusion in an organisation, not GIS diffusion at the level of individual users. It is acknowledged in Chapter four that the latter is an important aspect of diffusion but is beyond the scope of this research. This working objective of the project, together with the advice of the contact officer, helped refocus the emphasis of the case study quite early on. The study would examine all programs/divisions in the department that used or had an interest in GIS. Individual stakeholders' role in the uptake of the technology would only be examined when it affected the overall diffusion of GIS in the organisation.

5.5.3 Data analysis strategy

The purpose of the case study is to collect data concerning the development of the corporate GIS of the department chosen from the State Government of Victoria. From the data, evidence is teased out to test the model of diffusion of corporate GIS proposed in Chapter four. The study is a single (embedded) case study. Therefore the detailed development of GIS in the embedded business units in the department is studied first. Then the big picture of development of the corporate GIS in the department is pieced together from data of the embedded units.

Based on the organisational perspective of describing GIS (see Chapter four), the detailed GIS capabilities developed over the years in each major business unit of the department, together with the key events, stakeholders and their interactions, are recorded in tables chronologically as far as possible. To facilitate analysis of the data and comparison across business units, the data in each table are arranged into two columns. The left-hand column records the development of the technological elements of GIS, that is, the data, the information technology (hardware, software and communication networks), the people with GIS expertise and the standards. The right-hand column records the organisational setting, external context, and other background information required to understand why the GIS in the various business units in the department have developed in the observed way. The purposes served or intended to be served by the GIS capabilities are also identified as far as possible.

The contents of the tables are raw data collected during the case study and are considered not directly relevant to the discussion in this thesis. They are not submitted as part of this thesis. Instead, the process of GIS development for each major business unit of the department is summarised in the main text of thesis to highlight the pertinent details required for the analyses that follow.

Through a pattern matching process using the GIS capabilities recorded in the data tables described above, the modules of business process GIS and infrastructure GIS are identified for each business unit. The pattern of GIS development in each unit is reconstructed diagrammatically and chronologically using these two types of modules of GIS as building blocks. The changing identities of the corporate GIS over the years are also tracked diagrammatically using the same building blocks. In the process, evidence to test the validity of the model of diffusion of corporate GIS is teased out in accordance with the prescribed list in the first section of this chapter.

5.6 Chapter Summary

To validate the hypothesis stated in Chapter one, it is necessary to validate the model of diffusion of corporate GIS at Figure 4.4. It involves collecting field data of the development of a corporate GIS. The data are then analysed to identify patterns of relationships that match those predicted by the diffusion model:

- A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with a module of infrastructure GIS supporting the development of one or more modules of business process GIS.
- Diffusion takes place when the purposes served by a module are focused and well defined.
- Diffusion of a corporate GIS takes place in the dispersed scenario.
- Reinvention of a corporate GIS can be monitored by the outcome of diffusion of the modules of GIS in the focused scenario.

The purpose of the field study is to address the two research questions posed earlier:

- How does GIS diffusion take place in an organisation?
- Why does GIS diffusion progress in the way observed?

Based on the nature of research question, the need for control over behavioural events and the focus on contemporary events, it is determined that the best approach of the field study is the case study methodology. The candidate of the study is to be a department of the State Government of Victoria. The department should have a well-developed GIS that has impact on a wide range of business programs. The department is to be chosen through a Departmental GIS Development Profile Survey.

A framework is developed to assess the state of development of GIS in the eight state departments concerned. This framework is made up of three criteria, namely, *reach*, *range* and *routine*. The criteria assess the extent of access to GIS, of sharing of geographic information, and of designing the GIS for by all member of the organisation respectively. For each of the three criteria, parameters are identified to provide a composite measure for the states of development of GIS in the departments. Questions were designed to collect data based on these parameters.

Taken into consideration the opportunities and constraints identified during the planning of the survey, it was decided that instead of a postal survey, the survey would be conducted face to face. The survey was to be followed by a semi-structure interview to solicit details concerning critical stakeholders and events in the course of GIS diffusion in the department. The change enables the survey to serve an additional purpose—to provide data for an initial broad level validation of the model of diffusion of a corporate GIS prior to the case study. Two questionnaires were designed for departments with and without GIS respectively. The details of the survey were summarised in the Departmental GIS Development Profile Survey Protocol that was prepared to guide the survey and to gain support of the State GIS coordinating agency.

Once a department for the case study was selected, details of the case study were finalised and summarised in the Case Study Protocol. The Protocol was also sent to the State GIS coordinating agency to maintain its interest and continued support in the study.

Initial contact with the primary contact in the target department revealed that the original approach of the case study was not realistic. On reviewing the objectives of the project and the field study, it was decided that the case study should refocus on all programs that used or had an interest in GIS. Individual stakeholders' role in the uptake of the technology would only be examined when it affected the overall diffusion of GIS in the organisation.

According to the data analysis strategy for the case study, the data of GIS development for the department selected is recorded in a set of tables. These tables systematically record the development of GIS chronologically in terms of the development of the five elements of GIS under the organisational perspective of GIS. Through a pattern matching process, modules of business process GIS and infrastructure GIS are identified and used to reconstruct the patterns of GIS development of the department and its business units chronologically. In the process, evidence to test the model of diffusion of a corporate GIS is teased out.

Chapter 6
Outcomes of the Survey

6.1 Introduction

Based on the methodology described in Chapter five, this chapter reports the results of the Departmental GIS Development Profile Survey, and the findings of the associated interviews. Then the meaning and significance of the results are analysed to select the department for the case study. The outcome of the survey also provides initial evidence in support of some of the predicted observations listed out in section 5.1 in Chapter five.

6.2 GIS development profile survey

The survey to determine the profiles of GIS development of the eight departments of the State Government of Victoria was conducted during the period 25.11.96–20.12.96. Appendix 6 is a list of the departments involved and the representatives nominated to participate in the survey.

The confidentiality policy described in the Survey Protocol stipulates that the names of the departments and respondents will not be mentioned when documenting the results. In accordance with the policy, the eight departments surveyed are represented by the eight capital letters *A* to *H* in this chapter. Once the department for the case study is chosen, its name will be reported in full.

In general, all respondents were able to answer all the questions except questions No. 1-3. These questions seek to identify the size of each department in terms of staff, budget, and offices/business units (abbreviated as business units). All respondents found it difficult to provide the statistics despite the fact that the questionnaires had been sent to them before the survey. While acknowledging that these statistics are not always at hand, the response confirms the potential pit-falls of using a postal survey as mentioned in the last chapter. A face-to-face survey is more appropriate.

Question No. 7 is used to ascertain if a department has a GIS or not. Based on the responses to the question and follow-up clarifications, it was agreed with the respondents that four departments, that is, departments *A, B, C* and *E*, had GIS, and the other four, that is, departments *D, F, G*, and *H*, had none. Since the primary objective of the survey is to select a department with the best developed GIS, the results and discussion in next subsection concentrates on the departments that had GIS.

6.2.1 Results of the survey—*reach, range* and *routine*

Table 5.3 in the last chapter lists out the parameters of the three criteria of *reach*, *range*, and *routine*, which are developed to assess the state of development of GIS in an organisation. The questionnaire includes questions designed to gather data for the parameters of each of the three criteria.

Questions No. 22–25 concern *reach*. No. 22 enquires about the percentage of offices/ business units (abbreviated as the percentage) that own or have direct and automatic access to GIS hardware and software. This is the key parameter for *reach*. Questions No. 23–25 enquire about the percentages that have their own staff with GIS expertise, that have their own geographical databases, and that are planning or developing their own GIS respectively.

Questions No. 27–31 concern *range*. No. 27 enquires about the percentage that have their GIS data directly and automatically shared with the rest of the department. This is the key parameter for *range*. Questions No. 28–31 enquire about the percentages that have staff with GIS expertise that also service other offices, that have adopted all departmental standards, that have cooperated/are cooperating with one another to develop shared GIS capabilities, and that have cooperated/are cooperating with other offices outside the department to develop shared GIS capabilities respectively.

Questions No. 35 and 37–39 concern *routine*. No. 35 enquires about the percentage that have their GIS customised for use by all staff. This is the key parameter for *routine*. Questions No. 37–39 enquire about the percentages that have modified the GIS to better suit one or more business processes, that have partly re-engineered one or more business processes for GIS, and that have fully re-engineered one or more business processes for GIS respectively.

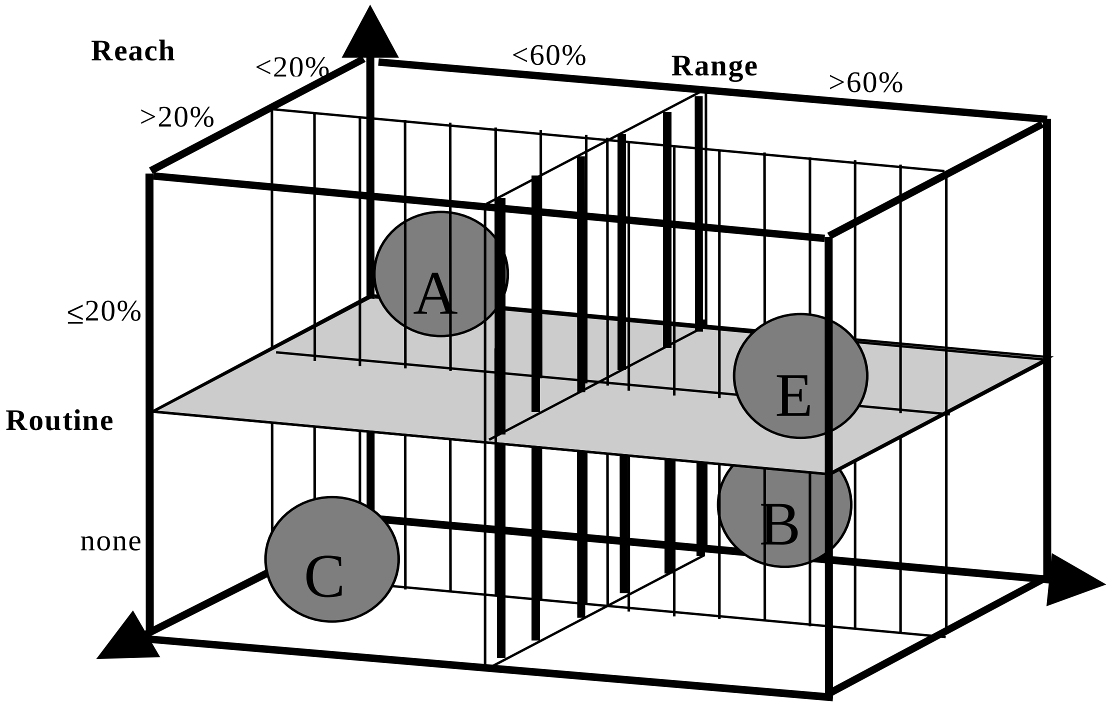
The results are summarised in Table 6.1. In the table, the parameters and the associated questions are grouped under the three criteria. The key parameters for each of the three criteria are highlighted in bold print. The best score for each parameter is also highlighted in bold in the table.

According to the methodology described for the creation of a three-dimensional *reach-range-routine* matrix in subsection 5.3.1 in Chapter 5, the scores of the departments under each key parameter are separated into two convenient groups and substituted into the respective axes in Figure 5.2. For each department with GIS, the relative state of development of GIS is represented by the niche the department occupies in the three-dimensional matrix in Figure 6.1. Department *E* is found to occupy the niche that represented the best achievement in all three parameters. Therefore, based on a quick but rough means of assessment using the *reach-range-routine* matrix, Department *E* is found to have the best developed GIS.

Table 6.1 Summary of survey results for the parameters of the three criteria of GIS development: *reach*, *range*, and *routine*.

Question		Departments (by code)			
No.	Criteria and Parameters	A	B	C	E
	Reach				
22	**Access to hardware/software**	≤20%	no idea	21-40%	**41-60%**
23	Own GIS staff	≤20%	**41-60%**	21-40%	21-40%
24	Own GIS databases	21-40%	**>80%**	61–80%	21-40%
25	Planned to adopt GIS	none	no idea	**21-40%**	**21-40%**
	Range				
27	**Directly and automatically shared GIS data**	none	≤20%	none	**61-80%**
28	Shared GIS staff	≤20%	none	≤20%	**21-40%**
29	Adopted GIS standards	none	na	none	**≤20%**
30	Co-operation (internal) to develop shared GIS	≤20%	≤20%	41-60%	**61-80%**
31	Co-operation (external) to develop shared GIS	≤20%	≤20%	**41-60%**	≤20%
	Routine				
35	**Customised for use by all staff**	**≤20%**	none	none	**≤20%**
37	GIS modified to suit businesses	≤20%	none	**41-60%**	being developed
38	Process re-engineering (part)	≤20%	none	**21-40%**	≤20%
39	Process re-engineering (full)	≤20%	none	**21-40%**	≤20%
	Counts of parameters that each department scored best	1	2	5	**7**

Figure 6.1 helps to identify Department *E* as the best candidate for the detailed case study. However, in case Department *E* was not willing to cooperate, it would be difficult to choose an alternative based on the relative position of the remaining three departments in the three dimensional matrix. This is because each of the three remaining departments has the second best score for one key parameter. A more detailed analysis that takes the departments' scores for other parameters into consideration is required.



Legends:
Reach—the extent business units have access to GIS hardware/software
Range—the extent to which data can be directly and automatically shared
Routine—the extent to which GIS is customised for used by all staff
} Measured in percentage of offices and business units in a department

Figure 6.1 Diagrammatic representation of the states of GIS development in the four departments with GIS

The detailed scores for all the parameters identified in Table 5.3 are recorded in Table 6.3. The department that excels in a parameter has its score highlighted in bold. The bottom row of the table keeps a count of the number of parameters for which a department has the best score. Department *E* has the best overall score of seven out of thirteen, and excels fairly evenly in each of the three criteria. Department *C* has the second best score of five out of thirteen. Departments B and A have the substantially lower scores of two and one. Therefore, Departments *C* and *E* are both eligible as candidates for the case study, with Department *E* being the most desirable. In case Department *E* is unable to cooperate in the case study, Department *C* is an alternative.

6.2.2 Results of the survey—other measures of state of GIS development

Apart from the parameters identified under the three criteria of *reach, range* and *routine*, there are other indirect measures of state of GIS development. These measures are information about the internal context of the department, and the GIS management practices adopted by the department. This information provides indications/indirect measures about the state of development of GIS in a department. Table 6.2 summarises results for twelve such measures (corresponding question numbers in the first column). Again, the best score for each measure is highlighted in bold.

Table 6.2 Summary of results for other measures of state of GIS development.

Question No.	Measures	Departments (by code) A	B	C	E
10	Years of using GIS	6	6	8	**10**
11	Departmental GIS strategy	none	none	**being developed**	**being developed**
14	Offices with GIS strategy	≤20%	in head offices	**41-60%**	21-40%
15	Offices with GIS manager	≤20%	none	41-60%	**61-80%**
16	Approach to managing GIS	decen-tralised	decen-tralised	**mixed**	**mixed**
33	Use By Specialist	≤20%	none	**21-40%**	**21-40%**
34	Use By Trained Staff	none	no idea	**41-60%**	**41-60%**
36	Ad Hoc Use	≤20%	41-60%	41-60%	**61-80%**
40	Benefit realisation	21-40%	**41-60%**	≤20%	≤20%
41	Means to encourage GIS use	**8**	none	6	6
42	Means to encourage GIS uptake	**7**	none	2	none
43	Means to encourage GIS sharing	none	1	**2**	1
	Counts of measures that each department scored best	2	1	5	**7**
	Previous scores in Table 6.1	1	2	5	**7**
	Total scores	3	3	10	**14**

Question No. 10 enquires about the number of years a department has been using GIS. Theoretically, the longer the time a department has been using GIS, the more experience it has with GIS diffusion. Question No. 11 ascertains if a department has a departmental GIS strategy. The presence of a strategy indicates that a department recognises the value of GIS and is serious about the technology. Questions No. 14–15 enquire about the percentage (of business units) that have a GIS strategy and a GIS manager respectively. A higher percentage indicates a more mature GIS. Question No. 16 enquires about the approach to managing the departmental GIS. A mixed approach that is partly centralised and partly decentralised is regarded as more advanced than either a completely centralised or a completely decentralised approach. A completely centralised approach often denies users the flexibility to adapt GIS to specific business needs. On the other hand, a completely decentralised approach discourages the development of department wide standards and infrastructures.

Questions No. 33–34 enquire about the percentage that have their GIS used by GIS specialists and staff trained to use the GIS software respectively. As re-engineering of both GIS and businesses in the State Government of Victoria is still limited, more business units that have GIS designed for use by both GIS specialists and specially trained staff still represent more advanced GIS development. For the same reason, more business units that use GIS in an *ad hoc* manner (question No. 36) also means better GIS development.

Benefit realisation (question No. 40) is the ultimate purpose of GIS development. A higher percentage that has realised the benefit from using GIS indicates a more mature system. Questions No. 41–43 enquires about the means departments used to encourage use, uptake and sharing of GIS respectively. More means in place indicates more experience in managing GIS.

In the assessment using the 12 measures, Departments *C* and *E* still are the leaders with Department *E* having the highest score of seven out of 12. By taking into consideration the scores of the departments in the previous assessment recorded in Table 6.1, Table 6.2 shows that Department *E* has a total score of 14 out of 25 parameters/measures, while Department *C* has a total of ten. Even by taking into consideration the internal organisational context and the GIS management measures adopted by the departments, which provide the background in which GIS diffusion takes place, Department *E* comes out as the undisputed leader in terms of the state of development of its GIS. Department *C* remains the second place all along.

6.2.3 Primary outcome of the survey

A three-tier analysis has been carried out to assess the state of development of GIS in the State departments of Victoria. The first level is based on the quick and rough method using the key parameters identified for the three criteria of *reach, range* and *routine*. Though the department with the best-developed GIS is identified, the method is not sensitive enough to identify the second best department, which is needed as an alternative candidate for the case study. The second level of analysis is then conducted, and all the parameters identified for the three criteria are included in the analysis. To confirm the outcome, an additional assessment is conducted involving measures that are based on the internal organisational context and GIS management practices.

In all three analyses, Departments *C* and *E* consistently stand out as the better performer. In all, Department *E* scores 14 out of 25 parameters/measures and is considered to have the departmental GIS that is at the most advanced state of development. The first runner-up in the assessment exercise is Department *C* that scored

10 out of 25. Departments *A* and *B* both scored three out of 25. As a result, Department *E* is chosen as the candidate for the detailed case study with Department *C* being the second choice. Department *E* stands for the Department of Natural Resource and Environment.

6.2.4 Secondary outcomes of the survey

In the previous subsections, most of the responses to the questions are used to determine the most suitable department for the case study. The responses not discussed so far are those given to Questions No. 4–6, 8–9, 12–13, 17–21, and No. 44. Questions 4–6 enquire about whether there is a departmental IT strategy, the percentage that have their own IT strategy, whether there is a departmental IT platform respectively. Questions 8–9 enquire about the justifications for the departmental GIS and the year GIS was first considered respectively. Questions 12–13 enquire about the nature of the office that administers the departmental GIS strategy and the involvement of members of the decision-making body in the departmental GIS strategy respectively. Questions 17–20 enquire about the role of internal and external stakeholders on the development of GIS for various business processes and of shared GIS capabilities in the department. Question 21 broadly assesses the requirements of geographic data, analytical capabilities and information products of professional and technical groups in the department. Question 44 focuses on the patterns of development of the departmental GIS. The responses to these questions, including those from the semi-structured interview, lead to two outcomes. On the one hand, they provide valuable background information of GIS diffusion in the State Government of Victoria. On the other hand, they also help validate some of the observations predicted by the diffusion model of corporate GIS and listed in the section 5.1 of Chapter five.

The survey and the interviews together paint a picture of GIS diffusion as follows. The land administration sector in government initiated the land information system project LANDATA in 1984 to develop an integrated textual land information system that was to be linked to a set of digital maps to be produced in the process. The focus of the project was to streamline operations in the land administration sector, not an exercise conducted to address the geographic information needs of the government as a whole.

GIS development in the departments of the State Government of Victoria started as early as mid-1980s, many years before the formulation of a formal GIS development strategy in government in 1991. Departments at that time enjoyed great autonomy in deciding whether to adopt the technology or not.

GIS was first considered in 1983 and was introduced in 1986 within the natural resources sector of Government. The planning sector took up GIS next in 1988, to be followed by the asset and infrastructure management sector within the core government in around 1990. Application of GIS to other sectors in government also started at about the same time. Even in the education sector, GIS was first applied in asset management (School Asset Management System). It must be noted that the application of GIS to asset and infrastructure management had started in mid 1980s in the utility companies which were state owned enterprises but not part of government.

Basically, all departments had a departmental IT strategy. Only one had its strategy redeveloped on account of a recent restructuring of the department. Only two out of the eight departments had a departmental GIS strategy that was still being developed. In three departments, a significant percentage of business units had their own GIS strategies and their own GIS managers. Generally, the four departments with a GIS adopted either a decentralised approach or a mixed (centralised and decentralised) approach towards GIS management. It is interesting to note that the two departments with more advanced GIS both adopted a mixed approach of GIS management, representing a more mature attitude towards GIS management. The decentralised approach of the other two departments with GIS basically represented a *laissez faire* approach to GIS development.

The primary justification for the technology in the early years of GIS development was simply the tangible and intangible benefits identified by the advocates and managers. This was cited unanimously by all departments with GIS as the justification for GIS in the past. Even at present, the same reason was still an important justification as cited by two out of four departments with GIS. Cost-Benefit analyses and business case were more a recent approach of justification. The bias towards the less rigorous approach of justification was probably due to the fact that both economic rationalism and formal departmental GIS strategy were more a recent trend. Many of the investments in GIS in the past were justified only by benefits identified by managers of the business processes.

In the case of the departments without GIS, they all agreed that the key reason for not adopting GIS was that *GIS was not considered essential for departmental business processes*. Other reasons cited by half of these departments were *lack of in-house expertise* and (the fact that GIS) *did not match priorities of senior management*. This confirms the *performance gap* theory (subsection 4.2.2 of Chapter four) which suggests that for GIS diffusion to progress, GIS, as an innovation, must address a performance gap (problem) which is identified in the organisation in the *agenda-setting* sub-stage of the organisation innovation process. The performance gap is normally identified by business managers or senior management in the organisation.

It is also interesting to note that the percentages of offices and business units that were realising or had realised benefits of GIS as predicted (Question No. 40, Table 6.2) were fewer than the departments with less well-developed GIS. This observation appears illogical at first. On probing further, a logical reason emerged. One group of respondents (Department *B*) suggested that all GIS developed by the business units were focused, aiming solely at delivering pre-defined benefits to the business processes being served.

Another seemingly illogical observation is that unlike the two department with better developed GIS, the two departments with less well developed GIS had contrasting attitudes to improving GIS use or uptake (Questions No. 41–43, in Table 6.2). One department (Department *A*) used the widest range of means to encourage GIS use and uptake while the other department (Department *B*) had none. One possible explanation lies in the awareness of senior/middle management in each department. Senior management of one department might have become aware of the value of GIS and were trying hard to remedy the situation.

The departments were asked about the relative impact of ten groups of internal stakeholder on GIS development. All departments, including those without GIS but had responded, agreed that the *departmental GIS coordinator, managers of GIS-using units*, *users of the various GIS for business processes*, and the *GIS coordinators of the business units* had a high level of impact on the development of GIS for various business processes. The great majority of departments felt that the *ministers-in-charge* (four out of six), and the *senior management* (five out of six) had a high level of impact. The other stakeholder groups had a low level of impact. They include *IT managers*, *managers of non-GIS-using units* (and/or other departmental support units), *unions*, *other non-users but with vested interests*. It should be noted that starting with this paragraph and for ease of discussion later on, the levels of impact of stakeholders are re-grouped from six as in the questionnaire (extremely high to extremely low) to two (high and low).

For development of shared GIS capabilities, only two departments with GIS were in a position to respond. Both departments agreed that the *departmental GIS coordinator*, *managers of GIS-using units*, and the *GIS coordinators of the business units* had a high level of impact. There was disagreement regarding the role of *senior management* and *users of the various GIS for business processes*. The other stakeholder groups generally had a low level of impact.

These responses regarding the relative importance of stakeholder groups in GIS development within an organisation give rise to two important results. Firstly, respondents were able to distinguish between GIS for business processes and shared GIS capabilities. This is confirmed by the fact that in practice, the respondents could assign slightly different levels of impact (based on the original six-level scale given in the questionnaire) to each stakeholder group in relation to each type of GIS. These two types of GIS stand for *business process GIS* and *infrastructure GIS* respectively. The ability of the respondents to distinguish between the two types of GIS in their departments helps confirm one of the predicted observations listed in Chapter five: ‘A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure…’.

Secondly, the responses identify the *departmental GIS coordinator*, the *managers of GIS-using units*, and the *GIS coordinators of the business units* as the three core stakeholder groups that have a consistently high impact on the development of GIS, irrespective of whether it was *business process GIS* or *infrastructure GIS*. This result is to be expected as these three groups have the most to gain in the successful introduction of GIS. However, this result has an important implication: important stakeholder groups such as *senior management* and *users of the various GIS for business processes* did not always have a high impact on GIS development as normally expected. Instead, their levels of impact varied with departments and appeared to rely on individual organisational context. Owing to the nature and scale of the survey, it is impossible to give a level of confidence to these results. However these results are definitely possible in view of the *social interactionist* nature of GIS diffusion, and are worthy of further verification in future.

The departments were asked about the relative impact of twelve groups of external stakeholder on GIS development. Up to four departments with GIS and two departments without GIS had responded. All stakeholder groups were recognised by at least one department as having an impact. However, there was no single group that had a consistently high level of impact on GIS development in all departments surveyed. A simple majority was noted for *politicians*, *OGDC* (government GIS coordinator), *Department of Treasury and Finance*, *collaborators in the departmental businesses*, and *academia* to have high level of impact.

The fact that there was no single stakeholder group that commanded a consistently high level of impact or above in the development of GIS in the State Government departments reflects the opportunistic nature of GIS development in response to forces/drives from outside the department. Though the impact of external stakeholder groups might be strong, the impact was not consistent across all departments. No one external stakeholder group can influence all departments all the time.

The departments were asked about the relative extent of requirement of GIS capabilities and products among seven internal user groups in a department. *Senior management* and *ministers* were consistently found to require GIS capabilities to conducts their businesses to a high extent. With a couple of exceptions and uncertainties, *managers of the business units*, and *professional and technical staff of the business units* also were found to require GIS capabilities to conducts their businesses to a high extent. The other stakeholder groups had a low level of impact.

This result suggests that *senior management* and *ministers* should be a key driving force behind GIS development. However, earlier findings in this subsection suggest it is the GIS coordinators and *managers of GIS-using units* in the department, who had a consistently high level of impact on GIS development. This should be viewed in the context of the finding that, according to all four departments without a GIS, the single most important reason for not adopting a GIS was that GIS was not considered essential for business processes.

Ministers and senior management may have the necessary resources, and may ask difficult questions that can be answered by geographic information products best generated by GIS. Very often, they may not be aware of GIS and its practical value. If the managers and users in the business units do not recognise the value of a GIS in solving problems they face in their businesses and in providing answers to their superior officers, they will not recommend GIS to their ministers and senior management in the first place. Without being aware of the technology, it is difficult for ministers and senior management to do anything to promote GIS diffusion/development.

This finding confirms the relevance of the *agenda-setting* sub-stage of the organisational innovation process in GIS diffusion in an organisation. In fact, all four departments without a GIS had not passed beyond this sub-stage of diffusion. The finding also provides evidence in support of another predicted observation listed in Chapter five: ‘Diffusion takes place when the purposes served by a module are focused and well defined’.

The departments were asked about the patterns of requirements of GIS capabilities and products of different professional and technical groups. Three departments reported to be *basically similar with minor variations*, while four reported to be *basically different with varying degree of overlapped requirements*. The respondents from the remaining department had no idea of the pattern. In summary, seven out of the eight State

Government departments would need at least some shared GIS capabilities. No department had totally different patterns of requirements of GIS capabilities and products among its user groups. This strongly supports the presence of *infrastructure GIS*, that is, shared GIS capabilities in the departments surveyed.

In the last question of the questionnaire, each department (with GIS) was asked about the sequence of events that best describe its process of development of GIS. The sequence of events chosen by three out of the four departments was *continued development of separate GIS for various business functions in different business units.* The other sequence chosen by the remaining department was: *development of one or more GIS for business functions, followed by the development of a set of generic shared departmental GIS capabilities, based on which more GIS for the business functions were developed.* The first sequence description suggests that at least in the case of the departments of the State Government of Victoria, a corporate GIS is not necessarily an integrated entity. It may simply be made up of independent modules of GIS for specific business functions, that is *business process GIS*. The second sequence description not only confirms the concurrent presence of *business process GIS* and *infrastructure GIS* in an organisation. It also establishes the supporting role of *infrastructure GIS* to the development of *business process GIS*. In general, the result provides evidence in support of the predicted observation: 'A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with a module of infrastructure GIS supporting the development of one or more modules of business process GIS'.

6.3 Chapter Summary

A set of parameters has been developed under the three criteria of *reach*, *range* and *routine* to assess the state of development of GIS in an organisation. By means of questionnaires, the Departmental GIS Development Profile Survey gathered data in terms of these parameters to assess which department of the State Government of Victoria had the best developed GIS. The survey revealed that four out of the eight departments had GIS, that is Departments *A, B, C* and *E*. The department with the best developed GIS was selected from these four departments through a three-tier analysis.

The first level of analysis made use of a three-dimensional matrix formed by the three key parameters for the three criteria of *reach*, *range* and *routine* respectively, Department *E* was shown to occupy the niche that represented the best developed GIS. In the second level of analysis, the four departments were compared on the basis of all the parameters identified under the three criteria. In the final level of analysis, the departments were again compared using other measures developed on the basis of the internal organisational context and the GIS management practices of the departments. In the latter two analyses, Department *C* and *E* were consistently found to be the two departments with better GIS development. Department *E* was the best in both cases, getting the best score in a total of 14 out of 25 parameters/measures analysed. The first runner-up was still Department *C*, which scored 10 out of 25. Departments *A* and *B* both scored three out of 25. As a result, Department *E*, that is, the Department of Natural Resource and Environment, was chosen as the candidate for the detailed case study. Department *C* would be the second choice.

The survey and the associated semi-structured interviews pieced together some background information of GIS development in the State Government of Victoria. GIS development tended to concentrate within the government sectors where the professions were primarily concerned with surveying, land administration and management, or had their professional activities directly related to the locational aspects of things such as, planning and resources/assets/infrastructure management. Even development in other government sectors often began in organisational units that provided similar professional services.

Further, GIS development with the State Government proliferated at a time when control and coordination from central government was limited. The primary justification for the technology both in the past and, to a certain extent, at present was the tangible and intangible benefits identified by the advocates and managers. Once there was a perceived need for the technology, development would go ahead. However, when there was no perceived need, GIS diffusion in an organisation stalled as illustrated in the four departments without GIS. The *performance gap* theory discussed in Chapter four is also applicable in explaining GIS diffusion in the State Government of Victoria.

All departments responded agreed that the *departmental GIS coordinator*, *managers of GIS-using units*, and the *GIS coordinators of the business units* are the core internal stakeholder groups that consistently had a high level of impact on the development of GIS, irrespective of the nature of the GIS. Despite being perceived as one of the most important users of GIS services and products, *ministers* and *senior management* did not necessarily have a high level of impact on GIS development in all departments. This was probably due to the lack of awareness of GIS among these users/stakeholders.

There was no single group of external stakeholders that had a consistently high level of impact on GIS development in all the departments at all time. Even important external stakeholders like *politicians*, *the State GIS coordinator*, and the *Department of Treasury and Finance* only had significant impact on some departments at some of the time.

Though the impact from the external environment might be great, it was generally opportunistic.

The results of the survey and the associated interviews also provided initial evidence in support of the GIS diffusion model developed in Chapter four. Two of the relationships predicted by the model were confirmed. The first was: ‘A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with an infrastructure GIS supporting the development of one or more business process GIS’. The second was ‘Diffusion takes place when the purposes served by a module are focused and well defined’. The evidence was derived from the perceptions of the respondents, and their responses regarding the extent and patterns of requirement of GIS data, services and products by internal user groups, and the perceived sequences of events of GIS development in departments.

Chapter 7
Outcomes of the Case Study

7.1 Introduction

Based on the outcome of the GIS development profile survey as described in Chapter six, the Department of Natural Resource and Environment (DNRE) was identified as the preferred candidate for the more detailed case study. This chapter starts by giving a brief description of the past and current organisational structures of DNRE to set the scene for the case study. The social, economic and political context that have affected the development of DNRE and its GIS have been detailed in Chapter two and are not repeated here.

The chapter then summarises the development of GIS in each key business function of DNRE in their alphabetical order. Each summary is supplemented by a diagrammatic and chronological representation of the pattern of GIS development using modules of business process and infrastructure GIS as building blocks as described in Chapter five. The significance of the patterns of development of GIS in DNRE is discussed. This chapter ends by a discussion of the implications of the findings of the case study on GIS management in general.

7.2 The Department of Natural Resource and Environment

The Department of Natural Resources and Environment was formed in April 1996 by the amalgamation of eight government organisations. These organisations included the former Department of Agriculture, Energy and Minerals, the Department of Conservation and Natural Resources, the Land Titles Office, Office of the Valuer General, Office of the Surveyor General, Office of Geographic Data Coordination and the Land Conservation Council. The last four offices had a history of being part of a different department, (such as the Department of Justice, the Department of Treasury and Finance, the Department of Crown Land and Survey, and Department of Properties and Services), at different time in the past two decades. The former Department of Agriculture, Energy and Minerals was created from the amalgamation of the Department of Agriculture and Department of Energy and Minerals in 1992. The Department of Conservation and Natural Resources evolved from the Department of Conservation, Forests and Lands in 1993, which in turn was created from the amalgamation of the Department of Conservation, the Victorian Forests Commission, the National Parks Service, and the Department of Crown Land and Survey in 1985. Under the economic rationalist policy of the State Government, the trend was for State departments to become bigger and multi-functional. As the structure of the Department of Natural Resources and Environment has changed since the field study, the report that follows describes the position of the department at the time of the interviews.

The Department had over 5,000 staff, working in over 200 locations and was charged with the duties of managing Victoria's public lands, natural resources, and assisting primary industries to maximise sustainable production of value added products and services for Australian and international markets. The head of the Department was the secretary who reported to two ministers, namely, the Minister for Agriculture and Resources, and the Minister for Conservation and Land Management.

The secretary was assisted by a team of senior administrators. This team was made up of a deputy secretary, one executive director (equivalent to a Deputy Secretary) for each of the functions of performance evaluation, portfolio management and regional coordination, and six divisional executive directors. These divisional executive directors headed the six divisions of DNRE, which included the Catchment Management and Sustainable Agriculture Division, Forests Service Division, Land Management and Resource Information Division, Minerals and Petroleum Division, Parks, Flora and Fauna Division, and Primary Industries Division. These divisions were responsible for the 13 programs administered by DNRE. The Appendix 10 provides a brief description of the 13 programs (http://www.nre.vic.gov.au/about/annrpt97/index.htm).

The divisions planned their programs and coordinated services delivery functionally. Services were actually delivered across Victoria by six regions and 15 major research institutes under the charge of the Executive Director for Regional Coordination. The six regions were Port Phillip, North East, Northern Irrigation, South West, North West, and Gippsland. Appendix 11 lists the research institutes that existed at the time of the case study. Development of GIS in DNRE took place mainly in the divisions, and to a lesser extent, in the regions. There were few or no GIS in the areas of general administration, performance evaluation and portfolio management. Therefore, the case study covered mainly the six divisions, and to a minor extent, the six regions.

The management philosophy of the State Government had been outcome-oriented all along. The thinking of the Secretary of Department of Agriculture aligned with this philosophy. As a result, since taking office in 1992, the secretary remained as the head of the successive departments, including DNRE, which were formed as a result of amalgamating with the Department of Agriculture. The secretary did not care about structure in the department. This led to the creation of project teams in the Primary Industries Division, and Catchment Management and Sustainable Development Division. This management structure would be extended to other divisions eventually.

The Secretary used to be a manager in the Department of Agriculture. He was an ‘information junkie’ and had also used GIS products before. He thought strategically and wanted to achieve. Since he was aware that he needed information to achieve and to meet the business needs of the department, he demanded information. He had direct access to data and maps through his personal computer. He was also keen to bring the data to the users. He saw the value of information management in general and GIS in particular. With the state’s key land management and administration agencies grouped under his charge in DNRE, he became the first secretary to take an active role in formulating policy for GIS development at both the state and the department level.

7.3 Records of GIS Development in DNRE

Each subsection in this section summarises the development of GIS of one division of DNRE. The summaries are arranged in alphabetical order of the divisions. Each summary is illustrated by a diagrammatic and chronological representation of the GIS development process using modules of business process and infrastructure GIS as building blocks. These summaries and diagrams are the source of data from which evidence is teased out in support of the model of diffusion of a corporate GIS.

7.3.1 Catchment Management and Sustainable Agriculture Division

The Division of Catchment Management and Sustainable Agriculture (CMSA) was responsible for administering three programs: the Catchment Management and Sustainable Agriculture Program, the water agencies program, and the weeds and pests program (Appendix 10). The division had six branches: Pest Plants and Animals, State/Commonwealth Programs, Catchment and Water Resources, Sustainable Development, Office of Rural Affairs, and Water Bureau. CSMA was formed as a result of the amalgamation of two precursor branches: the Sustainable Development Branch of the Department of Agriculture, Energy and Minerals (DAEM), and the Catchment and Land Management Branch of the Department of Conservation and Natural Resources (DCNR).

There were a number of teams under each branch. Some were responsible for providing divisional support services such as contract management and customer research. Some served as purchaser of the various business functions of the division. Natural Resources Monitoring and Assessment Team of CMSA was one of those purchasers responsible for data collection service. The team arranged to purchase information services and products from various research institutes and services providing bodies on behalf of other teams in the division. The institutes and bodies included the Australian Bureau of Statistics, various institutes conducting research in vegetation, soil science, and water resources, Natural Resource Systems (NRS), GIS and Client Systems (GEDIS), Centre for Land Protection Research (CLPR).

Different modules of GIS capabilities were developed in CSMA over the years to serve different needs within the units of its two precursor branches. This took place under changing context both inside and outside the precursor branches and their parent organisations. The following paragraphs summarise the events of GIS development that have taken place in CMSA over the years.

From 1986 to 1994 when the Sustainable Agriculture Branch (SAB) was still part of Department of Agriculture, projects that required GIS capabilities were inevitably jointly undertaken with the *de facto* GIS/mapping unit at the Environment Science Unit (ESU) of the State Chemistry Laboratory. These projects constituted individual modules of business process GIS in the SAB, which were supported by the module of infrastructure GIS at ESU.

In 1993 local area networks, personal computers (PC), and PC-ArcView 1 were introduced to the regions with the necessary data and training. In 1994, a wide area network was introduced. In 1995, the manager of ESU and part of the GIS unit in ESU were restructured by the secretary into the Industry and Resources Information Service (IRIS), and were placed under SAB.

IRIS took up GIS and other projects that had a corporate emphasis. In 1995/6 it arranged for the introduction of PC-ArcView 2 and the associated training to the regions. Over this period, regional staff of SAB started to use and experiment with the GIS software. The software was used to map the adoption rate of various agricultural practices recommended to farmers over the years, using data supplied from various sources, including ESU, and CLPR in DCNR.

The GIS expertise developed among regional staff, together with access to a set of standardised (*de facto*) GIS hardware, software and data, constituted modest modules of infrastructure GIS in SAB in the regions. These modules of infrastructure GIS supported development of new *ad hoc* GIS projects required in the process of carrying out the business of the branch. These projects constituted simple *ad hoc* modules of business process GIS.

With the amalgamation of departments to form DNRE in 1996, IRIS became the Natural Resources Monitoring and Assessment Team, the manager of which became the divisional Land and Resource Information Manager, representing the interest of the division in the management of land and resource information in DNRE.

Prior to 1996 when the Catchment and Land Management Branch (CLMB) was still part of DCNR, projects that required GIS capabilities were undertaken or supported by CLPR and NRS (or its predecessors). Originally NRS was the *de facto* GIS products and services supplier of DCNR. In the latter half of the 1980s, apart from providing general GIS advice and services, NRS also supported the Land Capability Mapping System in the Keith Turnbull Research Institute, a dedicate research institute of CLMB. In this case, the Land Capability Mapping System constituted an on-going module of business process GIS while NRS served as a module of infrastructure GIS, providing GIS hardware, software and data management service in support of the system.

Gradually the small business unit that managed the Land Capability Mapping System evolved into a module of infrastructure GIS providing advice and software in support of minor mapping projects of CLMB. These minor mapping projects would otherwise be too small to arouse the interest of NRS and gain its support.

The project team that undertook these minor mapping projects accumulated GIS expertise and other GIS capabilities over the years. These expertise and capabilities were eventually consolidated into the GIS unit in the newly formed Centre for Land Protection Research at CLMB. Serving as a module of infrastructure GIS, the GIS unit of CLRP undertook other GIS/mapping projects (*ad hoc* modules of business process GIS). Sometimes, the projects were undertaken jointly with other agencies that had more advanced GIS capabilities. In the process, technology transfer took place and the capabilities of the GIS unit in terms of expertise, data, hardware and software improved significantly. CLPR served as the intellectual pool of soil and land management, and the GIS capabilities developed in the GIS unit constituted a module of infrastructure GIS.

As the GIS unit grew, it maintained contact with NRS and kept with the GIS standards set by NRS for DCNR. NRS was also contracted to provide data management support to the unit, serving as a module of infrastructure GIS. As a result, resources were freed to allow the unit to support the GIS needs of agencies outside CLMB, such as SAB of Department of Agriculture. With the creation of DNRE, CLPR was put under the umbrella of the Executive Director of Regional Coordination as a service provider.

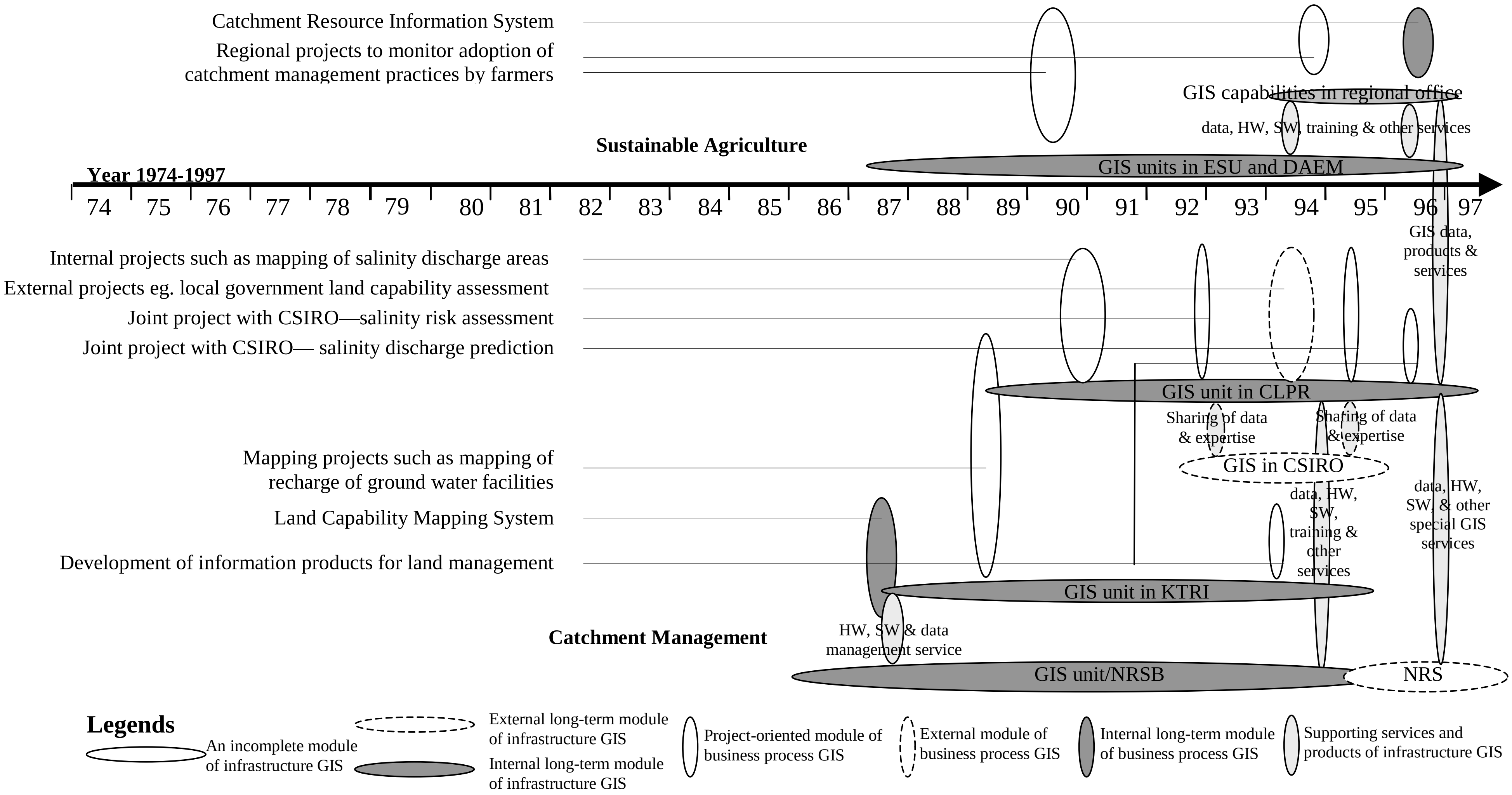


Figure 7.1 Chronological development of GIS modules in Catchment Management and Sustainable Agriculture Division

Figure 7.1 illustrates the chronological development of GIS in CMSA by portraying the development of the modules of business process and infrastructure GIS identified in the summary above. The Figure also describes how the divisional GIS developed with GIS modules in one divisional unit supporting the development of GIS modules in others.

7.3.2 Forests Service Division

The Forests Service Division (Forests Service) was in charge of two programs of DNRE: the Forests Management Program and the Fire Management Program (Appendix 10). The division had four branches: Forests Management, Fire Management, Commercial Forestry, and Center for Tree Technology. Forest Management was concerned with collection of forest resources data, production of forest management plans and calculation of sustainable yields. Fire Management looked after the fighting and prevention of fire in state forests. Commercial Forestry was concerned with planning of proposed tree-cutting regimes (coupes) through timber harvesting to forest regeneration. It also administered the levy collected for the maintenance of logging roads. The Center for Forest Tree Technology was a government research institute that examined ways to better grow and utilise trees.

The key function of Forest Management was to manage the state's forests to give sustainable yield. This was a statutory obligation that could only be fulfilled through the production of forest management plans, using appropriate forest resource data. Forest Management Branch had four sections to meet this obligation. The first one was Forest Resource Inventory (FRI) Section, which was responsible for collecting data of Forest resources. The second one was Forest Planning and Assessment (FPA) Section, which was responsible for strategic forest planning, developing forest management plans, and delineating areas for harvesting. The third one was Forest Information (FI) Section, which was responsible for the analysis of data to determine sustainable yield of each harvest area. The yield data in turn served as a guide for operations of the Commercial Forestry Branch. The last one was Education and Recreation Section, which was responsible for education, recreation and conservation management in state forests.

Forest Management Branch was the eminent user of GIS in the division, to be followed by Fire Management Branch. Commercial Forestry Branch, the Education and Recreation Section of Forest Management Branch and the Center for Tree Technology did not do anything with GIS directly. The GIS services and products required by staff in these latter business units were contracted out to the GIS specialist sections in the division or to the corporatised departmental GIS service provider, NRS. The following paragraphs summarise the events that have taken place in the development of GIS in Forests Service Division over the years.

Back in the mid-1970s, Forests Service was part of the Forests Commission. Managers of FPA were already aware of GIS and its potential, and were pushing for the adoption of GIS. The Commission was amalgamated with the Department of Conservation and other organisations to form the Department of Conservation, Forests, and Lands (DCFL) in 1985. The FPA managers struck an alliance with the Director of Conservation who championed the adoption of GIS and remote sensing at the senior management level.

Together, they acquired the expertise of developing and using GIS. At the same time, they were also marketing the technology to managers at various levels, particularly senior management, raising their awareness of the value of GIS. They did not acquire any hardware or software and accumulated no GIS data. Their focus was on changing the organisational setting of the department to make it more conducive to adopting GIS. In effect, they were developing part of a module of infrastructure GIS. Through their cooperation, this incomplete module of GIS supported the development of the first business process GIS—a pilot study linking GIS to an existing textual forest resource information system called FRIYR. With the help of the study, the value of GIS was demonstrated to senior management and staff of Drafting Services Branch.

Driven by the Director of Conservation, a water engineer with strong GIS background was hired to establish a GIS unit in the Conservation Division of DCFL in 1995. The new GIS manager had a vision to develop a GIS to serve the whole department, and eventually to serve the whole government.

With the general support of senior management, the new GIS manager purchased a GIS software (Arc/Info) licence and the associated hardware. However, no funding was allocated for continual development of the one-person GIS unit. In order to get the funding required to develop the GIS unit, the GIS manager had to undertake project on behalf of sponsors in the department. He went to the managers of the 18 regions of the department, promised them a series of GIS products, and got two-year funding for the development of the GIS unit.

Computer and application developing scientists were employed to tackle data issues and to develop applications to generate the GIS products promised. Together with the hardware and software already acquired, the GIS unit gradually became a module of infrastructure GIS ready to serve the department. A prototype integrated GIS project was undertaken in a Forests Service regional office in Dandenong to demonstrate the benefits of integrated outputs from a functional GIS. The experience of the project also formed the basis of future data standards and GIS policy.

On the retirement of the Director of Conservation by the end of 1986, the GIS unit was incorporated with Forests Service. At that time, the new Director of State Forests and Lands who was aware of the value of GIS, was supportive of the GIS unit. The unit was placed under the charge of the Manager of Forest Assessment. The manager was aware of the value of data and supported the GIS manager's corporate and government wide approach to GIS development. Keeping to the practice of the retired Director of Conservation, the GIS manager was allowed to maintain a separate budget for coordination of GIS development both in the department and the government. As a result, the GIS manager was able to team up with other managers in the natural resource section to form the Natural Resource GIS Coordinating Committee (NRGISCC) in 1986 to campaign for the provision of GIS data by government.

In 1987, Forests Service decided to undertake a pilot study in the forests at Otway to demonstrate to the regions the way to prepare forest management plans. On the advice of the Manager of Forest Assessment, the planner in charge of the project adopted GIS as the mapping tool and the tool to do simple spatial analyses. Owing to the lack of quality maps and digital map data, the GIS manager and the planner gained the support of the departmental GIS steering committee to digitise their GIS data from 1:100 000 topographic maps. By this time, the Drafting Services Branch of the DCFL had acquired its own GIS. It was asked to digitise the base layers, such as roads and streams.

Based on the experience of the pilot project, Forests Service routinely used GIS to prepare forest management plans. On popular demand and the availability of better maps and spatial data, more current plans produced digital GIS data/maps at a scale of either 1:100 000 or 1:25 000, or a mix of the two.

Though the GIS unit was run as a centralised departmental resource and did departmental work, most of the funding was obtained in a decentralised way, mainly by doing projects for Forests Service. Extra funding was obtained through taking on externally funded projects. The GIS manager's strategy was to use the forest management plans (and other projects) as the backbone to bring the themes of the GIS layers together, to develop skills in the GIS unit, and generally to achieve the vision of developing a corporate GIS. The data accumulated and the expertise acquired in undertaking these project, together with the hardware and software used, formed modules of business process GIS developed in Forests Service. These modules could be short term or long term, internal or external, depending on their clients and purposes.

In 1990 the manager of the GIS unit was seconded to the Department of Finance to plan and implement a government wide GIS study (see Chapter two). As a result, the GIS unit was amalgamated with the remote sensing unit of Forests Service and placed under charge of the head of remote sensing. The new GIS manager continued with the strategy of building the GIS unit through undertaking projects. Significant funding was received from projects funded by state and federal programs.

At the same time, a wide area network was introduced into DCFL. The GIS unit helped the regional offices to gain access to GIS products and services kept in the unit by purchasing GIS hardware and software and training dedicate regional GIS operators for them. Each region had access to Arc/Info at the head office and other major offices. Each region was provided with a GIS operator and regional hardware (including digitisers and plotters). These regional GIS capabilities constituted modules of infrastructure GIS that allowed minor *ad hoc* GIS projects to be developed locally.

Generally GIS operators were funded by any program that could afford to keep them. GIS capability of each program in a region depended on the access of the program staff to these operators, which could vary from region to region. Traditionally in Forests Service, the more timber a region had, the bigger was its budget and the earlier its forest management plans were prepared. Extra funding would be provided for the early preparation of the Forest Management Plan if an area was the centre of a controversy. As a result, the power users of GIS in Forests Services belonged were primarily forests management staff located in the regions of North East, South West and Gippsland.

Prior to 1993, the GIS unit was located in the same building as its clients in Forests Service and communication was good. In 1993, the GIS and remote sensing unit was amalgamated with the Drafting Services Branch to form the Natural Resource Systems (NRS) Branch. Together they moved away from Forests Service. Communication barriers started developing. Needs of clients in Forests Service were not well articulated; staff of NRS Branch started interpreting the data on behalf of their clients. Further, when GIS data were accumulated to a certain extent, forestry professionals became better aware of their data needs and wanted more control over the data. All these events led Forests Service to develop its own GIS, and to re-engineer the business processes of the Forests Management Branch. Two new sections were created, namely, the Forest Information (FI) Section and Forest Resource Inventory (FRI) Section. These new sections were to train their own foresters with GIS expertise. In 1993, DCFL was also restructured into the Department of Conservation and Natural Resource (DCNR),

The development of GIS in FRI was to support the key business process of keeping forest resource inventory. It was driven by a long-term state program called the State

Forest Resource Inventory and initiated in 1992. As the data accumulated, FRI became the key data supplier of FI, which was responsible for specialised data modelling to forecast the sustainable yield of a forest. On the other hand, the development of GIS in FI was mainly funded by senior management of Forests Service. Senior management was willing to put resources into FI because they needed well presented and accurately analysed data to justify decisions concerning forest operations that were often deemed to be intrusive and destructive.

While the projects of preparing forest management plan continued to contribute to the growth of NRS Branch, these projects also fuelled the development of GIS capabilities in FI. Forest planners did not develop significant GIS expertise. They preferred to rely on NRS Branch and FI to supply GIS analytical services and products for their work. FI was also happy to maintain the *status quo*. Apart from providing sustainable yield modelling forecast and supporting forest planners, FI also undertook various long term and short-term GIS projects. These projects included *ad hoc* growth modelling projects for regional managers, and other state wide or national conservation studies.

Following the footsteps of NRS, both FRI and FI developed their own GIS capabilities in terms of hardware and software, GIS data, standards and expertise. In the process, they had actually developed their own modules of infrastructure GIS that they used to develop different modules of business process GIS. It was the latter modules of GIS that supported the projects they undertook to fulfil their mandatory duties.

By July 1, 1994, as a step further towards realising the purchaser/provider management model, the $2 million budget of NRS Branch was handed backed to the purchaser, that is, the policy units of DCNR. NRSB was forced to win contractual work negotiated with other business units of DCNR. It started to be run as a commercial business. In 1995, NRS Branch was officially split into NRS Branch, the purchaser, and NRS, the provider. NRS would eventually move out of the department. In the course of the case study, some managers had expressed concern that NRS was no longer part of DNRE and therefore could not be relied on to act in the best interest of the department.

Since the early 1990s, Fire Management Branch was developing infrared remote sensing capabilities to track behaviour of forest fires. Recently, it developed a GIS to allow infrared remote sensing images to be superimposed on electronic maps of the departmental GIS for fire fighting and other purposes.

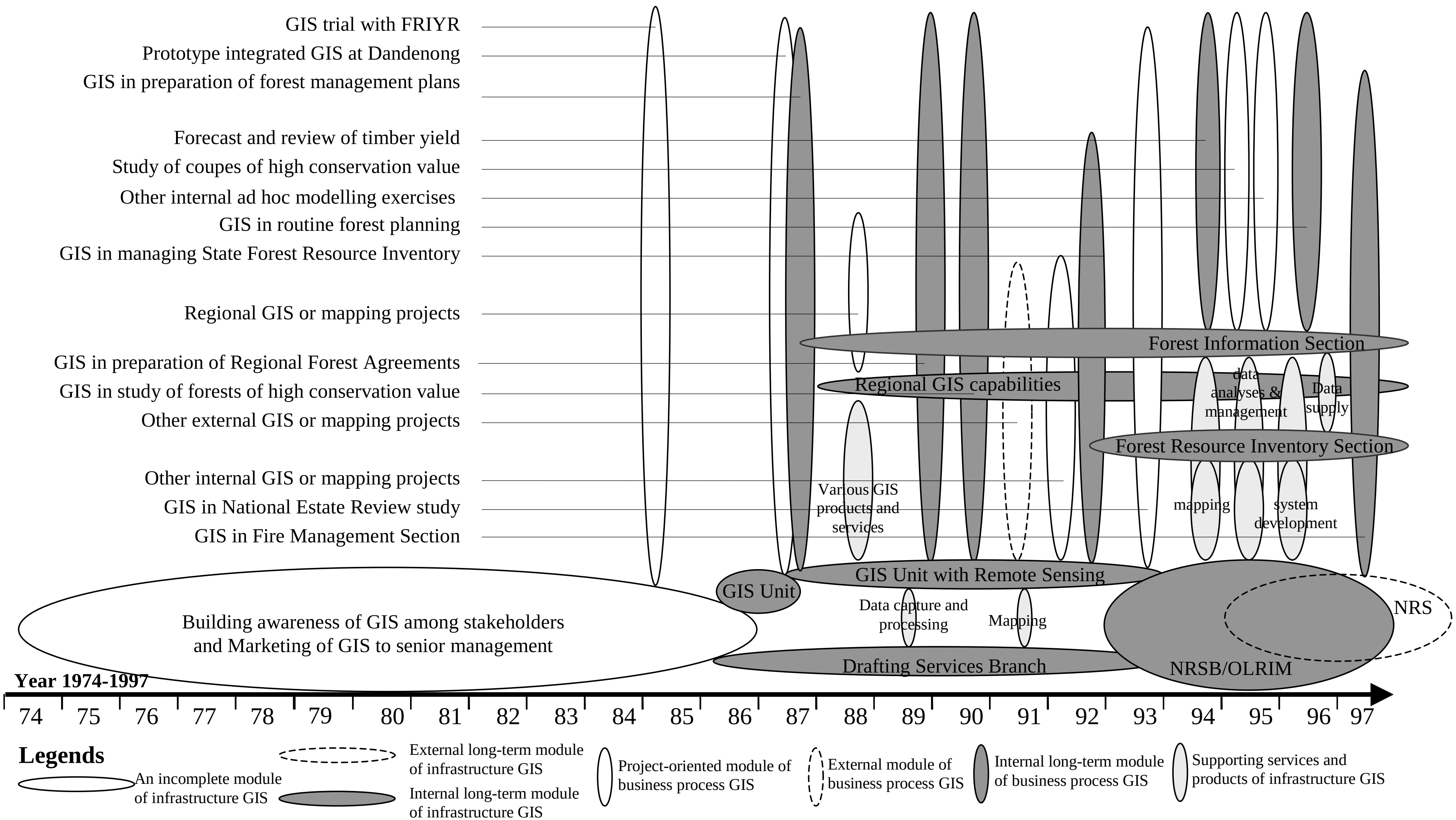


Figure 7.2 Chronological development of GIS modules in Forests Service Division

Commercial Forestry Branch, and recreation and education were interested in GIS but had limited access (through the local GIS operators). There was not much impetus from the section managers to develop GIS. If the section managers understood GIS personally or through education by their subordinates, they then would be in a position to sell the technology to branch managers. To address the limitation, a senior forester from Commercial Forestry had been nominated the GIS representative of the branch.

Figure 7.2 illustrates the complicated pattern of GIS development in the dynamic environment of the Forests Service Division over the years.

All along, the Division of Forests Service has its own budget and has significant autonomy regarding how the budget can be used. The same culture also prevails at the branch and section level. Together with the needs of senior management for efficient and effective access to data to justify their decisions, the culture has prompted the development of GIS in the division. However, due to the different data requirements by staff at different administrative levels, there was no central focus for GIS development. Different business units had their own strategies of GIS development.

7.3.3 Land Management and Resource Information Division

The Land Management and Resource Information (LMRI) Division was responsible for administering the Land Management and Resource Information Program (Appendix 10). The division was formed by the amalgamation of a number of agencies involved in the State's traditional activities of land administration and management, and in the more recent activity of GIS development. LMRI currently was made up of eight branches or offices. They included Crown Land and Assets (CLA), Geospatial Policy and Coordination (GPAC), Geographic Data Victoria (GDV), Office of the Surveyor General (OSG), Office of Valuer General (OVG), Land Titles Office (LTO), Office of Land Resource Information Management (OLRIM), and Business Reform.

CLA acted as the Government landlord for Crown land occupied by people and institutions other than DNRE, and to provide the 'land bank' and real estate function for DNRE and Government. GPAC was responsible for developing geospatial information strategy and the associated pricing policy for the state, and coordinating the development of the state's spatial data infrastructure. GDV was the state's mapping authority responsible for the custody and maintenance of the state digital map base. The map base included the digital topographic databases (DTDB), digital cadastral databases (DCDB), and the state digital road network (SDRN).

OSG provided all sorts of survey services to government, including the regulation of the surveying profession in Victoria. It also managed the state's geodetic network. OVG was concerned with quality control and supervision of municipal valuations, tracking land/property trends, provision of property sales data to the public, and provision of valuation indices. LTO was primarily concerned with registration of land titles (deeds) and transfer of land ownership. Unlike the above agencies the activities of which had a statewide interest, OLRIM was the information management arm of DNRE. It was responsible for coordinating the development of a common information management strategy (primarily geographic information) among the divisions through consultancy studies and liaison with a network of Land Resource Information Managers. Each Land Resource Information Manager represented the interest of the corresponding division in DNRE. Business Reform was the office in charge of business re-engineering of LMRI as a whole, and was mainly an administrative office.

The first six offices of LMRI listed above had participated in one way or another in the development of the spatial data infrastructure in the State of Victoria over the last two decades. Some of the events have been described in Chapter two. The following paragraphs summarise the events that have taken place over the years.

In 1979, after an exercise to identify surplus government land, the Surveyor General became aware of the need of an integrated computerised land information system (LIS). After a series of studies, the government finally agreed to the development of such a system in 1982. The project was called LANDATA, and was supervised by a steering committee chaired by the Surveyor General. A corporate plan of LANDATA was produced in 1984, committing LANDATA to producing seven key products. The products included a text-based LIS that recorded land description, ownership, and valuation data, a Register of Government Owned Land, a Crown Land Administration system that handled crown land administration data, a Master Index to access all land information system, a digital cadastral mapping system (DCDB), a Natural Resource Directory for natural resource data in the state, and a public enquiry service. However, the main emphasis was on the LIS and the DCDB. LANDATA is not considered a full module of infrastructure GIS as what it developed was not a GIS. However, it can be regarded as an incomplete module of infrastructure GIS since it provided an opportunity to educate the State Government of Victoria about GIS and GIS development.

The development of the DCDB was simpler as it was under the sole charge of the OSG, which, in turn, had delegated the duty of preparing the metropolitan part of the DCDB to the Melbourne Metropolitan Board of Works (privatised in the early 1990s into the Melbourne Water Corporation (MWC)). By 1986/7, OSG secured the technology and base maps, developed its own digital mapping expertise, and was pushing ahead with digitising the rural DCDB. The two sets of DCDB were both in computer-aid-design (CAD) format. Like LANDATA, as OSG did not produce the DCDB in GIS format, it is not considered a GIS module. However, it did provide other agencies with CAD-based digital mapping data to develop their own GIS capabilities, OSG can be regarded as an incomplete module of infrastructure GIS.

The development of the LIS was not as smooth as the DCDB. This was because all participating agencies had their own agenda and were not cooperating fully. In particular, LTO was reluctant to cooperate, as it had no awareness of GIS and no interest in GIS. It only wanted to be left alone to automate its business system to meet the demand of its customer. Until the late 1980s, the automation exercise of LTO was at a more advanced staff, and LTO was more willing to cooperate. But it was too late. The government deemed that LANDATA was not achieving enough to cover its cost, and downgraded it into the public enquiry service of LTO.

When many agencies were busy with the planning and implementation of LANDATA, Crown Land and Assets (CLA) started developing its own text-based LIS called Regional Administration and Management System for the administration of crown land. The system was later replaced by the Land Information Management System (LIMS), which was still text-based initially. In 1986 a cartographer was hired to examine the feasibility of handling spatial data in-house and eventually to link the textual data of LIMS to the corresponding spatial data. Like LANDATA, prior to giving LIMS GIS capabilities, CLA is regarded as an incomplete module of GIS.

All along, OSG was satisfied that CAD-based mapping data were sufficient to meet its business needs. However, since mid 1980s, the natural resource sector had been developing GIS capabilities. Members of the natural resource sector needed GIS-based mapping data, and formed a Natural Resource GIS Coordination Committee (NRGISCC) to campaign for the provision of such data by OSG.

Unable to get additional resources, OSG continued to supply digital mapping data in CAD format. In 1989, CLA bought the CAD-based DCDB from OSG and started to convert it to GIS format for use with LIMS. From then on, the GIS capabilities in LIMS became a module of infrastructure GIS, supporting the development of GIS capabilities for the planned business modules of LIMS. These modules in effect represented modules of business process GIS. As the GIS experience of the users of LIMS grew, some cooperated with CLA to develop custom-made modules of business process GIS. CLA was able to make use of the new GIS capabilities to develop LIMS further.

By 1990, with the support of the Premier's Office, the members of NRGISCC decided to by-pass OSG. They convinced senior management from nine natural resource agencies to pool their management resources together to hire an international consultant to study the GIS policy in the state. The study took place in 1991 and produced a report that had a strong economic rationalist emphasis. The government accepted the report. The Office of Geographic Data Co-ordination (OGDC) was created to oversee a more detailed GIS planning study of the state government as recommended by the consultants. The government selected two key members of NRGISCC to head OGDC.

In 1991, LTO was sufficiently interested in GIS to start a GIS pilot project in consultation with OSG and OGDC. Though there were some junior staff in LTO with some knowledge of GIS, they were not in a position to push for GIS and the project was followed by a long gestation period.

In 1992, with the creation of the State Data Centre (SDC) in Ballarat, the staff of the mapping unit of OSG in SDC purchased some PC-based GIS hardware and software. They started to develop their own GIS expertise in Ballarat to serve the local community. As a result, staff from the imaging unit of LTO and the local surveying unit of OSG, who were part of SDC, became exposed to GIS and picked up their own GIS expertise. The manager of the imaging unit of LTO in SDC was later appointed the Assistant Director of Land Parcels and Survey Services of LTO in 1993. With the help of the junior staff who was knowledgeable of GIS, the new assistant director who had been exposed to GIS in SDC, pushed for the development of GIS for charting purposes in LTO. This effort gave LTO its first module of business process GIS in 1996.

The GIS consultants finished the planning study in 1993 and produced a set of GIS strategies for the state government. On being asked to implement the strategies, OGDC started to push for the development of core digital based maps such as DCDB and DTDB in GIS format. At that time, the metropolitan DCDB (CAD-based) was digitised and owned by MWC. OSG had been trying to take back the database from MWC through legalistic means since 1991. Through separate meetings, OGDC managed to persuade MWC to hand the database back to government in 1994. One key condition was for OGDC to take charge of both the metropolitan and rural DCDB. To meet this condition, a unit called Geographic Data Victoria (GDV) was set up within OGDC to manage the whole DCDB.

In early 1995, the common manager of OGDC and OSG decided to transfer the key digital map bases and the mapping function from OSG to GDV. The GIS group in the mapping unit in SDC was placed under GDV and was renamed Geographic Resource Centre. OGDC then made use of the centre to undertake projects from across the state to promote GIS. All along, prior to taking over the mapping function, OGDC did not have any GIS data, and is considered an incomplete module of GIS.

Overwhelmed by the extra duties of managing the digital map bases and the mapping function, OGDC did not carry out much of its policy and coordination functions. With the creation of LMRI, OGDC was replaced by two offices, namely, GDV and Geospatial Policy and Coordination (GPAC). Together the two agencies had control of GIS data, hardware and software, and the expertise to develop applications. In effect GDV and GPAC had become a module of infrastructure GIS in government, supporting the development of other modules of business process GIS.

Some examples of the modules of business process GIS developed by GDV/GPAC included various promotional GIS projects, the development of geospatial data pricing policy, and the development of short term and long term GIS strategies for the state. Another example was the maintenance program of the digital map base, which included the out-sourcing of the management of the complete set of DCDB.

At about the same time, the government continued to realise its purchaser/provider model of management. LIMS was moved from CLA to the corporatised NRS. NRS was bound by contract to provide current level of service to CLA for three years. The GIS purchaser group that remained in CLA continued to specify new and improved services to be developed by the provider group in NRS.

Though OSG lost its mapping unit to OGDC, its surveying team in SDC had also picked up some GIS expertise from their colleagues of the old mapping unit in SDC. As a result, OSG retained some GIS expertise and planned to introduce GIS capabilities in the second phase of its Survey Marks Enquiry System in 1997—a project to make the details of the network of survey marks in Victoria more accessible to surveyors.

Figure 7.3 illustrates the pattern of GIS development in the Land Management and Resource Information Division over the years.

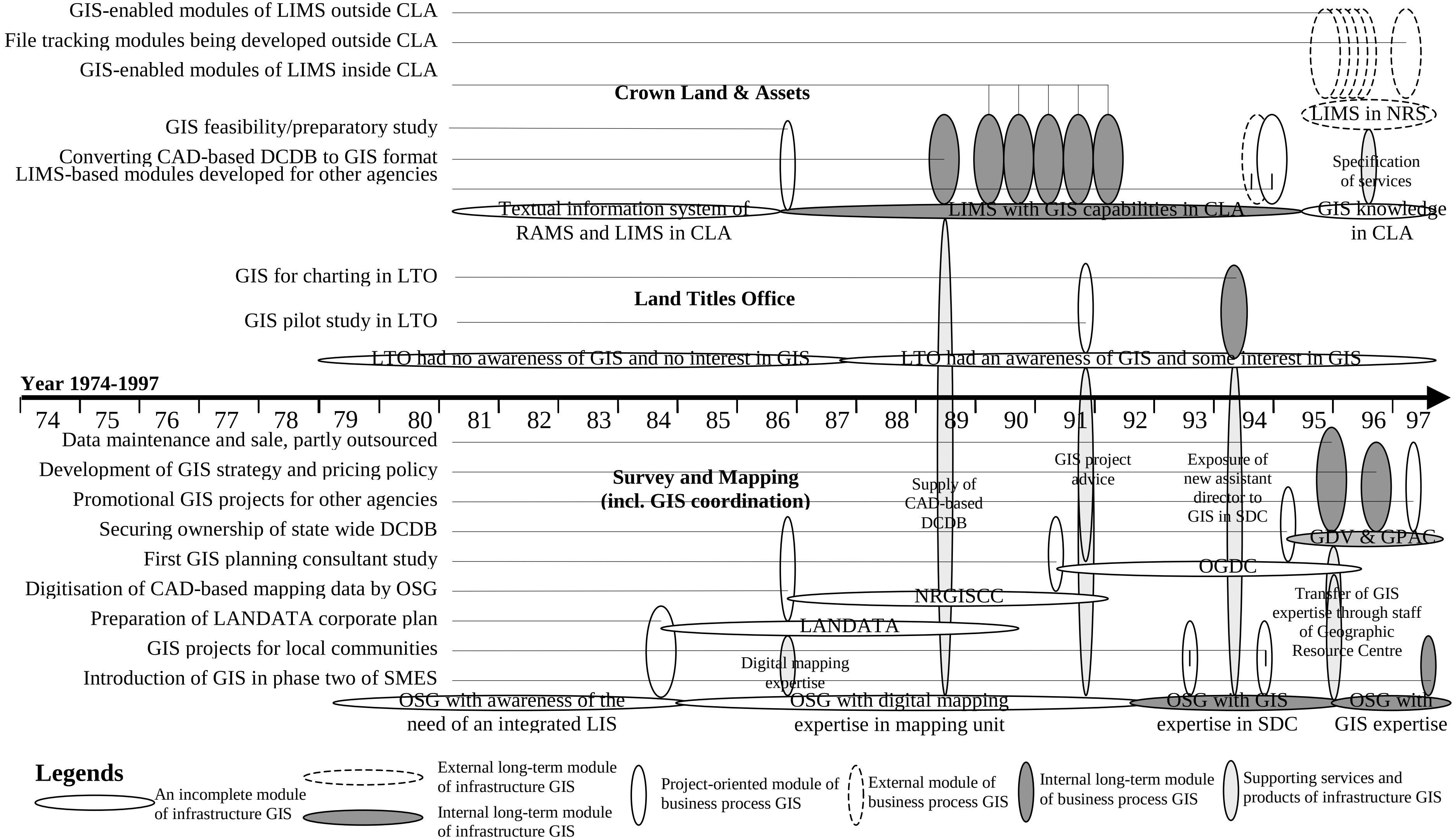


Figure 7.3 Chronological development of GIS modules in Land Management and Resource Information Division

7.3.4 Minerals and Petroleum Division

The Minerals and Petroleum Division looked after the Energy & Minerals program of DNRE. There were four branches in the division. Geological Survey Victoria was responsible for all the geological research, and geology related survey and mapping in the state. Exploration and Mining looked after the mineral side of the business of the division. Oil and Gas was responsible for the energy side of the business. Extractive Industries was concerned with the extraction of sand, aggregate and other construction materials within the state. Exploration and Mining was the major branch and had three sections: Tenement Title, Operations, and Industry Development. All the branches in the division were concerned with regulation and marketing of the state's energy and mineral resources.

One of the early predecessors of Minerals and Petroleum in 1983 was the Mines Department under the previous Liberal Government. It was restructured seven times under successive Labour governments, attaching to different departments. In 1992, under the new coalition (Liberal and National Party) government, it became the Department of Energy and Minerals. Two years later, it was amalgamated with the Department of Agriculture into the Department of Agriculture, Energy and Minerals. In 1996, the new department amalgamated with the Department of Conservation and Natural Resources to form DNRE. Minerals and Petroleum had been developing in a very volatile environment. The following paragraphs summarise the events that have taken place in the development of GIS in Forests Service Division over the years.

Since the introduction of the new Mines Act in 1983, the division was keen to automate its business processes. Despite the introduction of new computers and software, without in-house computer expertise and awareness of technology, early automation exercises were not successful. In 1985/86, a project was initiated to introduce legislative changes and to develop a system to facilitate information dissemination to potential mining investors to promote mining investment in the state. The system was called the Integrated Geological Database and was initiated from within Geological Survey Victoria. As the project was concerned primarily with geological data and did not take into consideration the whole business process, the return did not justify the investment. Eventually, the project did not get the support of senior management. Though unsuccessful, the project provided staff of Minerals and Petroleum with much needed experience in developing GIS. Therefore, it constituted an incomplete module of infrastructure GIS.

Based on the experience of the Integrated Geological Database project, the head of electronic data processing unit in the Exploration and Mining Branch proposed a new integrated GIS project called Geological Exploration Development Information System (GEDIS). With the support of branch managers, a project team was set up to promote, plan and implement the project. The project took a whole business approach and involved process re-engineering. The benefits were better quantified and the project team secured the support of successive levels of managers, and ultimately, the support of the Chief Executive Officer.

A full time project manager was hired and academic experts from the University of Melbourne were involved to market the project to government. The government subsequently granted an initial funding of A$8 million over three years to develop GEDIS. The project team became a GIS unit in Minerals and Energy.

In the past, the Exploration and Mining Branch (previously called the Minerals Branch) was a very influential branch with its own electronic data processing unit. Though the organisational setting in which GEDIS was developed continued to change over the years, the managers of the branch and the project manager continued to re-justify the case of GEDIS to new secretaries and ministers. These managers also continued to gain government funding to develop the system.

The modules of GEDIS were developed in order as planned. Each module represented a link in the chain of business process of delivering critical investment information to potential mining investors. Each module served as a module of business process GIS. As each module was completed, the data and technology acquired, standards developed, and expertise accumulated in the GIS unit facilitated the development of the next modules. The GIS unit itself served as a module of infrastructure GIS, growing and improving with the modules of business process GIS in a planned and coordinated manner. Indeed, the project team was so good at developing applications that on amalgamating with the Department of Agriculture, the team took over the duty of providing the new department with technical GIS support and developed applications to meet the geographic information needs of the agriculture sector. Good example was the development of Insight, the Executive Information System. Currently in DNRE, the team was also asked to provide similar service to other divisions in the department to complement, not compete with, the services of the corporatised NRS.

Figure 7.4 illustrates the pattern of GIS development in the Minerals and Petroleum Division over the years.

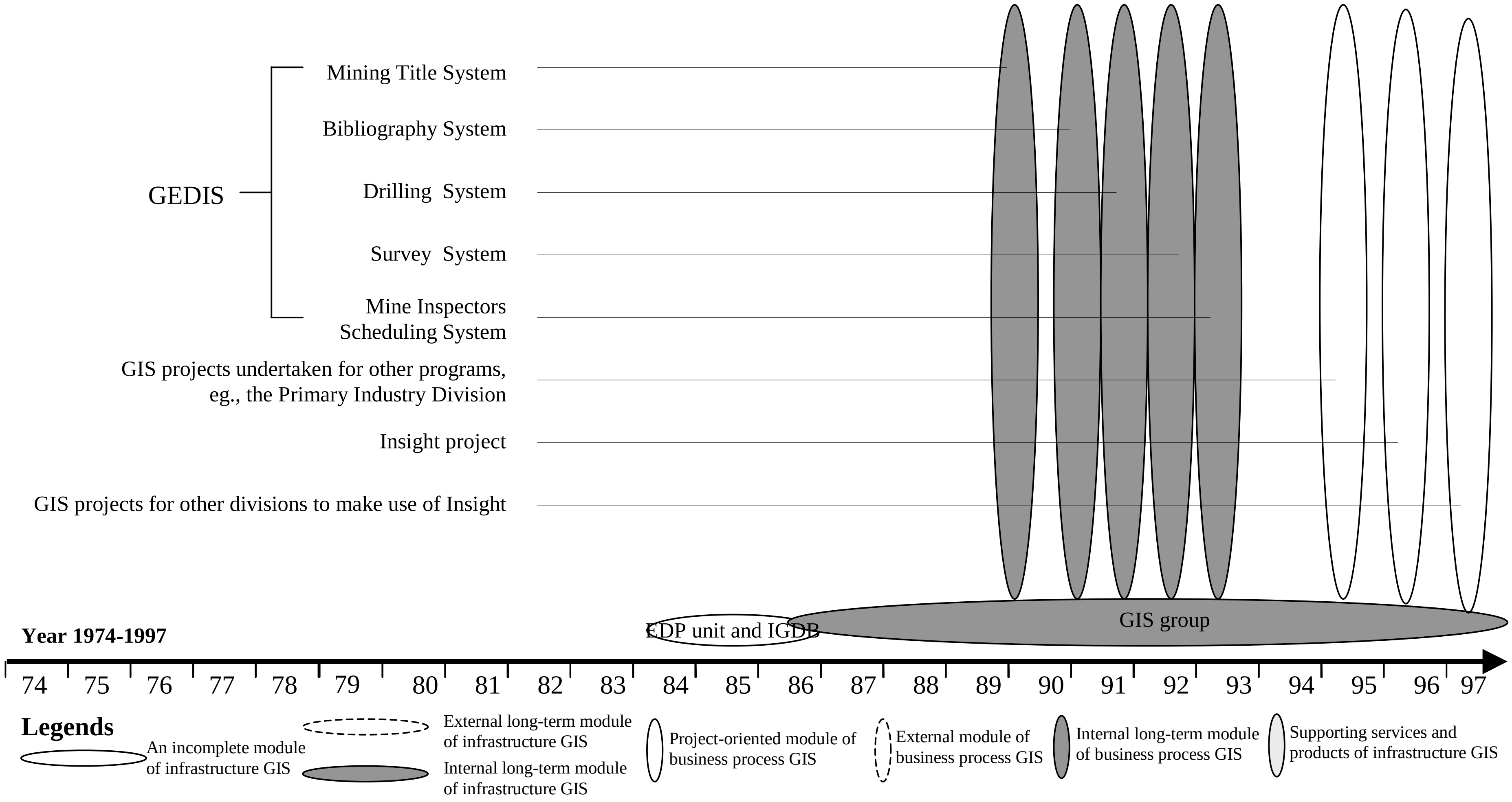


Figure 7.4 Chronological development of GIS modules in Minerals and Petroleum Division

7.3.5 Parks, Flora and Fauna Division

The Parks, Flora and Fauna (PFF) Division was made up of three branches, namely, the Parks and Reserves Branch, the Business Management Branch and the Flora and Fauna Branch. The first two branches looked after the Parks Program and the Coasts and Ports Program while the third branch look after the Flora and Fauna Program (Appendix 10).

The Parks and Reserves Branch was made up of the Parks and Reserves Policy Section, the Conservation Programs Section, and Parks Victoria. The first section was responsible for development and implementation of program policies, and served as the purchaser. The second section was responsible for managing the natural resources and developing a representative protected area network. Parks Victoria was a section that served as a service provider to the division. It managed the cultural resources in the state and was responsible for visitor and tourist services. It would be corporatised later on. The Business Management Branch looked after capital development, marketing and promotion. The predecessor of the Parks and Reserves Branch and the Business Management Branch was the National Parks Service of Victoria.

The Flora and Fauna Branch was primarily concerned with ensuring adequate conservation of the Victorian flora and fauna through coordinating the gathering of information, and advocating conservation by educating the public and lobbying in various planning processes. The branch was made up of a dedicated research institute called the Arthur Rylah Institute, and four other sections that comprised the Wildlife Section, the Flora Section, the Fresh Water Ecology Section, and the Program Coordination Section. Within each Section, there were different outcome-based activities such as information management, community involvement, threatened species management, and bio-diversity conservation. In each section, there was staff responsible for each outcome-based activities, as well as staff who work in the regions. The trend was for the sections to migrate to outcome-based activity groups.

The manager of the information management office in the Wildlife Section was also the Land Resource Information manager. This manager provided advice/service right across the Flora and Fauna Branch and to the Parks and Reserves Branch as well. Despite DNRE’s policy towards corporatisation of non-core businesses, the Arthur Rylah Institute was currently not being corporatised. While the Fauna Section had always been under the conservation sector of the Department of Conservation, Forest and Land, the Flora Section initially came under the land sector. After a while, the Flora Section was drawn from land to the forestry sector and subsequently back to conservation, forming the current Flora and Fauna Branch. The following paragraphs summarise the events that have taken place in the PFF Division of DNRE.

In PFF, GIS development in the Flora Section and the Wildlife Section could be traced backed more than 15 years ago. On the contrary, the Parks and Reserve Branch did not start its GIS development until about 15 months ago at the time of the case study. Through the Wetland Survey Program that was started in 1975, the staff of the Wildlife Section and its counterparts in the Arthur Rylah Institute developed in-house PC-based database management techniques. In 1981, a person from the Melbourne University was hired to develop a FORTRAN program to input attributes of maps from a digitiser directly to the computer for storage and map-making. This was to facilitate the management of the wildlife data collected during the survey. Though not actually developing a GIS, the effort paved the way for the development of the Wildlife Atlas and can be viewed as an incomplete module of infrastructure GIS.

In 1982, owing to the difficulty in managing the data of wildlife distribution, the Wildlife Section decided to develop a centralised Wildlife Atlas in the Arthur Rylah Institute. A member of staff developed a PC-based DBase application for the purpose. This application, together with the in-house mapping application developed in 1981 provided a crude raster-based map interface to record wildlife distribution in the Wildlife Atlas. A manager and an assistant were assigned to maintain the Atlas and to provide enquiry and standard query services.

The database was built up from the research activities of the institute and incidental data collected by the members of public. The Atlas was text-based and PC-based, with some mapping capabilities. It contained mainly point data which were referenced spatially by Longitudes and Latitudes. It was replicated on PC in regional offices for use by field staff who was responsible for updating the Atlas. The Wildlife Atlas was in effect a crude GIS, though few people were aware of the technology at that time. The entire project of Wildlife Atlas began to assume the role of a module of business process GIS.

In 1985, the Wildlife Section became part of DCFL. With the introduction of GIS (initially in the conservation sector) and the departmental wide area network in DCFL in 1986, the Wildlife Atlas was up-loaded to the corporate GIS for updating and analysis. The raster-based maps of the Atlas were also converted to vector-based maps. The GIS unit of DCFL (NRS) developed a module of business process GIS to provide access to the Atlas through graphic terminals. However only head office staff could afford the expensive graphic terminals. The field staff had to continue to push for access to data on the corporate GIS.

In 1987, a former head of the Wetland Survey Program was appointed the current Information Manager for the Wildlife Section. An information system was developed so that the Wildlife Atlas could be queries from a remote text terminal by specifying an area delineated by a pair of latitude-longitude coordinates. Owing to the sensitive nature of the data, most data would have to be generalised before being made accessible through the departmental network.

In 1990, with funding from both state and federal government, an officer was put under the information manager to undertake a long-term project to map the habitats of the state's faunal emblem, the Leadbeater's Possum. As the data, standards, hardware and software and expertise in relation to GIS accumulated, the information unit became a module of infrastructure GIS in the Wildlife Section. This module supported the undertaking of more *ad hoc* conservation studies that in turn improved the GIS capabilities of the information management unit. Currently, the information management unit worked quite independently. However, it continued to use the data, hardware and software managed by the departmental GIS service provider, NRS, and also some of NRS's specialist GIS/mapping services.

The development of the GIS in the Flora Section was similar to that of the Wildlife Section. It started with the employment of the Manager of Flora in the mid-1970s to conduct quantitative floristic surveys. The flora data and the locational data were stored on a WANG PC and the manager wrote a PC-based program to help flora specialists to manage and interpret the data. Despite having mapping done manually, the system was in effect a very crude GIS and can be considered a module of business process GIS. The capabilities of the software were improved continuously by the manager, including the addition of mapping capabilities. The Manager of Flora eventually formed a company to market the improved versions of the software. Apart from the Flora Section, the software was also adopted by universities, consultants, and field study clubs.

The floristic data continued to be collected through various floristic surveys commissioned by internal and external agencies. With over one million records, the point data were centrally managed on the corporate computer in a main stream database management software called Sybase, instead of Arc/Info. The PC-based software was continued to be used by flora specialists in the section to manage and, more importantly, to interpret the floristic database. This was considered to be the core business of the section. The corporate GIS was mainly concerned with the production of specialised products, such as vegetation maps, which were important in public planning meetings. This function was regarded not as importance. The PC-based GIS together with the DNRE's departmental GIS formed a module of infrastructure GIS. This module underpinned the development of business process modules that supported the routine activities of the Flora section.

Unlike their counterparts in the Flora and Fauna Branch, the staff of the Parks and Reserves Branch was traditionally reluctant to invest in information systems, especially in large-scale branch wide systems. Though the branch was aware of the GIS products and services provided by NRS in the department, the policy of the director had been to invest in the development of facilities in the parks. All GIS/mapping products were purchased on an *ad hoc* basis from the lowest bidders. There was no focus on data management, no branch wide system and no information technology staff or expertise in the branch. The branch relied on departmental for information technology supports. Only stand alone PC-based information systems/GIS were developed in the regions.

Even with the replacement of the old director in 1992, the culture changed only very slowly to accommodate the development of large-scale information systems (including GIS). The head of Parks and Reserves, who used to be the manager of the Wildlife Section, was aware of the value of GIS. Even this manager progressed very slowly. Eventually in 1994, a GIS operator was seconded from NRS to the branch to help deliver GIS services to the Conservation Programs Section (previously, Ecological Management Section). With funds from the Australian Nature Conservation Agency, the branch was able to contract NRS to develop a digital thematic map layer of the boundaries of all parks and reserves in the state. The layer was kept on the corporate computer and accessible via the GIS operator seconded to the branch.

The next logical step was to link park attributes to the digital map. This led to the consideration of an integrated information system. The information manager of the Wildlife Section was asked to help. The manager asked the GIS operator to develop a conceptual framework of the information system called Parks and Reserves Information Management System (PRIMS). Again with funding from the Australian Nature Conservation Agency, a senior policy officer was deployed to produce a Parks and Reserves Database User Specification, and to generally supervise the development of the Parks and Reserves module of PRIMS by NRS. Other modules were also being developed. However, at the time of the case study, GIS products and services were only available from the corporate GIS maintained by NRS. The Parks and Reserves Branch still did not have a functional GIS.

Figure 7.5 illustrates the pattern of GIS development in the Parks, Flora and Fauna Division over the years.

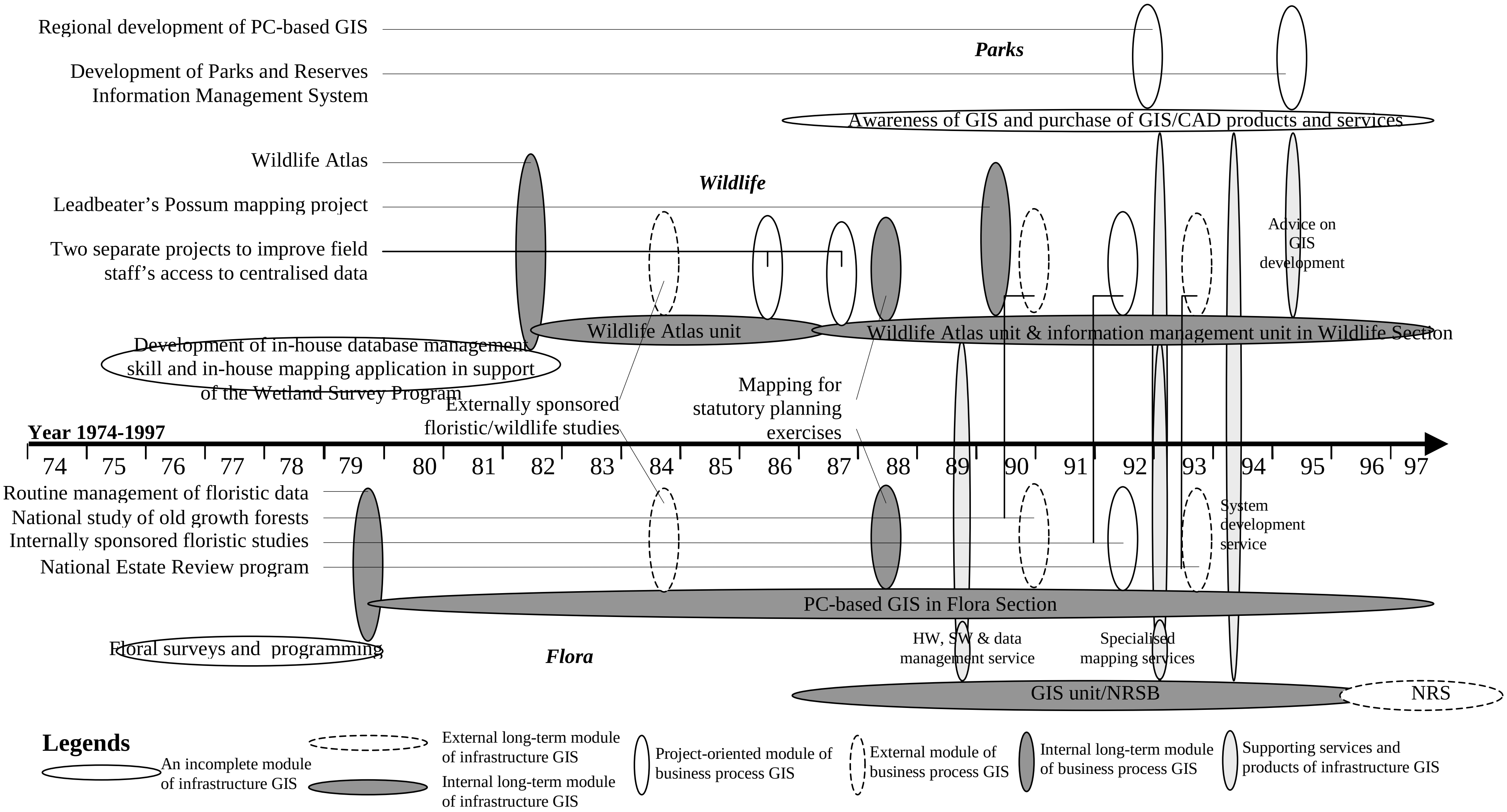


Figure 7.5 Chronological development of GIS modules in Parks, Flora and Fauna Division

7.3.6 Primary Industries Division

Headed by the Chief Scientist's Office, the Primary Industries Division had two branches: Agriculture Victoria, and Victorian Fisheries. The Agriculture Victoria Branch continued to undertake the majority of the work of the former Department of Agriculture. The work was consolidated into two programs, namely, the Agriculture Industries Program and the Agriculture Quality Assurance Program (Appendix 10). In the past, it also looked after the program to develop and promote sustainable agriculture. Currently, that program was amalgamated with the catchment management activities of the former DCNR into the Division of CMSA. In general, the work of Agriculture Victoria Branch was regulatory in nature, and concerned with agriculture extension and policy formulation. It achieved its objection by working with and through the agriculture industry.

In the past, it was necessary to attract outside funding to supplement the work of the division. All regional agriculture research institutes that supported the branch's core business had matching funding from the private sector. Examples of such institutes included the Institute of Sustainable Irrigated Agriculture at Tatura and the Sunraysia Horticulture Centre in Mildura. Generally, funding was from diverse sources.

Prior to the amalgamation with Department of Agriculture, Energy and Minerals in 1996, Victorian Fisheries Branch had always been part of the Conservation Program. Fishing stocks were considered as public goods and Victorian Fisheries was charged with the stewardship of the stocks under the Fisheries Act. The stocks had to be managed in a biologically sustainable and economically efficient manner, taking into consideration the social, regional, political and conservation aspects. Therefore, it was justifiable for the branch to have the dedicated support of a research institute, namely the Marine and Freshwater Resources Institute (MAFRI). All along, Victorian Fisheries had been buying research results, both biological and economical, from MAFRI or its precursor institutes.

MAFRI was founded in July 1996, with the amalgamation of the Victorian Fisheries Research Institute (including the inland fisheries research station at Snobs Creek), the Freshwater Ecology Group of the Arthur Rylah Institute, and the Victorian Institute of Marine Sciences. It existed as a business unit under Victorian Fisheries. There was a review of the status of MAFRI and it was decided that its corporatisation should be delayed for one year as a trial. As MAFRI held the data about the fishing stock, it was in public interest to keep it in Government. The prevailing feeling was that it would remain in the Department as a business unit in the Division of Primary Industries, with Victorian Fisheries Branch as it's principal client (50% of budget).

When GIS was first implemented at MAFRI, Victorian Fisheries had been relying on MAFRI to provide the GIS information products that it needed in the form of paper maps. Though Victorian Fisheries' staff wanted access to the technology, it did not have the resources to develop hardware and software needed for its own GIS or to make use of the GIS data collected by MAFRI. The following paragraphs summarise the events that have taken place in the Primary Industries Division.

In 1985 the manager of the Environmental Science Unit (ESU) in the State Chemistry Laboratory was looking for ways to better manage and utilise soil data in order to justify the existence of the Soil Survey Unit. The manager of the GIS unit of DCFL advised the manager of ESU to adopt GIS. In 1986, the GIS unit provided ESU with temporary access to GIS hardware and software in support of ESU's new remote sensing system. In the same year, the manager of ESU gained the support of the Director of the State Chemistry Laboratory to acquire the GIS hardware and software.

Without the recurrent funding to sustain the GIS, the manager of ESU went to the regional staff to promote the new GIS and remote sensing capabilities. Funding was obtained from regional offices to undertake *ad hoc* soil related projects. The GIS was used originally to manage the business process of management and dissemination of soil data kept in the Soil Survey Unit of ESU. Therefore, initially, the GIS was a module of business process GIS. As more soil data were digitised and became more accessible, the data, the GIS hardware and software and the GIS expertise in ESU were used to undertake more *ad hoc* projects sponsored by the regional staff members. Gradually, the GIS capabilities in ESU took up the additional role of a module of infrastructure GIS.

In the early years, the GIS unit in ESU had a strong regional focus, undertaking primarily regional GIS/mapping projects such as the fallow land mapping project in West Gippsland. In 1992, with the appointment of an information conscious secretary who recognised the value of GIS, the GIS unit gradually took on projects that had a strong head-office focus. The secretary eventually restructured the GIS unit to form the Industry and Resources Information Service (IRIS) in 1995. In the same year, the GIS unit/IRIS arranged for the introduction of ArcView (version 2.0) to PC in regional offices. Together with the wide area network introduced into the Department of Agriculture earlier in the year, regional staff was given access to corporate GIS data.

Only a small percentage of the regional staff trained to use ArcView remained as regular users of GIS. These users, together with the corporate data, hardware and software accessible to them, constituted a module of infrastructure GIS, capable of supporting simple GIS/mapping projects in the regions.

In the same year, following the amalgamation of the Department of Agriculture with the Department of Minerals and Energy, the managers of the GIS units in both departments met and agreed on an arrangement of division of labour. The GIS unit of the Department of Minerals and Energy would build GIS applications for the agriculture sector with IRIS concentrating on project specification and management. One example of such a project was the Insight Project—an ArcView-based Executive Information System designed to meet the information needs of senior management. Originally, the project was intended for the Department of Agriculture. It was subsequently expanded to the whole of DNRE.

In 1990/91, a GIS was independently developed in a unit established under the computer manager of the Institute of Sustainable Irrigated Agriculture at Tatura. The GIS was funded by the Shepparton Irrigation Region Land and Water Salinity Management Plan (the Shepparton Plan) and was originally proposed to provide information to inform politicians and other people of the progress of the Plan. Based on this purpose, the GIS can be considered as a module of business process GIS.

At first, the GIS unit produced one-off maps for public relation purposes. Then the unit used the GIS to manage and coordinate the salinity and water table data collected by local conservation group members, or community members hired for the work. The data allowed the assessment of the salinity problem in the Shepparton Region, and the subsequent prioritisation of regional research and remedial actions.

The GIS unit grew in terms of data, hardware and software, and expertise by supporting various projects sponsored by the Shepparton Plan. The specifications of the GIS used in the project also formed the *de facto* standards for future projects. In time, the GIS unit had developed into a module of infrastructure GIS to serve the Shepparton Region. It helped to develop *ad hoc* modules of business process GIS aimed at meeting the geographic information needs of the various business activities involved in the implementation of the Shepparton Plan.

As the implementation of the Plan progressed, it was found that the salinity information generated by the GIS unit was a good indicator of productivity. The GIS unit realised that its focus had broadened from the Shepparton Plan to the economic development of the whole region of Shepparton. This led to the involvement of the GIS unit in projects that affected business planning of regional agencies and general regional development planning by government.

Though contact was established between the GIS units at ESU and at Tatura quite early on, cooperation existed only in the form of avoiding duplication and making use of specialised expertise of each unit. The same relation was maintained with the one-person GIS unit established in 1994 in the Sunraysia Horticulture Centre in Mildura. This concludes the description for Agriculture Victoria Branch. The description for Victorian Fisheries Branch follows next.

All along, Victorian Fisheries relied on its dedicated research institutes for research information products, including maps. Therefore, development of GIS in Victorian Fisheries was primarily concerned with development of GIS in the research institutes. The head of the Biometry and Computing Division (head of IT) of the Victorian Fisheries Research Institute (VFRI) first saw the benefit of GIS during a meeting with the consultants responsible for the state government wide GIS planning study in 1993. The head of IT realised that the display of fishery catch and effort data could be enhanced and better managed by GIS.

Later in the year, funding became available from the Australian Nature Conservation Agency to develop a Marine and Coastal GIS in support of the preparation of an inventory and classification of Victoria's marine ecosystems. This project was jointly run by VFRI, the National Parks Services of DCNR, and the Land Conservation Council. With the encouragement of the head of the GIS unit of DCNR, it was decided that a GIS unit was to be set up in VFRI to develop the GIS in question.

In 1994, a very experienced GIS specialist working in the region of Forests Service Division was recruited to head the GIS unit in VFRI. By initially making use of the GIS data, hardware and software provided by the GIS unit in DCNR (that is, NRS), the head of GIS unit was able to kick-start the GIS unit, and immediately embarked on the planning of the Marine and Coastal GIS. The development of the Marine and Coastal GIS relied on projects undertook by the GIS unit in three main areas on behalf of other business and research units in Victorian Fisheries. Firstly, it was the provision of GIS services to research activities in marine and freshwater fisheries. Secondly, it was the maintenance of data gathered from surveys of the ocean floor. Thirdly, it was the collation of existing data to generate coastal and marine resources atlas. It also assisted in the Insight project by making catch and effort data available for viewing through ArcView at a scale of 1:500 000 over the computer network of DNRE.

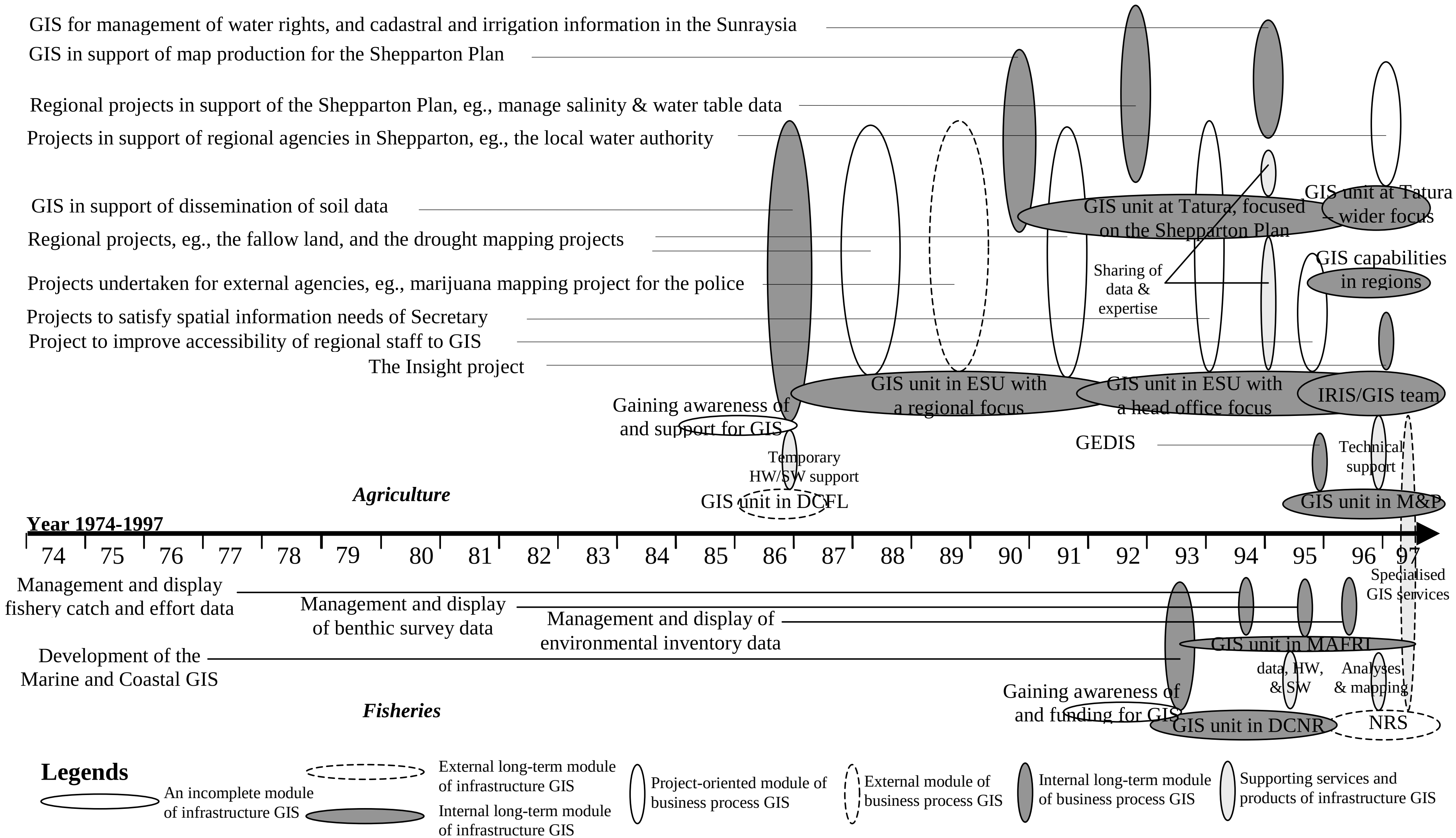


Figure 7.6 Chronological development of GIS modules in Primary Industries Division

In the process the Marine and Coastal GIS continued to grow with data from these projects. This GIS initially served as a module of business process GIS that supported the preparation of an inventory and classification of Victoria's marine ecosystems. The funding from the additional projects undertaken enabled the GIS unit to grow substantially from an initial two-person, NRS-dependent unit that did not have its own data, hardware and software, to a five-person unit that had its own GIS capabilities in MAFRI. NRS still served as a contractor to provide specialist GIS services. The GIS unit had grown into a module of infrastructure GIS that provided GIS services to various business units in Victorian Fisheries. There was also a plan to expand GIS activity into the Environment Impact Assessment area. The Marine and Coastal GIS would continue to develop passively depending on the scale and scope of the projects undertaken by GIS unit.

Insight was made available initially to senior management and Land Resource Information Managers in DNRE in December 1996. Other staff, particularly staff of Victorian Fisheries would soon have direct access to the technology. The fishery staff was keen about having direct access to GIS for the first time. It was expected to change the way head office staff of Victorian Fisheries would make use of GIS.

Figure 7.6 illustrates the pattern of GIS development in the Primary Industries Division over the years.

7.4 Outcomes of the Case Study—Model Testing

Based on the hypothesis of this thesis, the special qualities of a GIS as seen in the organisational structure, that is, a corporate GIS, are identified. The impact of these qualities on GIS diffusion is depicted in a model of diffusion of a corporate GIS, which is described in Chapter four. In Chapter five, it is argued that in order to test the hypothesis, the model has to be validated through the matching of the following four sets of predicted relationships by the relationships observed from the development of an actual corporate GIS.

1. A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with a module of infrastructure GIS supporting the development of one or more modules of business process GIS.
2. Diffusion takes place when the purposes served by a module are focused and well defined.
3. Diffusion of a corporate GIS takes place in the dispersed scenario.

4. Reinvention of a corporate GIS can be monitored by the outcome of diffusion of the modules of GIS in the focused scenario.

The subsections that follow discuss how the predicted relationships are matched.

7.4.1 Identity of the corporate GIS—GIS modules and their roles

The development of GIS capabilities of each division of DNRE over time has been summarised in the previous section by tracking the development of the five elements of GIS (organisational perspective of describing GIS). Based on the purposes served, these GIS capabilities have been grouped into two basic modules of GIS, that is, infrastructure and business process GIS. For example, each set of GIS capabilities accumulated over the years by GIS managers in each division could be regarded as module of infrastructure GIS. Each module of infrastructure GIS allowed a GIS manager to undertake GIS projects resulting in the development of modules of business process GIS. These may be *ad hoc* short term business process GIS as in the case of the fallow land mapping project (Figure 7.6), or long term business process GIS as in the production of forest management plan (Figure 7.2).

As pointed out in Chapter six, the first predicted relationship has been confirmed initially by the perceptions of respondents in the Departmental GIS Development Profile Survey. The evidence discussed in the previous paragraph suggests that a corporate GIS does comprise modules of infrastructure and business process GIS, with the former supporting the latter. This further confirms the first predicted relationship.

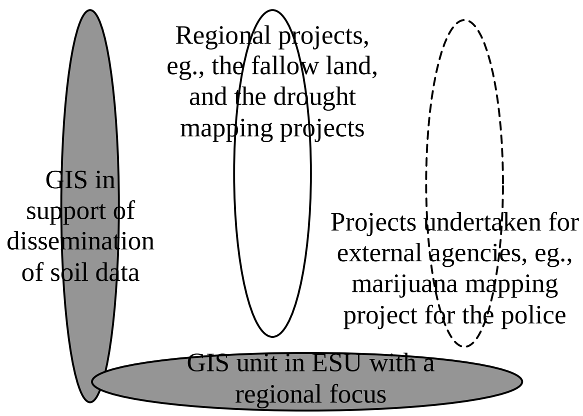


Figure 7.7 Pattern of GIS development started by a module of business process GIS

It is interesting to note that on closer examination of the evidence, the relationship between the two basic modules in terms of the sequence of their development appears more complex that that predicted. Based on the chronological order of development of the two basic modules of GIS as illustrated in Figures 7.1–7.6, three patterns of development of business process and infrastructure GIS are identified. Firstly, a business process GIS may initially be developed in a certain business function as in the case of the GIS unit developed to manage soil data in the Environmental

Science Unit as illustrated in Figure 7.6 and reproduced in Figure 7.7. Over time the GIS capabilities may be accumulated to such an extent that they enable other business process GIS to be developed, both within and without the original business function. In this case, the GIS capabilities assume the additional role of an infrastructure GIS that grows out of the original module of business process GIS. Over time, this additional role may overshadow the original role of the GIS.

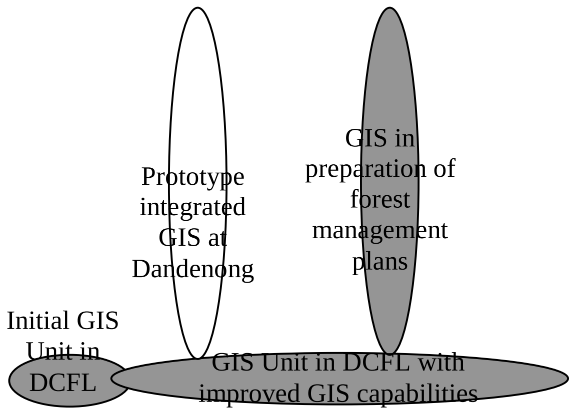


Figure 7.8 Pattern of GIS development started by a module of infrastructure GIS

Secondly, a module of infrastructure GIS may be developed first as in the case of the GIS unit established in the Department of Conservation, Forests and Lands as described in Figure 7.2 and reproduced in Figure 7.8. Initially, it may or may not be associated with any particular business function. But very soon, it is used to develop one or more business process GIS in one or more business functions, and remains primarily as a module of infrastructure GIS.

Thirdly, given the right project and resources, a GIS may be developed as a well planned and integrated system. The infrastructure GIS and the first module of business process GIS are developed simultaneously. A good example is the development of GEDIS in the Department of Energy and Minerals as illustrated in Figure 7.4.

The above evidence from the case study confirms that there can actually be three sequences of development for the two basic modules of GIS. Firstly, the business process module supports the development of the infrastructure module. Secondly, the infrastructure module supports the development of the business process module. Thirdly, the two modules develop together hand-in-hand. These three sequences also represent three patterns of development of a corporate GIS. Evidence from Figures 7.1–7.6 suggests that the more common pattern is the development of a module of business process GIS from which a module of infrastructure GIS is subsequently developed.

7.4.2 Identity of the Corporate GIS—Roles of the Managers

Evidence from the case study also suggests that managers (including GIS managers and coordinators, and certain key GIS specialist) at various levels within the administrative hierarchy of an organisation, play a very important role in the diffusion of a corporate GIS. The visions these managers have for the GIS will determine not only the purposes and the organisational boundaries served by these modules, but also the pattern of development of the modules of business process and infrastructure GIS.

At one end of the spectrum, managers with a more focused vision may concentrate on the development and maintenance of one particular module of business process GIS that serves a specific unit in the organisation. A good example is the case of the GIS specialist who made use of the departmental digital map to develop a simple GIS module for fire monitoring in the Fire Management Branch in Forests Services (subsection 7.3.2). Managers with a focused vision tend to make little effort to facilitate diffusion of the GIS capabilities they have developed to other business processes/programs. Diffusion of GIS will often confine within the organisational unit the GIS module is located.

At the other end of the spectrum, managers may have a broader vision of developing GIS capabilities to serve the needs of users within a division, a department or even an entire state. There are two examples. One is the GIS manager of the Department of Conservation, Forests and Lands, who had a vision of developing a state wide GIS (subsection 7.3.2). The other is the manager of ESU, who had a vision of serving the regional staff of the Department of Agriculture and other external clients (subsection 7.3.6).

Given enough resources, these managers with broad visions can develop an integrated GIS, developing modules of infrastructure and business process GIS simultaneously within a specific organisational boundary. Good examples are the manager of GEDIS in the Department of Energy and Minerals (subsection 7.3.4), and the manager of LIMS in the Crown Land and Assets Branch (subsection 7.3.3). In due course as diffusion of the integrated GIS progresses, people from other business processes in the same business function or from other business functions may want to develop tailor-made GIS modules from the integrated GIS. This had happened to LIMS and to a limited extent to GEDIS as well. As a result, a tight linkage is created between the integrated GIS and other GIS modules that it supports.

In most cases, resources available are insufficient. The managers have to adopt a more proactive strategy of GIS development. Initially they may seek to develop either a business process or infrastructure GIS in a certain business function. Then, they make a strong effort to facilitate the diffusion of the GIS among the potential users in the organisational boundaries they have chosen, by actively marketing the GIS capabilities to other business functions and to managers at different levels of the administrative hierarchy. Various modules of business process GIS will be developed to meet the immediate geographic information needs of their clients.

On the one hand, these GIS projects serve to enhance existing GIS capabilities. This will allow a new module of infrastructure GIS to be developed, or an existing module of infrastructure GIS to be better prepared for newer and bigger GIS projects. On the other hand, these projects also serve to educate and demonstrate the value of GIS to existing and potential users in the organisational boundaries chosen, to improve people's awareness and receptiveness of GIS.

As diffusion of the modules of infrastructure GIS progress within the organisational boundary chosen, more and more business process GIS are developed. As diffusion of the modules of business process GIS progressed, more members of staff in other business functions or in other business processes in the same business function are willing to adopt GIS. Some even begin to develop their own modules of GIS, infrastructure or business process, often with support from existing GIS modules.

Certain modules of infrastructure GIS, such as that of DCFL and ESU, served as *de facto* standards (subsections 7.3.2 & 7.3.6), facilitating development of other modules of GIS. As a result, links among the various modules of GIS are created in the form of specific products and services provided by the modules of infrastructure GIS. These links generally are created over the years in a haphazard manner, depending on the current strategic thinking of the GIS managers and their supervisors.

Some linkages are tight, suggesting that the business process GIS involved will not function properly without the support of the infrastructure modules. Good examples are the cases of the integration between the GIS of the Wildlife Section and NRS (subsection 7.3.5), and that of the GIS unit of Department of Agriculture and that of the Department of Energy and Minerals (subsection 7.3.6). Other linkages are loose as in the case of the relation between the GIS of CLPR and NRS (subsection 7.3.1), and that of the GIS unit at Tatura and the GIS unit of ESU in Melbourne (subsection 7.3.6).

Irrespective of the resources available, modules of business process and infrastructure GIS will develop hand-in-hand. The pattern of development depends very much on the visions of managers at various administrative levels in an organisation. Their decisions determine the relationships established between the GIS modules and will mould the overall identity of the corporate GIS. When there is adequate resource, development is better planned and more efficient. Otherwise, development is more haphazard and takes longer to complete. GEDIS and LIMS are examples of the former; the GIS in NRS, IRIS, Tatura, and MAFRI (subsection 7.3.6) are examples of the latter.

7.4.3 Scenario of Diffusion for modules of a Corporate GIS

The second relationship predicted by the model of diffusion of a corporate GIS is that diffusion of the GIS modules of a corporate GIS takes place in a focused scenario when the purposes served by the modules have been clearly identified. Indeed, as in the case of the corporate GIS of DNRE, the objective (targeted problem) and the organisational boundary of each module of business process GIS developed were clearly defined. For example, a key module of business process GIS in Forests Service was developed to produce forest management plans. Preparation of these plans was the duty of the Forest Planning and Assessment Section. Therefore the organisational boundary of this module was Forest Planning and Assessment Section in Forests Service. Another example is the fallow land mapping project for mapping cropping practices. This project was conducted solely on behalf of the regional office of Wimmera in western Victoria.

In the case of the modules of infrastructure GIS, the situation appears not as clear-cut. For modules such as the GIS unit of DCFL (Figure 7.2) which was developed as an infrastructure GIS for DCFL, its purpose and the organisational boundary were clearly defined at the outset. Therefore diffusion of these modules also took place in the focused scenario.

However, in the case of the modules that initially served as a business process GIS, but eventually developed an additional role of an infrastructure GIS. Good examples are the GIS units at ESU (Figure 7.6) and at the Forest Information Section (Figure 7.2). These modules had simultaneously acquired two basic roles of a GIS over time. The purpose and organisational boundary served by the original business process GIS were confused and became uncertain with the introduction of the additional role. This suggests that diffusion of this infrastructure module should take place in the dispersed scenario, like a corporate GIS. On closer examination, this is not the case.

Take the example of the GIS unit at ESU, the unit originally was developed as a module of business process GIS to better manage the soil data in the Soil Survey Unit of ESU. However, the vision of the GIS manager gave the module an additional but independent identity of an infrastructure module. This additional identity of the GIS module was meant to use the soil data to serve the business needs of agencies and offices outside ESU. To the staff of ESU and the wider community outside ESU, the two identities represents independent modules undergoing diffusion in separate organisational settings. In due course, with the accumulation of data and expertise that were not related to the management of soil data, the identity of the module of infrastructure GIS would become more distinct.

By defining clearly the purposes and organisational boundaries served by each of the two roles of the GIS unit at ESU, each role was given a separate identity that is equivalent to an independent module. This also allows diffusion of each identity to take place in a focused scenario. Therefore, together with other evidence presented in this subsection, the second predicted relationship is also confirmed.

7.4.4 Scenario of Diffusion for a Corporate GIS

The six divisions of DNRE undertook twelve broad business functions, for example, forestry, parks, fauna, and crown land and assets. Each business function has develop a unique collection of modules of infrastructure and business process GIS to support its activities. By bringing the collections of GIS together, a corporate GIS of DNRE can be visualised as shown in Figure 7.9.

To examine the diffusion of the corporate GIS of DNRE as a whole, the GIS must be examined from a different perspective. This is possible by grouping the GIS modules of the twelve business functions according to their previous parent departments as in Figure 7.10. By examining Figure 7.10 in conjunction with Figure 7.9, four main clusters of GIS can be identified. They were brought together in 1996 to form the current corporate GIS of DNRE.

One cluster was developed in the Department of Agriculture. The GIS developed in the Department of Energy and Minerals and its precursor departments represented the second cluster. The third cluster was developed by the offices of the Department of Conservation, Forests and Lands and its successor, the Department of Conservation and Natural Resources.

The last cluster is a loosely related group of GIS capabilities developed by agencies belonging to the land administration sector within the State Government of Victoria. In the past two decades, these agencies were scattered among a wide spectrum of departments such as the Department of Finance, Department of Treasury and Finance, Department of Justice, Department of Crown Land and Survey, and Department of Property Services.

Each of the four clusters can be viewed as a corporate GIS, serving the interest of the respective departments. The situation of the last cluster of GIS is a bit awkward. However by viewing departments involved in the last cluster of GIS as a super-organisation within the State Government looking after land administration issues, that cluster of GIS can still be considered a corporate GIS.

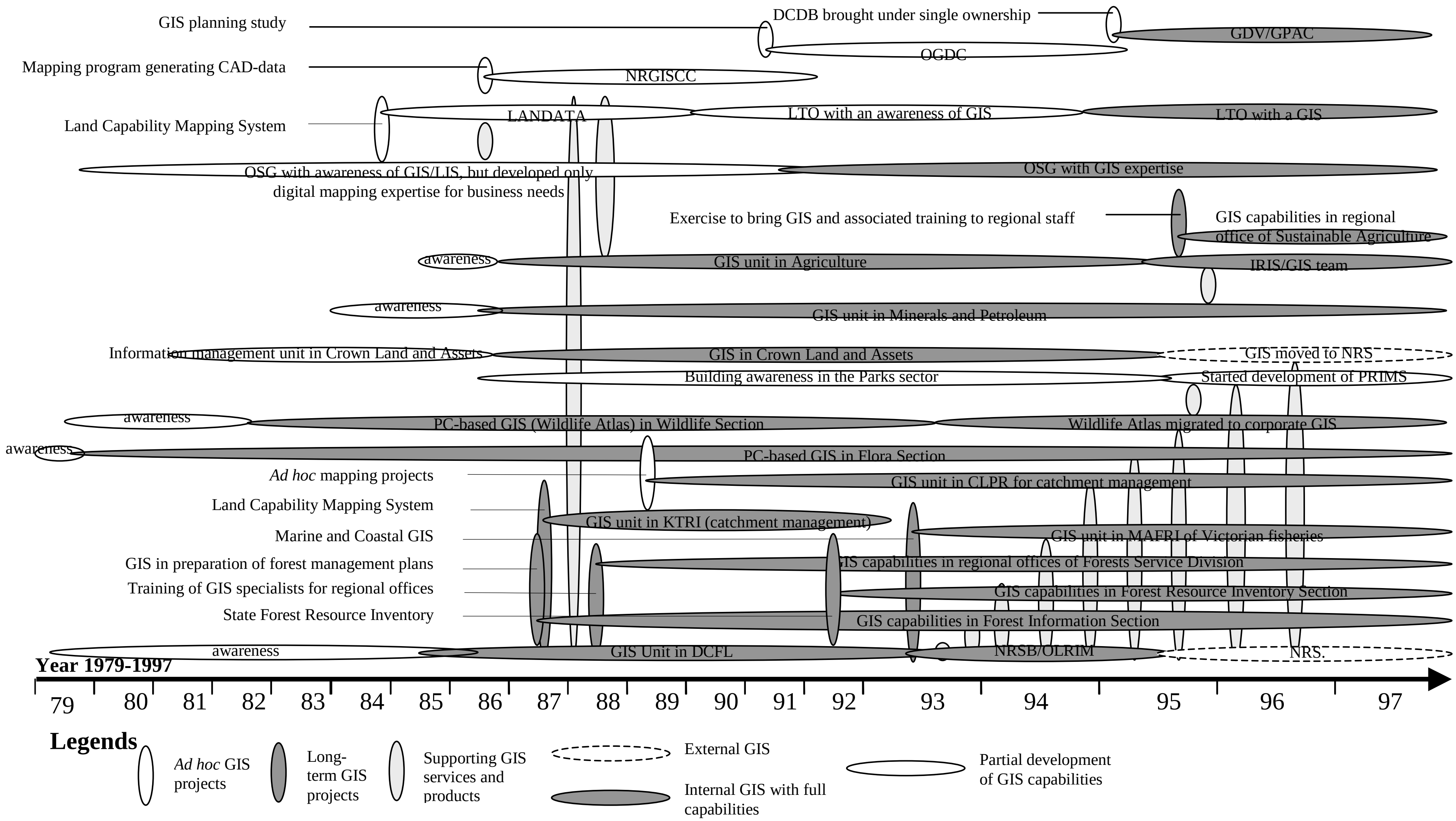


Figure 7.9 Chronological development of GIS modules in DNRE

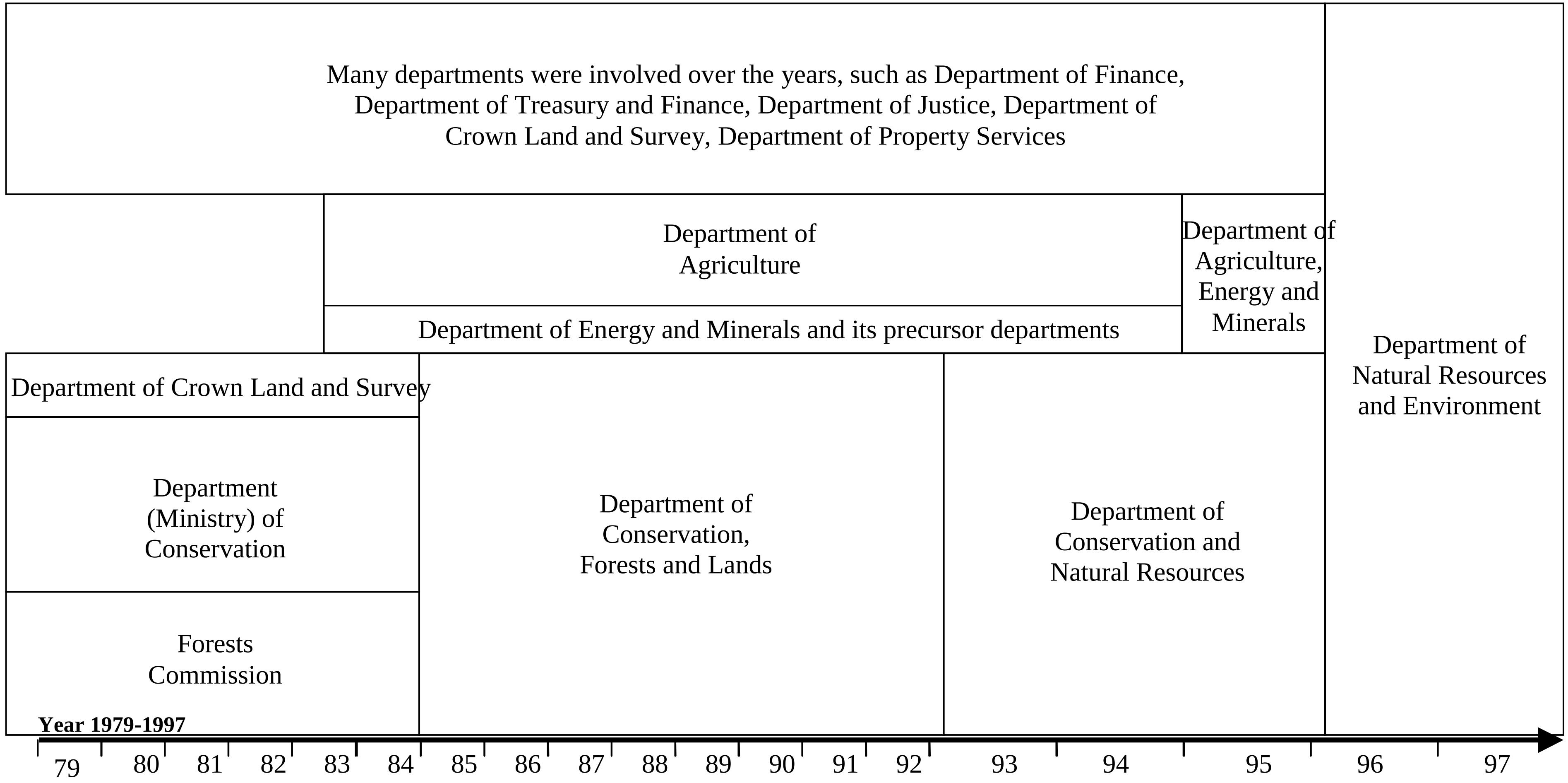


Figure 7.10 The precursor departments of the agencies in DNRE (read in conjunction with Figure 7.9)

With the exception of GEDIS, the corporate GIS of the Department of Energy and Minerals, the other three corporate GIS represented GIS capabilities developed over time by visionary and dedicated managers and professional who worked together at different levels of management to achieve their goals (see subsection 7.4.2). The identity of each of the corporate GIS could not specified at the outset.

Despite support from senior managers, there was no resource for the GIS managers of each cluster of GIS to develop an integrated system. These managers only had a rough idea who and what purposes the systems would serve in the short term. They had to adopt an opportunistic project-oriented approach to develop their systems. They would build up a simple system initially, using whatever resources they could muster. With the GIS capabilities in this early system, some would undertake projects primarily in support of their mandatory business functions. Other would canvass for sponsorship from their counterparts in other business functions. Continual development of their GIS relied heavily on undertaking both *ad hoc* and long term projects that could be funded from a wide variety of sources.

In a haphazard manner, these projects helped to build up the GIS data, hardware and software, standards and expertise, and an organisational setting conducive to the adoption of GIS. The reliance on unpredictable projects for development of the three corporate GIS suggests that these GIS diffuse in a disperse scenario. This pattern of GIS development also confirms the third predicted relationship listed early in this section.

However, the dispersed scenario is not the only scenario in which a diffusion of corporate GIS will take place. For a few years in the late 1980s and the early 1990s, the corporate GIS (GEDIS) of the Department of Energy and Minerals was an integrated system developed to meet well defined information needs of the mining investors. The benefits of the system were tangible and significant, and easily convinced the government to provide the funding required. Therefore resource was not a problem.

Right from the start, the identity of the GIS and the organisation boundary it served, the priorities and the purposes of the GIS modules were all clearly defined. Therefore within a limited time span, GEDIS diffused across the Department of Energy and Minerals in a focused scenario. However, when the department amalgamate with another department in the mid-1990s to form the Department of Agriculture, Energy and Minerals, GEDIS became only part of a new corporate GIS.

In the new department, the corporate GIS would have to address the new but largely unclear information needs of the department in addition to the traditional needs of the

Department of Energy and Minerals. Therefore within a longer time frame and as part of a new corporate GIS, diffusion of GEDIS also took place in a dispersed scenario. Therefore, in the long term, diffusion of a corporate GIS does take place in a dispersed scenario as predicted in the model of diffusion of a corporate GIS.

7.4.5 Reinvention of Corporate GIS

The fourth relationship listed early in this section predicts that reinvention of a corporate GIS can be monitored by the outcome of diffusion of the modules of GIS in the focused scenario. Figure 7.7 portrays the corporate GIS, which is formed by grouping the 12 unique collections of GIS modules of the six divisions of DNRE together into one entity. As discussed in subsection 7.4.3, the diffusion of all the modules took place in a focused scenario. The reinvention of the corporate GIS can be followed in Figure 7.7 by tracking the modules of GIS that were developed over a certain period of time. Therefore the diagrammatic and chronological presentation of the development of the corporate GIS of DNRE at Figure 7.7 help to confirm the fourth predicted relationship.

On closer examination the figure, it is found that each collection of GIS modules is linked to another instead of being independent of one another. As discussed in subsection 7.4.2, these linkages were formed in the process of realisation of the visions of the GIS managers involved. A linkage is formed when a module of infrastructure GIS in one business function helps another business function to develop its own modules of business process GIS as a one-off project. An example is the creation of the Marine and Coastal GIS in MAFRI of the Fisheries program with the help of GIS unit of DCNR (that is, NRS) (Figure 7.6). In a more long-term manner, the infrastructure GIS may provide recurrent support to GIS modules of other business functions. An example is the provision of data management service and access to hardware and software to the GIS unit at CLPR by NRS (Figure 7.1). All these linkages cement the GIS modules in the six divisions of DNRE into an integral whole of the corporate GIS of DNRE.

This finding highlights a limitation of the fourth predicted relationship—reinvention of a corporate GIS is not just counting the GIS modules that have completed or are going through diffusion. Reinvention of a corporate GIS involves the creation of linkages between the GIS modules over time in addition to the collection of GIS modules. The linkages will change as the organisational boundary served each module is changed, either through organisational restructuring, or through the change in the GIS strategy of the managers involved. Therefore, to study reinvention of a corporate GIS as an integral whole, one should also monitor the development of linkages between the modules.

7.4.6 Section summary—model testing

The second objective of the thesis is 'to identify and test the qualities of GIS that can improve the understanding of GIS diffusion'. The model of diffusion of a corporate GIS in Figure 4.4 in Chapter four fulfils the first half of the objective. To test the qualities of GIS identified, four sets of relationship predicted by the model must be matched by the actual relationships identified in the case study. This section confirms all four sets of predicted relationship and fulfils the second objective of this thesis.

There are some findings that can help to refine the predicted relationships. For the first predicted relationship, instead of one sequence as predicted, there are actually three sequences of development of the modules of infrastructure and business process GIS. This translates into three patterns of development of a corporate GIS. For the third predicted relationship, instead of taking place only in the dispersed scenario, given the right resources, diffusion of a corporate GIS can also take place in a focused scenario within a more limited time frame. For the fourth predicted relationship, instead of just examining the outcome of diffusion of the GIS modules, reinvention of a corporate GIS as a whole, must be monitored by examining the linkages developed over time between the GIS modules in addition.

7.5 Outcomes of the Case Study—Other Observations

7.5.1 Role of managers

In Chapter six, the Departmental GIS Development Profile Survey reveals that the *departmental GIS coordinator*, *managers of GIS-using units*, and the *GIS coordinators of the business units* consistently had a high level of impact on the development of both infrastructure and business process GIS. *Senior management* is also found to have a high level of impact on the development of business process GIS. The crucial role played by these managers in GIS development is confirmed by the observation in the case study (subsection 7.4.2).

The managers involved in the development of a GIS in an organisation often include not only the GIS manager but also managers from other administrative levels. Often, it takes cooperation between managers at more than one level to develop the first module of GIS. The manager at the lower level normally will tackle the technical issues while the manager at a higher level will tackle funding and other organisational hurdles. This kind of cooperation is observed for GIS units in a wide range of business functions in DNRE, including Agriculture (ESU), Fishery (MAFRI), Forestry (Forest Information Section), and Catchment Management (CLPR).

Sometimes, very senior managers may be involved, resulting in GIS capabilities that serve several business functions, the whole department, and even the entire state. Corresponding examples are the development of the GIS unit of DCFL, the development of the Executive Information System called Insight in DNRE, and the development of the State's spatial data infrastructure by OGDC.

As the managers involved in the development of GIS in each business functions may have different visions and different resources available to them, the strategies they choose will be different. Apart from the impact these managers have on the sequence of GIS development as described in the previous section, they also affect the detailed GIS capabilities developed. These managers, particularly the GIS managers and business unit managers, often have to interpret and prioritise the known and potential information needs of GIS users when resource is limited. They will then develop the GIS capabilities based on the resources available.

For example, they will make decisions regarding the type, scale, accuracy, and coverage of the spatial data to be collected. This is illustrated by the collaboration between a forest planner and the manager of the GIS unit of DCFL to decide the scale of map data to be digitised (subsection 7.3.2). The managers will also decide on the specialised analytical functions to be acquired, and the hardware and software on which development of GIS is based. For example, the manager of the Flora Section decided to adopt a PC-based system using a GIS software developed in-house, which was capable of help flora specialist to interpret the floristic data. On the other hand, the manager of the departmental GIS adopted Arc/Info on a main frame computer, providing generic GIS analytic functions. These findings from the case study confirm the role of managers as gatekeepers in the development of GIS in an organisation.

Owing to the variation in the personal characteristics of managers, their outlook and their background and experience, these managers can have a wide range of visions regarding GIS development. It is these different visions and the resulting cooperation and turf wars among managers that have brought about the wide array of patterns of GIS development in the six divisions of DNRE as illustrated in Figures 7.1–7.6. Some business units took a long time before they would even consider GIS (Parks in subsection 7.3.5), while some embraced the technology very early on (Forests Service in subsection 7.3.2).

It is also these different visions that promote GIS development in DNRE on the one hand, and limit compatibility between systems on the other. The challenge is to manage these visions to strike a compromise for the benefit of the organisation as a whole.

7.5.2 Additional characteristics of the GIS modules

Each module of GIS may take on additional characteristics depending on the detailed role it played in one or more business functions. These characteristics are generally determined by the purpose and organisational boundary served by each module, which in turn are decided by the managers involved in developing the GIS module.

A GIS module can be called *internal* or *external* depending on whether it is located inside a certain organisation or organisation unit. A typical example is NRS. Prior to its corporatisation in 1995, NRS was considered an internal module of infrastructure GIS. After its corporatisation, NRS was considered by some managers as an external module of infrastructure GIS which could not be relied on (subsection 7.3.2). Actually, to ensure an effective delivery of service in spite of the purchaser/provider management model, senior management of DNRE had decided not to corporatised many GIS units in the department, which were playing the role of an infrastructure. Good examples are GEDIS, and the GIS units in CLPR and the Forest Information Section.

Examples of internal and external modules of business process GIS can be found from the GIS projects undertaken by the GIS unit of ESU (Figure 7.6). The projects undertaken jointly with the regional offices are considered internal, while the marijuana mapping project undertaken on behalf of the police is external.

A module of GIS can also be *short term* or *long term*. A short term module of business process GIS can be a pilot study, a prototype (see forestry projects in Figure 7.2) or, simply an *ad hoc* one-off project, as in the case of the mapping of recharging of ground water by staff of Catchment Management Branch (Figure 7.1). A long-term module of business process GIS often serves an on-going business process or a long-term project. An example is the Marine and Coastal GIS developed by the GIS unit at MAFRI (Figure 7.6). By its role, a module of infrastructure GIS tends to be long term in nature.

The case study has revealed that many managers in DNRE used modules of business process GIS to fuel the development of their modules of infrastructure GIS. As their experience with these two basic modules of GIS increased, the visions these managers had for their infrastructure modules also changed in terms of the purposes and organisational boundaries served by these modules. The direction of change tended towards specialisation. Based on the nature of specialisation, additional characteristics for a module of infrastructure GIS can be identified.

A module of GIS is made of five elements. If its five elements are not fully developed, the infrastructure GIS is only an *incomplete* module. Such a module may simply involve the marketing effort to improve the stakeholders' awareness of GIS (see the module developed from 1974 to 1986 in the Forests Service Division in Figure 7.2). On the other hand, the GIS may still be under development and is not fully functional, as in the case of Parks and Reserve Information Management Systems in the Parks and Reserve Branch (Figure 7.5).

A module of infrastructure GIS may be *hierarchical* in practice, serving a specific part of the organisation. In an *administrative* context, a module may have sectional or divisional focus. For example, while GEDIS used to serve what constituted the Division of Minerals and Petroleum in the past, the GIS unit at the Forest Information Section of Forests Service primarily served the staff of the sections of Forest Information and Forest Planning.

In a *geographical* context, a module of infrastructure GIS may have a regional or a departmental/state wide focus. For example, while IRIS tended to examine issues that had a statewide implication, the GIS unit at Tatura focused primarily on regional salinity or development issues (subsection 7.3.6).

In a *functional* context, a module of infrastructure GIS may provide services needed by a wide range of business functions in an organisation. For example, NRS offered a wide range of general GIS services to many clients. The services included large-scale system development and maintenance, general data management, general application development, and large scale or specialised drafting and mapping. At the other end of the scale, a module of infrastructure GIS may specialise in serving a particular business function. For example, the GIS units in MAFRI, CLPR, and in Tatura specialised in analyses involving marine resource data, land use/management data and salinity data respectively.

A module of infrastructure GIS may even specialise in serving part of a business function. For example, the Forest Information Section specialised in using GIS to display results of (sustainable yield) modelling using linear programming technology, as part of the complete business function of maintaining a sustainable production of timber in the State of Victoria. The Forest Resource Inventory Section specialised in the quality assurance processes in the collection and input of raw forestry data.

By defining the purpose and organisational boundary served, the managers give each module of GIS a unique identity as reflected by the characteristics it acquires. This identity makes each module of GIS a more homogeneous entity that is easier to be studied. Causal relationships observed for similar (modules of) GIS can be compared in a more meaningful way.

Further, the case study shows that in an organisation, the purpose and organisational boundary of a module of infrastructure GIS are continually being redefined as the GIS experience of managers increases. Each module of infrastructure GIS may specialise in a different direction. The outcome is that there is no single module of infrastructure GIS that can meet the needs of all potential users in an organisation, at least, not in the long run. Though less efficient, locally developed modules of GIS are more likely to meet the local business needs of the organisation. More importantly, locally developed modules of GIS empower local managers and users to make better use of GIS and to realise its benefits.

7.5.3 Section summary—other observations

The success of GIS diffusion in an organisation depends very much on the extent of cooperation among managers at different administrative levels. Managers have different visions. Based on a vision, each manager interprets the needs of a business function, and interacts with one another to develop and realise a GIS development strategy. The strategy adopted by each manager determines the purpose and organisational boundary served by the module of GIS to be developed. This, in turn, gives each module of GIS a set of additional characteristics, and as a result a unique identity that is important in the study of GIS diffusion.

As the GIS experience of the managers increases, their visions for GIS change in terms of the purposes and organisational boundaries served by the GIS. That results in the specialisation of many modules of infrastructure GIS. This outcome suggests that, in the long run, there is no single module of infrastructure GIS that can meet the needs of all potential users in an organisation.

7.6 Implications for GIS Management

Evidence from the survey and case study suggests that diffusion of a corporate GIS is a disaggregated process with each module of the corporate GIS going through diffusion in a focused scenario. The clear definition of each module of GIS in terms of its purpose and its organisational boundary is a pre-requisite for diffusion to take place. It also gives each module a clear identity and allows the stakeholders involved to be better defined. While this finding has significant implication for GIS diffusion research, it also affects the way one manages GIS in general. The following subsections discuss how this finding affects management of spatial data infrastructures and corporate GIS.

7.6.1 Management of spatial data infrastructures

In the old days when mapping data were kept on paper, it was expensive for individual business functions (private or government) to maintain and produce their maps. Therefore it made sense to centralise the management of the paper-based map data in a public mapping agency, and to produce high quality multipurpose maps in bulk but in a limited number of scales and formats. This *mapping paradigm* that worked smoothly in the past, was applied to the management of jurisdictional spatial digital infrastructures (SDI) in the current digital age. The resulting strategy was to ask the jurisdictional mapping agencies to digitise the best available maps centrally and to manage these digital maps as jurisdictional SDI.

This strategy allowed the mapping agencies to automate its business process while producing SDI at the same time. Provided a jurisdiction is willing to make such a large capital investment, the strategy appears sound and efficient, at least in producing the 'first-cut' of the SDI. This is also in line with a popular pattern of GIS development as highlighted in subsection 7.4.1. The pattern is to make use of GIS capabilities developed for a particular business function to develop a module of infrastructure GIS to support the GIS needs of other business functions. Provided the map digitisation exercise is funded adequately, the strategy would be implemented by a single agency based on its own business function. There is no need to involve other agencies and the generation of the SDI appears effective and efficient.

However, continued application of the mapping paradigm and the associated strategy of centralised activities to managing SDI has two limitations. Firstly, to automate the mapping production process, CAD-based data are sufficient. There is no need for digital mapping data to be in GIS-format. Digitisation of mapping data in GIS format is expensive. Under the push by governments for economic rationalism, a mapping agency may be forced to produce the cheaper CAD-based data, leaving the GIS users with the expensive task of cleaning up and converting the spaghetti data into GIS-ready data.

Secondly, mapping agencies tend to work to a long cycle of map revision, often in terms of decades rather than years. Therefore, for dynamic digital base map such as the digital cadastral databases (DCDB) that may change on a day-to-day basis, mapping agencies face a critical problem of data updating and upgrading. This problem is aggravated by the fact that the mapping agency is often not directly involved in the actual collection and utilisation of data of a particular map base. For example, the cadastral data needed for the updating of DCDB are collected and used by a wide variety of business functions (such as utilities, local government, LTO, VGO) that are concerned with land administration in the states of Australia.

Even when mapping agencies are responsible for the collection of data to update a digital base map as in the case of the digital topographic databases (DTDB), problems are looming. Current satellite technology is making up-to-date digital topographic data more accessible and affordable to business functions such as those concerned with natural resource management. These business functions may choose to have more control by obtaining their data from a third party rather than relying on a central supplier of the DTDB. In short, traditional mapping agencies may be a good mechanism of generating a 'first-cut' of SDI based on the map collections in their custody. There are doubts as to their long-term role in the management of the SDI.

As a 'first-cut' of SDI is a module of infrastructure GIS, the strategy adopted by GIS managers in DNRE to sustain the development of their modules of infrastructure GIS offers a way forward in managing the SDI. The first thing these manager did was to canvass for support of sponsors from other business functions to develop modules of business process GIS using the capabilities of the infrastructure module. In the process, the data, expertise, hardware and software accumulated and standards developed were fed back to the infrastructure module to sustain its continual development.

Likewise, as many business functions as possible could be persuaded to make use of the 'first-cut' of the SDI to develop modules of business process GIS. One of the conditions of the cooperation would be for the better and more current data collected through the business process modules to be fed back to the SDI for its continual maintenance and development. The challenge of adopting this approach is to put the necessary economic, legislative, inter- and intra-organisational mechanisms and incentives in place.

7.6.2 Management of corporate GIS

Evidence from the case study suggests that a corporate GIS is developed through the cooperation of managers from different administrative levels in an organisation. In the process managers develop modules of infrastructure GIS in support of the development of modules of business process GIS to meet the needs of their business units, and that of others. At the same time they would strive to mould the GIS to realise their visions.

As the needs of the business units and visions of the managers are often different, the outcome of GIS diffusion is the development of modules of GIS at different levels within the administrative, geographic and functional structures of the organisation. This pattern which is clearly observed for the modules of infrastructure GIS in DNRE, suggests that no single module of infrastructure GIS can support all the modules of business process GIS required by all the business functions of an organisation.

For the sake of efficiency and cost reduction, traditionally a centralised GIS unit is established in an organisation to be a single modules of infrastructure GIS that supports an integrated 'corporate GIS'. The objective is for the 'corporate GIS' to meet all the spatial information needs of the organisation. The case study reveals some significant limitations of a centralised approach.

Even when such an infrastructure module (the GIS unit) is created, sooner or later, it will be found that limited by the resources available, it is impractical for the GIS unit to develop certain modules of business process GIS. Either the modules are too small or specialised, or there are simply too many business process modules waiting to be developed. Many clients of the GIS units of DCFL and ESU had experience such difficulties in the past. In other cases, with increasing experience of using GIS, some business units may decide that they are not being served properly, as in the case of the Forests Service Division of DNRE. In any case, the needs of business units are not being met. Without their own resources, some business units will have to go without the geographic information services they need. Those units that have sufficient re-deployable resources will be able to develop their own modules of infrastructure and business process GIS. The outcome is that the corporate GIS will continue to grow, but in a haphazard manner.

Even when the business units are being served adequately, there is still a problem. Long term reliance on an infrastructure module for GIS services or products may numb the desire by the business units to learn about the technology. Good examples are the forest planners and park managers who had been relying on NRS and other contractors to provide GIS services and products. They have no expertise or incentive to apply the technology in innovative ways, limiting the potential benefits that can be realised.

The limited technical expertise also hampers the ability of the users to negotiate with the GIS service providers for better services, as illustrated by the experience of the park managers of DNRE. This is potentially a serious problem especially in the current trend of economic rationalism. Being classified as non-core business, certain infrastructure modules are being corporatised and moved out of the organisation, together with vital GIS capabilities and expertise as in the case of NRS of DNRE. Already, senior divisional managers of DNRE were resisting corporatisation of further infrastructure module for fear of losing the ability to maintain services in strategic areas. Therefore, despite the obvious benefits of developing a centralised module of infrastructure GIS to develop and service other modules of business process GIS in an integrated manner, this approach has its limitation. The challenge in the future management of a corporate GIS is to strike a balance between developing a GIS efficiently and meeting users' needs.

The case study of DNRE reveals that a corporate GIS is made up of two parts. One is the modules of infrastructure and business process GIS. The other is the relationship (or linkages) established between existing or new modules of GIS. It is the second part that makes the corporate GIS work an integral whole. Recent advance in the GIS technology has made the development of GIS modules by managers a simpler job than it was ten or twenty years ago. However, as GIS is made more accessible to manager, the institutional and organisational issues of managing the linkages between the GIS modules remain as difficult if not more difficult to overcome.

Based on the experience of the State Government of Victoria in general and that of DNRE in particular, a new breed of GIS/information managers are required to manage the development of linkages among the GIS modules, and to oversee the diffusion of the corporate GIS. Assuming that an organisation may already have some GIS modules developed to various extents, the first task these GIS/information managers have to do is to assess the current and target states of development of GIS in the organisation. Based on the states of development identified, they will get the commitment of senior management of a GIS vision and the associated strategies to bring the development of GIS in the organisation from the original state to the target state.

These managers are not directly involved in the physical development of GIS capabilities or modules. Their primary task is to realise a vision of corporate GIS and to make the GIS work by facilitating the establishment of the right linkages between GIS modules. They would encourage GIS modules to be developed and maintained by the most relevant business functions. They would also liaise with managers at different levels in the organisation to match the vision of corporate GIS with the corresponding visions of the business units, and vice versa. They are concerned with the building, maintenance and development of cooperation or linkages among existing and new GIS modules. These linkages are what make the corporate GIS function as an integral entity. To allow the process to take its own course would take a decade or more.

Since a realistic assessment of the states of development of GIS in an organisation underpins the development of a GIS vision and the appropriate GIS strategy, it is important that the assessment is not done rashly. The objective framework of assessment based on the three criteria of *reach, range* and *routine* is a good starting point. Three levels of analysis using different combinations of parameters have been developed to allow assessment based on the three criteria.

At this point, this section fulfils the third and last objective of this thesis—to develop principles to support better GIS management.

7.7 Chapter Summary

This chapter reports the findings of the case study that examined the development of the corporate GIS of DNRE. The development of GIS capabilities in each of the six divisions of DNRE is summarised and illustrated by a figure that shows the pattern of GIS development diagrammatically and chronologically. Based on data presented, evidence is identified in support of all four sets of predicted relationship listed in Chapter five. As a result, the case study fulfils the second objective of this thesis.

The case study also produces some findings that can help to refine the predicted relationships. Firstly, instead of one sequence as predicted, there are actually three sequences of development of modules of infrastructure and business process GIS. This translates into three patterns of development of a corporate GIS. Secondly, instead of taking place only in the dispersed scenario, given the right resources, diffusion of a corporate GIS can also take place in a focused scenario within a more limited time frame. Thirdly, instead of concentrating on the outcome of diffusion of the GIS modules, reinvention of a corporate GIS should be monitored by examining the linkages developed over time between the GIS modules in addition.

Evidence from the case study also suggests that the managers (including the GIS managers) of different business functions in an organisation play significant roles in the diffusion of the corporate GIS. This confirms the finding of the survey that GIS coordinators and business managers consistently have a high level of impact on GIS development. These managers realise their visions regarding GIS development by interacting and cooperating with their counterparts at other administration levels in the organisation. Together, they drive the diffusion of GIS in the organisation. Further, the evidence also suggests that no single infrastructure GIS is able to meet the needs of all business units in an organisation in the long run.

The outcomes of the case study have significant implications in two aspects of GIS management. The first aspect concerns the management of spatial data infrastructures. Development of the ‘first-cut’ of a jurisdictional SDI can be achieved effectively and efficiently through the automation of the jurisdictional mapping function. Afterward, other business functions may be more suitable to provide data to update and upgrade the SDI. One approach to make this happen is to encourage both public and private business functions in a jurisdiction to make use of the SDI. In return, these business functions are required to supply better and more current data collected through the business process modules they have created.

The second aspect concerns the management of a corporate GIS. To maximise the benefits of a corporate GIS, development of a single module of infrastructure GIS that serve all business functions in an organisation is neither practical nor sustainable in the long run. The solution is to maximise diffusion of the corporate GIS, which requires a new breed of GIS/information managers. These managers would oversee the diffusion of the corporate GIS. While not directly involved in the physical development of the GIS modules, they would encourage relevant business functions to develop the GIS modules required. They are more concerned with the development of linkages among the modules by encouraging cooperation between managers of business functions. It is these linkages that make the corporate GIS an integral entity, and help realise the vast potential benefits of a corporate GIS.

The *reach-range-routine* framework developed for the Departmental GIS Development Profile Survey is a good starting point to help the new breed of GIS/information managers determine the states of development of GIS in their organisation and plan GIS development strategies accordingly. At the conclusion of this chapter, the third and last objective of the thesis is fulfilled.

Chapter 8
Conclusions

8.1 The Research

Chapter one describes the importance of GIS diffusion research and states the hypothesis of the research:

> *Diffusion of GIS in an organisation is affected by the qualities of GIS as seen in the context of the structure of the organisation.*

To test the hypothesis, three objectives are identified for the thesis:

1. To understand the elements of GIS diffusion.
2. To identify and test the qualities of GIS that can improve the understanding of GIS diffusion.
3. To develop principles to support better GIS management.

The research strategy adopted to meet the objectives is made up of five parts, namely, literature review, exposure to GIS implementation and diffusion activities, model generation, model validation, and data analysis. The scope and assumptions of the research are also described. A section on the structure of the thesis sums up the chapter and provides pointers to the various chapters that follow.

Chapter two describes the political and functional relationships among the three levels of government in Australia, that is, federal, state and local. It is found that the activities of state governments in Australia generally have the most direct and immediate impact on the livelihood of the citizens. The states are also key spatial data providers in Australia, responsible for managing the medium to large scale topographic and cadastral maps, and the road network maps. These maps, in turn, underpin the political and socio-economic development of Australia. Therefore, improved understanding of diffusion of GIS in state governments will benefit the livelihood of the people in Australia directly.

The willingness of the State Government of Victoria to cooperate in research, and the long and well documented history of GIS development in the government and make it an ideal source of data for this research into GIS diffusion. The brief record of the development of GIS in the State government of Victoria described in Chapter two also sets the scene for the discussion that follows in this thesis.

Chapter three relates GIS diffusion research back to its grounding disciplines, namely, innovation research and socio-technical systems research in the disciplines of organisational behaviour and information systems. In the process the chapter provides the necessary theoretical background in support of the hypothesis of this thesis. This is achieved by providing an overview of the four elements of the diffusion paradigm of innovation research, namely, *innovation*, *communication channels*, *time* and *social system*. The overview is supplemented by experience of researchers in socio-technical systems. Concurrently, the current achievements and limitations of GIS diffusion research under each of the four elements are described.

Though the scope of current GIS diffusion research is wide, there are certain areas that require more in-depth study. However, it can be safely concluded that the elements of diffusion paradigm are also applicable to GIS diffusion. Based on Rogers' definition of diffusion, GIS diffusion can be defined as *the process by which an innovation of GIS is communicated through certain channels over time among the members of a social system*. This definition also fulfils the first objective of this thesis.

To address the limitations of current GIS diffusion research and to accommodate the trend of GIS research, an integrated framework of GIS diffusion research based on a well-defined organisational boundary is suggested. The research framework portrays GIS as a dynamic entity that is central to GIS diffusion research. The chapter concludes that to support future integrated GIS diffusion research, it is necessary to find a better way to identify GIS over time and within a pre-defined organisational context.

To take up the challenge identified in the previous chapter, Chapter four reviews the definitions of GIS in the literature with a view of identifying the precise nature of GIS. Three perspectives on the nature of GIS have been identified, namely, *identificational*, *technological* and *organisational*. The *identificational* perspective describes the uniqueness of GIS. The *technological* perspective describes the tangible form and functional capabilities of GIS. The *organisational* perspective emphasises the multi-element nature of GIS, bringing to the fore the organisational setting that affects diffusion of the technology.

GIS diffusion research suggests that the identity of GIS changes in the course of its diffusion in an organisation. Therefore, it is important to be able to track the changing identity of GIS. Based on Rogers' model of the *organisational innovation process*, two scenarios of GIS diffusion can be identified. In a *focused* scenario of diffusion, the pre-defined problems in the organisation that GIS is to address are focused and well defined. In a *dispersed* scenario, the problems are broad and strategic in nature with potentially great impact and resource requirement.

It is found that while current perspectives on the nature of GIS adequately describe the changing identity of a GIS in a *focused* scenario of diffusion, they do not allow satisfactory monitoring of diffusion of a corporate GIS, which typically takes place in a *dispersed* scenario. As a corporate GIS serves an entire organisation, its function in the context of the organisational structure gives it some unique qualities. As a result, the *productional* perspective is developed to describe the qualities of a corporate GIS.

The *productional* perspective views a corporate GIS as making up of modules of *infrastructure GIS and business process GIS* that play the roles of an infrastructure or a business process respectively. The *productional* perspective of GIS is applied to Rogers' model of organisation innovation process to give a model of diffusion of a corporate GIS. In this model, the corporate GIS is disaggregated into its modules. Diffusion of the GIS modules that address well defined problems takes place in a *focused* scenario. Those modules that do not address well-defined problems will remain in the *dispersed* scenario. Diffusion will only take place in the *focused* scenario when these modules match up with some well-defined problems later on. The model of diffusion that highlights how the *productional* perspective of (corporate) GIS can affect GIS diffusion forms a working model for the hypothesis of this thesis.

To help test the hypothesis of the thesis, Chapter five lists four sets of predicted relationships derived from the model of diffusion of a corporate GIS. These relationships have to be matched by relationships observed in the development of an actual corporate GIS, and are reproduced below.

- A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with a module of infrastructure GIS supporting the development of one or more modules of business process GIS.
- Diffusion takes place when the purposes served by a module are focused and well defined.
- Diffusion of a corporate GIS takes place in the dispersed scenario.
- Reinvention of a corporate GIS can be monitored by the outcome of diffusion of the modules of GIS in the focused scenario.

A field study to document the detailed development of GIS in an organisation is needed to provide the necessary data. Based on the objectives and the nature of the field study, it is determined that the best approach is to adopt the case study methodology. As argued in Chapter two, the State Government of Victoria is an ideal focus for the study. To make the study as fruitful as possible, it is decided that the study should be conducted in the department with the best developed GIS in the State Government. The department is to be chosen through a Departmental GIS Development Profile Survey.

Central to the survey is a *reach-range-routine* framework, which is developed to assess the state of development of GIS in the eight state departments concerned. This framework is made up of three criteria, namely, *reach*, *range* and *routine*. The criteria assess the extent of access to GIS, of sharing of geographic information and of designing the GIS for by all member of the organisation respectively. Under each of the three criteria, parameters are identified to provide a composite measure of the state of development of GIS. Questions were designed to collect data based on these parameters.

Taken into consideration the opportunities and constraints identified during the planning of the survey, it was decided that the questionnaire survey would be conducted face to face. This would be followed by a semi-structure interview to solicit details concerning crucial stakeholders and events in the course of GIS diffusion in the departments. Two questionnaires were designed for departments with and without GIS respectively. The methodology of the survey was summarised in a survey protocol that was prepared both as a plan for the survey, and as a tool to gain the support of the State GIS coordinating agency and the state departments.

Once the survey had identified the department for the case study, details of the case study were finalised and summarised in a case study protocol. This protocol was also used to gain the support of the department chosen. Initial contact with the primary contact in the target department helped to refocus the case study on the development of GIS in all the programs of the department. The role of individual stakeholders in GIS diffusion was not examined.

A set of data analysis procedures is designed for the case study. The events of GIS development in the selected department are documented together with underlying reasons. Through a pattern matching process, modules of business process GIS and infrastructure GIS are identified and used to reconstruct the patterns of GIS development in the department and its business units chronologically. In the process, evidence to test the model of diffusion of a corporate GIS is teased out.

Chapter six reports the results of the survey. Based on the three criteria of *reach*, *range* and *routine*, a three-tier analysis was conducted providing assessments at three levels of sophistication. The Department of Natural Resource and Environment (DNRE) consistently had the best assessment at the three levels of analysis and was chosen for the detailed case study.

The survey and the associated semi-structured interviews pieced together some background information of GIS development in the State Government of Victoria. GIS development tended to concentrate within the government sectors where the professions were primarily concerned with surveying, land administration and management, or had their professional activities directly related to the locational aspects of things such as, planning and resources/assets/infrastructure management. The primary justification for the technology both in the past and, to a certain extent, at present was the tangible and intangible benefits identified by the advocates and managers. Once there was a perceived need for the technology, development would go ahead. However, when there was no perceived need, GIS diffusion in an organisation stalled. In fact this was the main reason why four out of eight departments in the State Government of Victoria did not have a GIS.

All departments responded agreed that the *departmental GIS coordinator*, *managers of GIS-using units*, and the *GIS coordinators of the business units* are the core internal stakeholder groups that consistently had a high level of impact on the development of GIS, irrespective of the nature of the GIS. There was no single group of external stakeholders that had a consistently high level of impact on GIS development in all the departments at all time. Though the impact from the external environment might be great, it was generally opportunistic.

The results of the survey and the associated interviews also provided initial evidence in support of the GIS diffusion model. Two sets of relationships predicted by the model were confirmed. The first was: 'A corporate GIS is made up of modules of GIS which play the role of either a business process or an infrastructure, with an infrastructure GIS supporting the development of one or more business process GIS'. The second was 'Diffusion takes place when the purposes served by a module are focused and well defined'.

Chapter seven reports the findings of the case study that examined the development of the corporate GIS in DNRE. The development of GIS capabilities in each of the six divisions of DNRE is summarised and illustrated by a figure that shows the pattern of GIS development diagrammatically and chronologically. Based on data presented, evidence is identified in support of all four sets of predicted relationship. As a result, the case study fulfils the second objective of this thesis and confirms the hypothesis:

> *Diffusion of GIS in an organisation is affected by the qualities of GIS as seen in the context of the structure of the organisation.*

The case study also produces some findings that can help to refine the predicted relationships. Firstly, instead of one sequence as predicted, there are actually three sequences of development of modules of infrastructure and business process GIS. This translates into three patterns of development of a corporate GIS. Secondly, instead of taking place only in the dispersed scenario, given the right resources, diffusion of a corporate GIS can also take place in a focused scenario within a more limited time frame. Thirdly, instead of concentrating on the outcome of diffusion of the GIS modules, reinvention of a corporate GIS should be monitored by examining the linkages developed over time between the GIS modules in addition.

Evidence from the case study also suggests that the managers (including the GIS managers) of different business functions in an organisation play significant roles in the diffusion of the corporate GIS. This confirms the finding of the survey that GIS coordinators and business managers consistently have a high level of impact on GIS development. These managers realise their visions regarding GIS development by interacting and cooperating with their counterparts at other administration levels in the organisation. Together, they drive the diffusion of GIS in the organisation. Further, the evidence also suggests that no single infrastructure GIS is able to meet the needs of all business units in an organisation in the long term.

The outcomes of the case study have significant implications in two aspects of GIS management. The first aspect concerns the management of spatial data infrastructures. The initial development of a jurisdictional SDI can be achieved effectively and efficiently through the automation of the jurisdictional mapping function. Afterward, other business functions may be more suitable to provide data to update and upgrade the SDI. One approach to make this happen is to encourage both public and private business functions in a jurisdiction to make use of the SDI. In return, these business functions are required to supply better and more current data collected through the business process modules they have created.

The second aspect concerns the management of a corporate GIS. To maximise the benefits of a corporate GIS, development of a single module of infrastructure GIS that serve all business functions in an organisation is neither practical nor sustainable in the long term. The solution is to maximise diffusion of the corporate GIS, which requires a new breed of GIS/information managers. These managers are more concerned with encouraging managers of business functions to develop GIS modules and to make use of these modules to help one another to develop new GIS modules. It is the interlinked network of GIS modules that will help realise the vast potential benefits of a corporate GIS. The *reach-range-routine* framework developed for the Departmental GIS Development Profile Survey is a good starting point to help the new breed of GIS/information managers determine the states of development of GIS in their organisation and plan the GIS development strategies accordingly. At this point, the third and last objective of the thesis is fulfilled.

8.2 Implications for GIS Diffusion Research

This thesis has confirmed that the qualities of GIS as seen in the context of the structure of an organisation do affect GIS diffusion—the diffusion of a corporate GIS. This has been possible by applying the GIS diffusion research framework proposed in Chapter three to the study of the element of *innovation* (GIS in this case) in GIS diffusion. This results in valuable insights into the nature of a corporate GIS, and how the nature affects GIS diffusion. However the generic value of the same framework in GIS diffusion research is yet to be proven through the application of the framework in future designs of studies into other elements of GIS diffusion.

Based on the argument in Chapter three, Rogers' model of *organisational innovation process* has been used to depict the process of GIS diffusion in an organisation. The model has proven to be valuable in the development of the model of diffusion of a corporate GIS in this research, and in explaining why four departments out of eight in the State Government of Victoria did not adopt GIS. It appears that Rogers' model has great potential in assisting future research into GIS diffusion. Again its value is yet to be proven through its application in future designs of GIS studies.

Apart from validatinig the model of diffusion of corporate GIS (Chan and Williamson 1998), the study of GIS development in the State Government of Victoria also provides additional insight into GIS diffusion. Firstly, apart from the *identificational* perspective that distinguishes GIS from other competing technologies, a corporate GIS can be defined holistically to at least three levels of detail. The *productional* perspective is the first level, which provides a high level description of a corporate GIS in term of its GIS modules and the roles they play in realising the business objectives of an organisation. In the next level, the *organisational* perspective describes the detailed composition of each GIS module in terms of the GIS elements. The *technological* perspective then describes the form and functions of each GIS module.

Secondly, description of the patterns of GIS development in the *productional* perspective in subsection 7.4.1 suggests that successful development of a business process GIS depends on that of an infrastructure GIS and *vice versa*. Likewise, a GIS is described as multi-element in nature in the *organisational* perspective. Failure in the development of an element will often significantly hamper the successful development of other elements and that of the GIS as a whole (Campbell and Masser 1992, Croswell 1989). These observations together suggest that a corporate GIS as an innovation, is a *technological cluster* that refers to a group of closely related technologies embodied in an innovation. This group of technologies, when promoted to users as a whole can facilitate the diffusion of the innovation in study (Rogers 1995).

This concept is important in GIS diffusion research. For example, based on the *productional* perspective of GIS, diffusion of a corporate GIS may be facilitated by promoting the development of an infrastructure module together with one or more business process GIS that it supports. The value of this approach is confirmed indirectly by the LANDATA project (Williamson, *et al.* 1998). The project was managed primarily as an infrastructure to support land administration reform in the State of Victoria. It eventually did not deliver enough business benefits to justify its existence.

Thirdly, the dynamic and modular nature of corporate GIS accounts for the difficulty in finding causal relationships that can be generalised across different environments (Onsrud and Pinto 1993). To overcome this dilemma, it is necessary to acknowledge this nature of a corporate GIS when designing GIS diffusion studies.

The *productional* perspective provides a framework to structure a corporate GIS in GIS diffusion research by grouping GIS capabilities of the corporate GIS into GIS modules. This disaggregates the monolithic corporate GIS into more manageable and homogeneous units. Together with the other three perspectives of GIS the *productional* perspective provides a tool to describe and monitor the development/reinvention of a corporate GIS in a holistic manner. This allows the observed behaviours of stakeholders to be related back to specific GIS modules rather than to the whole corporate GIS. This will improve the identification, interpretation and cross comparison of generic causal relationships in GIS diffusion studies.

Lastly, the relationships predicted by Chan and Williamson's model have only been tested in a government environment. Though the theories underpinning the development of these relationships are generic to all organisational environments, it would be interesting to test if these relationships are applicable to the private sector and non-government organisations.

Further in recent years, development of spatial data infrastructure (SDI) at various government levels has gain increasing interest from the GIS community. As SDI is a specialised GIS, it will be of both academic and practical interest to investigate how the relationships described in this paper can be applied to the study of diffusion of SDIs. In additions to these areas of research, table 8.1 provides a list of possible research topics in the context of the diffusion paradigm.

Table 8.1 Potential research topics for GIS diffusion in future.

Elements of diffusion	Research topics
Innovation	What are the other possible socially constructed identities of GIS in an organisation?
Communication Channels	What is the nature of the communication channels required for the successful diffusion of two basic types of GIS modules?
	Who are the key players in the communication network needed for the diffusion of the GIS modules?
Time	What is the appropriate model to describe GIS diffusion in an organisation?
	What is the appropriate model to describe GIS diffusion among individual members of an organisation?
Social System	What types of decision are involved in the diffusion of a corporate GIS and the associated GIS modules?
	Which factors involving the norms, the culture and the structure of the organisation will affect the diffusion of a corporate GIS and the associated GIS modules?

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Appendix 1. A list of conferences attended, and researchers and managers with whom I had discussion in the course of the research.

The conferences attended are:

- The 1994 AURISA Conference in Sydney,
- The 1995 New Zealand Conference on Geographical Information Systems and Spatial Information Research at Massey University in Palmerston North,
- The 5th South East Asian and 36th Australian Surveyors Congress in Singapore,
- The 1995 AURISA Conference in Melbourne,
- The 1996 Australia Surveyors Congress in Perth,
- The Conference on "Managing Geographic Information Systems for Success" at the Melbourne University in 1996,
- The 1996 URISA Conference in Salt Lake City,
- The International Workshop on Dynamic and Multi-dimensional GIS held in 1997 in Hong Kong.

During the New Zealand conference, the author was able to talk to the following researchers and manager:

- Associate Professor George Benwell of the University of Otago,
- Mr Derry Gordon, Senior Lecturer of the Civil Engineering Department of The University of Canterbury,
- Mr Richard Murcott, Manager Land Information of the Department of Survey and Land Information of New Zealand.

During and after the Singapore conference, the author was able to visit the following government GIS offices and talk to the managers and researcher:

- Mrs Sujati Sastro-Halim, Manager of Land Systems Support Unit, Ministry of Law of Singapore,
- Mr Jeh Heng Chua, Senior GIS Analyst of Land Systems Support Unit, Ministry of Law of Singapore,
- Mr Pong Chai Goh, Senior Lecturer of the School of Civil & Structural Engineering at the Nanyang Technological University,
- Mr Chung Hang Wong, Senior Land Surveyor of the Land Information Centre, Lands Department of Hong Kong,
- Mr Albert Liu, Secretary of the joint Computerisation Committee of the Work Branch and the Planning, Environment and Lands Branch (GIS sub-committee), Works Branch of Government of Hong Kong.

- Mr Wing Yuen Lam, Senior Town Planner, Computer System and Services Unit, Planning Department of Hong Kong,
- Mr Eric Tsang, Project Manager, SCADA/Mapping, Transmission Department, The Hong Kong and China Gas Company Limited.

During the Perth conference, the author was able to visit the State government GIS coordinator's office and talk to the following managers:

- Mr Andrew Burke, Director of the Western Australia Land Information System Program,
- Mr Henry Houghton, Director of Mapping and Survey, Department of Land Administration of Western Australia,
- Mr Peter Byrne, Vice President of the International Federation of Surveyors during 1992-95.

During the Melbourne University conference, the author was able to talk to the following consultants/ researchers and manager:

- Ms Rebecca Somers, GIS Consultant, Somers-St. Claire, Virginia, USA,
- Mr William Holland, Managing General Partner of GeoAnalytics, Wisconsin, USA,
- Mr Jim Dixon, Ministry of Planning, Western Australia.

Prior to the URISA conference, the author was able to conduct a study trip to University of Sheffield in United Kingdom and the National Center for Geographic Information and Analysis, University of Maine, USA. During the study trip and conference, the author was able to talk to the following researchers:

- Professor Ian Masser, Department of Town and Regional Planning, University of Sheffield, United Kingdom,
- Associate Professor Harlan Onsrud, National Center for Geographic Information and Analysis, Department of Surveying Engineering, University of Maine, USA,
- Dr Heather Campbell, Department of Town and Regional Planning, University of Sheffield, United Kingdom,
- Dr Massimo Craglia, Department of Town and Regional Planning, University of Sheffield, United Kingdom,
- Associate Professor Max Egenhofer, National Center for Geographic Information and Analysis, Department of Surveying Engineering, University of Maine, USA,
- Mr Xavier Lopez, PhD Candidate, Department of Surveying Engineering, University of Maine, USA,
- Dr Zorica Budic, University of Illinois at Urbana-Champaign, USA,

- Mr Bijan Azad, GIS adviser to the Government of Lebanon, World Bank.

During the international workshop in Hong Kong, the author was able to talk to the following researchers:

- Professor Anthony Yeh, Director, Geographical/Land Information System Research Centre, University of Hong Kong,
- Professor Y. C. Lee, Department of Surveying and Geo-Informatics, Hong Kong Polytechnic University,
- Dr Hui Lin, Director, Joint Laboratory for GeoInformation Science, Chinese Academy of Sciences & the Chinese University of Hong Kong.

Visiting and resident specialists of the University of Melbourne, who had provided advice to the author are:

- Professor Peter Weill, Foundation Chair of Management (Information Systems), Director of Centre of Management of Information Systems, Melbourne Business School, The University of Melbourne,
- Professor Leon Mann (specialist in organisation theory), Melbourne Business School, The University of Melbourne.
- Professor Peter Dale, University College of London, President of the International Federation of Surveyors, 1996-1999.
- Professor John McLaughlin, Vice President (Research and International Cooperation), University of New Brunswick, Canada.
- Professor Peter Fisher, Department of Geography, University of Leicester, United Kingdom, Editor of the International Journal of Geographical Information Science.
- Mr Bill Robertson, Former Surveyor General and Director General, Department of Survey and Land Information, New Zealand.

Appendix 2. A sample of datasets managed by the State of Victoria other than the core datasets.

The following list of data is extracted from Tomlinson Associates Ltd. (1993, Appendix 1, p. 2-1–2-2)

LANDMMT100 (100K)
LGA Map (25K)
VICROADS RNDB (250K)
ABS CCD Map (25K)
Melways Grid
PRISM Disp. & Val. DB
Planning Scheme Ordinance
Zones & Controls File
Contaminated Properties Registry
LGA Map (100K)
District Boundary Map (25K)
Country Directory Grid
ABS CCD Map (100K)
ABS Statistics
Australian Electoral Roll
AMPIS Database
Bldg. Floorplan Images
Parish Map Layer (25K)
Dist. Boundary Map (100K)
Prov. Boundary Map (25K)
Soil/Landscape Layer (100K)
Topo Map (10K)
ABS Parish-based agricultural statistics
AEC Div. Bdry. Map (25K)
Historic Building Register
School Assets Layers
Fire Facilities Database
FIRESTRAT100
FOREST25
Hab. Ref. Electoral Roll
LANDSYS250 (250K)
LCC Regions Layer (500K)
Dept. of Agriculture Region Layer (250K)
LGA Map (2.5K)
LIMS Layers (2.5-25K)
LIMS Textual Database
LTO Plan Images
PLU25
Prov. Boundary Map (100K)
TREE100-90 (100K)
WETLAND100 (100K)
AEC Div. Bdry. Map (100K)
AEC Div. Bdry. Map (2.5K)
AMG Grid
BIOL-SOS100
COMP25
DPH Amendment Tracking System
DPD ISIP Layers (2.5-25K)
DPD ISIP Textual Database
ESOCLIM Climate (250K)
FLORA100 (100K)
Hydrogeol. Map Series 250K
LAMS amd
SDMB Utilities Easements
GEDIS Borehole database
GEDIS Borehole Layer 250K
GEDIS Extr. Tenements database
Hazchem Sites Map (25K)
Noise Source Map (25K)
Prim/Sec. School Yield Rates
REGION100
RWC Asset Database
RWC Fac.Main.Mgt. System
RWC Groundwater Database
RWC Irr.Base Maps (15/31K)
RWC Stream Gaug. Stn. File
SEC High Volt.Dist. Net Map
SEC Subdiv.Bdy. Map (2.5K)
Site Plan/Bldg Draw. Images
SLOPE25
SEC Map CCDs/Split CCDS (25K)
Soil Chem . Database

Appendix 3. The two questionnaires used in the Departmental GIS Development Profile Survey.

The Questionnaire for Department with GIS

Record of the interview		
Code number: ____ Date of Interview:____		
General information of the department		
1.	What is the size of staff?	________ nos.
2.	What is the size of budget? (estimated) recurrent: capital:	__________A$ __________A$
3.	How many offices and business units are there? (Estimated) Before amalgamation After amalgamation	 ________ nos. ________ nos.
4.	Is there a departmental IT strategy?	yes no being dvlped 2 3 4
5.	What proportion of the offices/business units have their own IT strategy? • none • 20% or below • 21-40% • 41-60% • 61-80% • more than 80% • no idea	 1 2 3 4 5 6 0
6.	Is there a departmental IT platform to which the IT of individual business units can link and access departmental data directly? If yes, are there business units making use of this link?	yes no being dvlped 2 3 4 22 23
7.	Is there a GIS in the department? If no, proceed to questionnaire for department without a GIS.	yes no 2 3
The current organisational setting and GIS management practices		

8.	What were the justifications for the departmental GIS?	past (1) now (2)
	• part of a project funded from outside the department	2 2
	• it was essential technology for a project	3 3
	• benefits identified – tangible and intangible	4 4
	• comprehensive cost-benefit analysis	5 5
	• a complete business case	6 6
	• matches the priorities in the mind of senior management	7 7
	• other competing projects are not attractive enough	8 8
	• other, please specify ________________________	99 99
9.	Which year was GIS first considered?	19 _____
10.	Which year was GIS first introduced?	19 _____
11.	Is there a current department-wide GIS strategy?	yes no being dvlped 2 3 4
12.	Which office administers the departmental GIS strategy?	
	• IT office	2
	• An office providing other corporate support services such as finance, human resources, straetegic planning etc.	3
	• An office responsible for one of the key business functions	4
	• One of the regional offices	5
	• Central Information Management Office	6
	• others, please specify _______________________	99
13.	Is departmental Secretary or members of the decision making body directly involved in the planning and implementation of the GIS strategy?	yes no 2 3
14.	What proportion of the offices/business units have their own GIS strategy?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0

15.	What proportion of the offices/business units have their own GIS coordinator/manager?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
16.	What is the approach toward management of the departmental GIS?	
	• completely centralised	2
	• completely decentralised	3
	• partly centralised and partly decentralised	4
Stakeholders, internal and external:		
17.	To what extent did the following stakeholders in the department affect the development of GIS for various business processes?	low——>high 1 2 3 4 5 6
	• The ministers-in-charge	2 2 2 2 2 2
	• Senior management	3 3 3 3 3 3
	• IT managers	4 4 4 4 4 4
	• The departmental GIS coordinator	5 5 5 5 5 5
	• Managers of GIS-using units	6 6 6 6 6 6
	• Users of the various GIS for business processes	7 7 7 7 7 7
	• The GIS coordinators of the business units, if any	8 8 8 8 8 8
	• Managers of non-GIS-using units and/or other departmental support services units, please specify _________________	9 9 9 9 9 9
	• Unions, please specify ______________________________________	101010101010
	• Other non-users who may have a vested interest in the development of the GIS, please specify ______________________	999999999999

18	To what extent did the following stakeholders in the department affect the development of **shared** GIS capabilities in the department?	low——>high 1 2 3 4 5 6
	• The ministers-in-charge	2 2 2 2 2 2
	• Senior management	3 3 3 3 3 3
	• IT managers	4 4 4 4 4 4
	• The departmental GIS coordinator	5 5 5 5 5 5
	• Managers of GIS-using units	6 6 6 6 6 6
	• Users of the various GIS for business processes	7 7 7 7 7 7
	• The GIS coordinators of the business units, if any	8 8 8 8 8 8
	• Managers of non-GIS-using units and/or other departmental support services units, please specify ________________	9 9 9 9 9 9
	• Unions, please specify ___________________________________	101010101010
	• Other non-users who may have a vested interest in the development of the GIS, please specify _____________________	999999999999
19.	To what extent did the following stakeholders outside the department affect its development of GIS?	low——>high 1 2 3 4 5 6
	• Politicians	2 2 2 2 2 2
	• Government IT coordinator	3 3 3 3 3 3
	• OGDC (Government GIS coordinator)	4 4 4 4 4 4
	• Department of Treasury and Finance – micro-economic reform, financial austerity measures, improve productivity	5 5 5 5 5 5
	• Federal Government–eg. national competition policy or other	6 6 6 6 6 6
	• Counterparts in other states/ countries – peer pressure to develop GIS	7 7 7 7 7 7
	• Suppliers of various components of GIS inside government but outside the department – hardware, software, applications, data, expertise/trainings, standards	8 8 8 8 8 8
	• External suppliers of various components of GIS – hardware, software, applications, data, training, expertise, standards	9 9 9 9 9 9
	• Customers/ users of the department's services	101010101010
	• Collaborators in the departmental businesses	111111111111
	• Academia – education & research, providing staff & products	121212121212
	• Other groups who may be affected directly or indirectly by the operations of the department, pl. specify ______________	999999999999

20	In general, to what extent does the following groups of stakeholders require geographic data and spatial analyses in conducting their businesses?	low——>high 1 2 3 4 5 6
	• senior management/ministers	2 2 2 2 2 2
	• managers of departmental supporting services offices	3 3 3 3 3 3
	• professional and technical staff of departmental supporting services offices	4 4 4 4 4 4
	• general and clerical staff of departmental supporting services offices	5 5 5 5 5 5
	• managers of the business units	6 6 6 6 6 6
	• professional and technical staff of the business units	7 7 7 7 7 7
	• general and clerical staff of the business units	8 8 8 8 8 8
	• no idea	0 0 0 0 0 0
21.	What is your experience regarding the requirements of geographic data, geographic analysis capabilities and the resulting geographic information products of different professional and technical groups in your department?	
	• totally different	2
	• basically similar with minor variations	3
	• basically different with varying degree of overlapped requirements	4
	• no idea	0
Progress of diffusion of departmental GIS (see definitions):		
22.	What proportion of the offices/business units own or have direct and automatic access to GIS hardware and software?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
23.	What proportion of the offices/ business units have their own staff with GIS expertise?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0

24.	What proportion of the offices/ business units have their own geographical databases to carry out their businesses?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
25.	What proportion of the offices/business units do not have a GIS but are planning or developing their own GIS?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
26.	What proportion of the offices/business units do not have a GIS and are not going to adopt/utilise GIS?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
27.	What proportion of the offices/business units have their GIS data directly and automatically shared with the rest of the department?	
	• none	1
	• only departmental/regional headquarters have access	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0

28.	What proportion of the offices/business units have staff with GIS expertise (technical/management) that also service other offices?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
29.	What proportion of the offices/business units have adopted all the departmental GIS standards?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
30.	What proportion of the offices/business units have cooperated/ are cooperating with one another to develop shared GIS capabilities?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
31.	What proportion of the offices/business units have cooperated/ are cooperating with other offices outside the department to develop shared GIS capabilities?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0

32.	What proportion of the offices/ business units are reluctant or known to refuse to cooperate with one another to develop shared GIS capabilities? • none • 20% or below • 21-40% • 41-60% • 61-80% • more than 80% • no idea	 1 2 3 4 5 6 0
33.	What proportion of the offices/ business units have their GIS used by GIS specialists only? • none • 20% or below • 21-40% • 41-60% • 61-80% • more than 80% • no idea	 1 2 3 4 5 6 0
34.	What proportion of the offices/ business units have their GIS used by staff trained to use the GIS software? • none • 20% or below • 21-40% • 41-60% • 61-80% • more than 80% • no idea	 1 2 3 4 5 6 0
35.	What proportion of the offices/ business units have their GIS customised for used by all staff? • none • 20% or below • 21-40% • 41-60% • 61-80% • more than 80% • no idea	 1 2 3 4 5 6 0

36	What proportion of the offices/ business units use GIS in an *ad hoc* manner?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
37.	What proportion of the offices/ business units have modified the GIS to better suit one or more business processes?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
38.	What proportion of the offices/ business units have partly re-engineered one or more business processes for GIS?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
39.	What proportion of the offices/ business units have fully re-engineered one or more business processes for GIS?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0

40.	What proportion of the offices/ business units have realised or are beginning to realised the full benefits of GIS as predicted?	
	• none	1
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
41.	Are there any activities used or arrangements in place to encourage use of GIS by staff?	
	• none	1
	• demonstrations	2
	• hands-on experience	3
	• training courses	4
	• promotional materials/newsletters	5
	• ceremonies to encourage achievement of GIS proficiency	6
	• user-friendly interfaces	7
	• ergonometrically designed equipment	8
	• training scholarships	9
	• paid visits to GIS sites	10
	• paid/subsidised attendance of GIS conferences	11
	• paid/subsidised professional memberships	12
	• rewards	13
	• better promotion prospects	14
	• others, please specify _______________________	99
42.	Are there any activities used or arrangements in place to encourage uptake of GIS by offices/ business units?	
	• none	1
	• demonstrations	2
	• hands-on experience	3
	• training courses	4
	• promotional materials/newsletters	5
	• ceremonies to encourage achievement of GIS proficiency	6
	• free GIS consultations	7
	• paid visits to GIS sites/ conferences	8
	• centralised procurement of GIS for offices	9
	• budgetary incentives	10
	• others, please specify _______________________	99

43.	Are there any organisational arrangements in place to encourage sharing of GIS capabilities among offices/ business units?	
	• none	1
	• centralised identification of opportunities	2
	• paid visits to GIS sharing sites/ conferences	3
	• centralised building of infrastructure	4
	• budgetary incentives	5
	• others, please specify _______________________	99
44.	Which of the following sequences of events best describe the process of development of GIS in your department?	
	• continued development of separate GIS for various business functions in different business units	2
	• development of one or more GIS for business functions, followed by the development of a set of generic shared departmental GIS capabilities, based on which more GIS for the business functions were developed	3
	• with successful pilot GIS test/s, a set of generic departmental GIS capabilities was built early on to support development of subsequent GIS for other business functions	4
	• development of one or more GIS for business functions, then, planned concurrent development of GIS capabilities for both specific business processes at present and general use later on	5
	• a mixture of two or more of the above, please specify ____	6
	• other, please specify ________________________________	99

The Questionnaire For Department Without A GIS

The current organisational setting and GIS management practices		
8.	What were the reasons for the not adopting a GIS?	
	• lack of funding	2
	• GIS was not considered essential for dept'al business processes	3
	• benefits identified did not convince senior management	4
	• comprehensive cost-benefit analysis failed to justify GIS	5
	• not developed a good business case	6
	• lack of data	7
	• lack of in-house expertise	8
	• lack of standards	9
	• culture of department did not encourage change	10
	• other technical problems, please specify ______________________	11
	• did not match priorities of senior management	12
	• there were other more important projects	13
	• bad experiences of other innovative IT projects	14
	• no champion in senior management	15
	• lack of advocate in the business units and other offices	16
	• resistance/objection from trade union/s	17
	• resistance/objection from other stakeholders in department	18
	• peers in other states or countries are not using GIS	19
	• discouragement from state policies	20
	• discouragement from federal policies	21
	• other, please specify _______________________	99
9.	Which year was GIS first considered?	19 _____
10.	Which year was GIS rejected?	19 _____
12.	Which office coordinated the evaluation of GIS?	
	• IT office	2
	• An office providing other corporate support services such as finance, human resources, strategic planning etc.	3
	• An office responsible for one of the key business functions	4
	• One of the regional offices	5
	• Central Information Management Office	6
	• others, please specify _______________________	99
13.	Is departmental Secretary or members of the decision making body directly involved in the evaluation of the GIS strategy?	yes 2 / no 3

14.	What proportion of the offices/business units have considered adopting GIS?	
	• none	1
	• only departmental/regional headquarters	7
	• 20% or below	2
	• 21-40%	3
	• 41-60%	4
	• 61-80%	5
	• more than 80%	6
	• no idea	0
Stakeholders, internal and external:		
17.	To what extent did the following stakeholders in the department affect the decision regarding adoption of GIS?	low——>high 1 2 3 4 5 6
	• The ministers-in-charge	2 2 2 2 2 2
	• Senior management	3 3 3 3 3 3
	• IT managers	4 4 4 4 4 4
	• The Champion/s for GIS within senior management	5 5 5 5 5 5
	• Managers of potential GIS-using units	6 6 6 6 6 6
	• Users of the various potential GIS-using units	7 7 7 7 7 7
	• The GIS advocates of the business units, if any	8 8 8 8 8 8
	• Managers of non-GIS-using units and/or other departmental support services units, please specify _________________	9 9 9 9 9 9
	• Unions, please specify ______________________________________	101010101010
	• Other non-users who may have a vested interest in the development of the GIS, please specify ______________________	999999999999

19.	To what extent did the following stakeholders outside the department affect the decision regarding adoption of GIS?	low——>high 1 2 3 4 5 6
	• Politicians	2 2 2 2 2 2
	• Government IT coordinator	3 3 3 3 3 3
	• OGDC (Government GIS coordinator)	4 4 4 4 4 4
	• Department of Treasury and Finance – micro-economic reform, financial austerity measures, improve productivity	5 5 5 5 5 5
	• Federal Government–eg. national competition policy or other	6 6 6 6 6 6
	• Counterparts in other states/ countries – peer pressure to develop GIS	7 7 7 7 7 7
	• Suppliers of various components of GIS inside government but outside the department – hardware, software, applications, data, expertise/training, standards	8 8 8 8 8 8
	• External suppliers of various components of GIS – hardware, software, applications, data, training, expertise, standards	9 9 9 9 9 9
	• Customers/ users of the department's services	101010101010
	• Collaborators in the departmental businesses	111111111111
	• Academia – education & research, providing staff & products	121212121212
	• Other groups who may be affected directly or indirectly by the operations of the department, pl. specify _______________	999999999999
20.	In general, to what extent does the following groups of stakeholders require geographic data and spatial analyses in conducting their businesses?	low——>high 1 2 3 4 5 6
	• senior management/minister	2 2 2 2 2 2
	• managers of departmental supporting services offices	3 3 3 3 3 3
	• professional and technical staff of departmental supporting services offices	4 4 4 4 4 4
	• general and clerical staff of departmental supporting services offices	5 5 5 5 5 5
	• managers of the business units	6 6 6 6 6 6
	• professional and technical staff of the business units	7 7 7 7 7 7
	• general and clerical staff of departmental supporting services offices	8 8 8 8 8 8
	• no idea	0 0 0 0 0 0
21.	What is your experience regarding the requirements of geographic data, geographic analysis capabilities and the resulting geographic information products of different professional and technical groups in your department?	
	• totally different	2
	• basically similar with minor variations	3
	• basically different with varying degree of overlapped requirements	4
	• no idea	0

Appendix 4. The Departmental GIS Development Profile Survey Protocol.

GIS DIFFUSION IN A GOVERNMENT ENVIRONMENT –

The Departmental GIS Development Profile Survey Protocol

PURPOSE

The primary purpose of the departmental GIS development profile survey is to solicit data to construct a series of profiles of GIS development in the eight State departments of the Victoria Government.

Based on these profiles and a set of pre-defined criteria to be described below, a department will be selected for a more detailed case study. The study is designed to describe the following elements of spreading (diffusion) of GIS in a government environment in greater detail:

- the main stakeholders
- their interactions/behaviours over time that result in the current state of GIS development observed
- the reasons for the interactions/behaviours

The study is prompted by the existing fragmented theoretical understanding of the process of GIS diffusion. It is hoped that the findings ultimately will lead to formulation of more effective GIS development strategies at different levels in government in general.

TOPICS STUDIED

Through a questionnaire survey and an associated semi-structured interview, the profile of GIS development for each State department is constructed. Data regarding the following topics will be gathered (see questionnaire for details of the questions quoted below):

- the way GIS development in the department is managed (Q.4-16, 19, 41-43)
- a list of stakeholder groups, internal and external (Q.17-19)
- the perceived importance of each group of stakeholders identified in the development of corporate GIS (Q.17-19)
- the degree of autonomy of offices/business units in the implementation of departmental GIS strategy (Q.5, 14-16)
- the general presence of business process GIS and infrastructure GIS in a department (Q.6, 20-23, 45)
- the extent of uptake of GIS among offices/business units (Q.24-28)
- the extent of cooperation in developing and sharing of GIS capabilities among offices/business units (Q.29-33)
- the user-friendliness of GIS among offices/business units (Q.34-36)
- the extent GIS capabilities are used routinely to automate business processes in offices/business units (Q.37-39)
- the overall success of GIS development among offices/business units (Q.40-41)
- means of encouraging use of GIS (Q.42)
- means of encouraging adoption/uptake of GIS (Q.43)
- means of encouraging sharing of GIS capabilities (Q.44)
- the pattern of development of GIS over time, in terms of business process and infrastructure GIS (Q.45)
- the extent geographic data and analytical functionalities are used by stakeholders (Q.46)

THE SELECTION CRITIERIA FOR THE CASE STUDY CANDIDATE

The criteria for the selection of a department for a detail case study into diffusion of GIS in a government environment are as follows:

- a well organised central administration in the department with clear and well developed IT/GIS strategies and coordinating units;
- a reasonably supportive head of department/departmental decision making unit;
- the business units in the department must have significant autonomy and be allowed to make its own decisions regarding funding allocation and GIS diffusion.
- a wide range of stakeholders affecting GIS development;
- a well developed infrastructure of both IT and GIS at the departmental level, and to a varying extent in certain agencies;
- there should be offices/business units that are both keen and reluctant to take up GIS;
- offices/business units are in varying extent of GIS development;
- the department is willing to cooperate with the investigator.

THE PROTOCOL

Access To Respondents

After the State election in April 1996, there was a major reshuffling of departmental responsibilities resulting in the creation of eight State departments. With the new Victoria State Government Directory still being printed at the time of production of this protocol, the current contact persons who are in charge of information technology in each of the eight State departments are ascertained by phone.

A letter of introduction from Professor Ian Williamson of the Department of Geomatics, the University of Melbourne, will be sent to the IT contact person in each department, outlining the background of the survey and requesting for an interview. The questionnaire for the survey will also be attached to each letter for the contact persons' reference. The interviewee/s may be the contact person or up to two nominated representatives considered most suitable to answer the questions. Two weeks after the letters are posted, the contact persons will be contacted to confirm the names of the departmental representatives. Interview sessions will then be arranged. The respondents will be requested to provide an organisation chart/ annual departmental report, and if available, various GIS justification or progress reports to provide background information for the survey.

As the survey is part of a research sponsored by government, a copy of this protocol, together with a copy of the letter to the departmental contact persons will be sent to the sponsoring offices, Geographic Data Victoria (GDV) and Geospatial Policy and Co-ordination Victoria (GPAC) (previously, the Office of Geographic Data Co-ordination) for information.

The Interview

Each interview involves a questionnaire survey to be followed by a short semi-structured interview. It should last about one hour. For departments which are in an advanced state of GIS development, issues being discussed may be more complex and the interview may take up to an hour and half. Each respondent will be encouraged to answer every question, providing the best possible answers according to his experience. In case a respondent feels not competent enough to answer a question, an alternative respondent for the question concerned will be requested.

Confidentiality

The departmental responses will be confidential. Each set of survey records will be labelled with the date of interview and a code number. Through a look-up table, the code numbers are related back to the departments, names, and ranks of the respondents. The look-up table will be stored separately from the records for up to five years. The records will be kept securely, and only the researcher will have access to them.

While each department and its nominated interviewee/s will be named and acknowledged in a list of survey participants, all data and findings will be grouped by the code number and reported in an aggregated manner. All reports and publications that draw on the findings of the survey will be sent to GDV and GPAC for vetting prior to submission or publication.

SURVEY PREPARATION AND PRE-TEST INTERVIEW

The following people have been asked to review the questions/model developed:

- Hok Pan Yuen (x7991), Statistical Consulting Centre
- Richard James (x 7627), Centre for the Study of Higher Education
- Professor Ian Williamson of Department of Geomatics (DoG)
- Selected postgraduate students in DoG, e.g., Paul Harcombe
- Graeme Dudgeon, David Alexander & Steve Jacoby of GPAC
- Mike Smith of GDV
- Peter Woodgate of Natural Resource Systems (DNRE)
- John Spring of Geographic Information Services
- Dr Peter Fisher of University of Leicester, UK
- Professor Leon Mann of Melbourne Business School

If possible, a contact will be invited from one of the departments to participate in a pre-test interview (going through the interview as planned) to assess if the questions asked can generate meaningful data for the research.

Appendix 5. Letter from the Secretary of the Department of Natural Resource and Environment to other secretaries of department of the State Government of Victoria.

Appendix 6. List of Respondents in the Departmental GIS Development Profile Survey.

Department	Name	Rank
Premier and Cabinet	Mike Harrington	Director, Special Projects,
	Andrea Heyward	Assistant Secretary, Executive Services
	Greg Hyams	First Assistant Secretary, Office of State Administration
Treasury and Finance	Kevin Pittman	General Manager, Information Services, Corporate Resource Agency
Education	Kevin Ward	Manager, School Assets Management Unit
	David Arblaster	Project Officer-Data Management and Analysis Branch
	Don Hudgson	Project Manager, Research and Planning Branch, Directorate of School Education
Human Services	Bob Reynolds	Assistant Director, Information Technology
	Peter McDonald	Assistant Director, Planning and Budget, Aged, Community and Mental Health
Infrastructure	Jo Moylan (Ms)	Executive Manager, Information Systems,
	John Cole	Senior Land Information Officer, Local Gov't Planning and Market Information
	John Hanna	Director of Forecasting & Analysis, Division of Strategic Planning & Engineering
Justice	Geoff Spring	Chief Executive officer, Bureau of Emergency Services Telecommunication
Natural Resources and Environment	Richard Gijsbers	Director (acting), Office of Land and Resource Information Management
State Development	Ian Munro	General Manager, Facilitation Services, Business Victoria
	Bernie Hassett	Manager, Rural Offices, Business Victoria

Appendix 7. Questions to be asked during semi-structured interviews in the Departmental GIS Development Profile Survey.

Semi-structured Interview – Departments with GIS

Can you elaborate on the justifications in the answer to Q.8?

Can you elaborate on the business functions (Q.14-15), extent of control (Q.16)?

Can you elaborate on the business functions in the answer to Q.25-26?

What are the roles played by the internal stakeholders (Q.17-18) in bringing about the present state of development of GIS?

What are the roles played by the external stakeholders (Q.19) in bringing about the present state of development of GIS?

(Federal government –National competition policy)

(State government –privatisation, corporatisation, downsizing, budget cuts/improved productivity, State competition policy, loss control of data, loss of expertise, no control over standards and departmental requirements, less GIS for business process, lost direct access to shared GIS capabilities)

(OGDC –funding, time, data, staff, standards, data sharing arrangements/incentives,)

(Others –GIS vendors/suppliers, perceptions of people, institutional arrangements & culture, inter-departmental institutional arrangements, customer demand, public demand in general)

(other government departments –data needs, formats, effectiveness & efficiency of business processes)

(vendors –technology, skills/expertise)

(clients –efficiency, effectiveness, appropriateness, quality of goods & services)

(academia –research, education/training)

What were the sequence of events that had occurred leading to the present development of GIS?

(key players, key issues, role played by OGDC – actual and expected)

What are the views of senior management towards GIS?

(any bearing on key business objectives of the department)

Which roles should OGDC/GDV/GPAC play in facilitating development of GIS in your department?

(funding, standards,)

How are the realisation of benefits identified in the justification of GIS monitored?

Semi-structured Interview – Departments without GIS

What kind of GIS did the department look at ?

(department-wide, regional office-wide, business unit-wide, certain business functions/processes)

(too big, too small)

Can you elaborate on the answer to Q.8 - reasons for not adopting?

What were the sequence of events that had occurred leading to the rejection of GIS?

(key players, key issues, role played by OGDC – actual and expected)

What are the views of senior management towards GIS?

(any bearing on key business objectives of the department)

What are the business functions of the offices/units referred to in your answer to Q.14?

What are the roles played by the internal stakeholders as reflected in the answer to Q.17 in bringing about the present state of development of GIS?

What are the roles played by the external stakeholders as reflected in the answer to Q.19 in bringing about the present state of development of GIS?

How are spatial data managed and spatial analyses carried out? (Q.20-21)

(individual business units, whole department)

How do you think the potential changes/lack of change in the next 3-5 years will impact the decision regarding adoption of GIS?

(changes in: senior management, business needs, customers/clients, OGDC, technological environment, government or its policies (state or federal) - micro-economic reform (downsizing, privatisation, corporatisation, contracting out, competitive tendering etc.), competition policy, public demand, pressure/interest groups, information industry)

Any reports that concern GIS for the department available?

Appendix 8. The case study protocol.

GIS DIFFUSION IN A GOVERNMENT ENVIRONMENT

THE CASE STUDY PROTOCOL
(GENERAL & ACCESS ARRANGEMENTS)

PURPOSE

To describe the process of GIS diffusion in a State Government Department selected: the Department of Natural Resources and Environment (referred to as the department from now on).

DATA

To collect the following data:

1. the purposes, composition, distribution, and current state of development of the departmental GIS – the collection of all GIS (whole or part) developed in the department;
2. the stakeholders of each identifiable GIS in each business units;
3. the events that have taken place in the course of development of each identifiable GIS and their relations with those events of other GIS.

KEY FEATURES OF THE CASE STUDY METHOD

The proposed study is a single (embedded) case study. Based on the findings of the Government Departmental GIS Development Profile Survey, a department is selected for the study. The department is taken to represent a government environment in which diffusion of GIS occurs.

In the past, many State Government departments have undergone major structural changes. The most recent change took place in April, 1996. Therefore, in the department selected, there may be recently transferred programs that are still adjusting to the new management system. Whatever GIS these programs have are probably developed in other departments over the years and in effect constitute a GIS belonging to a different department. Though GIS in these programs have great value for comparative study later on, they will only add to the complexity of the present study. Therefore, this study will restrict the investigation to those programs that have a long departmental lineage (core programs). These core programs together with other administrative and supportive branches in the regional and departmental headquarters, form the *unit of analysis* of the study. The different business units within these programs and branches form the *embedded units of analysis*. The stakeholders involved are the *units of contact*. The means of contact is semi-structured interviews supplemented by one or more questionnaires wherever appropriate.

ACCESS PROCEDURES

A letter from Professor Ian Williamson will be sent to the Secretary or a known member of senior management of the selected department, requesting for permission and support to conduct case study. The preliminary report of the Government Departmental GIS Development Profile Survey will be attached to the letter, highlighting the achievements of the research to-date, the reasons for selecting the department concerned, and the topics that has to be further studied in the case study proposed. The department will be requested to nominate a contact person with whom details of the program of the case study and the associated access procedures would be finalised.

As the survey is part of a research sponsored by government, a copy of this protocol, together with a copy of the letter to the department will be sent to the sponsoring offices: Geographic Data Victoria (GDV) and Geospatial Policy and Co-ordination Victoria (GPAC) (previously, the Office of Geographic Data Co-ordination) for information.

There are expected to be four levels of contacts in the department:

- Primary - the departmental contact officer,
- Secondary - the head and/or GIS manager of each departmental program,
- Tertiary - the manager or the GIS coordinator of each office implementing a program (the basic unit of analysis),
- Fourth level - the stakeholders identified by each level of contacts.

As the bulk of interviews will be carried out in individual program offices, the manager of each office should be asked to provide a temporary working space for the interviewer and a contact person who can provide some stationery and certain information about the office facilities that are accessible to the interviewer.

The Interview

As identified above, there are four levels of contacts, ranging from the departmental contact officer to local office managers and stakeholders. During the initial interviews at the first two levels of contact, a set of information will be collected in general to form a historical framework of GIS development in the department, and to prepare for data collection later on. The information includes:

- the general history of development of GIS,
- the key stakeholders in the diffusion of GIS,
- the progress of diffusion of GIS based on the extents of physical adoption, sharing and access to users, at the time of the interview,
- the composition, purpose, and ownership/custodianship of GIS as perceived by the respondents, at the time of the interview.

The first two sets of information will be collected through semi-structured interviews while the latter two will be collected with the help of standard questionnaires/forms. Depending on the schedule of the respondents, the interviews can be separated into two or three sessions.

Interviews with the third and fourth levels of contact will be conducted to uncover the details of each identifiable GIS, and the events that had taken place within the historical framework GIS development constructed from the initial interviews. The general and the more detailed information will be integrated to give a full picture of GIS development in the department. The findings together with any queries emerged will be discussed and clarified with the first two levels of contact in a second round of interviews to validate the findings.

Through initial interviews with the officers at a higher level of contact, the respondents for the next level of contact will be identified and means of access to them arranged. Prior to starting the study at each level, some background information of development of GIS would be required to fine-tune the data collection strategy. This includes:

- any reports produced in the past regarding the various GIS and/or their development in the department/programs;
- the organisation charts of the department/programs;
- past annual reports which described the achievements of GIS.

Confidentiality

Personal perceptions and opinions will be confidential. Findings relating to perceptions and opinions will be reported in an aggregated manner. However, to track the process of diffusion of GIS in the department clearly and accurately, real names and ranks of the stakeholders will be used when describing the history of GIS development. Events reported by each stakeholders will be cross-checked with other stakeholders involved and with available departmental documents whenever possible. All reports and publications that draw on the findings of the study will be sent to GDV and GPAC for vetting prior to submission or publication. The field notes will be stored securely and separately from any reports or analytical results for up to five years. Only the researcher and other persons approved by the department will have access to the field notes in this period.

The content of this section will be discussed and reviewed with the departmental contact officer. It will also be repeated to individual respondents prior to the actual interview.

Pretest

During the initial interview with the primary contact, a request will be made to select an office that is cooperative and has a fully functional GIS for a pretest. In the test, the procedures of data collection will be trialed and refined.

Special Documents

The preliminary report of the Government Departmental GIS Development Profile Survey submitted to Professor Ian Williamson will serve as good background reading concerning this case study. It is based on the survey findings that a government department is selected for this case study.

Prepared by
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30th January 1997

Appendix 9. Questions to be asked in the Case Study.

5 mins

- self introduction, background of study
- purposes:
    1. **what** GIS in program is made up of in your own words.
    2. the **history** of GIS development – need help of those who know the administration & management of GIS over the years *(what had happened? who were involved? when did things happen?)*
    3. point me to other persons or **stakeholders** who have brought about the present state of development of GIS, to help fill in the details of the development of GIS in the program

25 mins

- determination of respondents
  (if short of time, an overview from LRI manager and then point to other more appropriate respondents, otherwise, arrange another meeting with manager later on)
- organisation structure of the program, present and past
  (the functions and the business units involved, inter-unit business relationships, extent of needs for GIS)
- management structure/ policies for GIS, present and past
  (coordinator/manager? what are the planning & decision channels? who look after the GIS? when is liaison with OLRIM necessary? when to liaison with other programs directly? when issues are kept in house? what is the contractual and working relations with NRS inc.)
- What is the GIS in program made up of ?
- overview of development of GIS in the past
- future direction for GIS development
  (relation with departmental strategy, program objectives, problems)

30 mins

- What is the GIS in program made up of ?
  (all identifiable GIS, elements of GIS (eg., data, expertise), present state of development (3Rs), purposes in business processes)

30 mins

- overview of development of GIS in the past
  (key stakeholders, issues, achievements, setbacks)

Appendix 10. The thirteen programs administered by the Department of Natural Resource and Environment.

Catchment Management and Sustainable Agriculture Division

Catchment Management and Sustainable Agriculture Program

Seeks to achieve healthy catchments which protect and enhance the environment while supporting sustainable and more productive natural resource industries and regional communities.

Water Agencies Program

Ensures that the water industry, through the various agencies, provides clients and stakeholders in Victoria with sustainable, high quality and efficient water and waste water disposal services.

Weeds and Pests Program

Aims to improve environmental health and economic productivity by controlling pest plants and animals on all land.

Forests Service Division

Forests Management Program

Ensures sustainable management of Victoria's public land native forests; ensuring that timber production occurs on a commercial basis, establishing a secure framework in which industry can plan long term investment strategies. Also is responsible for developing the tourism recreation profile for State forests in the Victorian tourism industry and ensuring the long term sustainability of all forest values.

Fire Management Program

Delivers efficient, effective and integrated management of fire and fire related activities on public land for the purpose of protecting human life, property, assets and environmental values, and for sustaining biological diversity.

Land Management and Resource Information Division

Land Management and Resource Information Program

Manages the provision of integrated, authoritative and coordinated land information which is easily accessible, comprehensive, facilitates land related transactions and contributes to the prosperity of Victoria.

Acts as Government landlord for Crown land occupied by people and institutions other than NRE and prepares policies, strategies, guidelines and plans associated with the private and community use of Crown land.

Provides the "land bank" and real estate function for NRE, and for much of Government, involving land purchase, compulsory acquisition, disposal, rental and exchange of land and property.

Minerals and Petroleum Division

Minerals and Petroleum Program

Stimulates the generation of wealth through the sustainable development of Victoria's earth resources, while ensuring that community expectations for health, safety and environmental management are met.

Parks, Flora and Fauna Division

Parks Program

Responsible for developing a representative protected area network and the provision of natural and cultural resource management, visitor and tourism services.

Flora and Fauna Program

Ensures that Victoria achieves better biodiversity conservation outcomes in natural resource management and use by providing expert scientific and strategic advice on the protection and enhancement of flora and fauna and processes that threaten these assets, assisting the community to actively participate in biodiversity conservation and management, and ensuring that economic, recreational and other uses of flora and fauna are sustainable.

Coasts and Ports Program

Manages Victoria's coastal public lands on a sustainable basis whilst providing for public access and port management. The program manages Coastcare and Coast Action Initiatives to ensure community and local government are involved in improvements to Victoria's coast.

Primary Industries Division

Agriculture Industries Program

Supports the development of sustainable and internationally competitive agricultural industries which aim to generate $6 billion per annum of agriculture and food exports and ensure viable regional economies by the year 2001.

Agriculture Quality Assurance Program

Protects Victoria's reputation as a producer of high quality, clean food and agricultural products through services to prevent the introduction and spread of pests and diseases, to minimise the risk of chemical residues and to protect the welfare of animals.

Fisheries Program

Ensures Victoria's fishery resources and habitats that support those resources are conserved by careful management of commercial, recreational and aquaculture use within the context of ecological sustainable development, with community/client understanding, support and participation in resource management.