A REVIEW OF THE GIS PLANNING METHODOLOGY FOR VICTORIA: ITS RELEVANCE TO REAL LIFE SITUATIONS

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Abstract

The Victorian Government spent nearly $1 million in 1991-94 on international consultants undertaking one of the largest cost-benefit and strategic planning initiatives worldwide for the development of GIS. The objective was to review the GIS needs of state agencies in terms of management, finance, data and technology. The consultants developed a broad strategic plan for generating 61 information products to meet the information needs of five key programmatic areas of the State Government. A cumulative benefit of up to $312 million was forecast for an investment of $56 million over a six year period. The State accepted the review and decided to implement the strategy in a commercial manner, under the coordination of the Office of Geographic Data Coordination.

Due to the size and success of the study, many valuable lessons can be learnt from a critical review of the process involved and the events that made it possible. This paper will summarise the events that led up to the study, its methodology and outcomes, to be followed by an analysis of its merits and any limitation.

Introduction

In 1991, Victoria commenced a strategic planning study (to be referred to as the study below) which is one of the world's major comprehensive state-wide multi-agency Geographic Information System (GIS) planning exercise using a consistent planning methodology. It studied 39 state agencies and divisions in five major programmatic areas. Sixty-one information products from 270 datasets were identified. Together, they would require an investment of $56 million (all values are in Australian Dollars) in return for a potential benefit of $312 million, fully discounted over a six year period at a rate of seven percent. The study was successful. It aroused the State Government's interest and resulted in funding for the formulation and implementation of a detailed GIS development coordination strategy.

However, prior to this study, over a decade ago, there was a similar coordination initiative called Landata. The initiative aimed at generating seven products from which substantial benefit was promised to the government at a cost of about $10 million at 1983 value (Auditor-General,
Landata was subsequently found unable to fulfill its original goal of coordination (Deloitte Ross Tohmatsu, 1991). The 1991 study represented an initiative by the stakeholders within the State Government to reinstate coordination to GIS development. It took 18 months to complete at a cost of about $1 million. At this level of expenditure, it will be interesting to know to what extent the broad strategy recommended in the study, which was completed two years ago, is still relevant to Victoria’s prevailing situation. It is hoped that from a review of the study, lessons can be learnt to the benefit of future similar studies.

This article first summarises the major GIS initiatives that have taken place in Victoria over the last couple of decades. Then, the challenges faced by Landata and Office of Geographic Data Co-ordination (OGDC) - the current State GIS coordinating/development agency - will be compared and contrasted. To set the scene for later discussions, this article will briefly describe the methodology and findings of the study. An endeavor will be made to review the relevance of the recommended broad strategy to the current situations in Victoria and to discuss any weaknesses or limitations of the study. This is followed by the development of the concept of "modular GIS architecture" from the findings of the study. The concept will then be used to model the various stages of development of geographic/land information system (G/LIS) in Victoria. The final vision for GIS development for Victoria will also be derived. This article will conclude by suggesting the need for further research on the development of a set of assessment methodologies to facilitate the establishment of a comprehensively coordinated Victorian Government GIS.

To simplify subsequent discussions, the meaning of geographical data here will be taken to include all those data with a spatial dimension in them. Land Information System (LIS) will be taken to mean a computerised system of information concerning land administration.

**Historical Development of GIS in Victoria**

Computerised management of textual geographical data by the Australian Bureau of Statistics and the Bureau of Meteorology started in the late 60s (Massey, 1978; Lee, 1981). Computerisation of Victoria's core property information began in early 1970s. During this period, major State agencies like the Melbourne Metropolitan Board of Works (Cramer, 1977), the State Electricity Corporation (Kelly, 1977), and the State Road Authority (Pittar, 1977) also started to computerise their textual geographic databases. In 1974, the Department of Crown Lands and Survey of Victoria started using computers in the metric conversion program of all Parish and Township plans. By 1975, local government finance statistics had been computerised into the Australian Municipal Information System. However, Victoria's local government statistics still were compiled by hand (Cushing, Parish and Warren, 1975).

While more textual computerised databases were being developed by various State departments and agencies in 1976, Melbourne Metropolitan Board of Works began to consider the setting up of its LIS. The Royal Australian Survey Corps also introduced AUTOMAP to assist in the production of topographic maps (Bryant, 1977). More significant however, was the establishment by legislation of the State Coordination Council in that year. It's first task was a direction by the Premier to investigate and report on the desirability of a State computer-based LIS. It was observed that many agencies were going to start their own LIS (Anonymous, 1977).

By 1977, the study group appointed by the Council found that there were 104 land related data systems in the State Government, 67 of which were going through revision or being further developed. The group recommended the creation of the "legal" database to be supported by a "geographic" database, both of which together constituted a computerised cadastre (Eddington, 1979). In the mean time, only less than half of the local councils in the State were using computers, which were mainly used for financial purposes (Davis, 1977). By late 1977, the Department of Crown Lands and Survey acquired a computerised mapping system extension for its metric conversion program (Department of Crown Lands and Survey, 1977).
In 1978, there was already a "standard for the Exchange of Topographic Data on Magnetic Tape" used by the Australian Survey Corps and Department of National Mapping for feature coding. Melbourne Metropolitan Board of Works was also looking into a possible joint pilot project with other utility agencies to develop a digital base map (Melbourne Metropolitan Board of Works, 1978).

In 1979, after a lapse of two years, two more studies were conducted to expand on the concepts established by the 1977 study on the State LIS. The findings established the concept of an integrated LIS for Victoria (Miller, 1991). By late 1979, the Victorian Ministry of Conservation formed a Steering committee to investigate the "use of environmental data handling in planning" (Bishop, 1981). This represented a major and serious attempt of the environment and natural resource sector within the State Government to consider coordinating the production and use of its spatial data resources.

In 1980, the government approved the setting up of a special project group to address the issues identified for the proposed LIS in Victoria. However, due to funding problems, there was little development until 1982 when the Labour Government took over and the new Cabinet confirmed that an automated LIS be established as a key government priority (Miller, 1991). This move was later seen as part of a coordinated move by Government to effect reform of its Land and Property functions (Russell, 1986). The initiative was officially called Landata under the Department of Crown Lands and Survey. Three working parties were established to look into the three areas of interest: legal/fiscal, mapping and natural resources. A Corporate Plan was produced in 1983 (Department of Crown Lands and Survey, 1983), planning the generation of seven information products by 1988. In the interim period, several users identified in the 1979 reports had commenced development and implementation of their own computer systems (Miller, 1991). In 1981, the Standards Association of Australia published AS2482 - the standard for the interchange of Feature Coded Digital Mapping Data (Eddington, 1981). The pilot GIS for Upper Yarra Valley and Dandenong Ranges Authority, which was sponsored by the Ministry of Conservation also started in 1982 (Prattley and Norman, 1982).

After a long scrutiny and review of the corporate plan, funding was approved in 1984 and soon afterwards, Landata came under the responsibility of the Department of Planning and Environment. Then in 1985, it became the responsibility of the Department of Property and Services, after a brief period with the Attorney-General's Department (Auditor-General, 1990). In the same year, The Division of Survey and Mapping, the Land Titles Office, the Valuer-General's Office and Landata formed a functionally related Land Information Group within the Department of Property and Services after more than a century of divided administrative responsibility (Russell, 1986). This was to facilitate effective management of land related information.

In the mid 1980s, there was an increasing concern in government for cost recovery and increased efficiency in government services. A group of Swedish Government officials was invited in 1985 to develop a future strategy for Landata. The main concern of the strategy was cost recovery and the focus was on non-graphic parcel-based data to the exclusion of graphic and particularly topographic data (Williamson, 1992). This resulted in the expedited development of the Automatic Land Title System, in which Landata had to develop a major interest (Deloitte Ross Tohmatsu, 1991). In the same year, Melbourne Metropolitan Board of Works started to digitise the metropolitan cadastral maps of Melbourne which was subsequently completed in 1990. The change in the emphasis of the Landata programme raised a number of issues which were discussed in a symposium held in Melbourne (Turk and Williamson, 1987).

In 1990, Auditor-General queried the protracted nature of the Landata project as a result of the six products promised in the 1983 Corporate Plan being not fully operational by December, 1988. In 1991, a private consultant was asked to review the Landata project by the Director of Property and Services. The review concluded among other things that the land information coordination role of Landata had not been fulfilled (Deloitte Ross Tohmatsu, 1991). In the same year, there was a major government reorganisation with the appointment of a new Premier. The
new cabinet dissolved the Department of Property and Services. The Division of Survey and Mapping and Landata were put in the Department of Finance. The Titles Office was transferred to the Attorney-General's Department as a result of the pressure from the legal fraternity in Government to control land titles (Williamson, 1992).

In the period 1990-91, privatisation of the distribution of the parcel based map maintained by the Melbourne Metropolitan Board of Works was effected through the creation of a private company to manage all its spatial data. This had a destabilising effect on previous arrangement where data was in general exchanged at the cost of duplication. Further, due to the increasing pressure on privatising State-owned utilities, the utilities group in Victoria gained importance as a land information player (Williamson, 1992).

In 1991, the environment and natural resource lobby in the Government was getting more and more concerned about access to digital map data (mainly topographic) and the lack of an overall strategy of managing geographical data. This concern led to the involvement of the Office of the Premier and Cabinet and the group mandated for the State's information technology strategy, and resulted in a decision to review the GIS in the State. A group of about nine Chief Executive Officers with environment and natural resource interest decided to pool some of their management funds together to undertake a review through the Office of the Premier and Cabinet (Williamson, 1992). An overseas consultant was engaged to assist in the development of a GIS strategy for Victoria. The study comprised two stages and was completed in 1993 with the production of a broad strategy.

As a result of stage one of the study, the Office of Geographic Data Co-ordination was established in 1991 under the Department of Finance. Soon after, there was a ministerial reshuffle and OGDC was put under the Department of the Treasury, resulting in a further split in the coordination of land related data in the State (Williamson, 1992). The Liberal Party took over the Government in 1992 and a State GIS strategy was produced in the same year. In 1993, OGDC was brought under the Department of Finance.

After the completion of the study, OGDC was charged with the duty of designing the detailed implementation strategy. It was given a rolling budget of about three million dollars and was required to report to the Budget and Economic Review Committee of the Cabinet the progress of its work every six months. At the same time, the new Government adopted a rigorous policy of making the administrative machinery smaller and more efficient through privatisation, outsourcing, downsizing/ rightsizing.

In July 1994, full coverage of digital land parcel framework of rural Victoria was completed by Survey and Mapping, Victoria (formerly Division of Crown Lands and Survey). An agreement was also made with Melbourne Water Corporation (the former Melbourne Metropolitan Board of Works) for the State Government to take over the intellectual property right of the spatial property dataset. This was effected through the creation of a unit in OGDC called Geographic Data Victoria (GDV), which would assume the duty of managing the State Cadastral Map Base on behalf of the State in a commercial and eventually self-sufficient manner. Together with a similar agreement with Barwon Water at a later stage, GDV gained the right to market the complete cadastral map base for the State by the end of 1994 (Smith, 1994).

In early 1995, through a change in Government machinery, OGDC acquired the additional control of the State Digital Road Network and the State Topographic Map Base (scale: 1:1 000 000 and 1: 25 000) and took over Landata and the Mapping Division of Survey and Mapping Victoria (Office of Geographic Data Co-ordination, 1995). Departments were also required by the State's Information Technology & Telecommunication Policy and Guideline Statements to liaise with OGDC "prior to collecting or producing new geospatial data" (Department of Finance, 1995). At about the same time, OGDC was also in the process of contracting out the management of the Metropolitan Digital Cadastral Map Base.

The major events described above document the development of GIS in Victoria in the past two
to three decades. The events can be grouped into several overlapping stages for ease of understanding. The stages are listed out in a rough chronological order below:


**Situation Faced By Landata and OGDC**

By discussing with the major GIS user departments in the State, the 1991 study was able to identify four main problems regarding the current situation of topographic data management in Victoria. They were data, cost-timing, staff skill, and management. Data problem was concerned with availability, standards and common logical data model. Cost-timing problem was about the long lead time from investment to reaping of benefits. Staff skill problem was about the general shortage of skilled people to plan, manage and make use of the technology to generate the information needed by the department. This, to a certain extent, overlapped with the last problem of management, which was concerned with the lack of corporate vision and planning as a result of lack of GIS awareness and knowledge of senior and near-senior management. The issues of cooperation with in-house IT management division/department and managing data sharing among departments were also discussed under this problem (Tomlinson, 1991a). Note in particular that technical limitations caused by hardware and software were not raised. It reflected that the technology had already developed to such an extent that it no longer pose any serious problem to GIS development.

If data, GIS skill and management were still considered as problems in 1991, then the problems faced by Landata in the early 1980s when it was being developed, should have been more acute. At that time, there were still relatively few textual spatial databases and useful digital maps were virtually non-existing. GIS technology was developing and the capabilities of both the hardware and software in the market were rudimentary by current standards. The national standard for geographical data exchange had just emerged. GIS expertise was lacking, not only in the technical aspects, but also, and in particular, in the planning, coordination and management of large scale multi-agency GIS such as that of Landata. This was similar to the experience of a major early GIS initiative in Australian Capital Territory Electricity and Water Authority, the staff of which were reported to have faced enormous technical and management problems in the course of the development process (Allen, 1994). In fact similar problem occurred around Australia in the 1980s when different States G/LIS were being developed. Worst still was the lack of support and direction from top administration within the Government due to the relative ignorance of GIS and incomplete understanding of the significance of coordinated GIS for the State as a whole. This is reflected in the way the Government established the Land Information Group (which Landata was an integral member) and tried to make use of it to achieve its land administration and property management policy (Russell, 1986). With a triennial term of office, the Government at that time seemed to have little choice otherwise to meet its objectives.

Unlike the situation faced by Landata, OGDC is able to inherit a set of core geographical datasets - the State Cadastral Map Base, and the State Topographic Map Base. The development of the GIS technology in the last decade have been so great that, users in the State Government did not cited hardware and software as an impediment to GIS development (Tomlinson, 1991a). The technology is now fully operational and not an issue to OGDC. In fact, expertise in the various aspects of GIS management are more available than a decade ago, both
locally and oversea, albeit still in short supply (Tomlinson, 1991a). In general, a greater awareness of GIS, its potential and the need for State-wide coordination have been cultivated in the State Government, particularly after the 1991 study.

Although, OGDC is currently in a more favourable environment for GIS development, it has to assume a wider and more complex role in GIS management, which can be categorised roughly into three aspects. They are:

- a custodian and manager of core geographical datasets (digital and hard copy map base under its charge),
- a GIS and mapping authority to set and enforce State GIS and mapping policies and standards, and
- a GIS coordinator to facilitate the overall development of GIS within the State Government.

At the same time, like Landata, OGDC’s early phase of establishment coincided with the change of Government, subjecting it to similar political challenges as Landata. This time, it is the present Government’s policy towards a smaller and more efficient government through downsizing, rightsizing, outsourcing and privatisation. Being under the Department of Finance, OGDC is located in a more impartial position to carry out its functions. However, it is also placed in the forefront of Government’s policy drive. OGDC has to outsource all its major activities and is required to run Geographic Data Victoria in a commercial and self-sufficient manner when managing the State Digital Cadastral Map Base. Further, it is being monitored half yearly by the Budget and Economic Review Committee of the Cabinet regarding the progress of implementation of strategy across all Government agencies, particularly in the financial/ economic aspect.

It has to strike a delicate balance between the GIS authority and coordinator and a role model of Government Policy. To be an effective GIS authority and coordinator, it will have to return benefits to Government as predicted by the 1991 study. To be a role model, it has to operate in such a way as to fulfil the central policy of the Government - through outsourcing and commercialisation, while maintaining a small staff size. Again, like Landata over a decade ago, OGDC is breaking into new ground. There is currently little expertise in the market to cater for its needs (Price Waterhouse Urwick, 1995). Under this volatile condition, with a lapse of about two years after its completion, does the recommendations of the 1991 study remain relevant to the administrative environment in Victoria. A review will be conducted below to address this question. Before that the scene will be set by a brief description of the methodology and findings of the study.

**Methodology and Findings of the Study**

When the GIS strategic planning study started in 1991, the objective of the study was:

"to establish an overall strategy for the development of Geographic Information Systems (GIS) in government departments and agencies in the State of Victoria." (Tomlinson, 1991a)

The interim objective set for the broad strategy was to be:

"the development of a comprehensive State Geographical Data Model which will form a spatial data infrastructure in Victoria..." (Tomlinson, 1993a)

The ultimate objective was to:

"move toward cost-effectiveness both in the production of geographic information and in the benefit to government of having that information." (Tomlinson, 1993a)
The study was made up of two stages. The first stage started with a Situation Analysis - a preliminary assessment of the current situation and followed by the identification of problems in the State regarding coordination of natural resource data. Based on that, a broad strategy for GIS planning and management was developed. To achieve the objectives described above, it recommended, among other things:

- setting up of the administrative structure needed to successfully implement the GIS strategy. This resulted in the establishment of OGDC.
- production of a State GIS strategy.
- putting in place standard GIS planning and management processes throughout government to assist in achieving the potential benefits (Tomlinson, 1991b).

The first two items were completed by the Government. Funds were also provided for developing and applying a standard planning methodology to gather data to support and refine the broad strategy, and to facilitate the development of an implementation plan. Subsequently, as the second stage of the study, a comprehensive GIS planning exercise was carried out.

The Situation Analysis is in fact a process of "Program Analysis and Problem Definition". It analysed Victoria's "program of natural resource data management", identified the underlying problems, and proposed a broad strategy for improvement. The strategy comprised, among other actions, a detailed GIS planning process which was made up of "Needs Analysis", "Conceptual System Design", and "Cost-Benefit Analysis" (Chan and Williamson, 1995). A schematic summary of the methodology, based on the model of GIS justification/introduction developed by Chan (1994) is illustrated in Figure 1.
In the process of Program Analysis and Problem Definition, the activities of 12 State agencies, mostly of environmental and natural resource background were reviewed in respect of: the key programs and program budgets, current GIS investment and operations, required GIS information products, benefits of GIS technology, and impediment to GIS development. An overview of a further 11 agencies were also conceived from the information provided. The State was found to have invested about $134 million in GIS in the ten years prior to the study in 1991. Despite an estimated annual potential benefit of about $128 million, the current systems were found unable to achieve even the potential benefit expected of a well planned system at a benefit to cost ratio of 2.5:1. The other problems included lack of GIS priorities and
infrastructure, policy level direction and coordination, and general GIS skill (Tomlinson, 1991b). In general, the discussions and recommendations about GIS were essentially geared towards the management of the State’s natural resource data rather than all its geographical data.

In the second stage, the bias towards environment and natural resource interests was rectified. The rather narrow scope adopted in the first stage of the study was expanded to include parcel based as well as other geographical data in five key programmatic areas specially identified by the State Government. The planning process adopted a "top down" approach and was targeted primarily at senior management and their information needs. In the Needs Analysis, an educational seminar was organised for senior managers of agencies who were then asked to identify geographic decision making responsibilities and subsequently, potential information products for decision making. Later, more detailed one to one interviews with the departmental staff to help them describe the information products and assess the detailed data requirements, which were recorded in the Master Data Input List. Also documented were GIS functionalities and the nature and frequency of the processes for the generation of the information products. Together, they formed the Data Handling Load (Tomlinson, 1993b).

The Conceptual System Design started with the prioritisation of all the information products. From that, and together with the cost of production, the datasets needed to generate the information products were prioritised in an iterative way to best suit the agencies' requirements and constraints while maximising the benefits to the State. The scheduled and standardised production of the prioritised datasets would lead to the establishment of a State geographic data architecture. Eventually the State Geographic Data Model would be developed. Likewise, the data from the Data Handling Load allowed the design of hardware, software and communication/networking system, the introduction of which was again carefully scheduled in conjunction with the agencies' data acquisition decisions to maximise the benefit to the government (Tomlinson, 1993b).

In the Cost-Benefit Analysis, the data costs were derived from the data recorded in the Master Data Input List. The Data Handling Load also facilitate the generation of the hardware/software cost. These, together with other costs items such as site preparation, staff and application development form the cost part of the cost model. Benefits were identified and estimated by the departmental staff and included lower costs, time savings, increased demand, increased income, reduced liability, reduced expenditures, better decisions, increased resource utilisation, and external benefits. All costs and benefits were valued using standard methods, expressed in dollars and discounted at 7% over a 6 year period to facilitate comparison at present value (Tomlinson, 1993b).

The central theme of the broad strategy was to establish a comprehensive State Geographical Data Model (Tomlinson, 1993a). The findings of the study were that the Model would generate a potential benefit of $312 million at a cost of $56 million for the production of 61 information products from 270 datasets for State Government. The benefit to cost ratio was 5.5:1 over all products over six years, which was far better than the norm of 2.5:1 stated in the literature for well planned and managed GIS projects (Tomlinson, 1993a). The outcome was acceptance of the recommendations in the strategy report by the Ministers. OGDC was charged with the duty of detailed planning and implementing the strategy. Funds were also provided to support the running of OGDC.

The Strengths of the Study

Arguably, the primary strength of the GIS strategic planning study must have been its ability to escalate the awareness of the importance of GIS management among top State officials. This resulted in the allocation of resources for the proper planning of the development and management of the geographical data resources within the State Government. Many techniques were used in the study to make this possible. Briefly, these include (please refer to Chan and Williamson, 1995 for more detailed discussion):
• the application of a systematic, consistent and comprehensive planning methodology to identify the needs, to build up the State Geographical Data Model, and to justify the cost of developing the model in economics term.
• the close involvement of stakeholders, particularly those at the senior level, in conducting the strategic planning exercise to ensure that the data gathered reflected the actual positions as far as possible.
• the use of powerful figures in dollar term to inform and convince decision makers what would be at stake if the development of GIS was not properly managed.

Apart from these strengths of the methodology, the study has other important contributions to the development of the State Government-wide implementation plan. First, it documented four major problems (data, cost-timing, staff skill and management) against GIS development in Victoria. More detailed issues were discussed under these problems. They were mostly derived from the experiences of user departments. Generally, they are concerned with the management of three out of the five basic elements of GIS: data, software, hardware, procedures and people as identified by Dangermond (1988) (note that hardware and software were not considered as a problem at the time of the study). Being issues that concerned the basics of GIS, they are likely to have a long term relevance to real life management of GIS. They can serve as a base not only for the development of the broad strategy, but also the detailed implementation plan.

Normally, unless a strategy can be implemented immediately and be completed within a short period, few people can guarantee its relevance to actual management needs after, say, a couple of years or even shorter. This is irrespective of how relevant it was at the time of preparation. The case is particularly applicable nowadays in view of the very dynamic situations GIS managers are facing (Williamson, 1994). The study was aware of this and had highlighted in the strategy:

"The plan already developed during this consultancy is limited to five programmatic areas, and has a validity which will deteriorate through time." (Tomlinson, 1993a)

Managers in OGDC have to develop a three year GIS implementation plan for Victoria. They are fully aware of the fact that the position as revealed through the planning exercise may easily become outdated. There are doubts on currentness of the findings of the 1991 study. Good examples are the information needs identified, hardware and software combination designs, assumptions of continued support from CEOs and the low cost sharing of data among State departments etc. (Tomlinson, 1993a)

This does not mean that the broad strategy is no longer relevant to OGDC's needs. However, a distinction must be made between certain components of the broad strategy that will stay relevant to Victoria's need for a long time and those that will change rapidly with time. Important examples of the former are the main objective of GIS development and the interim targets that have to be met to achieve the objective. Associated with these are the methodologies needed to define the details of these targets and objective. Examples of the latter components are the government machinery and the mechanisms of achieving these targets and objective. They may easily be altered with a reshuffle of government or a policy change.

In this regard, all along in the report, the need to establish a State Geographical Data Model was stressed as the key objective. The study went into great depth to describe the various targets needed to be achieved to establish the Model. They included the identification of datasets required by the State Government, establishment of standards for data interchange, describing the data models for the datasets, the generation of communication protocols, and the production of a State geographic data architecture. Painstaking effort was made to identify the State's core geographical datasets and their best sequence of introduction. They were the basis for the eventual development of the State Geographical Data Model. The study also demonstrated in detail through the processes of Needs Analysis and Conceptual System Design, how all these interim targets, particularly the core geographical datasets, can be described
systematically and in detail.

These are of direct relevance to OGDC’s role as both the GIS authority as well as the custodian and manager of the State Digital Map Base. In fact, OGDC has been concentrating its initial effort in achieving these crucial targets as recommended by the study. This illustrates the relevance of this component of the broad strategy towards the actual implementation of the detailed strategy.

Further, the study sets a high standard for future GIS planning and justification exercises by the rigorous and comprehensive methodology it has adopted. It actually recommended using this as a pre-requisite for approving GIS projects. It is now hard to imagine any application for GIS funding in the State Government that is not support by a convincing cost benefit analysis. This has significant long term implications on future planning of GIS across government.

From the above discussion, it can be seen that the study has provided important background information concerning problems, interim targets and the main objective of GIS development, and has demonstrated the methodology for their detailed definition. By having these information and methodology in place, effort can continually be directed to achieving these targets and objective despite possible changes in their means of doing so, which are dictated by the prevailing policy. Their relevance is in a sense timeless unless the overall objective of the strategy is changed altogether.

The Limitations of the Study

State Government Policies

Under the current policy and in accordance with the recommendation of the study, the Ministers are expecting the outsourcing of all the major activities of OGDC. These include the Mapping Division recently transferred from Survey and Mapping Victoria, and the management of the core geographical datasets, particularly the updating and upgrading of the State Digital Cadastral Map Base. On the other hand, as required by the agreement between Melbourne Water Corporation and the State, GDV would have to be run in a commercial and self-sufficient manner when managing the Digital Cadastral Map Base. This development is different from what was recommended. In either case, it was found that there is little experience in the State to cope with the outsourcing and commercialisation activities (Price Waterhouse Urwick, 1995). There was also little guidance in the broad strategy to help OGDC face up to the new challenges.

Further, to support its strategy and the cost benefit analysis, the study assumed that there would be low cost sharing of data among State departments (Tomlinson, 1993a). Though in the mean time, the pricing policy is such that State departments are not charged for using the digital map base (Smith, 1994), the policy will be reviewed once the map base have been upgraded. There is a possibility that the Ministers may not be convinced of this arrangement and may ask all users to pay for the use of the map base. Should it turn out to be the case, the analyses and predictions made in the study may become invalid overnight. These may all be genuine limitations but are considered more acceptable than what are going to be discussed below, in terms of the long term relevance to Victoria.

Scope of Cost-Benefit Analysis

The study had pointed out in one of the strategy statements:

"Rigorous benefit-cost analysis has been applied to every geographic information product during the course of this study. The achievement of the levels of cost and benefit must be monitored across government with a consistent benefit-cost
methodology to track the realities in the implementation phase. A financial model of GIS cost-effectiveness in Victoria should be developed as a basis for inter-departmental cost sharing of dataset creation, costs of data exchange and investment decisions for GIS expansion.” (Tomlinson, 1993a)

The study was aware of the limitations of the approach of cost-benefit analysis it adopted. The approach was not comprehensive enough for either the cross-budget tracking of the realities during implementation, or as a basis for sharing the costs of data creation and exchange. The study presented only the best scenario of implementation of the broad strategy within the State Government to obtain a benefit to cost ratio of 5.5 : 1. There was no consideration of factors such as hidden costs (e.g., overheads and costs of planning and liaison etc.), or the risks of failure introduced by other real life constraints such as delays in hardware/software installation. The study also was not required to look at institutional issues, which inevitably will have a significant impact on the successful implementation of the GIS strategy (Croswell, 1989).

Although the approach adopted may be acceptable for planning at a strategic level for Victoria, it may need to be refined for the detailed implementation plan. Already, doubt has been cast on the findings of the cost benefit analysis which may have imparted an unrealistic expectation of benefits from a coordinated GIS on senior State officials (Chan and Williamson, 1995). One must bear in mind that while inflated results of a cost-benefit analysis may temporarily gain support for the initiation of a GIS project, the non-delivery of the predicted outcomes may also lead to the withdrawal of support (e.g., Landata), which may occur anytime in the course of implementation of the project.

**Scope of Overall Strategy**

The study stressed the development of a State Geographical Data Model as the main target to be achieved to meet the ultimate objective of cost-effective production and possession of geographical information by the State Government. However, it was not required to elaborate on what that model comprised and how it could be properly defined. Was it meant to be a network of decentralised geographical databases linked up under the format of the State geographic data architecture or was it something more? A void has been left in the broad strategy beyond the establishment of a data architecture with no specific targets nor clear processes of defining the target details. This position is not very helpful to OGDC once it has finished defining and establishing the data models, standards, metadata, and the comprehensive distributed data architecture for the State. Already, even prior to the completion of the study, there was a concern over the relatively limited scope that the study adopted. Worries like "Information technology and LIS/GIS technology alone will not return millions of dollars in savings to any government..." (Williamson, 1992) were sounded out.

To address the restrictions it faced, the study had documented the major assumptions it made and follow up actions needed when developing the broad strategy. For example:

"The costs and benefits estimates in this report assume low-cost availability of government data between government agencies in Victoria."

"The geographic information strategy should pay particular attention to the need to assure an adequate human resource of well educated individuals."

"In collaboration with the geographic data research community, develop a research agenda of issues that need to be examined because of their importance to the success of the State's geographic information strategy." (Tomlinson, 1993a)

In particular, the issues of coordinating the development of GIS development among State departments were tackled with a statement in the section of "Requirements for Going Forward":

"Senior level (CEO and Ministerial) direction must continue. Cross-portfolio..."
cooperation is crucial if a viable data architecture for access to multiple distributed databases by multiple systems in different agencies is to be achieved in the 1990s.”
(Tomlinson, 1993a)

Apart from the recommendation for the establishment of the Office of Geographic Data Coordination in the first stage of the study, the broad strategy has little provision for OGDC as the State GIS coordinator. This coordinating role actually serves as a critical link between the establishment of the State geographic data architecture and actual reaping of the predicted benefit through cost-effective implementation of GIS projects by the State Government. The decision to invest in GIS to meet departmental information needs is a two way process. On the one hand, the State will have to agree to invest while, on the other hand, the department will have to be convinced that it needs GIS. Each department is an entity with high autonomy. It would be a great administrative difficulty and an implementational nightmare if GIS is imposed on any department without its whole-hearted acceptance. Actually, there are many State departments and agencies, including some major ones, that are still waiting to be convinced of the value of adopting GIS. To help fill the void of coordination in GIS development in the broad strategy, a methodology to set and define the target is proposed in the following section.

A Model of GIS Development in Victoria

Burrough (1990) considered that a GIS had three components: hardware, software and the organisational context. Aronoff (1989) defined GIS as "a computer-based system that provides the following four sets of capabilities to handle georeferenced data: 1. input; 2. data management (data storage and retrieval); 3. manipulation and analysis; 4. output", all within a suitable organisational framework. The elaborations by the authors on this subject can conveniently be summed up with Dangermond's five basic elements of a GIS: data, hardware, software, procedure and people (1988). In very general term, it can be argued that a coordinated GIS within a State Government is also made up of the same basic elements. However, it will be too general to be of practical value to assist in the formulation of the implementation plan.

To this end, Williamson and Mathieson (1993) provided a list of fourteen components and strategic arrangements needed for a coordinated LIS for a city of about ten million people in their review of the success of the Bangkok Land Information Project. By studying the list in the context of the problems and issues affecting the development of both Victoria's LIS (Department of Crown Lands and Survey, 1983) and its GIS (Tomlinson, 1991a, b, 1993a), six consolidated elements can be identified for a State Government's GIS, and for that matter, any jurisdiction. They are:

- a set of core digital spatial data (including maps) of appropriate quality that is accessible for use by the rest of the community within that jurisdiction.
- a set of standards for exchange of the spatial data.
- a set of protocols to allow timely and efficient access to the high volume of data within the core spatial databases.
- a set of hardware and software (including application software) to support the management of the data and databases to meet the needs of the providers and users of data.
- a pool of technical, planning and management expertise available to support a cost-effective GIS needed to meet the information needs of the jurisdiction.
- a vision within the jurisdiction about using appropriate GIS to meet its strategic needs and the appreciation by top management of the need to develop and maintain that GIS.

When integrated, these elements form an architecture of GIS representing what Victoria has been trying in the past two decades to build up, to minimise data duplication and to maximise return to its investment. As to be discussed later, this architecture can be applied to describe the past and present state of development of GIS in Victoria. It can also be used to model a
target for future development of GIS in Victoria, for which, OGDC can formulate a holistic long term GIS development strategy.

This architecture is build on the visionary support of the top administration within the State and a pool of GIS technical, planning and management expertise to support the running of the set of hardware, software, and software applications, as well as designing and enforcing the data standards and the communication protocol for data security. The whole management and physical framework in turn house the geographical data resources of the State. However, it is interesting to note that both the Landata Corporate Plan and the 1991 study recommended a distributed structure for the State Government GIS with the creators looking after their own datasets, which in turn are all connected with one another. This recommended arrangement was echoed oversea in the implementation of the Bangkok Land Information System (Williamson and Mathieson, 1993) It appears to be more realistic and the architecture described above can be modified into a basic unit from which the GIS architecture of a State Government or jurisdiction can be developed. This unit of GIS architecture is diagrammatically depicted in Figure 2.

This unit can represent the basic central GIS architecture to be provided by the State's coordinator for use by other departments. Subject to individual needs, State departments may choose to use the service provided by the central unit of GIS architecture, or to build their own units. Though these units may be different from one another in their detailed compositions, they will be developed according to the standard adopted by the central architecture after consultation to ensure Government-wide compatibility. The process is illustrated in Figure 3. Please note that the outline of the GIS architecture unit in Figure 2 will be used to symbolise any unit of GIS architecture within the State Government in the following discussions. The degree of shading of each compartment within the outline directly represents the level of development of the corresponding element.

In the following sections, an attempt will be made to use the GIS architecture concept to model the major events of the historical development of GIS in Victoria and help to explain why they had come about. Then, based on the distributed structure of the GIS recommended for the State Government of Victoria by past investigators, a model of the future comprehensively coordinated GIS will be developed.

**Modelling of Victorian Governments GIS Development**

Based on the "modular GIS architecture" concept described in the previous section, the chain of events that led from an uncoordinated spatial management situation within the State Government (Figure 4a) via Landata (Figure 4b - c) to the establishment of OGDC (Figure 4d - e) can be viewed as one comprehensive process of building up the State Government GIS architecture. Landata was just part of the State's effort to establish the central unit of GIS architecture from scratch (Figure 4b - note the GIS architecture unit is not shaded, representing minimal development).

As Landata had to start from zero, the time and other resources needed was particularly great to develop the expertise, to build up the data (especially the digital map base) and the associated standards before the realisation of any benefit was possible. At that time the vision of coordination of top management was narrowly focussed on that of land administration and property management. The element of cost recovery loomed in the Government's administrative philosophy in the mid 1980s to the disadvantage of Landata. Its impact on Landata was amplified in the recommendations by the 1985 Swedish study to concentrate on the textual geographical data and cost recovery. This forced a change of direction in 1987 by Landata to pursue development activities which could produce positive financial returns, e.g., a public enquiry service (Deloitte Ross Tohmatsu, 1991). Landata's coordinating role was forgone and as a result, was placed in its position in late 1980s as depicted in Figure 4c.
In the course of development, the basic elements of the central unit of GIS architecture were building up under Landata (note that the unit in Figure 4c is shaded). The product it planned to deliver were in various stages of completion. By 1990, the Master Index linking the Titles Office, Land Tax Office and the Valuer-General's Office were completed. It also provided the basis for a completed network of the public enquiry service. The Crown Land Administration function was fully supported by the Land Information Management System, compiled and managed by the Department of Conservation and Environment. The Common File of Land Description was virtually completed while the Register of Government Owned Land, the Digital Cadastral Data Base and the Digital Topographic Mapping were all partially completed. Under the constraints Landata was facing, these were significant achievements and these activities of Landata were found to "enjoy support from their clients and contributing agencies" (Deloitte Ross Tohmatsu, 1991).

However, these achievements did not help foster Landata's role as a State G/LIS coordinator as originally perceived by many stakeholders, particularly those in the natural resource sector. Neither did the gradual change in direction of Landata over its early years of development help as the change was deemed to have been communicated and coordinated poorly (Deloitte Ross Tohmatsu, 1991). All these were a direct result of the lack of visionary support for a State Government-wide coordinated G/LIS from top administration as reflected in the blank bottom compartment in the GIS architecture unit (Figure 4c). However, it must be admitted that there had been significant support for the LIS Landata was developing from top management of the Department of Property and Services.

The change in direction resulted in the protracted delivery of the products promised. In particular, it aggravated the problem of access to digital topographic data by the environment and natural resource sector of the Government to develop their small to medium scale GIS. These culminated in the various reviews on Landata and the 1991 GIS strategic planning study (Williamson, 1992).

The reviews and the study constitute part of the learning process necessary to persuade the State Government to consolidate the effort of building the six elements of the its central unit of GIS architecture that had been building up by Landata. Although Landata changed from its original coordination role as depicted in Figure 4b to became a departmental unit of GIS architecture (public enquiry service) serving the land administration and property management functions of the State as depicted in Figure 4c, it acted as a catalyst to facilitate the establishment of the central GIS architecture unit that OGDC has taken charge of nowadays (Figure 4e - note the darker shading). In its early years of establishment, OGDC had virtually no GIS architecture under its control apart from the support of top administration. This is a sharp contrast to Landata's position in the same period. Now, starting with this unit of central architecture, it will be up to OGDC to work towards the target - a distributed structure of GIS recommended by previous investigators - as depicted in Figure 5 and to be explained below.

**Target of GIS Development for OGDC**

This target portrays OGDC as representing the central unit of the State Government's GIS architecture extending linkages to all other departmental units either directly or indirectly. The departments, to meet the needs of their business units, may develop smaller GIS architecture units in addition to the departmental ones. While the units may be developed to a different degree of sophistication, all units within the State Government GIS architecture should have access to one another’s services. Whether or not the central unit is most sophisticated depends on the needs of other State departments. In any case, it should be able to provide basic GIS services to those departments that only have occasional GIS needs.

This target can only be reached after OGDC have made enough effort to overcome both the technical and organisational hurdles in the process of developing the six basic elements needed to complete the central unit of GIS architecture. Though the 1991 study has already provided
relevant strategy for developing the core datasets (map base), the standards, the hardware and software, it will have to set and define the targets for establishing the communication protocol, building up the expertise base and most important of all, to build up the vision and maintain the support of top administration for a comprehensively coordinated GIS architecture. Regarding the mechanisms to achieve these targets, it will be dictated by the prevailing policy. Then, based on the model of the central unit, OGDC will have to make a even greater effort to break the organisation barriers among itself and other State departments to build up the State Government GIS architecture.

To achieve the ultimate objective of "moving toward cost-effectiveness both in the production of geographic information and in the benefit to government of having that information", OGDC will need access to a set of methodologies. One is needed to assess the readiness of different State departments to develop GIS to help prioritise the State's GIS investment. Another is to cost-effectively educate and convince departments with potential to build their GIS as part of the State Government's GIS architecture. Once they are convinced, the rest of the GIS planning and implementation will be taken care of within the departmental administrative machinery. OGDC still will have to follow that up by providing support, and to find a way to ensure maximisation of return both to the departments and the State. In all these cases, the methodologies will have to include means to evaluate alternatives while being able to overcome organisational/institutional barriers to change in order to be effective (Croswell, 1989). The GIS planning process adopted in the 1991 study, which has so far been proven successful, provides a good direction to follow. However, research is needed to develop the methodologies that are more realistic and help to convince top management with attainable goals and benefits, after taking into consideration possible risks of implementation.

**Conclusion**

It is not the purpose of this review to develop detailed strategy on behalf of OGDC. This is a far too complex task and, in any case, is not the responsibility of the authors. However, by reviewing the relevance of different parts of the broad strategy recommended in the study, it is hoped that future similar studies will be better conducted to meet the long term needs of the stakeholders. A concept of modular GIS architecture has been applied successfully in this article to describe the various stages of historical GIS development in Victoria. It is also used to build a more comprehensive model of GIS development in future for Victoria. With this model, it is hoped to set and define the ultimate target of GIS development for the State Government and to facilitate the planning for implementation. The model may also help to identify new research issues critical to the work of coordination.

At present, OGDC is working towards consolidating the core geographical datasets and developing the other elements of the central GIS architecture unit under its charge. Based on the findings of the 1991 study, the core datasets are being specified and maintained to a standard that meets the requirements of the key users. So far, the present charging policy should make the use of the core datasets by State departments and agencies attractive. This, together with the proper support and services made available by the central GIS architecture unit should provide enough incentives for the departments to build their datasets on the framework of the State's core datasets. In return, they will have to make their datasets available for use by other State departments. Hopefully, this will start an ever-widening cycle of data-sharing, culminating first in a State GIS geographical data architecture, and then in a comprehensively coordinated State GIS architecture with the various departmental units linking up with the central unit.

However, before it can start to deliver significant predicted benefits to the State Government, it has to persuade and help potential departments to develop and use the GIS services that they need, either using in-house GIS architecture or the central one. Benefit will not be accrued until the information produced by GIS is used to better deliver the core government business functions. To do this, any power bestowed on OGDC, either legal or administrative, will only
provide the necessary support for its work. Success will only come as a result of successful persuasion of the departments concerned through effective demonstration of the benefit of using the technology (Sonnichsen, 1989). Next to a good pilot study, based on the example of the 1991 study, a timely and relevant economic/financial evaluation will be a useful start.

The methodology used in the study has a limited scope and is suitable mainly for broad brush strategic planning purposes. Research is needed to develop a set of more refined methodologies to:

- initially justify a compromised pricing policy and to encourage the use of the core datasets by other State departments (and eventually by the rest of the State), while still be able to satisfy the prevailing administrative policy of the State Government.
- assess the readiness of State departments to adopt GIS to identify candidates for GIS investment.
- convince top management of the State departments and the State Government of the value of GIS in real life implementation situation.
- ensure and demonstrate the realisation of benefits predicted to reinforce top management's visionary and financial support, which constitute the foundation of the State Government GIS architecture.

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