JUSTIFICATION OF GIS AS AN INFRASTRUCTURE INVESTMENT - SOME OBSERVATIONS REGARDING GIS MANAGEMENT IN VICTORIA

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Abstract

It is pointed out that there are two components in the GIS investment by the State Government of Victoria: infrastructure investment and business system investment. Owing to inadequate funding up-front, so far, the emphasis of GIS development in Victoria is still on establishing the infrastructure. Development of business systems is lagging behind. The nature of GIS infrastructure investment is such that it relies on benefits derived from business systems developed from it to substantiate it. If Victoria's GIS investment is evaluated within a relatively short time frame, say four to five years from now, the infrastructure may not be mature enough. There may not be sufficient business systems implemented then to justify the GIS investment, the main bulk of which has been in infrastructure. It is recommended that while business systems can be evaluated in a short time frame like other financial investments, GIS infrastructure should be assessed at the end of the actual life cycle of the project when the business systems planned have been implemented.

There are three main management implications. First, State Departments should be assessed of their readiness to implement GIS. Second, there should be an agreed program of development and monitoring for both GIS infrastructure and business systems. Third, there should be an agreed mechanism by which, the costs and benefits of developing the GIS infrastructures and business systems can be shared in an equitable manner among the State Government and its Departments.

Introduction

It has been pointed out in recent reviews by Chan and Williamson (1995a; b) that the cost-benefit analysis in the Geographic Information Systems (GIS) planning study (referred to as the study below) undertaken by the State Government of Victoria in 1991 had a limited scope. It
only covered the cost of acquisition of data and technology, and the provision of training. All the work carried out behind the scenes, such as planning and management to overcome the various technical and organisational constraints, was not required to be included in the Cost Model.

From the previous experience in Victoria, Chan and Williamson also modelled GIS development within the State Government based on a network of modular GIS architectures. It is recognised that to establish such an integrated GIS takes a long time. The important question facing GIS managers today is how to maintain the support for the GIS initiative over time, i.e., how to continue to justify the GIS architecture and particularly the infrastructure that is still being built up?

Based on the concepts of the nature and management of Information Technology (IT) infrastructure of Weill, Broadbent, and St.Clair (1994), this paper examines the components of a GIS investment and suggests how they may be justified. The implications of these findings on the management of GIS in the State Government of Victoria will be discussed. For the purpose of this paper, unless otherwise stated, GIS is taken to be a computerised system that manages all georeferenced data. Land Information System (LIS) is taken to mean a specialised GIS that manages cadastral or parcel based data.

**What is a GIS?**

"What is a GIS?" is perhaps one of the most frequently asked question in the GIS literature. Dangermond saw GIS as consisting of five basic elements: data, hardware, software, procedure and people. Aronoff defined GIS as "a computer-based system that provides the following four sets of capabilities to handle georeferenced data: 1. input; 2. data management (data storage and retrieval); 3. manipulation and analysis; 4. output", all within a suitable organisational framework. Burrough considered that a GIS had three components: hardware, software and the organisational context. More recently, to provide a comprehensive conceptual framework for discussing the institutionalisation of GIS, Huxhold and Levinsohn identified four elements of GIS: the GIS paradigm, data management principles, technology and organisational setting. They may sound different but on closer examination, conceptually, they are actually referring to a similar list of components strategically grouped to facilitate discussion and analysis.

Based on the experience of the development of the Bangkok Land Information System (Williamson & Mathieson, 1993) and the GIS architecture in Victoria, Chan and Williamson have identified six components in a State Government GIS. They are: data, standards, hardware and software, data access and communication protocol, GIS expertise, and vision and long term support of top management. However, to be more concise and to facilitate later discussion, it is recognised that data access and communication protocols can be amalgamated with standards and GIS expertise. Further, the scope of each component can also be expanded to make them more generic. As a result, for the following discussion, a GIS is deemed to comprise five components: **data, information technology, standards, expertise, and the organisational setting.** The expanded scope of each component is described in Table 1.

**GIS as an Infrastructure**

According to Weill et al., the characteristics of IT infrastructure investments are:

- **large and long term;**
- underpins the **future competitiveness** of the organisation;
- often made **in anticipation of business development;**
- typically does not necessarily **provide direct business performance benefits,** which are realised by business systems connected to and enabled by the infrastructure;
- the **flexibility** offered by an enabling infrastructure can provide direct benefits by enabling economical or rapid implementation of other systems.
Table 1. Components of a GIS.

<table>
<thead>
<tr>
<th>Components of a GIS</th>
<th>Scope of Each Component</th>
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<tbody>
<tr>
<td>Data</td>
<td>all accessible data, both geographical and attribute, required to meet the geographical information needs, identified or latent.</td>
</tr>
<tr>
<td>Information</td>
<td>all computer hardware, software (including applications) and the associated communication technology required to meet the geographical information needs, identified or latent.</td>
</tr>
<tr>
<td>Technology</td>
<td>all agreed practices required to facilitate the sharing of the other four components of a GIS.</td>
</tr>
<tr>
<td>Standards</td>
<td>all knowledge, skills, procedures, and systems, technical or otherwise, acquired by the stakeholders, that are required for the smooth functioning of the GIS to meet the information needs, both identified or latent.</td>
</tr>
<tr>
<td>Expertise</td>
<td>all the operating environments, technical, political, or financial, created by the interaction among stakeholders, in which the GIS is to function.</td>
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The IT infrastructure is seen by Weill et al. as an integration of three elements: a collection of IT components which are bound together by the human IT infrastructure to provide a stable and reliable set of IT services. These services can be used as building blocks for business systems. The organisation’s IT is considered to be made up of an infrastructure and the associated systems of the business units. Depending on the needs, each business unit can have application systems that are supported by its own IT infrastructure in addition to the central one provided by the organisation.

There are also three views taken by decision makers of IT infrastructure according to the role it is deemed to play within an organisation: utility, dependent and enabling. The corresponding value drivers for the views are:

- **UTILITY** - cost savings via economies of scale
- **DEPENDENT** - business benefits for the life of the current strategy
- **ENABLING** - current and future flexibility

Based on the above concepts, the components of a GIS as depicted in Table 1 can be further categorised into two groups: infrastructure and business systems. The main differences between the two groups of GIS components are the type of data they service/provide and the scope of influence of these components within the organisation.

Infrastructure is more concerned with the core geographical datasets which are used by the GIS systems of the business units. In Victoria, good examples of the core datasets are the cadastral and topographical map base. Generally, the impact of infrastructure is felt organisation-wide. It provides the standards by which data are collected and transferred within the organisation. It includes the hardware and software needed to manage the core datasets and the communication technology needed for communication and sharing of data among central administration and the business units. It also makes available the technical and management expertise required to provide the services just described. Last but not least are the vision, the culture, the policies and management practices that make the environment conducive to the adoption of GIS by the stakeholders within the organisation.

On the other hand, business system GIS is concerned more about data that are collected and used mainly by the business units. It provides the standards, hardware and software that specifically meet the needs of the units concerned without prejudice to those of the infrastructure. Expertise is that required to meet the specific needs, such as modelling and scenario visualisation, of the business systems. To facilitate the acceptance and use of the business systems, locally developed management practices and incentive schemes may be developed upon the framework provided by the infrastructure.
The Nature of Victoria's GIS Architecture

The nature of the GIS architecture that is inherited and currently being upgraded by the Office of Geographic Data Co-ordination (OGDC) matches the characteristics of an IT infrastructure and can be regarded as the infrastructure component of a GIS. The detailed characteristics of OGDC's GIS architecture are described in the following paragraphs under the corresponding headings of characteristics of an IT infrastructure.

Large and Long Term

By 1991, the Victoria State Government had invested over $134 million and more than a decade in building up a GIS infrastructure. Though the work was started by Landata in a different context, OGDC has picked up the legacy and is currently building from it. The scope and strategy adopted for the development of the GIS in Victoria is different from the past. Nonetheless, the work still concerns areas such as creating the core datasets e.g., the cadastral and topological map base; and fostering cooperation among State Departments.

Future Competitiveness

For decades, Australian States have been competing among one and other for rights to hold major international events, or for local or oversea investments with a view to increasing employment and the boosting local economy (Murphy, 1995). Properly developed GIS expertise and capabilities can facilitate optimal management of State resources and economical provision of services and information crucial for public and commercial decisions in support of such initiatives. These are important in both the formulation of strategies to attract the attention of organisers of events and investors, and to help convince them that a State can better foster their business objectives. In this way, investment in a State-wide GIS helps to increase the competitiveness of a State in the short term and to maintain it in the long run.

In Anticipation of Business Development

Though quite a number of leading State Government Departments in Victoria are already using GIS, there are many more Departments that are adopting a wait-and-see approach, still lacking confidence with this new technology. The 1991 study examined the information requirements of 39 Departments. By coordinating the creation of the core datasets needed by these organisations beforehand as basic infrastructure and making the organisational setting more conducive to GIS adoption, OGDC will help minimise the cost of duplication and reduced efficiency in anticipation of the more widespread use of GIS by State Departments in future.

No Direct Business Performance Benefit

Now that OGDC controls the State's digital topographic, and cadastral map base as well as the State digital road network, it is working towards updating and eventually upgrading these digital map data. Close liaison is maintained with other national and state agencies to develop the necessary standards to facilitate GIS diffusion throughout the State. Apart from commissioning studies to increase the awareness and support of Ministers and top administrators within the State Government and developing expertise to manage GIS as a State resource, it also sponsors research into relevant technical and management issues to build up GIS expertise in general. However, all these undertakings are not contributing directly to the gaining of benefits for the Government. Benefits will only be accrued through the utilisation of GIS to generate information products for business purposes among the user departments. At present, neither the Government nor OGDC is benefiting substantially from the investment in the GIS architecture.
Flexibility

By avoiding any bias towards facilitating GIS development for any particular interest group within Government, OGDC will be taking an enabling view in managing the GIS architecture under its charge for the entire State Government. The technical and organisational base established by the GIS architecture provide flexibility for the efficient and economical development of GIS business systems by State Government Departments to meet their changing needs. By adopting this approach, not only will OGDC avoid the pitfall of specialisation by Landata on Land Information System development, it will also be ensuring flexibility to itself and other State Departments in developing the State GIS capabilities, now or in the future.

Victoria's State Government GIS Infrastructure

It is clear from the above discussion that the GIS architecture that OGDC is building for the State has all the characteristics of an IT infrastructure. As such, it can be considered to be an integral part of the IT infrastructure the State Government should be providing to satisfy its information needs. Based on the model of Weill et al., the roles that GIS and the more generic IT play in the delivery of IT for business processes can be represented in Figure 1.

The lower box in Figure 1 is the IT infrastructure of the organisation. It is depicted here as comprising a general and a GIS dimension of the IT components bound together by the human IT infrastructure of knowledge, skills and experience into shared IT services. The general and GIS dimension of the IT infrastructure together provide a stable and reliable set of services to support the business processes of the organisation. By proper maintenance through investment of time and other resources, this infrastructure will evolve with time to keep up with new technologies to produce new efficiencies. By having a stable base of services provided by the IT infrastructure to a reach and range[1] beyond current requirement, flexibility is built into the management process allowing far more rapid response to an emerging business need (Weill, et al., 1994) . It permits the regular modification of the IT for business processes to meet the changing demand.

While anyone can buy the necessary hardware and software for GIS, the good IT/GIS infrastructure that develops around them is not a commodity and thus difficult to create or duplicate. For GIS it is the core digital geographical datasets and the standards for its creation, maintenance, upgrading and exchange that make it stand out from the general IT infrastructure. By investing in data, standard and the human IT/GIS infrastructure (including the knowledge, skills and management vision (Weill, et al., 1994) ), an organisation or State is building up a major business resource that is unique, difficult to duplicate and that provides long-term competitive advantage (Keen, 1991) . OGDC is building up such an infrastructure.

Justification of GIS Investment - Victoria's Previous Approach

In the past, Victoria's major GIS/LIS project, Landata, was evaluated after about six years. The time frame for the 1991 GIS planning study was also six years. Generally speaking, a six years period or there about is appropriate for investment in GIS business systems which have a technology life cycle of a similar order. This is also valid for simple GIS projects. A typical scenario will be the implementation of a GIS within a department with simple mandates. In this case, the infrastructure is also the business system/s. Therefore, evaluation of either the infrastructure or the business system is the same as evaluating the whole GIS.

This is not so for GIS infrastructure investment a State Government situation. It is special in
that it is usually a large and long term investment, intending to provide a platform for the
flexible, speedy and economical development of other applications. These characteristics imply
that basically, its performance should be assessed on the basis of the number of business
systems it has enabled and more significantly, the benefits generated as a result. Without
supporting an appreciable number of performing business systems, it cannot be said to be
mature. Financially evaluating it before it is mature will only generate the inevitable biased
result that it is not a worthy investment. The situation is aggravated when the Government is
reluctant to provide adequate funding up-front for the full scale development of the
infrastructure, as in the case of Landata.

If on the other hand, adequate funding were provided up-front to facilitate the synergic
development of the various elements in an infrastructure, the development of business systems
might be pushed forward and benefits would realise earlier. Under this circumstances, when it
is time to financially appraise the GIS project, both the infrastructure and the business systems
may well be in place. There will be no need to distinguish between the two investments.

More than one year has passed since the Victorian Government accepted the recent GIS
Strategy Report and OGDC has been working towards creating the necessary GIS infrastructure.
Though GIS has recently been adopted by the emergency services sector in the State
Government, owing to funding limitations, the infrastructure is still not mature enough to attract
mass adoption of GIS by the State Departments. Without decisions by Departments to adopt
GIS now, there may well be insufficient performing business systems a few years later to help
justify the infrastructure investment. Though the six years planning time frame used in the 1991
study is only for an ideal situation, if the Government chooses to do so four or five years later,
it will serve as a convenient base for evaluating the GIS as other financial investments. It this
were the case, together with the inadequate up-front resources provided, the current GIS
infrastructure investment would not be given a fair chance to justify itself. After having accepted
the strategic direction of GIS development in Victoria, the attitude towards funding and
monitoring of performance of GIS by Government should be adjusted to match the nature of
the investment. Excessive emphasis on early return of benefits from GIS will encourage its
shallow and piece-meal development. The consequences will be:

- excessive duplication of resources through acquisition of data, technology, expertise, and
putting in place the right organisational setting;
- benefits accrued will be localised and confined to individual business units which have the
necessary political and economic support of decision makers;
- certain units' needs may be overlooked and thus will be denied the opportunity of taking
advantage of the technology.

An Alternative Approach to Justifying GIS

It is not the intention of this paper to advocate against economic justification of investment in
GIS in general or with regard to the infrastructure in particular. There is no doubt timely and
proper economic justification will help focus the attention of planners and managers and ensure
value for money invested by the State Government. Rather it is argued that justification should
be carried out in a manner compatible with the nature of the GIS investment in question using
fully the experience of establishing generic IT systems. For GIS infrastructure, the high up-front
cost with a long delay in realisation of benefits suggest that post-implementation economic
justification within a short time frame will often stifle or at least slow down its rate of
development. The direct consequence is the corresponding delay in the realisation of the
benefits predicted upon successful implementation of the business systems it facilitated.

The 1991 GIS planning study considered that technology and technical expertise were not the
factors limiting GIS development in Victoria at that time. Rather, it was the lack of awareness
and support of top administration as well as other hurdles such as, organisational issues,
education and training, and appropriate research that were creating problems (Tomlinson
Associates Ltd., 1991). Though the undertaking of the study and the establishment of OGDC were the result of the joint effort of a group of State Departments, the creation of a management environment conducive to the cooperative development of GIS in Victoria is still a major item in OGDC’s agenda. If State Departments are still hesitant to cooperate, GIS business systems development and the delivery of associated benefits will be delayed. When the infrastructure is immature in terms of any one of its components, the organisation is simply not ready for large scale GIS adoption. In the State Government of Victoria, the component that requires nurturing is organisational setting. On the other hand, take the case of the Republic of Singapore, the component concerned is standards [2].

These scenarios serve to illustrate that when GIS infrastructure is immature in any aspect, request for economic justification for GIS investment as a whole will not facilitate GIS development. Rather, delay may result. It appears that in order to be flexible in meeting the very dynamic situation in Victoria, OGDC may consider stressing the different nature of the two components of the State Government’s investment in GIS. One is in infrastructure as being developed by OGDC. The other is in business systems developed upon this infrastructure among user Departments. Being benefits oriented, there are good reasons to assess a GIS business system investment within a short time frame like that of other financial investments. On the other hand, the unique nature of infrastructure investment is such that its value should be evaluated at the end of the actual life cycle of the GIS development when the business systems planned are performing.

**Management Implications**

In view of the above, a responsible administrator should require the development of GIS infrastructure to be carefully planned and implemented according to a program agreed with the State Government. The emphasis should be to establish it in the most efficient and economic way. The progress should be monitored with the help of well defined milestones for the development of the elements of the infrastructure and other performance indicators. One important indicator will be the number or percentage of State Departments that are committed to implementing GIS business systems. Another is the rate of adoption by certain target Departments which are deemed to be able to benefit significantly from GIS. If for various reasons, the progress is not satisfactory, appropriate incentives, administrative, financial or even legislative, may have to be introduced to facilitate the rate of diffusion of the technology so that the progress of GIS development will not be unduly delayed.

At the same time, to help make the investment by the State more effective, it should be the duty of OGDC to assess the readiness of departments to adopt GIS (Croswell, 1989) and to help ensure that the departments chosen as candidates for GIS investment will successfully implement the projects. The objectives should be to facilitate optimal allocation of business systems investment and to help realise benefits promised by the projects. As illustrated in a very limited way in assessing the issues concerning GIS development in Victoria and Singapore, GIS infrastructure provides a good framework for assessing departmental readiness. A department may be deemed to have an immature GIS infrastructure, say in terms of the organisational culture and sense of value of the stakeholders. Advice and assistance can be provided to help improve the organisational setting, either before or in conjunction with the implementation of the project. A good example of upgrading the component of an organisation’s GIS infrastructure during the implementation phase is the use of change management techniques in the introduction of GIS into the Roads and Traffic Authority in New South Wales (Byrne, 1994). Sometimes, the problem is not so much of selecting the right candidate as persuading the right candidate to adopt GIS. Such a decision can be a significant commitment that certain CEO may not be willing to make.

When building up the infrastructure, there are hidden costs such as those being incurred for building up the standards, expertise and organisational setting by OGDC, which are not accounted for in the Cost Model of the 1991 GIS study. These costs may also be incurred by
certain major departments when trying to coordinate GIS adoption among their business units. Government will have to decide how these hidden costs should be catered for as it can be a significant commitment by the Departments concerned and can have a major impact on the outcome of implementation. As the Cost Model included only the costs of data and technology acquisition, should it be borne by the State in addition to the $56 million required for the State Government GIS or should it be shared between the State Government and the respective Department.

Once the infrastructure matures, business systems should flourish and real benefits will begin to flow. However, depending on the prevailing Government policy, there are different alternatives to cover the costs of GIS development. First, the Government may choose to bear the cost of infrastructure development in the same way as it invests in the State highway network, and ask for the cost of development of the business systems to be covered by the benefits they generate. Second, the Government may bear the initial cost of the infrastructure but request the cost be justified notionally by back-tracking the benefits through the service providers such as OGDC. The business system will still have to be justified. Third, funding the initial cost of building the infrastructure, the Government may ask all users of the infrastructure to pay a fee to contribute, partly or totally, to the cost of creation and maintenance of the infrastructure as part of the cost of developing the business systems. Each business system must of course be justified by the benefits it will generate.

Irrespective of the prevailing cost recovery policy, when candidates with potential are chosen, it will be desirable for OGDC or its appointed agent to work closely with the departments in the planning/justification process to agree on:

- how best to separate GIS infrastructure and business systems development investments to facilitate project justification;
- the timing of investments in infrastructure and business systems respectively to overcome known constraints;
- the milestones and performance indicators needed to monitor successful project implementation; and
- the sharing of benefits accrued.

This serves to focus the attention of the stakeholders to implement a GIS project to the satisfaction of all parties concerned. In financial term, the costs incurred at both the State Government level (including OGDC) and the State Department level, can also be properly justified by the benefits accrued.

**Conclusion**

Based on Weill's thesis on IT infrastructure, a GIS investment is shown to be made up of two components; infrastructure and business systems. Owing to the uneven distribution of costs and benefits in the life of a GIS development project, it is unrealistic to try to justify the infrastructure investment within a short time frame early in the implementation process. By convincing Government to treat the two components of GIS investment differently, a more realistic way of managing the investment is possible. Investment in infrastructure should be justified at the end of the life cycle of the GIS project by means of real benefits accrued from the use of the business systems. On the other hand, business systems, being benefits oriented, can be justified in a way more in line with the norms of financial investments.

There are three main management implications for justifying GIS investment in this way. First, a means of assessing the readiness of a department to adopt GIS is needed. Assessing the state of development of GIS infrastructure of that department is a good starting point. Second, depending on the prevailing policy, to equitably account for GIS investments incurred by both the State Government and its Departments, some costs and benefits sharing mechanisms should be in place before implementation. Third, the development of a proper monitoring
system. This system should comprise a program agreed with the State Government and State Departments regarding the development of the infrastructure and business systems respectively. It should also include the means of tracking progress and benefits of the program in a manner acceptable to the stakeholders.

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