Technical Issues in the Integration of Built and Natural Datasets in National SDI Initiatives

Victorian pilot project

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EXECUTIVE SUMMARY

The recognition of world problems such as social inequality, poverty, and environmental degradation has brought about a number of resolutions for a sustainable development around the world. Sustainable development objectives can be delivered by using an integral dataset of built and natural data to aid in making more informed decisions. This connection has been identified in the UN Bogor Declaration on Cadastral reform - section 4.7 (FIG, 1996) and the UN Bathurst Declaration on Land Administration for Sustainable Development (FIG,1999).

The need for the integration of the built and natural datasets has led to the development of a 3 years project currently coordinated by the Centre for Spatial Data Infrastructure & Land Administration, Department of Geomatics, University of Melbourne. This project will investigate issues in integrating built and natural data in different jurisdictions around the pacific region. This includes two states within Australia and six other countries. The integration issues investigated are legal, organizational, institutional, land policy, and technical. The knowledge gained will go towards the development of an integration model capable of being used in diverse jurisdictions around the world.

This report aims to contribute to the above project by investigating **technical issues** in the integration of built and natural data for the state of Victoria. Due to the delays in the arrival time of different datasets three different aims were investigated. The first was to investigate the technical issues in the integration of NSW and Victorian datasets, with national datasets. All background study has been based on this aim, but it was never carried out. The second aim was to investigate the technical issues in the already integrated built and natural datasets in the state of Victoria. The third was to investigate the technical issues in the integration of Victorian (state) and national built and natural datasets. In addition the last two aims compared two different case study sites in Victoria.

Due to constraint in time and resources the last two aims were partially examined. However, the constant change in aim/method has resulted in a well structured and comprehensive final methodology. This methodology can be seen as the main result of this research, as its concepts could be used in future investigations. This is not to take away from the value of the reduced quantity but comprehensive quality of data examination that was carried out.

Overall the Victorian built and natural integration was found to have minor technical problems. The comparison of the national and Victorian datasets highlighted problems in metadata and large feature discrepancies, generally 50m, but up to 2700m. In addition the two case study sites in Victoria had identical issues.
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1. PROJECT OUTLINE

1.1. Background

A society which is not geographically aware, or “spatially enabled”, is deprived of the ability to develop comprehensive socio-economic concepts and plans, and its effective implementation (Williamson et al 2005). The quality of decision making and policy development relies greatly on having all the necessary spatial information about the natural and built environments when required and hence the development of a National Spatial Data Infrastructure (SDI) Initiative to provide that information is becoming very significance in the social, economical and environmental context in Australia and many countries around the world.

The built and natural datasets, as the basic components for a SDI, are two very essential elements in sustainable development. For this reason, optimizing the value of these two datasets is recognized at both national and international level. The objective of this project to investigate issue in integration of built and natural datasets is therefore highlighted by a number of UN resolutions, and is aligned with the Australian Government Priority Goal to create “An Environmentally Sustainable Australia”.

ANZLIC – the Spatial Information Council is the country’s main facilitator in the implementation of the Australian Spatial Data Infrastructure (ASDI). The ASDI is a national framework for linking users with providers of spatial information. It comprises the people, policies and technologies necessary to enable the use of spatially referenced data through all levels of government, the private sector, non-profit organizations and academia. (ANZLIC, 2005)

However, as noted by Rajabifard and Williamson (2002), current research shows that despite years of effort and considerable interest, there are still obstructions in the development of an effective and comprehensive SDI, caused in most cases by a lack of support from stakeholders, related agencies and communities. It is proposed that by raising the awareness of the value of SDI and through a better understanding of the factors and barriers facing SDI development, this problem can be overcome.

Although the realisation of a truly integrated National SDI still seems sometime away, the importance and benefits of SDI are slowly being realised and appreciated by decision makers. This progress is evidenced with data collaboration projects being developed all over Australia. The NSW Community Access to National Resource Information (CANRI) is a successful example, an AUS 4 million project receiving high-level support from government, to link datasets from 10 government agencies via the Internet.
1.2. Significance of the Project

This pilot project is to investigate and describe the technical problems and issues in the integration of built and natural datasets in Victoria. This is part of a bigger 3 years project currently coordinated by the Centre for Spatial Data Infrastructure & Land Administration, Department of Geomatics, University of Melbourne.

The significance of this project is highlighted by numerous UN resolutions, such as Resolution 15 adopted by the 14th UN regional cartographic Conference for Asia-Pacific, which calls for issues in the integration of cadastral and topographic datasets to be investigated. This research is also nationally recognized and aligned in the priority goal of "An Environmentally Sustainable Australia", Sustainable use of Australia's biodiversity.

Apart from technical issues, the overall project will also investigate the legal, organizational, institutional and land policy issue when integrating built and natural data. Cases study from two Australian States: Victoria and New South Wales, and six countries in the Asia Pacific Region: Brunei Darussalam, Indonesia, Japan, Malaysia, New Zealand and Thailand will be carried out. Figure 1 illustrates how this pilot project fit in the overall project.

1.3. Problem

A National SDI provides the foundation to access built and natural environmental datasets, of which cadastral and topographic data are the foundation datasets. However, in most countries, these two foundation datasets amongst others are normally managed separately by different levels of government to serve different purposes. The lack of uniformity across different jurisdictions within a country often creates problems in attempts to integrate the two datasets at a national level.
1.4. Aim

To investigate and describe the technical problems and issues in the integration of built and natural environmental data. The knowledge gained will go towards the development of an integration model and framework capable of being used in diverse jurisdictions.

1.5. Objective

To find and record any technical problems arise from the integration of the built and natural datasets from Geoscience Australia and Spatial Information Infrastructure (Department of Sustainability and Environment, Victoria). Possible problems are difference in attribute consistency, metadata, reference systems, diversity in scale and logical consistency, etc. The findings will be achieved through the use of two local government areas in Victoria as pilot project areas (discussed in more detail in the Methodology section) and these findings will be compared and contrasted.

1.6. Hypothesis

A better understanding and description of the problems and issues in the integration of cadastral and topographic data within Victoria will aid in the development of an integration model and framework capable of being used in diverse jurisdictions.

1.7. Methodology

1.7.1 Data Analysis

During the course of this investigation the research aim was modified 3 times due to delays in arrival times of datasets from different government agencies. As all the datasets arrived late in the research timeframe (Vicmap dataset arrived a month before submission time, and Geoscience data two weeks before). The late changes limited the depth of analysis that could be carried out. On the other hand, the opportunity to modify the methodology allowed for a more in-depth understanding of the research leading to a comprehensive final methodology. The evolution of the methodology is therefore broken into 3 stages, each to highlight a major modification to the methodology. The methodology used during each stage is documented below. ESRI ArcGIS 9.1 was used for data analysis throughout the whole research.
**Stage 1:**

Initially, the project focus was:

*Highlighting technical problems when integrating built datasets from two state governments (i.e. NSW and Victoria) with natural datasets provided by the federal government (Geoscience Australia).*

The isolation of the technical problems was to be carried out individually by each researcher within their own case study area:

- NSW .................. Yi Lik
- Victoria ................. Nima

**Stage 2:**

Approximately a month before the submission time of the project the first dataset arrived from Victoria’s Spatial Information Infrastructure. Therefore the investigation of the two case study areas were to be conducted within two different local government areas within Victoria: the rural Shire of Yarra Ranges and the adjacent urban City of Casey. The datasets provided by the Victoria Government appeared to have already integrated both natural and build datasets, thus the project focus was changed to:

*Investigate any existing issues for these already integrated datasets. Compare the results from each case study site.*

The two case study areas were assigned to each researcher as followed:

- Yarra Ranges ....... Nima
- Casey ................. Yi Lik

The methodology was to break down the shapefiles into comparable groups shown below:

1. Address ⇔ property ⇔ transportation ⇔ satellite image
2. Property ⇔ planning ⇔ administration ⇔ satellite image
3. Elevation (10m) ⇔ Elevation (5m) ⇔ satellite image
4. Elevation (10m) / elevation (5m) ⇔ hydrology ⇔ vegetation ⇔ satellite image
5. Property ⇔ transportation ⇔ hydrology ⇔ satellite image (logical consistency)
6. Vegetation ⇔ transportation ⇔ property ⇔ satellite image

Then use the product descriptions provided with the datasets to select relevant shapefiles to investigate the following technical problems (Mohammadi 2005):
1. Attribute consistency
2. Metadata
3. Integration method
4. Problems in borders of different Local Government Areas (LGA)
5. Topology
6. Different symbols and texts
7. Logical consistency
8. Reference systems
9. Diversity in Scale

Stage 3:

During the data analysis process using only the Victoria datasets, the Geoscience Australia data arrived two weeks before the submission time of this report. As such the project aim was again modified to return closer to the original goal of this project. The new project aim is now:

*Highlighting technical issues in integrating natural and built datasets obtained from Geoscience Australia with those obtained from Victorian Government – Spatial Information Infrastructure.*

Thus the previous investigation was put at a halt, and a more strategic methodology (refer Figure 2) was developed in order to carry out the new aim.
Figure 2: Flowchart of Data Analysis
Using the steps shown in Figure 2, the irrelevant shapefiles were excluded. These include shapefiles without data definition, those which are not in the right reference system, and finally those which don’t have comparable data. After excluding irrelevant shapefiles, the comparable ones were grouped together using a top down approach. The top down concept refers to comparing groups of shapefiles against each other as opposed to individual comparisons. Both Geoscience Australia and Vicmap data have a few levels of shapefile classifications. Thus once a comparable group is found, the next classification level is referred to organize comparable shapefiles together. This breakdown is carried out until the shapefile level is reached. For a better understanding of the classification structures of the shapefiles refer to “Specification / Attributes Consistency” section under results. Figure 3 explains the top down concept diagrammatically.

![Figure 3: Top Down Approach](image)

It should be noted that due to the late arrival of the data, there was not enough time to check for all possible technical issues. Thus after consolidating the research supervisors only four major technical issues were investigated:

1. **Reference System**
   - Undefined Coordinate Systems?
   - Different Coordinate Systems used?
2. Metadata
   o Existence of layer metadata
   o Complicity of metadata
   o Definition of layers

3. Specification / Attributes Consistency
   o Naming convention
   o Grouping of Layers

4. Discrepancies
   o Problem in Borders
   o Uniform shift or irregular discrepancy?
   o Due to scale difference or collection method?

1.7.2. Documentation

A structured documentation of the technical issues found is very important to the research project. This is to allow readers to be able to recreate the same situation and to see the same issues highlighted. As a result the following template (Table 1) was designed to force the investigator to document all required information to allow for a recreation of the situation:

<table>
<thead>
<tr>
<th align="left">Themes examined:</th>
</tr>
</thead>
<tbody>
<tr>
<td align="left">The theme of the comparing layers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th align="left">File Used:</th>
</tr>
</thead>
<tbody>
<tr>
<td align="left">The directory of the layers used. This will highlight the location and specific layers used.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th align="left">Problem Discovered:</th>
</tr>
</thead>
<tbody>
<tr>
<td align="left">Summary of issues found.</td>
</tr>
<tr>
<td align="left">Insert screen shot of an example of the issue when applicable. In addition the location of the problem site should be highlighted in the general area.</td>
</tr>
</tbody>
</table>

| Unique Problem: Yes/No answer. Explanation if required. |

| **Table 1**: Documentation Template |
2. BACKGROUND INFORMATION

In order to understand how this pilot research related to the larger project, the SDI concept, its current status in Australia, and the real world application of SDI within an application (i.e. land administration) was researched. In addition, to understand the overarching principals of the datasets being investigated, i.e. built and natural datasets, research on cadastral and topographic data was also conducted. The background research was conducted assuming that all the required data would arrive on time and thus the current SDI status for both NSW and Victoria have been examined. Finally after the final aim of the project was finalised to include only the areas of Yarra Ranges and Casey, a quick background information on the two local government areas has also been provided.

2.1 Spatial Data Infrastructure

Spatial Data Infrastructure (SDI) is a conceptual information infrastructure initiative that underpins the design, implementation and maintenance of mechanisms that facilitate and coordinate the sharing of spatial data between stakeholders within and across jurisdictional levels. The concept of an SDI is not to establish a central database, but a distributed network of databases, managed by individual government and industry custodians (Geoscience Australia, 2005). The spatial infrastructure is comparable to services infrastructures such as road, rail and electricity networks, where the smooth running of the system relies upon effective guidelines, standards, administrative arrangements, people and technologies. (Rajabifard, 2004).

2.1.1. The importance of SDI

Spatial information is used in a wide variety of economic, social and environmental applications. The following list from Geoscience Australia (2005) gives a quick summary of applications that use spatial information (this list is by no means exhaustive).

- Environmental Assessment & Management
- Property Administration - including Native Titles
- Navigation - road, marine & air
- Resource Management - agriculture, mining, energy, forestry & marine
- Emergency Services Response - fire, ambulance & police
- Business Planning
- Census
- Disaster Management
The activities from the above list are carried out by many different organisations and government departments. For a long time, these different users of spatial data have been collecting and managing their own data needs, without the knowledge that the same data might already exist in someone else's office. It is this lack of collaboration between stakeholders that has created the current situation where unnecessary data are being collected and managed within various agencies at different jurisdictional levels, creating data silos.

In the fast changing and competitive world of today, time is money, and information is power. Quality decision making relies upon having current and correct information, and saving time and money relies upon having that information in a readily useable and easily available form. Therefore, the datasets that are scattered across agencies and jurisdictions are a great national resource, and having access to them is fundamentally increasing efficiency, reducing duplication of effort and supporting quality and speedy decision making throughout all levels of government and business.

Spatial information is one of the most critical elements underpinning decision making for many disciplines, situations and projects. This is highlighted by the fact that an estimated 90% of all information used by government has spatial characteristics or attributes (Paez, 2004). The potential benefits of SDI to increase the effective access, collection, delivery, management and utilisation of spatial data is therefore enormous, and pulling this important resource together has become a focus for many developed and developing countries around the world.

The simple objective of SDI to share spatial information among all stakeholders will ultimately:

1. Drive economic development;
2. Support better government and promote social cohesion; and
3. Promote environmental sustainability;

These three factors (economic, social and environmental) are known as the ‘Triple Bottom Line’ objectives, and are the ultimate goals for SDI and also the main driver in SDI development.

2.1.2. SDI Components

In order for SDI to be successful with the impact intended, the implementation of SDI cannot be tackled from just a technical viewpoint. Although the objective of this research project is focused on identifying the technical problems, in order to appreciate the dynamic and complex nature of SDI, it is important to gain a complete understanding of different components of SDI.

SDI is dynamic in nature, it is so because it has to operate in a constantly changing environment, taking into account technological advancement, sustainable development, business needs, social needs and politics etc.
Therefore, there are many factors influencing SDI, with the five generally agreed components being data, people, access network, policy and standards. These five components do not cover all aspect of SDI, rather as noted by Warnest et al (2005), the complex integrated components are identified and segmented as a basis to facilitate further discussion and to isolate problems.

The following modified diagram by Rajabifard and Williamson (refer Figure 4) shows the dynamic nature of how the five components interact with each other. The way people and data function in the system are governed by the technological components of SDI. The technological components comprise the access network, policy and standards, and the development of these components in turn is determined by technological advancement and changing user needs. These different forces interacting with each other demonstrate that the complexity of an integrated SDI goes well beyond just data.

**Figure 4:** Nature of Relationships between Components of SDI (Rajabifard & Williamson 2001) (Modified)
2.1.3. SDI Hierarchy

The better management and utilisation of spatial data assets has drawn many countries to develop and participate in the many levels of SDI initiatives ranging from local to state, national, regional and global. A model of SDI hierarchy (refer Figure 5) developed by Chan and Williamson (1999), and Rajabifard, et al (2000) can be used to better describe the development of SDI at different political-administrative levels.

![Figure 5: Hierarchy of SDIs (Rajabifard et al 2000)](image)

Figure 5 illustrates that an SDI hierarchy is made up of inter-connected SDIs at organisational, local, state or provincial, national, regional and global levels. One of the main things this diagram is trying to show is that SDIs at the local level or above are primarily formed by the integration of spatial datasets originally developed for use in corporations operating at that level and below. (Rajabifard and Williamson, 2002) This is in recognition that from little things, big things grow, and with many local governments and private corporations holding a number of strategic datasets in the area of property and rating, engineering design and management, asset management and health services, it is important to treat all as equal partners within the development of SDI. (McDougall et al, 2002).

The double-ended arrows inside the triangle are to show that there are complex relationships between SDI at different levels (vertical) and also within the same jurisdictional level (horizontal). These complex relationships are an acknowledgment that in different jurisdictions, there will be differences in protocols, standards, technologies and institutional infrastructures. Without fully understanding where and what these differences are, this concept of an integrated SDI at all jurisdictional levels will remain just that.

Rajabifard et al (2000) interpreted this SDI hierarchy in two views. The first view, known as the umbrella view, describes the level above which covers, like an umbrella, all the components of SDI underneath it. The second view, known as the building block view, describes the components at a lower level as the building
blocks for levels above it. The purpose of these two views is to show that the SDI hierarchy creates an environment in which decision-makers working at any level can draw on data from levels below or above, depending on the themes, scales, currency and coverage of the data needed.

2.1.4. SDI Development

The underlying key to the success of future SDI development is partnerships. This is because the main objective of SDI is to facilitate sharing and collaboration, and without partnership between organisations, meaningful sharing and collaboration will simply not be possible. However, as noted by Rajabifard and Williamson (2002), research shows that despite considerable interest and activities, the development of an effective and comprehensive SDI is hampered in most cases by a lack of support from members. Therefore, the main task for organisations with a leadership and/or a coordination role is to provide convincing arguments to persuade doubtful stakeholders to get involved and communicating this information in an effective manner.

In recent year, the realization of the importance of partnerships within the spatial information community has grown significantly. This is evidenced in Australia through a period of institutional strengthening. In the private sector, the forming of the Australia Spatial Industry Business Association (ASIBA) has provided a unified voice for the business community. In the academic sector, the creation of the Collaborative Research Centre for Spatial Information (CRC-SI) has advanced research and development. For individual spatial practitioners, there is now one single professional body, Spatial Science Institute (SSI), to provide representation for all working in different areas. Finally, Government is also re-positioning itself to adapt to the changing community and private sector demands for spatial information (Jacoby et al, 2001). The institutional strengthening and the creation of a unified body to represent different viewpoints has created a hub for sharing of ideas and communication, and will undoubtedly further enhance the development of SDI.

Although positive progress has been made in recent years, SDI is still a concept not fully appreciated by many in the spatial industry and more importantly among the general community. It is important to understand that this problem cannot be viewed as just technical problems, such as difference in intuitional arrangements, policies, standards and technologies, rather it should be addressed from a people centric perspective. This is because the real barrier hindering progress is people’s unwillingness to get involved. Overcoming technical problems will undoubtedly help minimise negative responses, however the real solution is to understand what the people need, then provide that right information to address their reservations, and create innovative projects that will demonstrate the benefits and hence stimulate interests. Without people actually wanting a SDI to happen, an effective and comprehensive SDI will remain just a concept. By being people centric, the core problem facing SDI is purposefully tackled.
The development of SDI is underpinned by building long term and mutually beneficial partnerships among all stakeholders, related agencies and communities. The success of building these partnerships relies upon leading and coordinating organisation being able to provide people-focused solution and communication to gain that support. To provide that solution, the underlining problems facing SDI must then be well understood. Rajabifard and Williamson (2002) proposed that the following issues should be addressed:

- Increasing the level of awareness about the nature and value of SDIs;
- Understanding the dynamic partnerships which are necessary to support a culture for sharing;
- Improving the SDI conceptual model to better meet the needs of communities;
- Identifying key factors that facilitate development by better understanding the complexity of the interaction between social, economic and political issues

In the research and development of SDI, Australia is internationally recognise as a leader in field and is largely credited with pioneering many of the early advancements in SDIs. In November 1996, ANZLIC released a discussion paper on defining the Australian Spatial Data Infrastructure (ASDI will be discussed in greater detail in the next section), and over many years ANZLIC’s model for the ASDI has provided an effective framework for SDI development (Clarke, 2001). The significant of this development is clearly shown from other SDI initiatives such as the Asia-Pacific SDI (APSDI) initiative of the Permanent Committee for GIS infrastructure for Asia and the Pacific (PCGIAP), where several elements, principles and commonalities of the ASDI are observable. Australia’s high standing in the research and development of SDIs is also illustrated in GSDI’s ‘GIS Cookbook’ (2001), where ANZLIC’s ASDI model is used as a reference to guide other practitioners in the SDI field. (Warnest et al, 2002)

2.2. SDI in Australia

Australia is a federation of six states and two territories with governance spread across a three-tier hierarchy of federal, state and local government. At each different level of government, the demand for spatial information varies depending on responsibility, and this variation in responsibility is reflected by the fact that states and territories collect and maintain datasets such as cadastre, road networks and topographic mapping for land administration, emergency services, utilities and main roads functions, while the commonwealth collects and maintains large amounts of spatial information in performing its respective functions, such as defence, census and trade. It is important to note that the private sector also collects enormous amounts of spatial information, which may be required for public needs. (Warnest et al, 2004)
These differences in responsibility and the lack of coordination and collaboration between jurisdictions have created the situation where a lot of unnecessary work and inefficiency is embedded in the collection and management of spatial datasets at different jurisdictions. Australia’s Commonwealth, State and Territory governments have responded to this shortcoming through the implementation of the Australian Spatial Data Infrastructure (ASDI).

2.2.1. Australian Spatial Data Infrastructure

The ASDI is the national initiative to provide an environment for the coordinated sharing of spatial data between different stakeholders. ANZLIC (2005) defined ASDI as a national framework for linking users with providers of spatial information. The ASDI comprises the people, policies and technologies necessary to enable the use of spatially referenced data through all levels of government, the private sector, non-profit organisations and academia.

The key working components of the ASDI are the Australian Spatial Data Directory (ASDD), Standards and Spatial metadata. Figure 6 shows that the ASDD is an online directory of spatial metadata searchable via the internet, and that standards are used to ensure all metadata are compatible. By collecting the metadata from spatial data custodians throughout Australia, the ASDD is providing an environment for users of spatial data to locate their desired data effectively. Currently, the directory comprises government and commercial nodes in each State/Territory and spatial data agencies within the Australian Government, totaling over 30,000 entries held on 24 nodes (ANZLIC, 2005).

![Figure 6: Key Working Components of ASDI](image)
ANZLIC's vision for the ASDI is that Australia's spatially referenced data, products and services are available and accessible to all users. This is being achieved by encouraging government and private sector to develop consistent policies to minimise barriers, and also the adoption of relevant international best practice wherever possible. The minimisation and removal of barriers through adoption of best practice will not only increase the quality of products and services, but also improve the confidence of users that the information provided is suitable for their needs (ANZLIC, 2005).

ANZLIC identified that issues such as:

- Immature institutional arrangements;
- Inconsistencies in the availability and quality of data;
- Inconsistent policies concerning access and use of data;
- Incomplete knowledge for existing data; and
- Lack of best practice in utilising technologies,

are the main barriers preventing the development of an ASDI. The priority actions noted by ANZLIC as important to removing barriers can be summarised into two including: To identify and engage all stakeholders in the evolution of the ASDI as a national initiative; and the implementation of value-driven and cooperative improvements through this understanding.
2.2.2. Administration of ASDI

The administration of ASDI in Australia is not the responsibility of a single organisation, rather it is a network of inter-governmental and inter-organisational agencies working together, with leadership provided by two key bodies (ANZLIC and PSMA). Figure 7 is a structural diagram showing how the different organisations interact with each other. In the following sections, an overview of the key national bodies mentioned in the diagram will be examined further, background information of other relevant agencies from the Commonwealth and the states of New South Wales and Victoria will also be provided.

Figure 7: Administration of ASDI

2.2.3. ANZLIC – The Spatial Information Council

ANZLIC is the peak intergovernmental council for spatial information in Australia and New Zealand, and is responsible for leading the development of the ASDI (GA, 2005). The ANZLIC council comprises ten senior officials from each of the Australian and New Zealand National Governments, and the six states and two
territories of Australia. These officials are generally responsible for the management and operational aspect of spatial information within their jurisdiction. This high level coordination and collaboration is important to facilitate the removal of barriers between all government jurisdictions and the private sector.

The Council's vision is that Australia's and New Zealand's economic growth, and social and environmental interests are underpinned by spatially referenced information that is current, complete, accurate, affordable, accessible and integratable (ANZLIC, 2005). The primary role of the council is to facilitate solutions to promote accessibility to and usability of spatial data and services provided by a wide range of organisations in the public and private sectors.

ANZLIC (2005) has three standing committees working on the advancement of the ASDI, the promotion of national consistent standards and policies and Land Administration reform. The three committees are:

- **Spatial Data Infrastructure Standing Committee (SDISC):** To facilitate solutions that remove barriers facing the ASDI and to monitor factors driving development.

- **Standing Committee on Land Administration (SCoLA):** To provide leadership and foster collaboration in identifying needs and actions in Land Administration reform.

- **Intergovernmental Committee on Surveying and Mapping (ICSM):** To provide leadership, coordination and standards for surveying, mapping and charting; and facilitate the assemblage and maintenance of national framework datasets.

ICSM originally operated as an individual group and reported to ANZLIC. However, in recognition of the close links between the development of policies by ANZLIC and the implementation of these policies by ICSM in areas such as surveying, mapping, geographic names and charting, ICSM became a standing committee of ANZLIC in 2003.

### 2.2.4. Public Sector Mapping Agencies

Public Sector Mapping Agencies Australia Pty Ltd (PSMA) was originally formed in 1993 by the mapping agencies from the Commonwealth and State/Territory governments to provide a national topographic dataset for the 1996 Census of Population & Housing. Such was the quality of the dataset, the demand for PSMA to provide national datasets in both the public and private sectors grew. The existing structure of the consortium was considered to be inappropriate for such
growth and hence the current PSMA Australia Pty Ltd was incorporated in June 2001.

PSMA is currently an unlisted public company limited by shares and owned by the state, territory and Commonwealth governments (exception of WA which is currently prevented from taking a share by state legislation). As a government-owned company, PSMA functions as a 'Clearing House' within the ANZLIC model for the ASDI, its main task being to facilitate access to seamless national datasets developed from the data jointly held by all these government agencies. As a "Clearing house", PSMA also removes barriers and simplifies licensing to Value Added Resellers, enabling and stimulating the spatial industry. (PSMA, 2005)

Data used by PSMA to create its products are collected and controled by different data custodians. The main data custodian at the national level is the National Mapping Division within Geoscience Australia, and in NSW and VIC, they are Land & Property Information NSW, and Land Victoria respectively. By establishing data licenses with PSMA Australia, the data custodians in return receive license fees from products developed by PSMA.

Currently, PSMA Australia produces five datasets for licensing.

- **Transport & Topography**: Encompassing the road, rail and air-services infrastructure network, and the Hydrology and Greenspace of Australia.
- **Administrative Boundaries**: Contains Bureau of Statistic, Electoral, Local Government, Suburbs and State Boundaries.
- **Points of Interest**: Includes over 175,000 cultural points, such as Accommodation, Cinema, Fire Station, Museum and Shopping Centre, etc.
- **CadLite**: A digital representation of all cadastral boundaries excluding easements and road/drainage casements.
- **G-NAF**: Stands for Geocoded National Address File, is a single authoritative Geocoded database of reference in Australia for street address data.

### 2.2.5. Office of Spatial Data Management

The Office of Spatial Data Management (OSDM) is part of a three-tiered structure to implement the Australian Government's Spatial Data Access and Pricing Policy. The other two bodies working in conjunction with OSDM are the Spatial Data Policy Executive (SDPE) and the Spatial Data Management Group (SDMG).

This three-tiered structure works as follows: SDPE, as the peak supervision body, provides strategic direction for SDMG, which is comprised of representatives from 32 Australian Government departments and agencies, and is the operational
manager for OSDM. Any instructions established by SDMG are carried out by
OSDM, and the following tasks are listed on OSDM’s webpage (2005).

- Providing administrative support for both SDPE and SDMG;
- Implement work plans and manage working groups established by SDMG;
- Facilitate sharing of experience and expertise between Government
  agencies;
- Provide technical advice to the SDMG;
- Promote efficient use of Government spatial data assets;
- Represent the Australian Government’s interests in spatial data
  coordination and access arrangements with the States and Territories; and
- Foster the development of a private sector spatial information industry.

2.2.6. Geoscience Australia

Geoscience Australia (GA) is the national agency for geoscience research and
geospatial information. GA is not directly involved in the research and
development of the ASDI, but as a commonwealth research agency, it is a keen
supporter and participant of research projects related to the ASDI. In addition,
GA also manages the gateway to the Australian Spatial Data Directory (ASDD);
provides a range of national fundamental datasets through its National Mapping
Division and is the custodian of Commonwealth data licensed to PSMA Australia.

2.3. SDI in New South Wales

2.3.1. Structure of NSW SDI

Coordination of Spatial information and activities within New South Wales is led by
the Board of Surveying and Spatial Information (BOSSI) within the Department of
Lands. However, as present there is no whole-of-government spatial information
coordination in the state, and much of the inter-departmental spatial information
collaboration is driven by four initiatives (Warnest, 2005), these are
• **NSW Government Chief Information Office (GCIO):** A whole of Government ICT Strategy coordinated by the Department of Commerce, to develop and deploy government wide strategies for the management of ICT within and between government, industry and the community.

• **Community Access to Natural Resources Information (CANRI):** A 4 Million AUD project to link datasets from 10 government agencies via the Internet to provide integrated access of natural resources data to the community. All natural resources in NSW has now been brought together via CANRI. For more information [www.canri.nsw.gov.au](http://www.canri.nsw.gov.au).

• **Emergency Information Coordination Unit (EICU):** A unit set up by the Director General Lands to implement and maintain a collaborative data sharing system for emergency service organisations to ensure the best spatial data is available to deal with multi agency emergencies, such as terrorism, natural disasters and criminal activities (Lands, 2005).

• **Planning Information and Services for NSW (iPlan):** An online “one stop shop” that provides access to state wide, location based, integrated planning information and services from 28 government agencies, the local governments and industry in NSW (iPlan, 2005).

Figure 8 below summarised how these four initiatives fit in the overall picture of spatial information coordination in NSW.

![Diagram of Coordination of Spatial Information in NSW](image)

**Figure 8:** Coordination of Spatial Information in NSW (Based on: Warnest, 2005)
2.3.2. Department of Land, NSW

Through its Land and Property Information Division (LPI), the Department of Lands has established an internationally recognised reputation as a “one stop shop” for all your land administration needs (Lands, 2005). This reputation is the result of embracing new technologies and greater expertise in the field, and also the strengthening of institutional arrangement where services previously provided by separate government departments and agencies are brought together to provide an integrated framework of Land Administration.

Through LPI, Lands is the custodian of NSW jurisdictional data licensed to PSMA, and as the official source of land information for the state, it is responsible for maintaining the state’s Digital Cadastral Database (DCBD) which contains fifteen layers of land parcel and other administrative data. Lands also maintains a Digital Topographic Database (DTDB), and to ensure that its data is up-to-date, Lands produces around 12,000 aerial photographs annually, with an approximate cycle of 5 years to renew the collection for the whole state. In additional, Lands also provides more than 35,000 parish and historic maps of NSW, and through its online initiatives such as the Lands GeoSpatial Portal (GSP), where all of the mentioned datasets can be easily accessed by anyone wanting to use the data.

Lands provides many different types of land related services and products, these are divided into the following categories:

- **Land and Property Information Division:** Titling, valuation, surveying, and other spatial information.
- **Crown Lands Division:** Administration and management Crown Lands.
- **Soil Services Division:** Soil conservation earthworks and consultancy services.
- **Emergency Information Coordination Unit:** Provide spatial data needs for counter terrorism and emergency response.
- **Native Title and Aboriginal Land Claims**
- **Land Boards**

2.3.3. NSW Summary

In recent year, spatial information in NSW is going through a phrase of renewal. This is evident via instructional strengthening activities, such as the creation of BOSSI to provide whole-of-government approach to spatial data management. Much of the current spatial information activity in NSW is primarily driven by individual initiatives occurring in isolation of each other. Although the success of some of these projects, such as CANRI in fostering cooperation between
organisations and also promoting the use spatial information has became a benchmark for other jurisdiction, there is however still much works need to do done before NSW return as a leader and pioneer in spatial information, like in early 1990 when it became the first state to complete the states DCDB with full coverage.

2.4. SDI in Victoria

![Map of Australia with Victoria highlighted](image-url)

2.4.1. Structure of Victoria SDI

Victoria covers an area of 227,420 km² accounting for only 3% of the country’s territory. However it is the most densely populated state, averaging 20.7 persons per square kilometre. It has a diverse economy, ranging from primary industry and manufacturing to high order services, such as information technology and knowledge-based industries. It is divided into 78 local government areas which provide governance (such as planning) and services (such as health) (Nedovic-Budica, 2004).

The governmental structure for information management has gone through a significant amount of restructuring during the last 20 years. In 1984, Landata was created as a state agency to manage duplications in maintaining digital information. The under resourced agency was unable to create a realistic cost-recovery policy for this digital information and thus in 1991 Geographic Data Coordination (OGDC) was created under the Department of Finance to create a map base. It managed to bring together rural and urban cadastres in a digital format. Geographic Data Victoria (GDV) was created under OGDC to manage the newly created cadastral data. The commercial responsibility of GDV led to the commissioning of certain functions (e.g. maintenance and distribution of digital data) to the private industry. By 1995 OGDC started to consolidate other datasets with the cadastre (e.g. topological data and road networks). In 1997 Geospatial Policy and Coordination Victoria (GPAC) was created which took over GDV as a result of restructuring. It created the GISNET (Which managed the state SDI) and developed a draft Geospatial Information Strategic Plan and a draft Geospatial Data Pricing Policy for the Victorian Government (Nedovic-Budica, 2004).

In 1997 Land Victoria offices consolidated Land Titles, Surveyor General, GPAC and GISNET. Thus Land administration and geospatial activities merged into the Land Victoria office. Land Victoria is a branch of the Department of Sustainability
and Environment (DSE), which is responsible for balancing development and protecting the states natural and cultural resources (Nedovic-Budica, 2004).

Today the states spatial information is primarily managed by a relatively new branch of DSE called Spatial Information Infrastructure (SII). In addition, SII coordinates the Victoria Government Spatial Committee (VGSC) and Victorian Spatial Council (VSC) which are made up of the major stakeholders of the states SDI. Their roll as pivotal drivers for the development of the states SDI strategy is discussed in more detail below. Figure 9 shows the current organizational structure governing Victoria spatial data (Rajabifard et al, 2005).

![Figure 9: Coordination of Spatial Information in Victoria (Based on: Warnest, 2005)](image)

### 2.4.2. Victoria Approach to SDI (SDI Drivers)

The recognition of the requirement of a SDI for Victoria was brought about by a Victorian GIS planning study undertaken by Tomlinson Associates in 1992. This report, which covered 40 state agencies and reviewed 270 datasets, recommended an investment of AUD 57 million over six years in the spatial information industry. It predicted a return fully discounted benefit of AUD 312 million to the state. To obtain this profit it insisted on the development of a digital cadastre as the fundamental map base. In addition, it laid the foundation for the ‘point and click’ vision (i.e. spatial objects acting as indexes to additional information about the object itself). This vision which will make spatial
information even easier to use and has become the aim of every state (Thompson et al, 2003).

The Tomlinsons’ recommendations have led to the development of the Victorian Spatial Information Strategies. These strategies are designed to last for three years and provide the state government with means to look ahead and direct the spatial information industry. It is designed by considering the states overarching goals (e.g. sustainable development) in addition to the roles and requirements of the public and private sectors and academia in regards to spatial information (Thompson et al, 2003).

So far there have been three different strategies with slightly different focuses. The first was called the Victorian Geospatial Information Strategy (VGIS 1997-2000). It aimed for the creation of framework datasets and for growth of private industry in spatial information. The second (VGIS 2000-2003) focused on establishment of best practice information management. These practices were broken down into eight components: custodianship, metadata, access, pricing, framework information, key business information, licensing and spatial accuracy (Thompson et al, 2003).

The current strategy is called the Victorian Spatial Information Strategy (VSIS 2004-2007). Its main focus is on distribution of data (online) and the development of partnerships (focusing on inter-governmental and inter-sectoral relationships). It has built on the previous eight components (VGIS 2000-2003) of best practice information management, while adding another two components: governance and privacy (SII, 2005).

VSIS 2004-2007 has been influenced by two of the states overarching goals: “Growing Victoria Together” and “the Standard Corporate ICT Infrastructure Strategy”. Growing Victoria Together is the state governments overarching vision emphasizing the need for spatial information in achieving its social, environmental and economic objective. The ICT (Information and Communication Technology) strategy highlights spatial information management as one of the fourteen high priority areas that requires further development in communication between government agencies (SII, 2005).

Previously VSIS was developed by the Geospatial Information Reference Group (GIRG). GIRG was made of the industry sector and the government, giving both a voice on key aspects of spatial information use and access. However some stakeholders perceived that GIRG was dominated by government policy, and that industry was not being well represented. The need to create better cooperation and partnership within government and the private industry saw GIRG was replaced by the Victorian Government Spatial Committee (VGSC) and Victorian Spatial Council (VSC). VGSC has representation from all State Government departments, Victoria Police, and VicRoads, while VSC represents members of the peak spatial industry bodies. Their primary task is to implement the Victorian Spatial Information Strategy 2004 – 2007. This will require working together to coordinate and manage partnerships between Government, industry and the
academic sector. In addition the members of VGSC and VSC are directly connected to national level SDI organizations (described above) including: ANZLIC, ASIBA, ASIERA, SSI, Geoscience Australia, and PSMA. As such these bodies incorporate the industry, academia, and different levels of government, allowing for mutual participation and benefits (Land Victoria, 2005).

Another two important areas which VSIS has continued to focus on include the growth of the private industry and participation in standards development. The state government has maintained the stance to utilize the private industry where possible. It does so by allowing active participation in maintaining fundamental datasets. In addition, it provides opportunities for the private industry to grow by acting as a data wholesaler allowing businesses to resell data as value added products. The second area, standards development is important as it improves ease of data exchange, creates higher quality data content, and greater acceptance of the data. As such the Victorian government has been actively involved in state and national bodies which contribute towards standards development. The most prominent body being the Standards Australia’s IT/4 Geographical Information which acts as a reference group for proposed standards and has input into international (ISO) standards for geographic information (SII, 2005).

2.4.3. Current results from the drivers (Products)

The VSIS, Spatial Information Action Agenda and standards developments have led to initiatives that have in different ways contributed to the states SDI. The current results are, PIP, Vicmap, VOTS, Land Channel, GPSnet, and the Land Exchange (Thompson et al, 2003).

**Property Information Project (PIP)** is a successful example of cooperation between two levels of government (local and state). PIP is the conciliation of local government rates databases with the cadastral map base, maintained by the state government. Land Victoria initiated the project by funding each local government for the initial conciliation. Then an agreement was made for the local governments to update any changes to the data (e.g. new subdivisions), in exchange for free maintenance of the data at the state level. This partnership shows the difficulties of pursuing a mutually beneficial relationship when it is not backed up with legislative power (it took 10 years before all 78 local governments agreed to participate). Yet at the same time it shows that the difficulty is worth while. The 500 agencies and organizations which utilise the states cadastral and related information can now easily access up-to-date information. The local governments have made saving in data acquisition and maintenance through a reduction in duplication of effort, in addition to many other benefits (Jacoby, 2002).

**Victorian Online Title System (VOTS)** completed in 2001, is the digital database of all freehold titles relating to land in Victoria. It includes ownership, dimensions, location, any restrictions (or caveats), and mortgage details. It
includes almost five million paper titles dating back to 1863. This database is accessible to all Victorians online, and it has saved money and time for the Victorian land administration system (Thompson et al, 2003).

**GPSnet** provides information about continuously operating GPS base stations around VIC (for accurate GPS position determination). It is provided through the Land Channel website, as the GPS positioning is augmenting traditional positioning using physical ground marked geodetic networks. Land Victoria aims to cover the entire state with GPS stations at an average spacing of 160km in rural areas and 50km in urban areas. More research is being conducted to send high accuracy solutions wirelessly to users over large areas (Thompson et al, 2003).

The **Land Exchange** allows land transactions to occur online saving time and money. It’s still yet to be fully developed but it incorporates other products mentioned above into an application which is expected to save users AUD 200 million per annum, and allow for faster and easier property dealings throughout Victoria (Thompson et al, 2003).

**Land Channel** has been implemented by Land Victoria and is the delivery website of spatial information products and services. Some of the products include almost five million titles and other land-related records which as described above were converted to electronic format through VOTS. For example, there are topographic maps covering the state at scales of 1:25,000, 1:30,000 or 1:50,000. These are provided in PDF format showing roads, contours, rivers and lakes, vegetation, buildings, landmark features, fence lines and text. Each map sheet (covering 5km x 7km) can be purchased for $1.50 each plus a $1.10 service fee for each order. The Land Channel website ([http://www.land.vic.gov.au](http://www.land.vic.gov.au)) is a powerful marketing tool and creates awareness for the spatial information industry. It generates in excess of 400,000 page impressions per month, and more than 55,000 property reports (Thompson et al, 2003).

**Vicmap** is the integration of the states eight framework information products. The cadastre acts as the fundamental geodetic control to the other products. Although not fully aligned, the maintenance of each layer is coordinated with the other relevant layers. (e.g. a modification in the Hydrography layer is aligned to the elevation and transport layers as well). The eight layers are:

1. Vicmap Control and Position – Use of Victorias survey ground mark network, and GPS base station network for control and positioning services.
2. Vicmap Property – Spatial and related information on Victoria’s 2.7 million properties.
3. Vicmap Address – property addresses for Victoria’s 2.7 million properties.
5. Vicmap Transport – networks for all roads (trafficable by four wheeled vehicles), rail and trams.
6. Vicmap Elevation – Height descriptions, including spot height, contours and DEMs.
7. Vicmap Hydrography – all surface water features.

These datasets can be purchase through Land Channel. They are available in ranges of suburb/town/locality (Land Vic, 2005).

Other themes which the state has developed are environmental data on water, vegetation, flora and fauna, agricultural data, pollution, soil, utilities, waste, climate and weather data, and health and human environment data. The scale ranges from 1:2500 to 1:250,000. Most of these datasets can be accessed online, however there are a mix of access constrains including: restricted, partially restricted, or unrestricted access, data for internal use only, and license agreements. For example some of the natural resources spatial and non spatial data, such as soil or climate, is provided by the Department of Primary Industries (DPI). These data have been made available through the Victorian Resources Online (VRO) website (http://www.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/vrohome). VRO is an initiative of DPI to provide a wide range of natural resources information with a major focus on map-based information (DPI, 2005).

2.4.4. VIC Summary

Victoria is arguably leading the way for state SDI in Australia (Batty, 2004). Its main driver is the VSIS which incorporates Victorian governments and the private industry goals and aims into a spatial information strategy. Although the organizational structure overseeing the spatial industry has constantly been changing, Victoria has managed to produce well developed spatial products which will continue to build the spatial industry within Victoria. This success has been due to the cooperation of the Victorian government with industry and academia, and the recognition of the importance of SDI development since the Victorian GIS planning study undertaken by Tomlinson Associates in 1992.
2.5. Land Administration

It is easier to discuss the relationship of land administration to SDI by painting an overall picture to explain why so much energy is being spent to develop them.

![Diagram showing relationship between current world problems, inefficient land management, and SDI]

**Figure 10**: Importance of SDI to land administration and to today’s world problems

As Figure 10 shows, some of today’s problems which are being faced on a world scale include poverty, social inequality, and environmental degradation. One way these problems can be aided to solve is by managing land in a more efficient and effective way. For example by having well informed planning there will be less environmental degradation and reduced risks to public disasters. Another example can be seen through the securing of property rights. If a property is secure, then the use and investment in that property increases, which is one of the fundamental requirements in growing the economy of a country (Ting and Williamson, 2001).

Implementation of effective land management policies is what land administration is concerned with. Land administration is defined by Dale and McLaughlin (1999) as “the process of regulating land and property development and the use and conservation of the land, the gathering of revenues from the land through sales, leasing, and taxation, and the resolving of conflicts concerning the ownership and use of the land”. The cadastral parcel is also described as the basic building block of land administration and that information management is the only function of land administration which does not already have a governmental organization dedicated to it.
It is easy to see that well informed decision making requires well developed information management. This is why the development of SDIs is required for effective land administration. The two main problems hindering more effective land administration and information management are:

1. Progress in information technology, leading to large changes in information management.
2. Problems in integration of a national cadastre (as spatial data is collected and maintained by different organizations and jurisdictions).

SDI has tried to overcome these problems by creating partnerships between stakeholders and interacting with new technologies to allow for better data availability for decision making. (Steudler, 2003).

There are other indirect ways which SDI helps world problems, such as increasing public awareness of these problems through information dissemination. Another example is in helping to develop an economy of a nation by creating opportunities for innovative business once fundamental data is available through an SDI. (Williamson 2001).

In the hierarchy of SDI the most relevant section to land administration is large (larger than 1:10,000) to medium (1:10,000 to 1:25,000) scale data. This is in comparison to small scale (1:25,000 and smaller) data which is at national SDI level or higher. The larger scale spatial information is closely connected to people and the decisions which impact their lives. It is this people relevant data that allows operations of natural resource management and land markets (land registration, cadastral surveying, land use planning, valuation, local government administration, administration of utilities and services). (Williamson, 2003)

For countries like Australia where land administration is a state responsibility, many of the large to medium scale data are provided by different jurisdictions. Each jurisdiction in turn collects these datasets based on their required tasks (e.g. road network, or natural resource management...). This results in core datasets which have similar patterns, but have different range and content reflecting local priorities. However most users want this data at a national level. This creates two focus areas:

1. Interoperability = attempts to deal with issues concerned with aggregating and exchanging spatial datasets between different organizations.
2. Custodianship = identifying the organization responsible for maintaining the integrity of a specific dataset (Grant and Williamson, 2003).

During the last decade the focus of development has been on small scale national, regional, and global SDIs. It is predicted that the next decade will see large scale data coming to the forefront of SDIs. An example of this change of focus is the establishment of the Centre for Spatial Data Infrastructure and Land Administration in the Department of Geomatics at the University of Melbourne.
This research body receives large funding from the Victorian state government on the basis of the need to understand the complex relationship between Land Administration and SDI (Williamson, 2003).

2.6. Cadastral and Topographical data

2.6.1. The Cadastre (Australian Case)

The cadastre is defined by FIG (FIG, 1995) as, “usually including a geometric description of land parcels linked to other records describing the nature of the interests, and ownership or control of those interests, and often the value of the parcel and its improvements.”

Today the Australian cadastral systems include:

1. Textual component – or the land register, it identifies the real property parcels (concentrating on freehold private ownership). It identifies the ownership and the owners’ rights, restrictions, and responsibilities, in addition to any easements and mortgages attached to the title.

2. Spatial component – Cadastral maps show the graphical representation of the land parcels relating to the registered title. Each parcel has a unique identifier and is fully computerised. However the treatment of public land and roads varies among the jurisdictions (Dalrymple, 2003).

This research will be concentrating on the spatial component (Cadastral maps) section of the system. However, because all sections are interconnected, a brief history of its development is given to appreciate the current problems in utilising it within an SDI.

During the colonization of Australia from 1788, it was required to alienate the land by surveying it and allowing it to be occupied. However due to the acceleration of growth in population, harsh conditions for surveying, and lack of professional surveyors many errors occurred during these surveys. This has been a cause of many hindrances in establishing a successful cadastral system (Dalrymple, 2003).

For approximately the first 70 years from the time of colonization a deeds conveyancing system (English general law) was used. This caused significant problems for land transfers, as for each transfer all the previous deeds (transfers) would have to trace back. For example a loss of one deed in the chain caused nullification of the title. In addition it was an expensive and cumbersome system to administer. Both Victoria and NSW still have titles under this system. In the 1850s Robert Torrens introduced a new system called the Torrens system. By 1874 all states of Australia has adopted it with each evolving its own system depending on their needs and history. However, all states developed two systems to manage private and crown land separately. Land title was used to control private land registration, and land survey to manage crown lands (i.e. alienate Crown land for private ownership). Prior to the Second World War subdivisions
started to occur more frequently, until today where development of private land far outweighs alienation of Crown land. As a result, a lot of effort is being put to combine the private and public cadastres in a digital format. In addition, to ensure the standardization of the core spatial data sets that underpin SDIs, the administrative and maintenance of the cadastre is still controlled by government, even though almost all cadastral surveying is now done by private firms (Dalrymple, 2003).

Australian cadastral maps are now all digitally available. This was developed by hand digitization of parcel details, townships, subdivisions, and road survey plans overlayed with ortho-photo maps. The typical scales of these maps are 1:2,000 – 4,000 (1:2,500 for Victoria) in urban areas and 1:10,000 – 50,000 (1:25,000 for Victoria) in rural areas. However the accuracy of certain areas is still problematic. The main issue being the scale of the boundaries, resulting in urban areas being meters out of position and in rural areas tens of meters out of position. However, the accuracy of the cadastral maps is continually being upgraded. This is because private land surveyors and government agencies continually validate and update the content. Overall, accuracies in urban areas are significantly better than 1m and often approaching 0.1m (Dalrymple, 2003).

The main issue in integrating cadastral maps with other spatial information can be traced back to the purpose of which the cadastral maps were obtained. These maps were designed to serve traditional land markets or land registration purposes. This is quite different from the characteristics of a modern multi-purpose cadastral map (Williamson 1996). Some of the issues due to this characteristic discrepancy are survey accuracy, seamless cadastres, and online data activities. However as can be seen from Figure 11 below cadastral maps, together with topographical data, are the backbone of state land information systems (Dalrymple, 2003).

![Generic Model of Land Information Systems in each State](Williamson, 1985)
2.6.2. Topographical Spatial Data (Australian Case)

Geoscience Australia defines Topographical maps as (GA, 2004): “depicting natural and constructed features of the Earth’s surface including landforms (represented by contours and spot heights), streams, lakes, dams, swamps, roads and tracks, localities, built-up areas, vegetation, conservation, defence and forestry reserves and Aboriginal lands.”

Geoscience Australia has been producing topographic maps for more than 40 years. These have been in paper format generally used for navigation and exploration. They are still available at scales of 1:100,000, 1:250,000 and 1:1 million. In addition a joint effort by the Australian Army and Geoscience Australia produced more than 2000 different topographic map titles at a scale of 1:50,000. These topographic maps have been produced from the latest satellite imagery, information from local and state authorities, as well as other informed sources. Since 1996 these maps have been available online, however as an image of the maps not the digital data itself. Today these images are georeferenced to assist in use with GPSs. It is foreseen that in the near future these maps will be provided in vector format (GA, 2004).

In addition to Geoscience Australia’s initiatives to create national topographical maps, each state has been making topographical maps for their own purposes. As a result there are duplications and inconsistencies in the extent, availability and quality of topographic information. The technological advancement and the increasing need for up to date spatial information drove ICSM (Intergovernmental Committee on Surveying and Mapping- described above) to establish a Permanent Committee for Topographic Information (PCTI) in November 2003. This Committee coordinates collection, maintenance and delivery of topographic information from the federal and state governments. In addition, it allows input from governments and industry stakeholder groups. Currently the main product is the “topographic map index” which is available from the ICSM web site. It allows viewing of spatial topographic data covering all of Australia. It is planned that this index will grow over time (ICSM, 2005).

2.6.3. Cadastral and Topographical Integration in Products

“Cadastral lite” is the integration of all cadastral databases from all jurisdictions in Australia on the national reference datum (GDA94). It is available from the Public Sector Mapping Agency. It is completely digitised and covers 10.2 million parcels including freehold, state owned land, strata and native titles. It came about after the realisation that the cadastre was the most appropriate fundamental database to support the integration of different spatial information. As such from 1980 to 2000 much effort was put to integrate the cadastral maps of all Australian states and territories. However as mentioned previously each jurisdiction has its own cadastral system. Thus to integrate these isolated cadastral maps, a topographic base map was used as a control (generally utilising a rubber sheeting approach). One of the great advantages of this integration is
the capability of assigning each parcel a unique identification number. This will enable better identification and cross referencing with other parcel based information (eg addresses) (Jacoby et al, 2002).

**A Digital Cadastral Data Base (DBDC)** is a state level digital database made up of the cadastre as the fundamental map base, with additional topographical information integrated to it. At this stage each jurisdiction has developed its own solution. However ICSM is coordinating cadastral standards to bring national consistency of the fundamental data sets of each jurisdiction. DCDB support activities such as: online delivery of vendor statements, rural and urban planning, emergency response, military operations, and environmental risk assessment (Williamson and Enemark 1996).
2.7. Significance of Study areas

The investigation of this pilot project was carried out on two municipalities in Victoria: Casey & Yarra Ranges.

2.7.1. Shire of Yarra Ranges

Yarra Ranges Shire is located in Melbourne’s outer east - between 30 and 110 kilometres east of the Melbourne GPO. The Shire covers an area of almost 2,500 square kilometres, the largest area of any metropolitan council and is home to more than 143,000 people (137,113 during 2001- Community profile id (2005)). The Shire of Yarra Ranges was formed in 1994 following the amalgamation of the former Shires of Healesville, Lillydale, Sherbrooke and Upper Yarra. The Shire offers a mixture of urban and rural communities. Around 70% of the Shire’s population live in the ‘urban’ areas of the Shire that represents approximately 3% of its landmass. The remaining population is distributed throughout rural areas.

2.7.2. City of Casey

The City of Casey is located 35km from the Melbourne CBD, in Melbourne's south east. Casey has a total area of around 400 square kilometres, and its population is estimated at 221,058 as of October 2005. Currently, approximately 55 families move into the area each week, totalling to 8,700 each year. It is expected the population will grow to 320,000, making it the largest and fastest-growing municipality in Victoria, and the third fastest growing city in Australia behind Brisbane and Gold Coast City Councils.

3. RESULT (PART 1)

Stage 1

*Highlighting technical problems when integrating built datasets from two state governments (i.e. NSW and Victoria) with natural datasets provided by the federal government (Geoscience Australia)*

The NSW Department of Lands was unable to provide the data on time, hence no data analysis was carried out for this stage.

Stage 2

*Investigate any existing issues for Victoria’s already integrated built and natural datasets*

The following combination of Vicmap Products were compared:

- Address ⇔ Property ⇔ Transportation ⇔ Satellite image
- Property ⇔ Planning ⇔ Administration ⇔ Satellite image
- Elevation (10m) ⇔ Elevation (5m) ⇔ Satellite image
- Elevation (10m) / Elevation (5m) ⇔ Hydrology ⇔ Vegetation ⇔ Satellite image
- Property ⇔ Transportation ⇔ Hydrology ⇔ Satellite image (logical consistency)
- Vegetation ⇔ Transportation ⇔ Property ⇔ Satellite image

The following technical problems were investigated.

- Attribute consistency
- Metadata
- Integration method
- Problems in borders of different LGAs
- Topology
- Different symbols and texts
- Logical consistency
- Reference systems
- Diversity in Scale

All problems found were documented using the template (refer Table 1).
**Comparison Layers:** Address ⇔ property ⇔ transportation ⇔ satellite image

**File Used:**

1. yarraranges\vmpropsimp_200509\PARCEL_MP.shp
2. yarraranges\vmpropsimp_200509\ROAD_CL_CHAIN.shp

**Problem Discovered:**

1) An extra line existing within the parcel (unique), disappears when parcel are not clear.
2) Road centrelines are not completed (not-unique).

**Unique Problem:** Yes
**Comparison Layers:** Address ☢ property ☢ transportation ☢ satellite image

**File Used:**

1) yarraranges\vmpropsimp_200509\PARCEL_MP.shp  
2) yarraranges\vmadd_200509\ADDRESS.shp

**Problem Discovered:**

1) Two address points on one parcel (not unique).  
2) Some properties appear to be skipped (i.e. street numbers) (not unique).

**Unique Problem:** No
Comparison Layers: Elevation (10m) ⇔ Elevation (5m) ⇔ satellite image

File Used:
1) yarraranges\vmelv1m_200509\VMELEV_EL_CONTOUR_1TO5M_line.shp
2) yarraranges\vmelv_200509\EL_CONTOUR.shp

Problem Discovered:
1) Different height contours are crossing over (not unique).
2) The same contour heights are at different locations (not unique).

Unique Problem: No
Comparison Layers: Address ⇔ property ⇔ transportation ⇔ satellite image

File Used:
1) yarraranges\vmtrans_200509\TR_ROAD.shp
2) yarraranges\vmpropsimp_200509\ROAD_CL_CHAIN.shp

Problem Discovered:
1) Inconsistencies between the two road layers (not unique).
2) Road sections incomplete for both layers (not unique).

Unique Problem: No
Comparison Layers: Address ★ property ★ transportation ★ satellite image

File Used:

1. casey\vmpropsimp_200509\PROPERTY_MP.shp
2. casey\vmpropsimp_200509\ROAD_CL_CHAIN.shp

Problem Discovered:

Logical Consistency? The road is not a parcel, hence should not have been filled in.

Unique Problem: No
Comparison Layers: Property ☞ planning ☞ administration ☞ satellite image

File Used:

1. mga55\vic_mosaic_murray_mga55.tiff
2. casey\vmplan_200509\EXTRACT_POLYGON.shp

Problem Discovered:

Problem in Borders: There is some small discrepancy on the eastern coastline of the area between the EXTRACT_POLYGON shape file and the satellite imagery. This problem is repeated which all other EXTRACT_POLYGON from other folders.

More boundaries: Using a different dataset, and a line file, instead of a polygon file, we can see that the border area can be matched more accurately than the example above.

Unique Problem: No
**Comparison Layers:** Vicmap vs. Vicmap

**File Used:**

1. Casey → vmpropsimp_200509
2. vicmap_property_simplified_diagram_v1_3_20041125.pdf

**Problem Discovered:**

**metadata file doesn’t match data provided:** For Casey → vmpropsimp_200509: The data provided does not match the info on the product description and the metadata. The most updated file is vicmap_property_simplified_diagram_v1_3_20041125.pdf, however the others files are not updated, hence there are difference in the number of layers provided and their naming.

**Unique Problem:** This problem is likely to be repeated for other datasets.
**Comparison Layers:** Address ⇔ property ⇔ transportation ⇔ satellite image

**File Used:**

1. casey\vmpropsimp_200509\PARCEL_MP.shp  
2. casey\vmtrans_200509\TR_ROAD.shp

**Problem Discovered:**

**Road is disjointed:** This is not a unique problem, and is repeated in many others area.

![Map Image]

**Unique Problem:** No
Comparison Layers: Address ☺ property ☺ transportation ☺ satellite image

File Used:
1. casey\vmpropsimp_200509\ROAD_CL_CHAIN.shp
2. casey\vmtrans_200509\TR_ROAD.shp

Problem Discovered:

Attribute inconsistency: The number of attributes for two different set of road data does not match.

<table>
<thead>
<tr>
<th>TR_ROAD</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>UFI</td>
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<td>pk</td>
</tr>
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<td></td>
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<tr>
<td>ROAD_SUFFIX</td>
<td>VARCHAR(2)</td>
<td></td>
</tr>
<tr>
<td>ROAD_NAME_1</td>
<td>VARCHAR(45)</td>
<td></td>
</tr>
<tr>
<td>ROAD_TYPE_1</td>
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</tr>
<tr>
<td>ROAD_SUFFIX_1</td>
<td>VARCHAR(2)</td>
<td></td>
</tr>
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<td>ROAD_NAME_2</td>
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</tr>
<tr>
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<tr>
<td>RIGHT_LOCALITY</td>
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<tr>
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<td>NRE_ROUTE</td>
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<td></td>
</tr>
<tr>
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</table>

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
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<td>pk</td>
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<tr>
<td>PFI</td>
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<td></td>
</tr>
<tr>
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<td>pk</td>
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<td>FEATURE_QTY_ID</td>
<td>VARCHAR(20)</td>
<td></td>
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<tr>
<td>UFI_CREATED</td>
<td>DATE</td>
<td></td>
</tr>
<tr>
<td>UFI_OLD</td>
<td>NUMBER(10)</td>
<td></td>
</tr>
</tbody>
</table>

Unique Problem: No
Comparison Layers: Property ↔ transportation ↔ hydrology ↔ satellite image

File Used:

1. mga55\vic_mosaic_murray_mga55.tiff
2. casey\vmhydro_200509\HY_WATERCOURSE.shp

Problem Discovered:

Hydrological layer doesn’t match river course shown on Satellite imagery: As can be seen from the diagram below, the section of the river in the selected region is shifted to the right by around 100m. This seems to be a unique problem.

Unique Problem: Seem to be.
Comparison Layers: Address ☻ property ☻ transportation ☻ satellite image

File Used:

1. casey\vmpropsimp_200509\PARCEL_MP.shp
2. casey\vmpropsimp_200509\ROAD_CL_CHAIN.shp
3. casey\vmtrans_200509\TR_ROAD.shp

Problem Discovered:

Inconsistency between two road layers: Although both road layers fitted within the space for road in the cadastral layer, there is inconsistency between the two road layers’ centreline. This problem is most likely to appear for curved road.

Unique Problem: No
4. RESULT (PART 2)

Stage 3: Highlighting technical issues in integrating natural and built datasets obtained from Geoscience Australia with those obtained from Victorian Government – Spatial Information Infrastructure.

The following results are documented in steps based on the stage 3 methodology described in Figure 2.

4.1. Data Structure/Naming Convention

To understand what features a shapefile represented, the structure of the metadata, and how it related to the provided shapefiles had to be examined. Below is the resultant analysis, and problems and outcomes that were found.

The GA datasets had no product description or metadata in the CD. After notifying the problem with our project supervisor, we were advised (see Appendix E) to download the Product User Guide for GEODATA TOPO 250K Series 2 from the GA website at www.ga.gov.au/nmd/products/digidat/250k.htm. This document will be referred to as the GA Guide for the remainder of the report.

4.1.1. Theme definition

The terminology “theme” used in Vicmap data description is not consistent and sometimes vague. For example even though it is defined in the glossary of every product description as:
"The information contained in the map production material can be divided into themes which contain logically-related geographic information, each theme capable of being used as a data set in its own right. Vicmap Transport contains a single theme: “Roads”.

This definition is not clear enough. It requires to be related to other terms used in the document. Otherwise, the selection criteria of how themes were classified needs to be explained. This term has not been put into context in other parts of the product description, nor has it been directly referred to either. For example, Theme description title under Vicmap Hydro Data Description breaks down each layer but hesitates to relate to them as themes.

Thus it was assumed based on the hints and organization of data that a Vicmap theme is a classification of layers describing the features which directly relate to it (e.g. TR_RAIL.shp and TR_RAIL_INFRASTRUCTURE.shp are classified under the theme RAIL as they are the only shapefiles describing the features of the railway infrastructure). Thus it is not the highest level of feature classification as was defined clearly by GA. Vicmap themes are further classified into what has been referred to as Vicmap products (e.g. Vicmap Hydro or Vicmap Properties simplified). Figure 12 is an example of how GA and Vicmap different in its data structure.

![Figure 12: Example of GA and Vicmap data structure](image-url)

Vicmap Theme

Hydro

- Navigation
  - HY_Navigation_Point.shp
  - HY_Water_Struct_Point.shp
  - HY_Water_Struct_shp
  - HY_Water_Area_Centroid.shp
  - HY_Water_Point.shp
  - HY_Watercourse.shp

- Hydrography
  - Waterbody
  - Drainage
  - Navigation
  - Waterpoint
  - Marine facilities
  - Offshore

GA Shapefile

- Point_Waterpoints.shp
- Polygon_Lakes.shp
- Polygon_Watercourse.shp

Feature

- Flats
- Woodland
- Penang
- Lakes
- Shoreline
- Spring
- Waterbody_point
- Rapids
- Waterfalls
- Watercourse
- Reservoir
4.1.2 Definition Layer

Apart from “theme”, the definition for ‘layer’ in the glossary for the GA Guide is another example of inconsistency, which contradicted within the document itself. Below are two examples:

1. “Layer” is defined on p.109 of the GA Guide as: The features in a theme are subdivided into one or more layers on the basis of the spatial objects used to represent the features. Linear networks, polygons and point features are placed in separate layers. However this is contradicted with in the report itself. For example:
   - Road transport layer includes both point and lines (on p.29, a layer is described as being allowed to have a mixture of point and line).
   - Built up Areas layer includes both polygons and lines.

2. An incorrect description is given on p.7 of the GA Guide: Features of the same type are grouped into features classes. There are 140 feature classes in TOPO 250K Series 2, with features having up to seven attributes. However, there are 140 features, not feature classes, which appear to be referring to layers.

4.1.3. Geoscience Australia Datasets

In comparison to the Vicmap datasets, it was very difficult to find the relevant GA feature definition for the provided shapefiles. The root of this problem is due to a few components described below.

The downloaded GA Guide has explained the structure of its datasets in the following hierarchical format: 140 different features are classified into 26 similar groups called Layers (also referred to as feature classes), and these 26 layers are further classified into 5 themes. Majority of these shapefiles appear to represent single features, while others incorporate a few features.

According to p.17-20 of the GA Guide, packaged products (CDs) are supposed to be provided in a set format in different directories and grouped in different themes. However, the provided data did not follow any of these conventions, and all shapefiles were under one directory. Fortunately, along with these shapefiles came a text file called report.txt, which shows the output result of how GA extracted the requested features. This output result was able to provide enough information for manual grouping of shapefiles (refer Appendix B).

Comparing the structure of the manually grouped shapefiles (based on the report.txt) with the structure of layers as explained in the GA Guide, section 5.2, it is clear that the provided data was extracted using a different classification system. According to report.txt, the following feature groups was used to extract the data:
However in the GA Guide, some of these shapefile groups are classified as themes, while some as layers, while some are not even mentioned.

The blurred nature of classification made it difficult to understand how the provided data was structured. For example, p.47 of the GA Guide explained “Relief” as a theme which includes the layers such as contours, spot heights and sand ridges. Where as in the report.txt file, the same shapefiles: Contours and Spot heights, have been included under the shapefile group of “Relief”, while “Sand ridges” is grouped under "Physiography". Thus to minimize the confusion, in this report layers defined in the GA Guide is referred to as “GA original layers”. While, the shapefile groups defined in the provided report.txt file is referred to as “GA provided layers”. Overall it appears the GA provided layers is a reclassification of the GA original layers.

In addition the names of the provided shapefiles are different from the conventions set out in the p.14-17 of the GA Guide. In the document, it is mentioned that shapefiles are named based on a series of codes. However the provided shapefiles use the following naming convention: filename starts with “arc”/“point”/“polygon”, then “_”, then a name describing the layer. Thus for the same shapefile, GA Guide states that the following name be used, “i5002w_r.shp”, while the provided file was “Polygon_Lakes.shp”.

The different in data structure and the confusion caused by naming inconsistency, lead to the following method to be developed to find shapefile definitions:

1. Search by name of the feature in the data definition section, Appendix C of the GA Guide.
2. If there is a shapefile that does not have feature definition, search for it under the layer names. If it exists, all the features within that layer need to be defined to define the file.
3. If there is a shapefile that does not have a feature definition, nor does it exist as a layer, check under the theme names. In such cases all features under the theme need to be defined to define the file.
4.1.4. Vicmap Datasets

The Vicmap data followed the same conventions as its product description. Thus it was much easier to find the shapefile definitions compared to GA. However there were still a few minor issues described below.

The dataset hierarchal structure was not explained as well as GA data description. According to the descriptions found in the glossary, “theme” has the same definition in both Vicmap and GA data description. However in reality they refers to different things. GA themes cover a broader range of features, and is the highest level of feature classification. While in Vicmap data, there is still another level of classification above what is referred to as themes. For example, “Hydro” is the classification of the themes: Hydrographic features, Hydrographic structures and Navigation. Figure 12 above is a graphical representation of this example.

Another minor problem was that the data folders (Figure 13.A) did not exactly match the names of the corresponding metadata (Figure 13.B). While most data/metadata can be easily matched, some like the two elevation datasets was not clear until both the data and metadata were examined. i.e. “vmelev1m_200509” and “vmelev_200509” data directories correspond to “Elevation Metro Contours” and “Elevation State wide Contours” metadata respectively.

**Figure 13.A Data Folder**

**Figure 13.B Metadata Folder**

![Figure 13: Vicmap Data Folder](Image)
4.2. Metadata

4.2.1. Vicmap Metadata

For the Victorian dataset, information about the data is provided in two documents: Product description and Metadata. The name of the directory which store the corresponding document for different theme of data is listed below (refer Table 2). In the CD provided by Land Victoria, the product description is located in the ./Product descriptions directory, the list below is showing the name of the child-directory which holds the product description file in that directory. The metadata is located in the ./Product descriptions/doc directory. Theme highlighted in red is excluded from further data analysis, because no information is provided or found online.

<table>
<thead>
<tr>
<th>Theme name</th>
<th>Corresponding Product descriptions (Name of child-directory)</th>
<th>Corresponding Metadata (Name of the file)</th>
</tr>
</thead>
<tbody>
<tr>
<td>vmadd_200509</td>
<td>./Address</td>
<td>Vicmap_Address_Metadata.pdf</td>
</tr>
<tr>
<td>vmadmin_200509</td>
<td>./Admin</td>
<td>None*</td>
</tr>
<tr>
<td>vmelev1m_200509</td>
<td>./Elevation Statewide Contours</td>
<td>None</td>
</tr>
<tr>
<td>vmelev_200509</td>
<td>./Elevation Statewide Contours</td>
<td>Vicmap_Elevation_Metadata.pdf</td>
</tr>
<tr>
<td>vmhydro_200509</td>
<td>./Hydro</td>
<td>Vicmap_Hydro_Metadata.pdf</td>
</tr>
<tr>
<td>vmplan_200509</td>
<td>./Planning</td>
<td>Vicmap_Planning_Metadata.pdf</td>
</tr>
<tr>
<td>Vmpropsimp_200509</td>
<td>./Property Simplified</td>
<td>Vicmap_Property_Metadata.pdf</td>
</tr>
<tr>
<td>vmtrans_200509</td>
<td>./Transport</td>
<td>Vicmap_Transport_Metadata.pdf</td>
</tr>
<tr>
<td>vmveg_200509</td>
<td>./Vegetation</td>
<td>None*</td>
</tr>
</tbody>
</table>

*Table 2: Vicmap data*
* Metadata is also not available online in Land Victoria’s website for Vicmap product.

### 4.2.1. GA Metadata

All layers provided by GA were checked against the data dictionary, Appendix C of the downloaded GA Guide. The result is listed in the following tables. In the following tables, Page No. of information is referring to the page number of the GA Guide, not this report. Layer highlight in red means no information was found and these layers were excluded for the rest of the analysis process.

<table>
<thead>
<tr>
<th>Point Layer Name</th>
<th>Page No. of information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft Facility Points</td>
<td>p.74</td>
</tr>
<tr>
<td>Building Points</td>
<td>p.74</td>
</tr>
<tr>
<td>Cartographic Points</td>
<td></td>
</tr>
<tr>
<td>Cemetery Points</td>
<td>p.75, but in Polygon</td>
</tr>
<tr>
<td>Errors</td>
<td></td>
</tr>
<tr>
<td>Horizontal Control Points</td>
<td>p.79</td>
</tr>
<tr>
<td>Locations</td>
<td></td>
</tr>
<tr>
<td>Mine Points</td>
<td>p.83</td>
</tr>
<tr>
<td>Populated Places</td>
<td></td>
</tr>
<tr>
<td>Railway Bridge Points</td>
<td>p.88</td>
</tr>
<tr>
<td>Railway Stop Points</td>
<td>p.89, but named as RAILWAY STATION</td>
</tr>
<tr>
<td>Road Crossing Points</td>
<td></td>
</tr>
<tr>
<td>Spot Elevations</td>
<td>p.101</td>
</tr>
<tr>
<td>Vertical Obstructions</td>
<td></td>
</tr>
<tr>
<td>Waterfall Points</td>
<td>p.103</td>
</tr>
<tr>
<td>Waterholes</td>
<td>p.103</td>
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<tr>
<td>WaterTanks</td>
<td>p.103</td>
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**Table 3: GA Point Layer**

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<th>Polygon Layer Name</th>
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<td>Administrative Void</td>
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</tr>
<tr>
<td>Built up areas</td>
<td>p.75</td>
</tr>
<tr>
<td>Flats</td>
<td></td>
</tr>
<tr>
<td>ForeShore flats</td>
<td>p.78</td>
</tr>
<tr>
<td>Cultivated areas</td>
<td></td>
</tr>
<tr>
<td>Cultural void</td>
<td></td>
</tr>
<tr>
<td>Polygon Geo data index</td>
<td></td>
</tr>
<tr>
<td>Habitation void</td>
<td></td>
</tr>
<tr>
<td>Hypsometric areas</td>
<td>p.47 and 79</td>
</tr>
<tr>
<td>Lakes</td>
<td>p.81</td>
</tr>
<tr>
<td>Mainlands</td>
<td></td>
</tr>
<tr>
<td>Map index</td>
<td></td>
</tr>
<tr>
<td>Mine areas</td>
<td>p.83</td>
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</table>

60 / 112
<table>
<thead>
<tr>
<th>Arc (Line) Layer Name</th>
<th>Page No. of information</th>
</tr>
</thead>
<tbody>
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<td>Administration Boundaries</td>
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</tr>
<tr>
<td>Canal Lines</td>
<td>p.75</td>
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<tr>
<td>Cartographic Lines</td>
<td>p.76</td>
</tr>
<tr>
<td>Contours</td>
<td>p.77, but named as Dam</td>
</tr>
<tr>
<td>Culture Boundaries</td>
<td></td>
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<tr>
<td>Dam Walls</td>
<td></td>
</tr>
<tr>
<td>Discontinuities</td>
<td>p.78</td>
</tr>
<tr>
<td>Foot Tracks</td>
<td></td>
</tr>
<tr>
<td>Framework Boundaries</td>
<td></td>
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<td>Graticules</td>
<td></td>
</tr>
<tr>
<td>Grids</td>
<td></td>
</tr>
<tr>
<td>Habitation Boundaries</td>
<td></td>
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<tr>
<td>Industry Boundaries</td>
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<tr>
<td>Marine Boundaries</td>
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<tr>
<td>Marine Infrastructure Lines</td>
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<td>Pipelines</td>
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<td>Railway Crossing Lines</td>
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<td>Railway Tunnel Lines</td>
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<tr>
<td>Road Crossing Lines</td>
<td></td>
</tr>
<tr>
<td>Roads</td>
<td>p.96</td>
</tr>
<tr>
<td>Sand Ridges</td>
<td>p.101</td>
</tr>
<tr>
<td>Spillways</td>
<td>p.101</td>
</tr>
<tr>
<td>Vegetation Boundaries</td>
<td>p.102, but named as Vegetation Line</td>
</tr>
<tr>
<td>Waterbody Boundaries</td>
<td></td>
</tr>
<tr>
<td>Watercourse Lines</td>
<td>p.103</td>
</tr>
</tbody>
</table>

**Table 4: GA Polygon Layer**

**Table 5: GA Line Layer**
4.3. Reference System

Both datasets provided by Land Victoria and GA use the Geocentric Datum of Australia 1994 (GDA94) reference system as its datum. All the vector data (i.e. shapefile in ArcGIS) from both organisations are available to be projected into Map Grid of Australia (MGA) projection, the case study areas are located in zone 55.

However, when both sources of data were opened up together in ArcGIS, an error message (refer Figure 14) appeared to notify that different coordinate systems were being used. The reason for this problem seems to be caused by the same reference system (GDA94) being named differently between Land Victoria and GA. The difference in naming is quickly summarised below.

**Geoscience Australia:**

- GEOGSC - GCS_GDA_1994
- DATUM - D_GDA_1994

**Land Victoria:**

- PROJSC - Map Grid of Australia Zone 55 (GDA 94)
- GEOGSC - Geocentric_Datum_of_Australia_1994
- DATUM - D_Geocentric_Datum_of_Australia_1994
The just mentioned problem of difference in naming did not affect the accuracy of the data when projected in ArcGIS, and this is because they were both using the same coordinate system, but named slightly differently. Therefore the “Don’t warn me again in this session” box was ticked during the data analysis process to ignore any further showing of the same error message. It is important to point out that the same error message box appeared also when working with datasets from just one provider. This problem was similar as before, which is due to the naming of the predefined coordinate system in ArcGIS being named differently as compared with the naming from Land Victoria and GA. By manually importing the projection used by the source data from Data Frame Properties → Coordinate System → Import (refer Figure 15), this problem was eliminated.
Figure 15: Manually import projection system using the Import button

No satellite imagery was used in stage 3 of the data analysis, however the coordinate system of these satellite imageries were examined for the benefit for other researchers working with these data in the future. The satellite imageries from Land Victoria are available in four systems according to its accompanied readme.txt file, this is summarised below (Folder, filename, Projection):

- 24bit vic_mosaic_murray_geov2.tif Geographic
- 24bit vic_mosaic_murrayvg_v2.tif VicGrid94
- GDA94LL vic_mosaic_murrayvg_geov2.tif Geographic
- mga54 vic_mosaic_murray_mga54.tif MGA zone54
- mga55 vic_mosaic_murray_mga55.tif MGA zone55
- VicGrid94 vic_mosaic_murrayvg_v2.tif VicGrid94

All the satellite imageries provided by GA are projected using the geographic coordinates (latitude and longitude) in decimal degrees based on the GDA94.
4.4. Comparable shapefile classes

Once the shapefiles without definition were excluded, the shapefiles which did not have comparable equivalents had to be excluded too. This was done by using the shapefile classification made by the data providers. Using the highest level of classification of the left over shapefiles, all the relevant classes were grouped together. All the left over classes were examined in more detail to find equivalent datasets to compare with. Thus each shapefile class was excluded with justification.

The following irrelevant GA themes and/or Vicmap products have been excluded because:

1. Vicmap Address – has no comparable GA theme to compare with.

2. Vicmap Planning / Reserved Area – Vicmap planning shows local area zones and overlays (e.g. VEGETATION PROTECTION), the closest GA theme would be Reserved Area (the “reserves” shapefile highlights reserves for nature conservation or Aboriginal sites...). However these boundaries have been assigned by different levels of government, thus it is not known if they should be the same or not. A more detailed research is required to find out how the zones/reserves were created.

3. GA Vegetation – cant be used as Vicmap vegetation does not have shapefile definition.

4. GA Framework – has no comparable Vicmap product to compare with.

Thus the only comparable shapefile groups are highlighted below in Table 6.
Table 6: Justification for Themes Used
4.5. Data Analysis

The following section contains the data analysis result for:

- Vicmap Hydro ⇆ GA Hydrography
- Vicmap Property Simplified & Transport ⇆ GA Infrastructure
4.5.1. Vicmap Hydro ⇆ GA Hydrography

Result for Yarra Ranges:

Theme examined:
Vicmap Hydro (Structure) ⇆ GA Hydrology (Waterbodies & Drainage)

File Used:
1. .\yarraranges\vmhydro_200509\HY_WATER_AREA_POLYGON.shp
2. .\TOPO250K\polygon_Lakes.shp

Problem Discovered:

Discrepancies: Discrepancy between lakes. Both shape and size. At the extreme vertices of the lake there is a discrepancy of greater than 350 meters at Lilydale lake (Green line).

Unique Problem: No.
Theme examined:
Vicmap Hydro (Structure) ⊗ GA Hydrology (Waterbodies & Drainage)

File Used:

1. `\yarraranges\vmadmin_200509\AD_LGA_AREA_POLYGON.shp`
2. `\TOPO250K\polygon_Reservoirs.shp`

Problem Discovered:

Discrepancies: Discrepancy between reservoirs. Both shape and size. At the extreme vertices of the reservoir there is a discrepancy of greater than 70meters at Silvan reservoir (Green circle).

Unique Problem: No.
Theme examined:
Vicmap Hydro (Structure) ⊙ GA Hydrology (Waterbodies & Drainage)

File Used:
1. \yarraranges\vmadmin_200509\HY_WATERCOURSE.shp
2. \yarraranges\vmadmin_200509\HY_WATER_POINT.shp
3. \TOPO250K\point_WaterfallPoints.shp

Problem Discovered:

Discrepancies: All waterfall points have discrepancies. The GA falls are not always on top of Vicmap watercourse streams. There is a discrepancy of greater than 370 meters at Cora Lynn falls (Green line).

Unique Problem: No.
Theme examined:

Vicmap Hydro (Structure) ⊙ GA Hydrology (Waterbodies & Drainage)

File Used:

1. \yarraranges\vmadmin_200509\HY_WATERCOURSE.shp
2. \TOPO250K\arc_WatercourseLines.shp

Problem Discovered:

Discrepancies: All GA watercourses follow the general outline of the Vicmap watercourse. However the GA data generalizes the Vicmap data. This discrepancy is most vivid when river snakes. There is a discrepancy of greater than 180meters at Yarra river (Green line).

Unique Problem: No.
Theme examined:

Vicmap Hydro (Structure) ☄ GA Hydrology (Waterbodies & Drainage)

File Used:

1. \yarraranges\vmadmin_200509\HY_WATER_STRUCT.shp
2. \TOPO250K\arc_DamWalls.shp

Problem Discovered:

Discrepancies: The GA dam walls are simplified into straight lines. There is a discrepancy of more than 60m at Silvan dam (green circle).

Unique Problem: No.
Theme examined:

Vicmap Hydro (Structure) ⊙ GA Hydrology (Drainage)

File Used:

1. yarraranges\vmhydro_200509\HY_WATER_AREA_POLYGON.shp
2. yarraranges\vmhydro_200509\HY_WATER_STRUCT.shp
3. TOPO250K\arc_Spillways.shp

Problem Discovered:

Discrepancy: While the only spillway long enough (>250m) for GA to capture in Yarra Ranges is very well aligned to the Upper Yarra reservoir spillway captured by Vicmap, it is not aligned at the ends of the spillway. The bottom part of this discrepancy may be because GA also includes the stilling basin as part of the spillway, but there is no mention of stilling basin in Vicmap data.

Unique Problem: No
Result for Casey:

**Theme examined:** Vicmap Hydro (Features) ✰ GA Hydrology (Waterbodies)

**File Used:**

1. \casey\vmhydro_200509\HY_WATER_AREA_POLYGON.shp
2. \TOPO250K\polygon_Reservoirs.shp
3. \TOPO250K\polygon_Lakes.shp

**Problem Discovered:**

**Discrepancy:** It is obvious that the two polygons are referring to the same features, and as shown in the diagram below, there are irregular discrepancies along the border.

**Additional Problem:** According to HY_WATER_AREA_POLYGON.shp (Vicmap) table attribute, the area shown is the LYSTERFIELD LAKE. However, the lake is covered in GA by polygon_Reservoirs.shp, instead of polygon_Lakes.shp which is the more logical shapefile for this feature to be covered.

**Unique Problem:** No
Theme examined:
Vicmap Hydro (Structure) ⊕ GA Hydrology (Waterbodies & Drainage)

File Used:
1. \casey\vmhydro_200509\HY_WATER_STRUCT_LINE.shp
2. \TOPO250K\arc_DamWalls.shp

Problem Discovered:

Discrepancy:

- The problem highlighted in the red box is showing the different in alignment between of the location of the same dam wall between Vicmap and GA data.

- The green box is showing a Dam wall in Vicmap with its length greater 250m, therefore should have been captured in GA Damwalls.shp file according to its data dictionary.

Unique Problem: No
**Theme examined:** Vicmap Hydro (Structure) $\Leftrightarrow$ GA Hydrology (Drainage)

**File Used:**

1. ..\casey\vmhydro_200509\HY_WATER_STRUCT_POINT.shp
2. ..\TOPO250K\point_WaterTanks.shp

**Problem Discovered:**

**Metadata definition Problem:** The features shown by Vicmap HY_WATER_STRUCT_POINT.shp are all tank_water according to its attribute table. Given that both features shown by Vicmap and GA is named as Water Tank or tank_water, it is obvious from looking at the map that they do not represent the same feature on ground.

This problem lead to further investigation of the data description: Vicmap tank_water is defined as a structure used for the storage of fluids including elevated water tower, gasometer, Oil storage tank, water storage tank & Gas storage tank. While GA WaterTanks is simply defined as a feature constructed on or below the ground for the storage of water.

**Unique Problem:** No, this definition inconsistency is likely to happen to another feature.
4.5.2. Vicmap Property Simplified & Transport ⇔ GA Infrastructure

Result for Yarra Ranges:

Comparison Layers:
Vicmap Property Simplified ⇔ GA Habitation

File Used:
1. .\TOPO250K\polygon_BuiltUpAreas.shp
2. .\yarraranges\vmpropsimp_200509\PARCEL_MP.shp

Problem Discovered:
Areas (generally small) assigned to “Built up areas” which are smaller than parcels. These areas are close to the boundaries. There appears to be possible development sights around these areas, just outside the boundaries.

Unique Problem: No
Comparison Layers:
Vicmap Property Simplified ⇒ GA Habitation

File Used:
1. `\TOPO250K\polygon_BuiltUpAreas.shp`
2. `\yarraranges\vmpropsimp_200509\PARCEL_MP.shp`

Problem Discovered:
1. The boundary of the built up areas are significantly different to the boundary of the Victorian parcels. Although the general pattern is followed.
2. Not all built up areas are within the extent of the built up area.

Unique Problem: No
Theme examined:

Vicmap Transport (Air) ☷ GA Aviation

File Used:

1. \yarraranges\vmpropsimp_200509\TR_AIR_INFRA_AREA_CENTEROID.shp
2. \yarraranges\vmpropsimp_200509\TR_AIRPORT_INFRASTRUCTURE.shp
3. \yarraranges\vmpropsimp_200509\TR_AIR_INFRA_AREA_POLYGON.shp
4. \TOPO250K\ point_AircraftFacilityPoints.shp

Problem Discovered:

Discrepancies:

Red box = There is a 45m discrepancy between the runway point of GA and the boundaries of the runway defined by Vicmap (Green line).

Blue box = On the other hand GA has two extra landing sights not depicted by Vicmap data.

Unique Problem: No
Theme examined:

Vicmap Transport (Air) ☢ GA Aviation

File Used:

1. .\yarraranges\vmpropsimp_200509\TR_AIR_INFRA_POINT.shp
2. .\TOPO250K\ point_AircraftFacilityPoints.shp

Problem Discovered:

Discrepancies: Of the 8 helipads depicted by Vicmap data only one is represented by the GA aircraft facility points. In addition the discrepancy between this helipad is about 2740m (green line). As they don’t have names they may be referring to different helipads.

Unique Problem: No
Theme examined:

Vicmap Transport (Road) ⇔ GA RoadTransport

File Used:

1. \yarraranges\vmpropsimp_200509\TR_ROAD.shp
2. \TOPO250K\arc_Roads.shp

Problem Discovered:

Discrepancies:

1. There are inconsistent discrepancies throughout the whole area between the roads. There is a 50m discrepancy at the intersection below (green line).

2. Only some roads (major) are covered by GA data.

Unique Problem: No
Theme examined:

Vicmap Transport (Rail) ◇ GA RailTransport

File Used:

1. \yarraranges\vmpropsimp_200509\TR_RAIL.shp
2. \TOPO250K\arc_RailwaytunnelLines.shp

Problem Discovered:

Discrepancies: There is a rail bridge for GA data, but it is not included in the Vicmap TR_Rail.shp which is supposed to incorporate railway tunnels as well.

Unique Problem: No
**Theme examined:**

Vicmap Transport (Rail) ⇔ GA RailTransport

**File Used:**

1. `yarraranges\vmpropsimp_200509\TR_RAIL.shp`
2. `TOPO250K\arc_Railways.shp`

**Problem Discovered:**

**Discrepancies:** The rails follow the same patterns but like roads there are discrepancies. Below (green circle) shows a discrepancy of greater than 50m.

![Map Diagram](image)

**Unique Problem:** No
**Theme examined:**

Vicmap Transport (Rail) ⇔ GA RailTransport

**File Used:**

1. `.\yarraranges\vmpropsimp_200509\TR_RAIL.shp`
2. `.\yarraranges\vmpropsimp_200509\TR_RAIL_INFRASTRUCTURE.shp`
3. `.\TOPO250K\arc_Railways.shp`
4. `.\TOPO250K\arc_RailwayBridgePoints.shp`
5. `.\TOPO250K\arc_RailwayStopPoints.shp`

**Problem Discovered:**

**Discrepancies:**

1. There is almost a one to one representation of railway stations, at close proximity to each other. The discrepancy shown bellow (green line) is greater than 45m. However GA data is missing a few stations.

2. The Railway bridges are very inconsistent, for both GA and Vicmap data. They cover different areas and the unavailability of bridge names does not allow for cross referencing.

**Unique Problem:** No
Theme examined:
Vicmap Transport (Rail) ⊗ GA RailTransport/ RoadTransport

File Used:
1. \yarraranges\vmpropsimp_200509\TR_RAIL.shp
2. \TOPO250K\arc_FootTracks.shp
3. \TOPO250K\arc_Railways.shp

Problem Discovered:

Discrepancies: GA footTracks is supposed to cover pedestrian ways not following vehicle tracks. However the Lilydale-Warburton rail trail which is designated as rail trail by Vicmap has depicted as foot track by GA. The disjoint railway gives the impression it is an old track which is not in use anymore. However the small yellow line on the low right hand side of the image depicts a section of this pathway that has been depicted as normal railway by GA connecting the foot tracks.

Unique Problem: No
Result for Casey:

Theme examined:

Vicmap (Property Simplified) ⇔ GA (Habitation)

File Used:

1. \casey\vmpropsimp_200509\PROPERTY_MP.shp
2. \TOPO250K\point_BuildingPoints.shp
3. \TOPO250K\arc_HabitationBoundaries.shp

Problem Discovered:

Discrepancies: According to the GA data description, point_BuildingPoints.shp and arc_HabitationBoundaries.shp should together cover all the built-up areas. However, as shown in the highlighted section, not all built-up area on the Vicmap PROPERTY_MP.shp is covered by the GA.

Unique Problem: No
Theme examined:
Vicmap (Property Simplified) ⇔ GA (Habitation)

File Used:

1. \casey\vmpropsimp_200509\PARCEL_MP
2. \TOPO250K\point_BuildingPoints.shp

Problem Discovered:

Discrepancies: Logically, building points from GA should be located inside a parcel property, however the examples below show that some points are located in the road section. Not all problems found are highlighted.

Unique Problem: No
Theme examined:
Vicmap Transport (Road) vs GA RoadTransport

File Used:
1. .\casey\vmtrans_200509\TR_ROAD.shp
2. .\TOPO250K\arc_Roads.shp

Problem Discovered:
Discrepancies:
- For GA arc_Roads.shp, only major roads are shown, therefore comparing with Vicmap TR_ROAD.shp, the amount of coverage is much less.
- For the roads that are covered by both data sources, it can be seen that they are not lined up properly on top of each other.
- The Vicmap TR_ROAD.shp provides more actual road features, such as highway exits, than just showing the general road layout.

Unique Problem: No
**Theme examined:**

Vicmap Transport (Rail) ⬤ GA RailTransport

**File Used:**

1. \casey\vmtrans_200509\TR_RAIL.shp
2. \TOPO250K\arc_Railways.shp

**Problem Discovered:**

**Discrepancies:**

- Vicmap TR_RAIL.shp is providing more actual features than GA arc_Railways.shp. This problem is shown in the red box.

- The rail from the two sources doesn’t match. The GA arc_Railways.shp generally zigzags along the Vicmap TR_RAIL.shp’s rail. The general discrepancy is about 40m. This problem can be seen in both red and blue box.

**Unique Problem:** No
**Theme examined:**

Vicmap Transport (Rail) ⊗ GA RailTransport

**File Used:**

1. `.\casey\vmtrans_200509\TR_RAIL_INFRASTRUCTURE.shp`
2. `.\TOPO250K\point_RailwayStopPoints.shp`
3. `.\TOPO250K\point_RailwayBridgePoints.shp`

**Problem Discovered:**

**Discrepancies:**

- Narre Warren station between Vicmap and GA is separated by 270m.
- No bridge point is shown in GA point_RailwayBridgePoints.shp, but Vicmap TR_RAIL_INFRASTRUCTURE.shp is showing that there are bridges in the area.

**Unique Problem:** No
**Theme examined:**

Vicmap Transport (Road) ⊗ GA RoadTransport

**File Used:**

1. `.\Product descriptions\Transport\VicmapTransport_Prod%20Desc_v2_4%20.pdf` (page 51)


**Problem Discovered:**

**Classification code inconsistency:** The classification code for road type is different for the two datasets.

<table>
<thead>
<tr>
<th><strong>Vicmap Transport: TR_ROAD</strong></th>
<th><strong>GA RoadTransport: ROAD</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Code</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>0</td>
<td>Freeway</td>
</tr>
<tr>
<td>1</td>
<td>Highway</td>
</tr>
<tr>
<td>2</td>
<td>Arterial</td>
</tr>
<tr>
<td>3</td>
<td>Sub-Arterial</td>
</tr>
<tr>
<td>4</td>
<td>Collector</td>
</tr>
<tr>
<td>5</td>
<td>Local</td>
</tr>
<tr>
<td>6</td>
<td>2wd</td>
</tr>
<tr>
<td>7</td>
<td>4wd</td>
</tr>
<tr>
<td>8</td>
<td>Unknown</td>
</tr>
<tr>
<td>9</td>
<td>Proposed</td>
</tr>
<tr>
<td>11</td>
<td>Walking Track</td>
</tr>
<tr>
<td>12</td>
<td>Bicycle Track</td>
</tr>
</tbody>
</table>

**Unique Problem:** No. Due to time constraint, no other layers were checked for classification inconsistency. However, it is likely that this problem will apply for other layers representing the same features.
5. DISCUSSION

5.1. Methodology and Aim

The lack of confidence in the time data was provided by different organizations meant that the aim of the research had to be modified slightly every time a new dataset arrived. As such there are three aims for this project, which resulted in a new methodology each time the aim was modified. However, the methodology change proved useful as a more in depth understanding was acquired each time. The final methodology:

- **First** requires learning how to use the metadata document.
- **Secondly** to understand how the provided shapefiles have been classified into groups.
- **Thirdly** to exclude any shapefiles which cannot be used in the analysis.
- **Finally** use a top down approach to see which shapefiles should be compared.

This approach is much more comprehensive, and can be used as a framework for similar analysis.

The top down method for selecting comparable shapefiles is much faster than trying to understand all shapefile definitions initially then grouping them (which can be very difficult if there are a large number of shapefiles). In addition, because the structure which the data is managed in is studied in detail, it aids for better understanding of how the data providers structure their datasets. Allowing for a comprehensive analysis as it is executed in a structured way.

However the problem with this method is that different organizations do not always structure their datasets in the same way. The dataset structure is generally driven by the organizations own visions of the dataset. Thus some features are hidden away under different shapefiles or different shapefile groups. Such a case occurred once while analyzing the GA hydrographical and GA Infrastructural themes. It was noticed that the Vicmap **Hydro** shapefile “HY_WATER_STRUCTURE_LINE.shp” represented pipelines as part of its features. However the GA shapefile “arc_Pipelines.shp” is under the theme **Infrastructure**. Thus the top down method failed to locate this comparable feature. On the other hand, this hidden feature was found in the end. This is due to the detailed analysis required to understand the shapefiles. However this pipeline analysis could not be carried out due to time constraints.

It is recommended for future use of the final methodology that more care be taken when excluding irrelevant layers at a higher level of shapefile classification. This can be done by a quick revision of the definitions of the excluded shapefiles, when a major feature can’t be found in one dataset.
5.2. Data Structure

The TOPO 250K was supposed to be supplied in a predefined folder structure, grouping different shapefiles groups together. Instead all 65 shapefiles provided by GA were placed in one single directory. As mentioned in Data structure/Naming convention under Result (section 4.1), these shapefiles were grouped manually based on the information provided on the report.txt file (“GA provided layers”). However, if these data were provided in groups, such as the five themes available in the GEODATA TOPO 250K Series 2 Product, the amount of time required to find the relevant metadata and understanding the data structure would have been significantly reduced.

In the GEODATA TOPO 250K Series 2 - Product User Guide, some of these “GA provided layers” are categorised as theme, some as layers (“GA original layers”), while some are not even mentioned. In addition, naming convention codes for the shapefiles described under GA Guild has not been followed.

The lack of clarity and information about these feature groups created much confusion in this project. This problem can be eliminated if metadata is provided for all the extracted data. It is recommended that for future project, data provider should be asked to supply data in groups, and to provide all relevant metadata.

5.3. Reference System

During the data analysis process, it was discovered that the rendering of Vicmap data in ArcGIS was fastest when the “coordinate system” of the “data frame window” was set to the projection system used by Vicmap, i.e. Map Grid of Australia Zone 55 (GDA 94). This was particularly useful when comparing Vicmap Property Simplified layers or Transport with GA data. Both of these Vicmap themes contain large amount of data, thus wasting time due to poor rendering performance. The time lags can also hinder effective comparison as small details between comparisons could be forgotten during this time. The time lag for Vicmap Property Simplified sometimes lasted as long a 3 minutes to fully render the layers. This is in comparison to an almost instant rendering when using the Vicmap projection system.

5.4. Comparison of Result

After comparing the results from the case studies in Yarra Ranges and Casey, all of the issues found were the same. The only exception to this has been a unique case in Yarra Ranges described on page 39. None of the other issues were unique to a specific site.

There were a few cases of terminology inconsistency within both GA and Vicmap metadata. Sometimes there would be an inconsistent use of terminology within one set of metadata itself (section 4.1). Thus understanding the structure and the
terms used by each data provider required a lot of effort. This can be easily avoided if the terminologies used to describe feature classifications is clearly defined, put in context (e.g. how a theme relates to a layer which relates to a feature...), provide sufficient examples and use universally. In addition, an easily accessible contact with the data providers is recommended to clarify such problems efficiently.

The comparison of GA data with Vicmap data highlighted that the selection criteria for some entities were different. Generally the GA data excluded entities smaller than a certain size. This resulted in instances of GA data missing features which Vicmap data represented. Especially if they were small scale entities (e.g. minor roads). Another selection criteria problem was the definition of certain features. For example GA spillway feature definition includes the stilling basin, where as Vicmap data does not. Thus this feature appears to have a discrepancy where the stilling basin exists.

Majority of discrepancies between GA and Vicmap data were approximately 50m. This may be due to the scale difference as Vicmap dataset was at a scale of 1:25,000 which GA dataset was at 1:250,000. However, the discrepancies did at instances reach as high as 2700m.

5.5. Time & Resources Constraint

The quantity and depth of analysis that could have been carried out was severely limited by the lack of time and resources for this research. These limitations have been due to:

- The uncertainty in the data arrival time;
- Late arrival of data;
- Access to the computer lab limited to 9am - 5pm on weekdays;
- External computer resources did not allow for the analysis section to be carried out outside the computer lab hours.

Although the best possible use of the available resources was made, not all comparable shapefiles were compared and some issues were excluded. While it is outside the scope of this pilot project to look at the institutional issues, the late arrival of the data reflects the room for improvement for the data providers.
6. CONCLUSION

A comprehensive methodology was developed to carry out the investigation of integrating Victorian and Geoscience Australia built and natural data. This methodology has been described in a general way and can be used as a framework for carrying out the same investigation for other situations.

The technical issues investigated have been metadata, reference systems, specifications/attribute consistency and discrepancies. Other technical issues were not investigated given the time and resource constraints described in discussion. In addition the GA theme “Relief” and Vicmap “Elevation” which could have been investigated for discrepancies were excluded for the same reasons.

GA metadata was difficult to use, as the structure and specifications were different between provided datasets and its metadata. In comparison, Vicmap metadata was by far easier to use as both metadata and the dataset were provided together in an organized way.

The specifications between GA and Victorian was not consistent. The amount of time required in trying to understand which GA shapefile could be compared with which Vicmap shapefile led to the development of the top down methodology. The top down methodology is a systematic approach to eliminate irrelevant data, and can be used for other case study in the future.

In conclusion, our investigation has highlighted some of the technical issues in integrating the built and natural data within the state of Victoria. In addition, majority of metadata, reference system, specifications/attribute consistency and discrepancy issues in integrating Victoria and national datasets from Geoscience Australia have been systematically documented. The documentation of these issues and the methodology developed for future research will aid in the development of an integration model and framework capable of being used in diverse jurisdictions.
7. REFERENCES


Paez (2004), Why we need the SDI, Lecture 15 for 451-418 Land Administration, Department of Geomatics, University of Melbourne.


Williamson, I.P., Grant, D and Rajabifard, A. (2005) Land Administration and Spatial Data Infrastructures, FIG Working Week 2005 and GSDI-8 Cairo, Egypt April 16-21


8. APPENDICES

- Appendix A - State Datasets – Land Victoria (Vicmap)
- Appendix B - Federal Datasets – Geoscience Australia
- Appendix C - Vicmap Hydro ☰ GA Hydrography
- Appendix D - Vicmap Property Simplified & Transport ☰ GA Infrastructure
- Appendix E – Email from supervisor
Appendix A: State Datasets – Land Victoria (Vicmap)

Below listed out all the layers we received from Land Victoria. The data provided by is cut from the product Vicmap on 2005/09.

<table>
<thead>
<tr>
<th>Vicmap Product</th>
<th>Layer Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address</td>
<td>ADDRESS.shp</td>
</tr>
<tr>
<td>Admin</td>
<td>AD_LGA_AREA_CENTROID.shp</td>
</tr>
<tr>
<td></td>
<td>AD_LGA_AREA_LINE.shp</td>
</tr>
<tr>
<td></td>
<td>AD_LGA_AREA_POLYGON.shp</td>
</tr>
<tr>
<td></td>
<td>AD_LOCALITY_AREA_CENTROID.shp</td>
</tr>
<tr>
<td></td>
<td>AD_LOCALITY_AREA_LINE.shp</td>
</tr>
<tr>
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|                 | PLAN_OVERLAY.shp
|                 | PLAN_UGA.shp
|                 | PLAN_UGB.shp
|                 | PLAN_ZONE.shp
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|                 | CAD_LINE.shp
|                 | CENTROID.shp
|                 | EXTRACT_POLYGON.shp
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|                 | PARCEL_MP.shp
|                 | PARCEL_PROPERTY.shp
|                 | PARCEL_UC.shp
|                 | PROPERTY_CAD_AREA_BDY.shp
|                 | PROPERTY_MP.shp
|                 | PROPERTY_UC.shp
|                 | ROAD_CL_CHAIN.shp
|                 | SYMBOL.shp
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|                 | TR_AIR_INFRA_AREA_POLYGON.shp
|                 | TR_AIRPORT_INFRASTRUCTURE.shp
|                 | TR_RAIL.shp
|                 | TR_RAIL_INFRASTRUCTURE.shp
|                 | TR_ROAD.shp
|                 | TR_ROAD_INFRASTRUCTURE.shp
| Vegetation      | VG_VEG_AREA_UNF_CENTROID.shp
|                 | VG_VEG_AREA_UNF_LINE.shp
|                 | VG_WINDBREAK.shp
### Appendix B: Federal Datasets – Geoscience Australia

The following data is grouped using report.txt.

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| Physiography  | arc_SandRidges.shp |
| Production    | polygon_ProductionIndexes.shp |
| RailTransport | point_RailwayBridgePoints.shp  
|               | arc_RailwayCrossingLines.shp  
|               | arc_Railways.shp  
|               | point_RailwayStopPoints.shp  
|               | arc_RailwayTunnelLines.shp |
| Relief        | arc_Contours.shp  
|               | polygon_HypsometricAreas.shp  
|               | point_SpotElevations.shp  |
| RoadTransport | arc_FootTracks.shp  
|               | arc_RoadCrossingLines.shp  
|               | point_RoadCrossingPoints.shp  
|               | arc_Roads.shp  |
| SeriesIndex   | polygon_GeodataIndexes.shp  
|               | polygon_MapIndexes.shp  |
| Surveymarks   | point_HorizontalControlPoints.shp |
| Utility       | arc_Pipelines.shp  
|               | arc_Powerlines.shp |
| Vegetation    | polygon_CultivatedAreas.shp  
|               | polygon_NativeVegetationAreas.shp  
|               | arc_VegetationBoundaries.shp  
|               | polygon_VegetationVoids.shp |
| Waterbodies   | polygon_Flats.shp  
|               | polygon_Lakes.shp  
|               | polygon_Reservoirs.shp  
|               | arc_WaterbodyBoundaries.shp  
|               | polygon_WatercourseAreas.shp  
|               | point_Waterholes.shp |
Appendix C: Vicmap Hydro ⇆ GA Hydrography

Vicmap Hydro:

1. Navigation Theme
   a. **HY_NAVIGATION_LINE**: Includes- Reefs & Ledges
   b. **HY_NAVIGATION_POINT**: Includes-; Buoys, Beacons, Rocks & Wrecks.

2. Structure Theme
   a. **HY_WATER_STRUCT_AREA_CENTROID**: Includes- Dam Batters & Spillways
   b. **HY_WATER_STRUCT_AREA_POLYGON**: Includes- Dam Batters & Spillways
   c. **HY_WATER_STRUCT_AREA_LINE**: Includes- Dam Batters & Spillways
   d. **HY_WATER_STRUCT_LINE**: Includes- Wharfs, Marinas, Offshore Platforms, Breakwates, Launching Ramps, Dam Walls, Spill Ways, Locks & Pipelines
   e. **HY_WATER_STRUCT_POINT**: Includes- Locks, Wells & Watering Places

3. Features Theme
   a. **HY_WATER_AREA_CENTROID**: Includes- Lakes, Flats (subject to inundation), Wetlands, Pondages (saltpan & sewrage), Watercourse Areas, Rapids & Waterfalls
   b. **HY_WATER_AREA_POLYGON**: Includes- Lakes, Flats (subject to inundation), Wetlands, Pondages (saltpan & sewrage), Watercourse Areas, Rapids & Waterfalls.
   c. **HY_WATER_AREA_LINE**: Includes- Shorelines & Junctions
   d. **HY_WATER_POINT**: Includes- Rapids, Springs, Waterfalls & Water body points (dams).
   e. **HY_WATERCOURSE**: Includes- Watercourses (ie channels, rivers & streams) & Connectors. Arcs run downstream.

GA Hydrography:

1. Waterbodies Layer
   a. **polygon_Lakes**: A naturally occurring body of mainly static water surrounded by land. Only lakes with an area of 62,500 square meters or greater have been captured. Lakes which are smaller than this and located on a watercourse are shown as Waterholes. Those not on a watercourse and smaller than the minimum size for lakes, are shown as Water point features.
   b. **polygon_Reservoirs**: A body of water collected and stored behind a constructed barrier for a specific use. Only reservoirs with an area of 140,625 square meters or greater have been captured. Reservoirs smaller than 140,625 square meters in area are shown as Water Tank features.
c. **polygon_WatercourseAreas**: A natural channel along which water may flow from time to time. Only watercourses with a length of 2.5 kilometers or greater have been captured. Only watercourses wider than 250 meters and with an area of 625,000 square meters or greater are shown as polygon features.

d. **points_WaterHoles**: A natural depression which holds water within a non-perennial watercourse. Waterholes with an area of 62,500 square meters or greater are shown as lakes.

2. **Drainage Layer**

   a. **arc_DamWalls.shp**: *Description*: A barrier of earth and rock, concrete or masonry constructed to form a reservoir of water storage purposes or to raise the water level. *Selection criteria*: Only dams with a length of 250 metres or more have been captured.

   b. **polygon_RecreationAreas.shp**: *Description*: An area of land maintained for Name recreational purposes. *Selection criteria*: These features replace Built-up Area Voids in GEODATA TOPO 250K Series 1, where the areas formerly shown as voids meet the definition of a Park. Parks will usually be surrounded by built-up areas, however they may also be isolated polygons outside the builtup area. Parks should not be confused with the Reserve-Name Conservation feature. Only parks with an area of 140 625 square metres or greater have been captured.

   c. **point_WaterTanks.shp**: *Description*: A feature constructed on or below the ground for the storage of water. *Selection criteria*: Water tanks are only shown in the unshaded areas on the Fences and Water Facilities Guide. Water tanks with an area of 140 625 square metres or greater are shown as Reservoirs. This feature may represent a single tank or a group of tanks.

   d. **arc_CanalLines.shp**: *Description*: An artificial watercourse conveying water for inland navigation or irrigation purposes. *Selection criteria*: Only canals with a length of 1.25 kilometres or more have been captured. Canals wider than 250 metres and with areas of 312 500 square metres or more, are shown as polygons

   e. **arc_Spillways.shp**: *Description*: A channel or duct formed around the side of a reservoir past the end of the dam, to convey flood discharge from the watercourse above the reservoir into the watercourse below the dam. *Selection criteria*: The spillway feature represents the spillway chute and any associated stilling basins. Where the water overtops the dam wall, a spillway is not shown. Only spillways with a length of 250 metres or more have been captured.

   f. **arc_WatercourseLines.shp**: *Description*: A natural channel along which water may flow from time to time. *Selection criteria*: Only watercourses with a length of 2.5 kilometres or greater have been captured. Only watercourses wider than 250 metres and with an area of 625 000 square metres or greater are shown as polygon features.

   g. **point_WaterfallPoints.shp**: *Description*: A sudden steep decent or vertical drop of water, created by a step or ledge in the bed of a watercourse.
3. Marine Layer

a. `polygon_ForeshoreFlats.shp`: Description: The part of the seabed, or estuarine area, between mean high water and the line of low water. Selection criteria: Only foreshore flats with an area of 390 625 square metres or greater, have been captured.
Appendix D: Vicmap Property Simplified & Transport ⇆ GA Infrastructure

**Vicmap Property Simplified:**

1. **ANNOTATION_TEXT**: All graphics text and display characteristics.
2. **CAD_AREA_BDY**: All cadastral boundaries, which make up properties and/or parcels.
3. **CAD_LINE**: CAD_LINE represents boundaries within the cadastral framework including easements boundaries and government road boundaries.
4. **CENTROID**: Spatial table containing centroid information related to the Parcel and Property polygons.
5. **PARCEL**: A spatial table containing the Parcel Identifiers.
6. **PARCEL_VIEW**: Spatial Representation of parcel or group of parcels.
7. **PROPERTY**: Aspatial table of all properties and occupancies.
8. **PROPERTY_VIEW**: Spatial layer for Property base and footprint objects.
9. **ROAD_CL_CHAIN**: Road Centre Lines as registered in Vicmap Property which are used as a key reference for Vicmap Transport – Road.
10. **SYMBOL**: Symbols as represented in the original MicroStation files.
11. **POINT**: Table containing the "XY" coordinates for all mapbase graphic elements.
12. **ADDRESS**: Vicmap Address.
13. **UNCONNECTED_CENTROID**: Centroid table containing the details related to properties and parcels that are not associated with a polygon.

**Vicmap Transport:**

1. **Airport facilities Theme**
   a. **TR_AIR_INFRA_AREA_CENTROID.shp**: Includes Airports
   b. **TR_AIR_INFRA_AREA_LINE.shp**: Includes; Airports
   c. **TR_AIR_INFRA_AREA_POLYGON.shp**: Includes: Airports
   d. **TR_AIR_INFRA_POINT.shp**: An area set aside or designated for the landing of helicopters
   e. **TR_AIRPORT_INFRASTRUCTURE.shp**: Includes; Airports & Runways

2. **Roads Theme**
   a. **TR_ROAD.shp**: Includes; Bridges, Connectors, Footbridge, Foot Tracks, Roads, Roundabouts & Tunnels
   b. **TR_ROAD_INFRASTRUCTURE.shp**: Includes; Bridges, Tunnels, Gates, Cattle Grids, Barirers, Level Crossings, Roundabouts & Intersections
3. **Railways Theme**
   a. **TR_RAIL.shp**: Includes; Railway Exits, Railway Yards, Railway Bridges, Railway Tunnels, Railways & Tramways
   b. **TR_RAIL_INFRASTRUCTURE.shp**: Includes; Railway Stations, Rail Bridges, Tunnel-rail

**GA Infrastructure:**

1. **Aviation Layer**
   a. **point_AircraftFacilityPoints.shp**: *Description*: A paved or cleared strip on which aircraft take off and land. *Selection criteria*: Only operational facilities are shown. Heliports are only included when they are not within the boundaries of another aircraft facility.

2. **Habitation Layer**
   a. **point_BuildingPoints.shp**: *Description*: A permanent walled and roofed construction or the ruin of such a construction. *Selection criteria*: Buildings in built-up areas are not shown. This feature may represent a single building or a group of buildings. Individual buildings are shown where the scale permits.
   
   b. **polygon_BuiltUpAreas.shp**: *Description*: An area where buildings are close together and have associated road and other infrastructure networks. Included terms are village, town and city. *Selection criteria*: In some instances, parts or suburbs of a town or city may be split from the main body of the built-up area by open land or a double-sided stream. In these cases, the separate built-up area polygons will carry some of the same attributes including the name, eg. ‘Melbourne’. Area features such as parks and lakes, and areas of open space which are not parks, are excluded from built-up area features. Areas of open space which are not parks and have an area greater than 390,625 square metres are excluded from built-up areas.

3. **RailTransport Layer**
   a. **point_RailwayBridgePoints.shp**: *Description*: A structure erected over a depression or obstacle to carry rail traffic. *Selection criteria*: Only significant railway bridges are shown. Railway bridges shorter than 100 metres are shown as points. Railway bridges greater than this are held as chains in the Rail network. Bridges which carry both road and rail traffic are held as coincident Road Bridge and Rail Bridge features in their respective networks. Attributes relate to the railway carried by the bridge.
   
   b. **arc_Railways.shp**: *Description*: A transportation system using one or more rails to carry freight or passengers. *Selection criteria*: Only railways with a length of 1.25 kilometres or more have been captured. Permanent sections of light railways are included. Short lengths of light railways, in position only during the seasonal harvesting of crops, have not been captured.
c. **point_RailwayStopPoints.shp**: *Description:* A recognised stopping place for trains where passengers may board or alight, or where freight is loaded and unloaded. There may or may not be a platform. *Selection criteria:* All railway stations on operational lined have been captured. Former railway stations on abandoned lines are not shown. Names of former railway stations are depicted as localities if the same name is not in use for another locality feature.

d. **arc_RailwayTunnelLines.shp**: *Description:* An artificial underground or underwater passage carrying a railway. *Selection criteria:* Railway tunnels are shown as points when they are shorter than 250 metres. Tunnels which carry both road and railway traffic are held as coincident Road Tunnel and Rail Tunnel features in their respective networks. Attributes relate to the railway which passes through the tunnel.

4. **RoadTransport Layer**

a. **arc_FootTracks.shp**: *Description:* A track designed to carry pedestrian traffic only. *Selection criteria:* Foot tracks will only be shown where they do not follow roads or vehicle tracks shown on the map. Generally, only tracks of national significance are included. Foot tracks with a length of less that 1.25 kilometres have not been captured.

b. **arc_Roads.shp**: *Description:* A route for the movement of vehicles, people or animals. *Selection criteria:* Only roads with a length of 1.25 kilometres or more have been captured. Minor roads may not be shown in built-up areas.
Nima and Yi Li,

250K Topo Data Metadata and User Guide available at:

Information on Satellite Imagery available at:

If you still require more info or the metadata is not available for
the imagery, let me know and I will get in touch with Geoscience
Australia directly.

Hope this helps,
Andrew.