Land Administration and Spatial Data Infrastructures – Trends and Developments

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Keywords: Land administration, Spatial Data Infrastructure (SDI), Cadastral systems, Geodetic Framework, Wireless Communication technologies, Benchmarking, Decision Support Systems.

ABSTRACT

Historically, the strength of a land surveyor lies in the ability to use and understand both measurement science and land management, and to apply these skills in a wide range of land related activities ranging from sustainable development to environmental management. In response to the theme of this conference which focuses on the role of Geomatics in Global Sustainable Development it is appropriate to consider how these skills have evolved and are evolving within the broad surveying discipline.

It is proposed that a major dimension of the measurement science skill is reflected in the growing importance of spatial data infrastructures (SDI) and the land related skills are reflected in the re-discovery that the role of land administration plays in serving economic, environmental and social priorities in society. While SDI play a much broader role than supporting land administration, land administration could be considered a key driver in SDI evolution.

The objective of this paper is to identify SDI and land administration trends and developments by drawing on the research of past, current and future projects undertaken by researchers in the Centre for SDI and Land Administration at The University of Melbourne.

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1. INTRODUCTION

In response to the theme of this Congress which focuses on geomatics (surveying) and its contribution to global sustainable development, it is appropriate to consider how the ability to use and understand both the measurement science and land management disciplines have evolved and are evolving within the broad surveying or geomatics discipline. The ability to apply these skills in a wide range of land related activities ranging from land development to environmental management, has long been an area of strength for professional land surveyors. It is therefore proposed that a major dimension of the traditional measurement science skill of surveying professionals is reflected in the growing importance of spatial data infrastructures (SDI) and the land related skills are reflected in the re-discovery of the role that land administration plays in serving economic, environmental and social priorities in society. While SDI play a much broader role in a modern economy than supporting land administration, land administration could be considered a key driver in SDI evolution.

The objective of this paper is to identify current trends in SDI and land administration in Australia with a view to identifying future roles for the spatial information discipline. In order to achieve this objective past, current and future projects undertaken by researchers in the Centre for SDI and Land Administration in the Department of Geomatics, University of Melbourne (http://www.geom.unimelb.edu.au/research/SDI_research/) are reviewed.

The Centre consists of 12 full-time personnel from a wide range of backgrounds comprising surveying, engineering, geography, law, computer science and science graduates. The focus of the Centre ranges from economic, social, and environmental policy through to spatial data management and technical issues concerned with GPS and the impact of wireless communication technologies.

The Centre has major support from the Victorian Government (Land Victoria), as well as from the NSW Government Support (Land and Property Information NSW), the Australian Federal Government (AUSLIG), the Australian Research Council, in addition to overseas organisations such as The World Bank and the United Nations. As a result of the particularly strong strategic alliance with Land Victoria, researchers in the Centre are able to test their research within the Victorian Government treating it as a "working laboratory".

The focus and breadth of the Centre can be seen in Figure 1, which shows the structure of *Land Administration studies* taught in the Bachelor of Geomatic Engineering course at The University of Melbourne (http://www.geom.unimelb.edu.au/subjects/451/418/index.html). Many members of the Centre are involved in the delivery of the course.

The paper concludes by summarising key lessons and issues arising from the review of trends and developments in land administration and SDI.

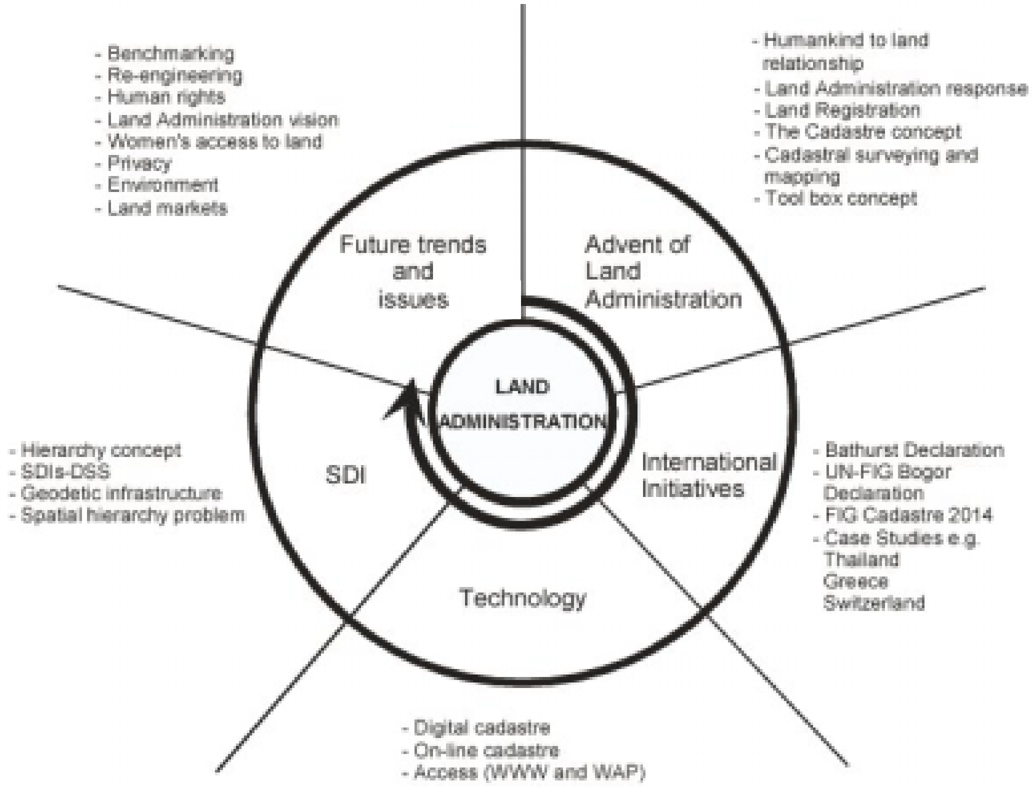

Figure 1

Structure of Land Administration Studies

2. BACKGROUND

Currently many nations are seeking to respond to community pressures to temper short-term economic imperatives with environmental and social concerns (Ting *et al.* 1997) that exist in the context of a world-wide information 'revolution'. This is a significant shift from the global emphasis on economic issues 20 years ago. As a result of the ease of communication, no country has the luxury of existing in isolation. The over-riding global driver of sustainable development which incorporates economic, environmental and social dimensions, and which is tempered by urbanisation, technology and globalisation, impact on all countries. These drivers are having a significant impact on the development of our land administration infrastructures and SDI, which in turn are influencing the required skills and education of future spatial information professionals (Bogaerts *et al* 2002).

Environmental issues are at the forefront of international policy development as evidenced by Agenda 21 from the 1992 UN Conference at Rio de Janeiro (Agenda 1993) and the 1997 UN

Summit on Global Warming. Environmental impact assessments are required by the World Bank and are becoming an essential feature of land use and associated land administration systems.

At the same time, from a social perspective, countries around the world are struggling to meet the challenge of incorporating indigenous rights into the mainstream of land administration in terms of the management of indigenous rights (Ting and Williamson 2001). For example, in Canada, the Inuit people have been granted a separate state. New Zealand's Resource Management Act aims to bring Maori issues into the mainstream of economic planning and land use (Ting and Williamson 2001). In Australia, the High Court's decisions in Mabo (*Mabo v Queensland* (No.2) (1992) 175 CLR 1) and now Wik (*Wik Peoples and Thayorre People v Queensland* (1996) 141 ALR 129) and legislation such as the Aboriginal Land Rights (NT) Act 1976 (Cth), will impact on Australian state land administration systems.

The influence of economic philosophies on land administration policies saw a significant shift in economic thought in the 1980s, away from Keynesianism towards privatisation. In response Australia commenced a path of minimising government intervention and reassessing competition policies within land administration (Lanphier and Parker 1997). This shift in economic thinking has coincided with a growing movement calling for centralised and coordinated global action on the environment and greater consideration of social attitudes to issues that transcend borders (Ting and Williamson 2001). These trends can be clearly seen in the 2001 World Bank electronic Land Policy Conference (http://www.worldbank.org/landpolicy).

3. LAND ADMINISTRATION

Over the last decade there has been a lot of attention internationally on what constitutes "best practice" in land administration and particularly cadastral systems in both developed and developing countries (Williamson 2001, Williamson and Ting 2001). In undertaking land administration reform by drawing on "best practices" in land administration, it is important to consider the factors that drive or affect the reform and the choice of the specific strategies adopted. These factors are many and varied which re-enforces the statement that the land administration system for each country requires its own individual strategy. On the other hand strategies can be developed using the "tool box" approach. That is each specific strategy and resulting system can be made up of many separate, well understood, proven and generally accepted principles and concepts.

3.1 "Best Practices" and Reform

In designing a strategy it is first important to recognise that almost every country will require ***a range of different strategies depending on the relationship of people to land*** in each individual region in the specific country. In simple terms these arrangements include:

- Cities and urban areas, where active land markets operate on titled land,
- Cities and urban areas, occupied by informal settlements (squatter, illegal or low cost systems outside the formal or regulatory structures),

- High value agricultural lands which are titled and are part of the formal land market,
- Private untitled lands in rural areas and villages,
- Informal or illegal settlements in rural areas, especially in government forests,
- Lands which are subject to indigenous rights,
- Lands in all categories which are the subject of claims from previously dispossessed persons, and
- Government or state lands, reserves and forests and usually many other forms of common property.

To some degree these categories are common to all developing (and many developed) countries.

The second consideration is that the relationship of people to land is dynamic with the result that there is ***an evolution in each of these categories***. None of these relationships stay the same in the long term. They are affected by the impact of the global drivers on the relationship of people to land such as sustainable development, urbanisation, globalisation, localisation, economic reform and environmental management, as discussed above. As a result a different land administration response is required for each area or situation, within an overall national vision or strategy. The categories of land tenure can be considered a continuum of land tenure relationships in a country where, to some degree, tenures evolve from undocumented customary or informal tenures to documented or formal individual private rights.

Third, the stage of development of the specific country has a major impact on the appropriate form of land administration response, and what is considered “best practice” for the individual country. As an example, in simple terms in the Asia-Pacific area, there are four general categories of countries:

- Developed countries, such as Japan, Korea, Australia, New Zealand and Singapore,
- Newly industrialised countries or countries in transition, such as China (PRC), Indonesia, Thailand, Malaysia and the Philippines,
- Countries at an early stage of development such as Vietnam and Laos, and
- Island states such as Fiji, Tonga and Vanuatu.

While each country has different development priorities, those in each group do share some similar priorities (Williamson 1994, Rajabifard and Williamson 1999). A complication is that many countries do not fit easily into these categories with some countries having aspects of all categories. But in general the stage of development overall of an individual country does significantly influence the choice of which land administration strategies are adopted.

The combination of all these factors determine, or at least strongly influence, the specific strategy(ies) adopted in reforming or establishing the land administration system.

3.2 A Land Administration "Tool Box"

These strategies draw on the land administration "tool box" for their institutional, legal, technical and administrative solutions (Williamson 2001). The "tool box" therefore includes a whole range of surveying and mapping technologies and approaches depending on the stage of development of the country and the major human-land relationship which is being surveyed or mapped. These options include sporadic and systematic approaches, graphical and mathematical surveys, different positioning technologies such as satellite positioning or scaling off photomaps, different mapping technologies such as photomaps, topographic mapping and simple cadastral maps.

In addition there are a range of options for recording land tenure relationships, which are important administrative and institutional "tools". There are government guaranteed land titles, deeds registration systems, title insurance systems, qualified titles (both to boundaries and title), individual ownership and communal or customary ownership.

For all these arrangements there are a range of technologies which are again strongly influenced by the wealth and development of the country. For example whether titles or deeds and cadastral maps will be computerised or held as paper records or whether the Internet can be utilised to access land records. Institutional arrangements are influenced by the same factors. Whether the system is decentralised, deconcentrated or centralised. Also see the paper by the author in this Congress in Session TS7.2 Cadastral Innovations II.

3.3 Benchmarking

The question as to what constitutes a good land administration system, cadastre or SDI is of great interest to international aid agencies, policy makers and administrators in both developed and developing countries. Similar questions relate to whether a jurisdiction warrants land administration reform and if a project does eventuate, how do you evaluate whether it has been a success or not. The FIG has been involved in starting to address such questions (Steudler *et al.* 1997). In this context a Land Administration System may be considered to be the processes of recording and disseminating information about *ownership*, *value*, and *use* of land, whereby a *spatial information infrastructure* links and underpins these processes (see figure 2).

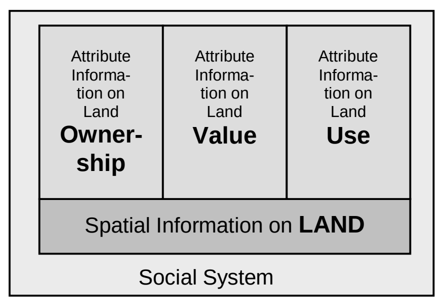

Figure 2: A Land Administration System

As a result of this interest, research is underway to develop a framework and methodology for benchmarking and evaluating Land Administration Systems. The methodology will use a case study approach to assist in developing a standardised country report, to help understand and analyse the overall network of the organisations and their impact on the whole Land Administration System. The methodology will provide indicators for use by *policy-makers* and *operational managers***.** Indicators for policy makers will be developed dealing with economic, social and environmental issues, and will include:

- *Economic issues* such as land market performance, agricultural productivity, access to credit revenue;
- *Social issues* such as security of ownership, reduced land disputes; and
- *Environmental issues* such as protection against encroachment and sustainable development.

Indicators for operational managers will be developed dealing with information management, people and infrastructure and will include:
- *Information management* such as use of information and data standards;
- *People* such as staff, academia and professional association; and
- *Infrastructure* such as legislation, organisations, operational links and budgets.

These investigations of the dimensions and components of land administration systems has formed a basis for more detailed research into spatial data infrastructures and associated legal, technical and institutional issues. See the paper presented in the Congress by Steudler and Williamson in Session TS7.1 cadastral Innovation I for more details.

4. SPATIAL DATA INFRASTRUCTURES

The last few years have seen a great deal of attention given to spatial data infrastructures. For example the United Nations Regional Cartographic Conference (UNRCC) for the Americas (2001) had the majority of papers addressing SDI issues. Also the annual Global Spatial Data Infrastructure (GSDI) conferences have attracted a lot of attention, especially in Australia. The concept of SDI at different jurisdictional levels from local, state and national through to regional (multinational) and global perspectives is complex. This, and the fact that the SDI concept is still evolving, has precipitated the need for research into the nature and concept of a hierarchical SDI in which it is important to understand the relationship within and between different jurisdictional levels. At the larger scales, SDI is intimately linked to land administration while at the smaller scales it links more to demography, geography and environmental management.

4.1 The SDI Concept

As a concept, Spatial Data Infrastructures (SDI) are an initiative intended to create an environment that enables a wide variety of users, who require access to and retrieval of consistent data sets, of a certain area covered by the SDI, in an easy and secure way (Rajabifard *et al.* 1999, 2000a, 2000b). The core components of SDI are commonly viewed as policy, access networks, technical standards, people (including partnerships) and data, which are the tools to provide an environment in which all stakeholders, both users and producers

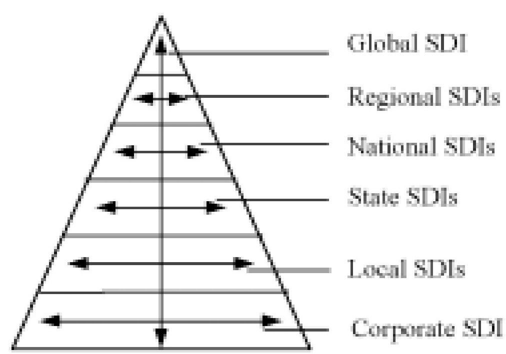

Figure 3: The complex SDI relationships within and between levels (Rajabifard *et al*. 2000a)

of spatial data**,** can cooperate with each other and utilise technology in a cost-effective way to better achieve the objectives at the appropriate political/administrative level (Chan *et al.* 2001, Rajabifard *et al.* 2001).

Relationships among different levels of SDIs are complex (Figure 3). This complexity is due to the dynamic, inter-and intra-jurisdictional nature of SDIs. One way to observe and map these relationships in the context of an SDI hierarchy can be to assess the impact and relationships of each component of any level of SDI on the same component of an SDI at a different level. Rajabifard *et al.* (2000a) observed the behaviour and inter-relationships between any level of SDI on the other levels through each of the components, and demonstrated a general pattern of direct and indirect potential impacts and relationships between them.

The development of an SDI is a matter of cooperation and partnerships between all stakeholders. Political support provides legitimacy and encourages the necessary financial investment for the SDI development. Knowledge about the types of data, its location and quality is also required. It is also important to provide access to the data as the measure of success of the SDI will be the widespread use that is made of it and an appreciation by its users that it is providing the promised benefits which were the justification for establishing the SDI.

With increasing frequency, countries throughout the world are developing SDI to better manage and utilise their spatial data assets. A number of publications document the various aspects of the development of national SDIs in recent years (Masser 1998, Onsrud 1998). These countries are also finding it necessary to cooperate with other countries to develop regional and global (multinational) SDIs to assist in decision-making that has an important impact across national boundaries. The key factors that facilitate the development of regional (multinational) SDIs involve complex social, technical, institutional and political research, which is being conducted in association with AUSLIG and the Permanent Committee on GIS in Asia and the Pacific (Rajabifard and Williamson 2000a, 2000b).

4.2 SDI Development: State and National

Automated systems, such as land title systems and digital cadastral or property maps, are being seen increasingly as an integral part of developing a state's or nation's SDI and demonstrate the potential for land administration and cadastral systems evolution driven by advances in technology.

The management of a cadastral system's digital spatial data has consequently prompted considerable research, generally with a focus limited to the organisation maintaining the cadastral map. Yet, the approach of viewing the maintenance of cadastral maps as a system encompassing the entire cadastral industry has not been comprehensively studied and documented (Hunter and Williamson 1990). This approach is seen as essential to transform cadastral mapping from its current organisation specific isolation, into a form that is truly interoperable with the processing of spatial cadastral information in a digital environment and a SDI.

To this effect research has been conducted (Effenberg *et al.* 1999) which substantiates the existence, analysis and design of a spatial cadastral system within the overall cadastral system. Comparative analysis of a number of international, western spatial cadastral systems, was conducted to establish the boundaries of a spatial cadastral system as well as methodologies to structure and document such a system, which was then undertaken for the spatial cadastral systems of the Australian state of Victoria. The developments of existing spatial cadastral systems, provides the basis for the presentation of a range of solution alternatives to manage the spatial data associated with the maintenance of the multipurpose cadastral map in a digital and Internet enabled environment.

4.3 SDI Development: Data Integration

At a more local level, one of the most fundamental problems restricting the integration, comparison and transfer of data within and between jurisdictions in SDIs is the fragmentation of data between non-coterminous boundary systems. Many administrative boundaries have been created by individual agencies to meet their specific needs with very little coordination. Due to this lack of co-ordination, current technologies for analysing geospatial information, such as Geographic Information Systems (GIS), cannot provide accurate results. As a result, there is a fragmentation of information over a series of boundary units. This fragmentation of information not only limits the potential uses for data collected but also the potential scope of GIS analysis possible between boundary layers.

To this effect research is being conducted towards the hierarchical reorganisation of administration boundaries to enhance data integration and exchange between agencies in both metropolitan (Eagleson *et al.* 2000, 1999) and rural environments (Eagleson *et al.* 2001a, 2001b). The methodology adopted utilises the principles of Hierarchical Spatial Reasoning (HSR) theory and incorporates them into the automated design of administrative boundaries.

4.4 Developing Business-Infrastructure Relationships

Importantly, SDI are not ends in themselves. Unless they serve a purpose and are driven by user needs their role and justification is questionable. The spatial data in the SDI is seen as basic infrastructure, which supports sustainable development, and in particular economic development, environmental management and social stability. It must be users or business systems, which drive the development of SDIs. The business systems that rely on the infrastructure in turn become infrastructure for successive business systems. And so the complex arrangement of partnerships develops as the SDI develops (Chan 1998, Chan *et al.* 2001). This has led to research to understand the relationship between infrastructures and business processes that rely on them. This is shown diagrammatically in Figure 4.

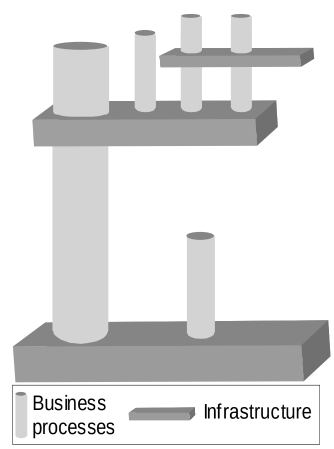

Figure 4. Infrastructure and business process modules (after Chan and Williamson 1999)

4.5 Developing Directions and Partnerships

As part of the on-going research into SDI development, the Centre organised an International Symposium on SDI at The University of Melbourne, 19-20 November, 2001, (http://www.geom.unimelb.edu.au/SDI/) directly preceding the 2001 AURISA Conference in Melbourne. This event was supported by International, National and State Organisations including Global Spatial Data Infrastructure (GSDI), Permanent Committee on GIS In Asia and the Pacific (PCGIAP), Permanent Committee on Spatial Data Infrastructure for the Americas (PC IDEA), European Umbrella Organisation for Geographic Information (EUROGI), Public Sector Mapping Agencies (PSMA), Australian Land Information Group (AUSLIG), Institute of Surveyors Australia (ISA), and Mapping Sciences Institute of Australia (MSIA) and Land Victoria, as well as keynote presentations from leading International and Australian government, industry and academic representatives.

The objective of the symposium is to provide a clearer insight to the trends and developments in SDI and particularly in their hierarchical nature and the key role that partnerships play in their operation. One of the future areas for SDI research is in modeling SDI and better understanding the role of partnerships in the operation of SDIs.

Topics covered in different sessions included:

- Global and Regional SDI Initiatives
- National SDI initiatives drawing on case studies from initiatives from the Asia-Pacific, Europe and the Americas
- Elements of National SDI Development –State, Local and Corporate SDIs, taking examples from Australia and the United States
- Socio-political, Economic and Cultural dimensions of SDI Development
- Technical Manifestations of the SDI Concept.

5. TECHNICAL FRAMEWORKS

Communication technologies such as the Internet and wireless are revolutionising methods of maintaining, disseminating and accessing spatial data. To fully utilise these technologies there must be a clear understanding of how they impact on and assist in implementation of a SDI that supports the human-land relationship.

The integration, and subsequent querying of spatial datasets, the locating and obtaining of datasets across a network, and the transfer of dissimilar spatial datasets across networks are all concepts that have arisen in an attempt to better utilise the spatial datasets that are in existence (Phillips *et al*. 1998). Wireless, Internet, GIS and the Global Positioning System (GPS) are applications seeking to tap into mainstream markets where the common underlying concept is a geoinformation system that has a combination of spatial and aspatial information useful in a range of contexts (Polley *et al.* 1997, Polley and Williamson 1999a). Research is on-going to understand the impact and potential of these technologies.

5.1 Positioning Technologies

Satellite positioning, and the GPS in particular, has established itself internationally as a major tool for spatial data acquisition. This is evidenced by the widespread implementation of permanent, Continuously Operating (GPS) Reference Station (CORS) networks. Germany, Sweden, United States, Netherlands, Great Britain, Japan, Hong Kong, Singapore and Australia are just some examples of countries that have established geodetic CORS networks in addition to any networks intended for safety of life, marine navigation, and fleet management for example.

It is recognised that for spatial data to be used correctly and wisely metadata that describes data quality, in addition to other attributes, should accompany it (Nebert 2000). Data quality for positional information is generally given in terms of a standard deviation and is a result of the data capture process. Mis-specification of this quality parameter may result in inappropriate use or reduced utility of the data. At present, the measures of GPS quality given by common software packages are either over-optimistic, or conversely, are overly conservative and therefore have low fidelity (Keenan and Cross 2001, Barnes *et al*. 1998, Wang 1999).

Research (Brown *et al.* 2001, Millner *et al.* 2001) being conducted by analysis of error at known reference stations aims to develop a general stochastic model that will provide higher fidelity and higher precision results over medium length static GPS baselines. Development of such a model will lead to an increased understanding of the stochastic properties of the double-differenced observables and, hence, to more correct stochastic modeling in other conditions. This will include estimates of the true errors at Victoria's GPSnet base stations and the relationships between the observing conditions and the stochastic behaviour of the observables in the Victorian Geodetic framework.

5.2 Communication Technologies

There has been great optimism about the potential of information and communication technologies in revolutionising land administration and the use of spatial data. The convergence of wireless communications, positioning technology and networking computing is now capable of providing new facilities, new applications and as a result, new challenges for spatial data providers and users.

Wireless access to data is a rapidly emerging field, particularly with the recent escalation and prominence of the wireless Internet and technologies such as the Wireless Application Protocol (WAP), I-mode and the upcoming General Packet Radio System (GPRS) and Universal Mobile Telecommunications System (UMTS). Wireless communication is inherently linked to location, and already many wireless providers are using GIS to supplement their services to clients. Relevant information, with respect to time and location, can now be delivered to users via devices such as mobile phones and Personal Digital Assistants.

However, the infrastructure requirements for wireless applications that utilise spatial information need to be determined and integrated into the future design of SDIs so that they may reflect and support the changing nature of spatial information use. Many applications that have been developed to date use and/or deliver spatial information to mobile users, however none of the applications currently access data through established SDIs. Rather than individual organisations duplicating and maintaining their own data sets, accessing them through some standard SDI would be most beneficial and would ensure that fundamental data sets would remain the responsibility of the custodian. Naturally, different applications will have varying spatial data usage requirements, however it is envisaged that there will be common infrastructure elements (such as query and delivery mechanisms) for a range of applications (Millner *et al.* 2001, Smith *et al.* 2001a and 2001b).

5.3 The Internet

The World Wide Web (WWW) is now a reliable and efficient source of information worldwide. With this in mind, traditional cadastral systems have been looking to the WWW as a tool that will better serve the users of land information. The motivations include reducing the cost of the cadastral system; extending the applications and marketable uses of registered cadastral survey information; improving overall efficiencies of lodgment, registration, examination and use of cadastral survey information; and ensuring that the system can take full advantage of developing technology (Falzon and Williamson 2001). The development of a digital environment to manage land information, in particular, cadastral data, seems to be the most logical solution (Falzon and Williamson 2001). This research and the research of Scheu *et al.* (2001) highlight the need for a more sophisticated form of digital lodgment of spatial cadastral data so that surveyors lodge their data through a QA process which incorporates adjustment routines thereby allowing the state DCDB to be updated automatically.

The advent of the Internet as a medium for cadastral data transactions has led to a great deal of conjecture about the solutions that could be produced to improve data transfers. Polley and Williamson (1999b) discuss how the combination of GIS technology and WWW presentation technology provides new uses for the cadastre and cadastral data and similarly provides for a wider and more diverse audience, especially though the ability to provide information tools that hide the underlying technology and provide a mix of spatial and non-spatial information. The move to providing widely useable information tools has seen GIS, Cadastral and Internet industries move closer together. As a result, GIS are becoming simpler information systems, the cadastral dataset is becoming a key portion of data within these information systems, and the WWW is presenting these information systems to new user bases.

One of the more significant improvements in the last few years was the adaptation of the WWW as the medium of integration and presentation of the cadastre (Majid and Williamson 1999). Map Server software extends GIS functionality across the WWW and enables the creation of live maps based on user queries. Map Servers allow developers to produce geographic information by gathering data from several sources simultaneously, thus behaving as a server to the users across the WWW (Majid and Williamson 1999).

The work of Phillips (Phillips *et al.* 1998, 1999) commenced research along this direction through the role of metadata engines in discovering and presenting information from multiple sources to users within a SDI. In terms of information discovery metadata engines have gone a long way toward creating collections of individual data sets located over a network from many different, and differently located, databases (Phillips *et al.* 1998, 1999). The importance of metadata engines is that they can be used to create virtual databases to be used in planning and decision making processes, with the support of spatial data base technologies including data warehouses, data marts, clearinghouses and addressing issues of interoperability, which are central to the concepts and achievement of SDI. Research into this area required modifying the public domain metadata search system “ISITE” to act as a metadata engine and test the relationship of these current data base and discovery technologies within the concept of developing SDIs (Phillips *et al.* 1998, 1999).

The trends towards developing multi-purpose cadastres to address planning for sustainable development issues as well as fiscal and economic imperatives is evident in a range of Western nations such as Australia (Williamson 1996); Canada (MacLauchlan and McLaughlin 1998); Denmark (Enemark 1994); Germany, Austria and Switzerland (Hawerk 1995); New Zealand (Robertson 1996); and USA (NRC 1983). Cadastral data is really but one important layer in the variety of datasets that would be useful for the complex decision making needed for sustainable development. There are therefore many benefits to the realisation of a Multi-Purpose Cadastre concept through the use of metadata engines, WWW, distributed databases and Map Servers. This has fuelled research into Australian and international developments on bringing cadastral systems online and assisting in managing complex land tenure systems (Majid and Williamson 2001). By developing a prototype of a multipurpose cadastre based on the trends and features of existing system developments many implementation issues were explored including data, spatial processing, data delivery and clients (Majid and Williamson 2001).

6. INSTITUTIONAL AND ADMINISTRATIVE FRAMEWORKS

People are the key to transaction processing and decision-making. All decisions require data and as data becomes more volatile human issues of data sharing, security, accuracy and access forge the need for more defined relationships between people and data. The rights, restrictions and responsibilities influencing the relationship of people to data become increasingly complex, through compelling and often competing issues of social, environmental and economic management. Facilitating the role of people and data in governance that appropriately supports decision-making and sustainable development objectives is central to the concept of SDI.

6.1 Land Administration Infrastructure

Land administration has a significant role to play in supporting sustainable development. It is proposed that sustainable development objectives can only be achieved when there is active co-operation between civil society and the information industry in a way that produces data that is able to alleviate the tension in decision-making between immediate economic priorities and sustainability concerns for key decision-makers.

However, current infrastructures for land administration do not adequately address the complex and dynamic relationship between public and private rights, restrictions and responsibilities in land use that arise from the competing priorities inherent in sustainable development objectives. Land administration infrastructure for sustainable development requires appropriate principles for integrated legal and institutional infrastructures (Ting and Williamson 2001).

The definition of such legal and institutional infrastructures has required tracing the evolutionary path of societies, the commerce of land and the emergence of land administration infrastructures, particularly with respect to the dynamic balancing act between individual right, public interest and the State (Ting and Williamson 2001). These justify the need for appropriate, integrated land administration systems to better support sustainable development. They also stimulate the need to develop key principles for a framework of legal and institutional infrastructures for land administration that will facilitate the necessary dialogue between private and public interests in land and land use to better support sustainable development (Ting and Williamson 2001).

These issues have been extensively researched with an example of this work being the joint United Nations – International Federation of Surveyors Workshop and Conference on Land Tenure and Cadastral Infrastructures for Sustainable Development. This was organised in Bathurst, Australia and was followed by an international conference in Melbourne, Australia in October 1999 (UN-FIG 1999, Williamson *et al.* 1999).

These initiatives resulted in The UN-FIG Bathurst Declaration on Land Administration for Sustainable Development. The workshop brought together 40 leading experts and researchers from around the world, from a wide range of disciplines, including six UN agencies, the World Bank, and the UN Director of Sustainable Development. They confirmed the pressing need to re-engineer land administration systems to manage the competing economic, environmental and social priorities that constitute sustainable development as described in the UN's Agenda for Development. The Declaration has been presented in the UN and other international forums around the world including at the UN Headquarters in New York and has been translated into several languages. The Bathurst Declaration builds on other cadastral initiatives such as the FIG Statement on the Cadastre (FIG 1995) and the joint UN-FIG Bogor Declaration on Cadastral Reform (UN-FIG 1996).

The application of these ideas in the future will be the extrapolation of land administration system principles to managing the competing economic, environmental and social priorities for the marine environment. This includes the requirements for a marine SDI and a system to ***administer*** the wide range of rights, restrictions and responsibilities in the marine environment. This research will become more urgent as countries start meeting the requirements of the United Nations Law of the Sea, which initially comes into effect in 2004.

6.2 Legislation

Legislative and administrative frameworks for addressing different problems related to the resolution of land ownership are imperative to developing the clear rights, restrictions and responsibilities, in human-land relationships, necessary for an integrated land administration system.

One problem arising in Australia in relation to this issue is that discrepancies in the location of boundaries of land parcels is widespread and appears inevitable. Alternative solutions are to restore the "paper" boundary, notwithstanding expectations of landholders founded upon occupation at the time of acquisition of parcel, or to permit occupational boundaries to become the new "paper" boundary. Where the occupational boundary prevails the "traditional" manner of bringing this into effect has been adverse possession as in Victoria. The less traditional method is to permit an assessment of the competing interests with the most "just" outcome being statutory encroachment, as in NSW.

A comprehensive land information management system should ideally disclose the complete legal status of all land with disclosure of all public and private rights and restrictions, including rights acquired under adverse possession. Adverse possession of part parcels permits the variation, rectification, and re-adjustment of boundaries with boundary definition being essential to parcel based spatial data sets (Park and Williamson 1999b). Recognising trends to develop national spatial data sets, if a national cadastre is ever to be considered a basic requirement will be a unified national law regarding land ownership. In turn this will require a unified approach to the issue of adverse possession of registered title land, and particularly adverse possession of part of a land parcel, which is a major obstacle in achieving this vision (Park and Williamson 1999a, 1999b).

According to the research of Park (Park and Williamson 1999a, 1999b) the best approach to the inevitable problem is to favour the occupational boundary over the paper boundary. The best available method to permit the occupational boundary is then via statutory encroachment, as adverse possession can be capricious, create much tension and does not necessarily permit a reduction in the transaction costs of the land market dealings.

The ideal outcome would therefore be a scheme suitable for adoption Australia-wide as an initial step towards the unification of an Australian Real Property law. Such a scheme would also be suitable for other jurisdictions that have a registered land title system, or which are in the process of introducing such a system. Adoption of a uniform scheme for Australia is conjectured to simplify the Australian land market and contribute to a less expensive comprehensive land information system or SDI.

Issues concerned with adverse possession and methods of addressing differences between occupational and mathematical boundaries are important but only one of several key research issues based in legislation or the law. For example research into the statutory control of spatial data requires attention, as does the issue of regulation of professionals in the spatial area (Ristevski and Williamson 2001).

6.3 Land Tenure Integration

It has been acknowledged that two land tenure systems exist within Australia, customary Aboriginal land tenure and the system of tenure based on English Common Law, generally reflected in the Australian Torrens System. Both land tenure systems are diverse by nature and are not overly compatible. The vastly different characteristics of Aboriginal land tenure to the Australian Torrens systems makes it difficult for the integration of the two tenure systems into one land registration system.

The unique relationship Aboriginal peoples have with the land has been highlighted in recent years with the passing and implementation of the *Native Title Act* 1993. This Act has endeavored to recognise traditional Aboriginal interests in land, previously recognised by the Common Law of Australia. An integral element of administering the native title process is the requirement that a map and a worded description of the claim area be supplied as part of the initial application.

Aboriginal land tenure boundaries have been mapped in the past by various anthropologists and historians. Mapping and definition of Aboriginal land boundaries by 'surveyors' are likely to provide alternative ways in which native title boundaries are determined, offering a different perspective on the spatial extent of Aboriginal land tenure. There is a need to accurately and unambiguously define the spatial extent of native title within the Australian cadastral system to support land-based infrastructure and the future of native title.

Brazenor *et al.* (1999) identified that a better understanding of Aboriginal land tenure and associated boundary definition is a vital first step towards mapping and documenting boundaries for the purposes of resolving native title disputes and developing institutional infrastructures that can better address the duality of tenure systems. This research explored:

- The characteristics and similarities/differences between the two tenure systems in a spatial context;
- The current methods employed in defining and mapping Aboriginal land tenure boundaries and the appropriateness for the purpose of native title determination;
- Possible ways in which Aboriginal land tenure could be defined and mapped in the future; and
- Possible incorporation of Aboriginal land tenure into the current land administration and land registration systems of Australia (see for example Brazenor *et al.*1999).

The difficulties of integrating customary or traditional tenure systems with "western" land tenure systems has been an ongoing research focus of the Centre as seen in Rakai and Williamson (1995), Ezigbalike *et al. (*1995) and Iatau and Williamson (1997).

6.4 Institutional Frameworks for Decision Support

> *Expanding human requirements and economic activities are placing ever increasing pressures on land resources, creating competition and conflicts and resulting in suboptimal use of both land and land resources. By examining all uses of land in an integrated manner, it makes it*

possible to minimize conflicts, to make the most efficient trade-offs and to link social and economic development with environmental protection and enhancement, thus helping to achieve the objectives of sustainable development (Article 10.1 Agenda 21, UNDSD 2001).

Agenda 21 (1993) confirms the need for institutional tools to facilitate equity, accountability and transparency in land-based decision-making processes, as well as structuring the multidisciplinary and multi-participant environments that characterise decision making for sustainable development and the operational environments of SDIs. Chapter 40 (Agenda 21, 1993) further states there is a need to strengthen capacity to collect and use multisectoral data across the different levels of government/community; to develop means of ensuring planning at different levels and sectors is based on sound information; and to make relevant information accessible in the form and at the time required.

As decision making for natural resource management increasingly involves multiple criteria, cross-disciplinary and multi-stakeholder consultation, the capacity for individuals, departments and organisations to make decisions alone becomes increasingly challenging. Government has an important role to play in developing infrastructure that supports the discovery, access and applications of tools for decision support.

In this context decision support refers to the automation, modeling and/or analysis that enables information to be shaped from data which is useful to decision making and enables improvement in the decision-process. Decision support can be used to structure, filter and integrate information, model information where gaps occur in data, can generate alternative solution scenarios as well as weight these as priorities, and importantly enable group as well as distributed participation in decision-making, usually by means of Decision Support Systems (DSS). DSS can be generally defined as an interactive, computer-based tool or collection of tools that uses information and models to improve both the process and the outcomes of decision making.

DSS are thus becoming important institutional tools for providing a structured, transparent and auditable record for the decision making process (including participants, identified stakeholders, preferences, values and priorities). They are tools which may facilitate an equity of access to the decision making process by relevant stakeholders, by people with different levels of experience with geographic information and to forums within which many stakeholders involved in an issue can collaborate.

For spatial decision making, there is significant capacity for institutional tools like DSS to support integrated decision making for land-based planning and management, and in the support of sustainable development objectives (Feeney *et al.* 2000, 2001). Internationally the importance of providing *more communication and cooperation among developers and users of decision support tools and services aimed at land, natural resource and environmental management* (Gunther 1998) has been recognised in the United States by the Interagency Group on Decision Support for land, environmental and natural resource management (IGDS) which was developed in 1997. However, there has been little research beyond this into the relationship between SDI and DSS, particularly the growing number and diversity of users. This has recently been recognised by the Global Spatial Data Infrastructure Steering Committee, who have established a working group on the relationship of GSDI to DSS

(GSDI 2001). It also encouraged the Centre for SDI and Land Administration to commence investigating, at the end of 1999, the relationship between SDI and DSS and the frameworks by which SDI can support the discovery, access and application of DSS for natural resource planning and management.

7. CONCLUSION

The objective of this paper was to identify trends and developments in land administration and SDIs by reviewing the past, present and future research undertaken by the Centre for SDI and Land Administration at The University of Melbourne.

So what can we learn from this review which has relevance for surveyors?

1. SDI and land administration build on the traditional strengths of the land surveyor of measurement science and land management, and as such are critically important areas for the surveying discipline and for education of surveyors.
2. Global drivers, and particularly environmental and social drivers, are tempering the traditional economic driver in the evolution of SDIs and land administration systems.
3. The different dimensions and components of land administration as reflected in different human-land relationships are now better understood. In this context land administration reform can draw on a "tool box" of legal, tenure, institutional and technical initiatives.
4. The evaluation of the performance of land administration systems is difficult with no accepted international processes or strategies. Benchmarking and related strategies provide one promising approach.
5. Jurisdictions require a comprehensive and holistic land administration vision and strategy in order to address current sustainable development objectives.
6. The most significant impact on the development of future land administration systems will be the clarification and implementation of SDIs. The SDI concept is still evolving. However a key component of SDIs is that they are dynamic in nature due to the intra- and inter-jurisdictional partnerships they are based on. These partnerships are important between jurisdictions, between urban and regional environments, between users and suppliers of spatial data in the industry, as well as in the implementation and reform of the administration, integration and reform of land administration systems.
7. Within this framework the relationship between infrastructures and the business systems they support is not sufficiently appreciated. SDIs without users or business systems that rely on them have little justification.
8. Communication and positioning technologies, such as the Internet, wireless applications and GPS, are revolutionising methods of maintaining, disseminating and accessing spatial data. To fully utilise these technologies there must be a clear understanding of how they impact on and assist in implementation of a SDI that supports the human-land relationship, particularly land administration systems, yet surprisingly little research is undertaken within the surveying discipline in this domain.
9. Recognising the very significant impact of technology on the evolving land administration systems and SDIs, without appropriate legal, land tenure and institutional infrastructures, the development of appropriate systems will be difficult, if not

impossible. As a result a reform strategy must consider both technical and non- technical solutions equally, and integrate these wherever possible.

10. Developing frameworks for decision support is a very important aspect of incorporating social, environmental and economic priorities in the integration of technical and non-technical solutions to complex questions and situations. Decision Support Systems can be developed as key institutional tools to facilitate equity, accountability and transparency in the decision-making process, as well as structuring the multidisciplinary and multi-participant environments that characterise decision making for sustainable development and the operational environments of SDIs.

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