Land Administration and Spatial Data Infrastructures

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Key words: Land administration, SDI

SUMMARY

Internationally the spatial data infrastructure (SDI) concept has focussed on national SDIs. However SDIs are increasingly focussing on large scale people relevant data (land parcel based data or build environmental data) with the result that today it is suggested most SDI activity worldwide is at this level. A central aspect in understanding these developments is the evolution of mapping, and the growth of land administration systems and national mapping initiatives in different countries.

The objective of this paper is to discuss the evolving nature of SDIs away from a simple national concept to a complex hierarchy where large scale SDIs are the major influence. The paper concludes with a discussion of policy development and the impact of institutional arrangements in managing spatial information.

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1. INTRODUCTION

The development of the spatial data infrastructure (SDI) has evolved as a central driving force in the management of spatial information over the last decade. The concept gained a major impetus from the statement by President Clinton in 1994 (Executive Order, 1994) regarding its application in the USA. Since this time discussion about SDI principles and experiences has been a focus on many conferences and seminars world wide, particularly at the level of United Nations meetings such as the regular United Nations Cartographic Conferences for both Asia and the Pacific, and the Americas. These activities have spurned the establishment of the UN sponsored Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) and similar organisations in the Americas and Europe. At the same time about 70 countries have established national SDI strategies (Cromferts *et al*, 2004) and an international organisation has been established called Global Spatial Data Infrastructure (GSDI) with the major focus of running an annual conference on SDI developments.

Discussion within these developments has centred on national SDI initiatives primarily driven by national mapping agencies which have the responsibility for SDI initiatives in their respective countries. This is highlighted by the active participants in PCGIAP for example where China (National Bureau of Surveying and Mapping), Australia (Geoscience Australia), Japan (Geographic Survey Institute of Japan), Korea (Geographic Survey Institute of Korea), India (Survey of India), Indonesia (Bakosutanal), Thailand (Royal Thai Survey Department) and Philippines (NAMRIA) are all the national mapping agencies.

Ironically however, most or at least much SDI activity in these countries is not administered by these organisations but by state or provincial organisations or organisations responsible for land administration or cadastral activities or city administration. It is this large scale, dynamic, people relevant data where most of the SDI action occurs but for many countries there is a sharp divide between the activities of these national mapping agencies and their land administration counterparts.

However the tide is turning. With the increasing desire for aggregated large scale spatial data sets (cadastre, road networks, street addresses, political boundaries and well as topographic data sets) and the need to integrate these data sets with national natural resource data sets, new institutional and policy arrangements are evolving and putting pressure on the traditional national mapping agencies by challenging their historic mapping role.

In order to understand these changes it is helpful to understand the evolution of mapping, the pre-cursor of SDIs, and the subsequent separate evolution of national mapping agencies and land administration or cadastral agencies in each country. This paper explores these evolutionary changes in the context of global drivers such as sustainable development and

national security. It then considers the policy and institutional impact these changes are making.

2. THE EVOLUTION OF MAPPING

Historically, mapping was driven by, among other things, the needs of trade, exploration, military ambitions and security. The results of mapping provided information, which initially responded to local needs. Those early maps - often commissioned by landlords - would have been concerned for example with individual land ownership or occupation rather than the locations of villages or towns. Gradually, as people moved outside the narrow orbit of their lives and began to travel overland, the need for reliable maps, which told them the direction in which to go, what to expect on route, and perhaps more importantly, the way back, became a vital imperative. At a higher level, those administering a region or a country needed to know its boundaries. Revenue officials needed to identify from where and from whom to collect taxes. Military commanders needed to anticipate what and where to defend and attack.

As early as the mid 1500s the Mughals knew clearly the extent of their empire. It had been surveyed in a rudimentary sense but, for their purposes, in an effective manner during the reign of Akbar (1556-1605). His able minister Abu'l Fazl developed and described the administrative boundaries under their imperial control. Much later in the mid 1800s the Pundits trekked thousands of miles through the Himalayas, returning from their journeys with information, which enabled the authorities at Dehra Dun to complete the final sections of the geographical jigsaw left empty by the Great Trigonometrical Survey of India. The tools they used were the compass, well measured pacing, the boiling point of water gave the altitude of places visited and Tibetan prayer-wheels with a revolving barrel were used to conceal their observations from the eyes of prying frontier officials. The result of these initiatives and mapping observations was to reflect in paper form the reality of the earth upon which we live. These maps were terrestrial in content but political in nature.

Many other countries proceeded to make advances in mapping sciences especially the seafaring nations of Portugal, Spain, The Netherlands, France and Great Britain.

For the above reasons virtually all nations developed national mapping agencies which produced small to medium scale maps. The national mapping agencies of today are the legacy of the need of countries to map their domains and neighbouring regions for primarily military, security and economic perspectives, a need which started centuries ago and has continued to the present.

At the same time countries developed systems to administer their land resource particularly from a land taxation perspective. The initiatives of the Egyptians several thousand years ago and the Doomsday Book in medieval England are early examples. In more recent times the cadastres of Napoleon and Marie Therese in Europe in the 18th and 19th centuries exhibit a more modern development.

In the last one and a half centuries, society became more sophisticated and banking systems became more comprehensive, land was seen as collateral and became a financial commodity. The concept of property rights was introduced whereby land was described and the owner and anyone having an interest in that land were recorded in some form. All these records were kept in tablet or written form (Ting *et al*, 1999; Ting and Williamson, 1999). Early land transactions were often made in public to ensure wide knowledge of the change of ownership. Symbols of the transfer of ownership were often exchanged on the site to ensure a corporate memory of the transaction with these symbolic activities still important today in land titling activities in developing countries.

Many other attributes or themes captured the imagination of society and they were often related to the land and the map base which was available. In modern times some of these layers of information have included population distribution, road maps, river systems, vegetation cover, soil types and cultural antiquities. As the analogue maps were replaced with digital mapping systems the integration of these layers became easier to accomplish and many combinations of information sets are now possible. In this environment an information deprived society is clearly limited in its social and economic development. It follows that a society which is not geographically aware, or "spatially enabled", is deprived of the ability to develop comprehensive socio-economic concepts and plans, and effective implementation. How can any relational analysis be done if the relative positions of subject themes e.g. development proposals, heritage sites, population dispersal or land use determination are unknown?

The above developments describe the evolution of two separate spatial information systems in most countries – one with a national natural environmental focus at small to medium scales and one with a more localised large scale built environment focus.

3. LAND ADMINISTRATION AND NATIONAL MAPPING

The "golden era" of national mapping agencies lasted for about 50-100 years in most countries and started in the mid 1800s (although some like the Survey of India and the Ordnance Survey in England have a longer history) and lasted well into the 1960s and 1970s. This was the era of the application of geodesy to national mapping, the refinement of photogrammetry as the key mapping science, national geodetic surveys and the objective of national coverage of most countries at 1:50,000 to 1:100,000 scale mapping. The need for highly skilled personnel to support these national mapping programs, especially after World War 11, also spawned the establishment of many university programs offering degrees in surveying, mapping, survey engineering, geodetic science and geodetic engineering. This gave a significant impetus to the professional status of surveyors even though the majority of the graduates continued to be employed in the traditional cadastral survey or land management/development field.

During this period, the large scale spatial information activities tended to concentrate on cadastral surveying for the alienation of lands and land development, and were focussed on supporting land registration activities at local, state or provincial levels. The focus tended to

be on cadastral surveying with these surveys charted approximately on cadastral charting maps, or local or village cadastral maps, also often used for land valuation and land tax purposes. During this period these large scale spatial information activities, which by their very nature tended to be localised in nature, were very much the "poor cousin" to the high profile national mapping programs which used the latest technology and were seen as contributing to defence and economic development.

The last 20-30 years of the 20th Century saw the rapid development of information and communications technologies (ICT), together with the development of Global Positioning System (GPS) and geographic information system (GIS) technologies which revolutionised the collection, management, presentation and use of spatial information. However this technology was now cheaper and more freely available. While the national mapping agencies availed themselves of these latest technologies, so did the cadastral and land administration agencies, with a great enthusiasm.

The result of this technological revolution has been that the national mapping agencies have continued to undertake their traditional work, albeit more effectively and efficiently. However the large scale land administration sector has been revolutionised. The new technologies have enabled the land administration organisations to create digital large scale cadastral data bases and increasingly large scale topographic data bases with many of them in the more developed countries creating large scale virtual representations of their built and natural environments.

However these two developments, at a small scale national mapping and a large scale land administration level, have evolved and continue to evolve in isolation in many countries, as highlighted previously by the PCGIAP member state representatives. It is into this environment that the SDI concept, driven by technological advances as well as the potential economic, environmental and social benefits, has evolved over the last decade or so.

4. THE SDI CONCEPT, LAND ADMINISTRATION AND SUSTAINABLE DEVELOPMENT

The SDI concept started with a focus on national priorities and data. It is an initiative underpins the design, implementation and maintenance of mechanisms that facilitate the sharing, access and utilisation of spatial data across different communities to better achieve their objectives. With this in mind, many communities are developing SDIs to better manage and utilise their spatial data by taking a perspective that starts at a local level and proceeds through state, national and regional levels to the global level. This has resulted in the development of different forms of SDI at and

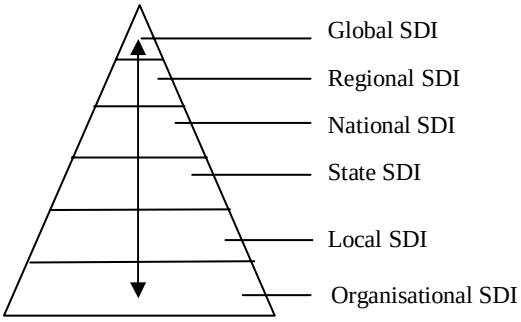

Figure 1. A Hierarchy of SDIs at different levels of

between these levels and giving more attention to the SDI hierarchy which assist in decision-making (Figure 1).

Furthermore, it has evolved to embrace all forms of spatial data represented by the SDI hierarchy with the more developed systems moving from a data focus within a product based model to an implementation focus within a process based model.

4.1 Spatial Data Infrastructures

First, the five components of SDI should be remembered as shown in Figure 2. But most important the central objective of SDI is to link people to data!
Second it must be remembered that an SDI for a country like Australia which is a federation of states is a hierarchy of layers or components from corporate level through local government, State government to the national level. Importantly the Australian SDI (ASDI) includes corporate, local and State government data sets as shown in Figure 1. As such the ASDI has both inter-jurisdictional and intra-jurisdictional linkages.

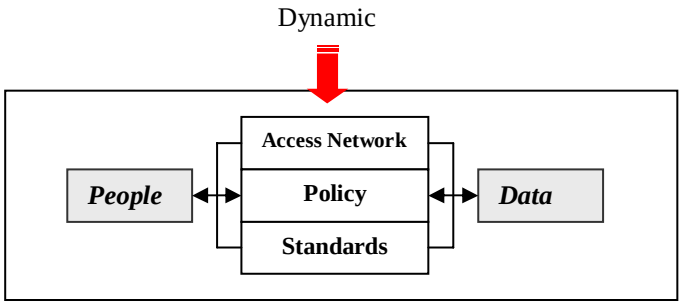

Figure 2: Nature and relations between SDI

The third important concept is that mature SDIs evolve from a Product (or data) based model to a Process based model as shown in Figure 3. This is particularly relevant to the evolution of the ASDI where the focus at an Australian Government level has moved from a focus on national mapping to facilitating access to data within the ASDI framework.

Lastly it is important to understand that an SDI is not a “data base”. It is an infrastructure which links people to data and comprises policies, access technologies and standards. For further discussion about SDI concepts see Williamson *et al.* (2003).

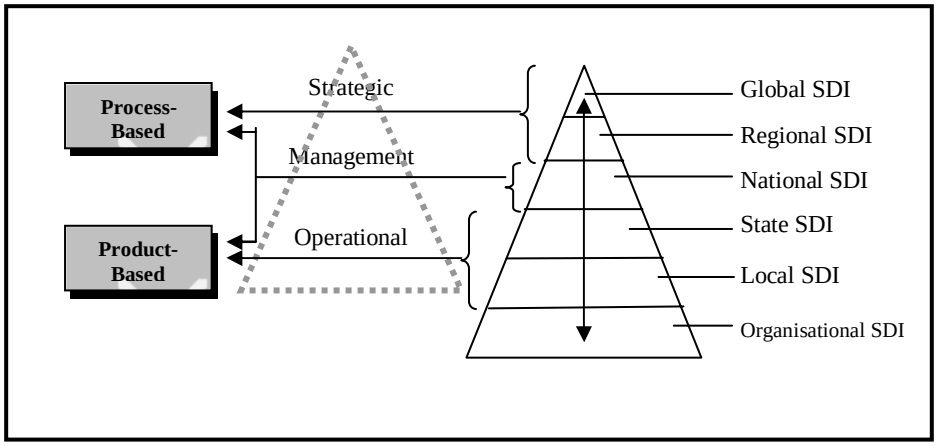

Figure 3: Relationships between SDI Hierarchy and different Model of SDI development

4.2 Land Administration

Each country or state has a resonsibility to manage and administer land from an economic (and particularly by facilitating land markets), social and environmental perspective. They undertake the land market responsibility by building land administration systems which administer land ownership, land use and land values. These activities are usually administered through a department of lands or land information. The social, environmental and natural resource aspects are administered through departments of the environment, sustainability, agriculture, primary industries or natural resources.

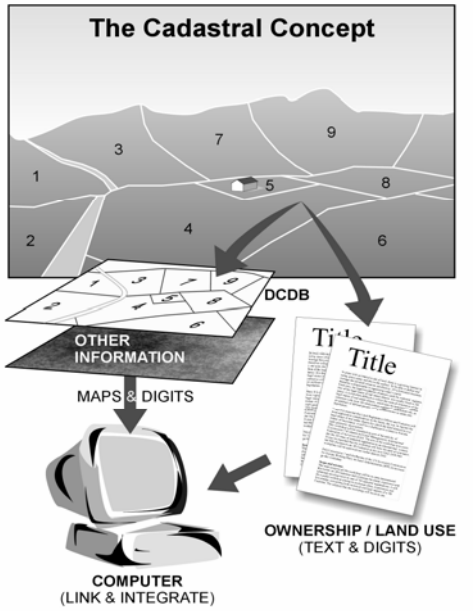

Figure 4: The Cadastral Concept (FIG, 1995)

The land administration activities strongly influence the way a country or state operates and the policies they develop recognising that land administration is a major funding source (land tax, stamp duty on property transfers).

One of the primary tasks of such a land administration system is to support the operation of an efficient and effective land market. This includes cadastral surveys to identify and subdivide land, land registry systems to support simple land trading (buying, selling, mortgaging and leasing land) and land information systems to facilitate access to the relevant information. This has resulted in each jurisdiction creating a land information system based on land or cadastral parcels as shown in Figure 4.

As a result of sustainable development drivers, the controls and restrictions over land have become much more complex as shown in Figure 5, and aim at ensuring safety standards, durable building structures, adequate service provision, business standards, social and land use planning, and sustainable development. The replication of land related systems in resource and water contexts is demanding new flexibilities in our approaches to administration (see Wallace and Williamson, 2004 for more details).

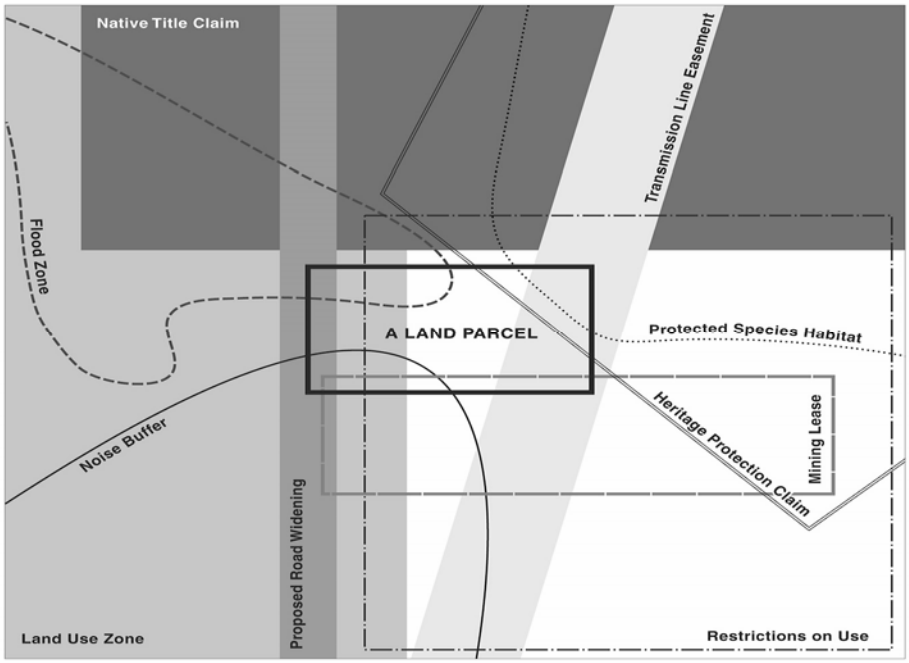

Figure 5: Overlapping rights, restrictions and responsibilities (RRR)

Due to this "triple bottom line" driver and the need to manage this increasingly complex arrangement of rights, restrictions and responsibilities (RRR), land administration systems are starting to support more sophisticated land markets which include complex commodities such as mortgage backed certificates, water rights, land information, time shares, unit and property trusts, financial instruments, insurance products, options, corporate development instruments and vertical villages.

Simply a land market is a complex and dynamic range of activities, processes and opportunities. It is a concept that is continually evolving, primarily in response to sustainable development objectives, although it is also being facilitated by information and communications technologies. The concept of a land market is shown in Figure 6 and the growing range of complex commodities is shown in Figure 7.

Modern land administration systems and their supporting SDIs now have to accommodate the trading of complex commodities within modern land markets.

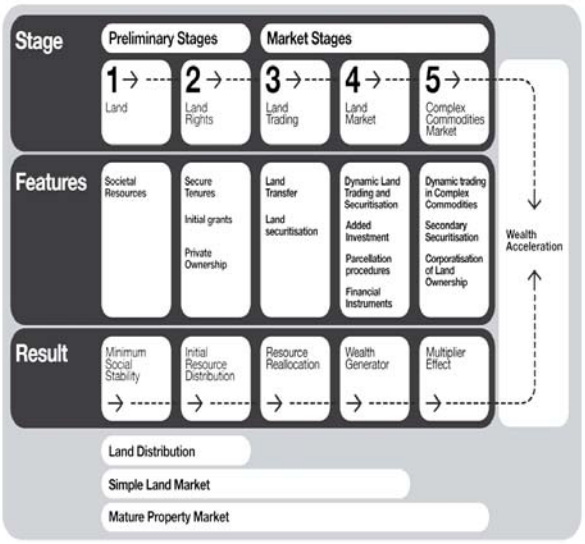

Figure 6: Evolution of land markets
(Wallace and Williamson, 2004)

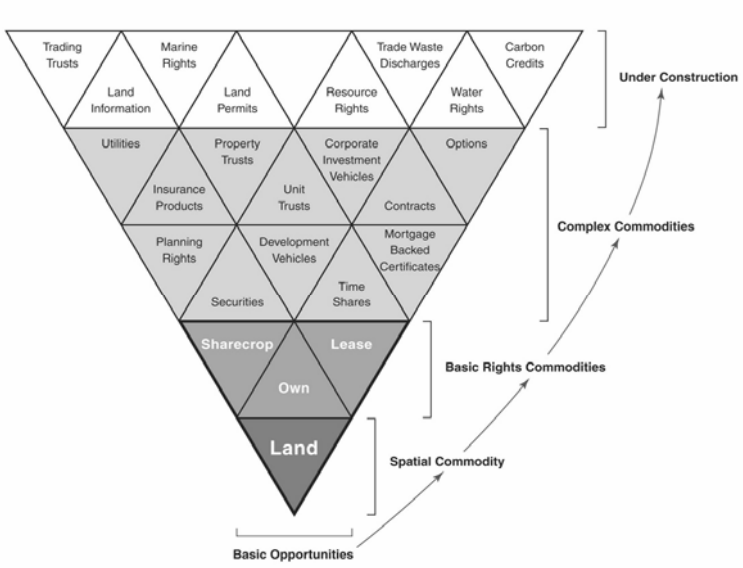

Figure 7: Complex commodities market
(Wallace and Williamson, 2004)

Figure 8: Land Administration Arrangements
(Enemark, Williamson and Wallace, 2004)

At the same time modern societies are now realising that there are many rights, restrictions and responsibilities relating to land, which exist but have not been formalised by governments for various policy or political reasons. This does not mean these rights don't exist but that they simply have not been formalised. Modern LAS have to recognise both formal and informal RRR if "triple bottom line" objectives are to be achieved.

A model for a modern land administration system that meets sustainable development principles (Enemark *et al,* 2004) is shown in Figure 8. The key lesson from this discussion is that this large scale "people relevant data" is driving many SDI developments.

While small to medium scale national activities, local government (and particularly its role as a custodian for planning and street address data) and regional SDI initiatives (such as in the Asia and Pacific region promoted by PCGIAP) are making positive contributions to the SDI vision, it is the large scale land administration initiatives (often at a state or provincial level) where most of the SDI activity is occurring in many countries. This is where most of the current challenges in SDI development are being faced at inter- and intra-jurisdictional levels.

5. IMPLICATIONS FOR SDI DEVELOPMENT

In returning to the main theme of this paper, users increasingly want national integrated large scale data sets, not the traditional national small scale data sets which do not have cadastral data or detailed natural environment. Now that many countries and states in federations have developed or are developing such large scale data sets, the role of national mapping agencies is being questioned, unless they re-invent themselves to be custodians for coordinating the large scale data. There is also a role to aggregate and generalise the large data to small scale to link with demographic and broad national policy planning.

If national mapping agencies don't change direction from their traditional roles, their future is uncertain.

One opportunity for national mapping agencies is to move more aggressively into the marine dimension. See the initiatives in marine cadastre by the PCGIAP at this website http://www.gsi.go.jp/PCGIAP/98wg/98wg3.htm and the research being undertaken in the Marine Research Group at the University of Melbourne, Australia: http://www.geom.unimelb.edu.au/maritime/marineresearch.htm. However coordination of the integration of large scale datasets in the SDI hierarchy offers one of the best opportunities.

Whatever happens, every country will increasingly require some form of national SDI coordination (and leadership). Whether this is a re-engineered national mapping agency or is it a consortium of the major large scale producers, there will always be the need for nation wide SI focus at the national political level (marine, defence, security, transport, GNAF, etc).

Herein lies the challenge for national mapping agencies. Unless they engage with the large scale producers of spatial data and especially built environment data (mainly cadastral data) there run the risk of being marginalised.

6. CONCLUSION

The main game for spatial information managers is now the delivery of a virtual world which facilitates decision making at a community level within a national context. This requires integration of the natural and built environmental data sets and the need for a spatial data infrastructure that facilitates this integration.

With this in mind, this paper discussed the evolving nature of SDIs from a simple national concept to a complex hierarchy concept, and their relationships with land adminisration. Following this dicussion, the paper further discussed policy development and the impact of institutional arrangements in managing spatial information. Based on these discussions, it is highlighted that the integration of the natural and built environmental data sets and the need for an SDI to facilitate this integration requires new strategies, new partnerships, new models and new funding arrangements particularly between the national mapping agencies and the custodians and producers of large scale data.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support of Mr Ed Garvin and Omnilink, the University of Melbourne, and the members of the Centre for Spatial Data Infrastructures and Land Administration at the Department of Geomatics, the University of Melbourne, in the preparation of this paper and the associated research. However, the views expressed in the paper are those of the authors and do not necessarily reflect the views of these groups.

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BIOGRAPHICAL NOTES

Ian Williamson is Head, Department of Geomatics, University of Melbourne, Australia, where he is Professor in Surveying and Land Information, and Director of the Centre for Spatial Data Infrastructures and Land Administration. He is Chair, Working Group 3 (Cadastre) of the United Nations sponsored Permanent Committee for GIS Infrastructure for Asia and Pacific (PCGIAP). He was Chairman of Commission 7 (Cadastre and Land Management) of the International Federation of Surveyors (FIG) 1994-98 and Director, United Nations Liaison 1998-2002. His teaching and research interests are concerned with designing, building and managing land administration, cadastral, and land and geographic information systems in both developed and developing countries. He has consulted and published widely within these areas.

Donald Grant was appointed as Surveyor-General of New South Wales in January 1986 and resigned from this position in late 2000. He is presently working as an international consultant in land administration. In 1993 he was made a Professorial Associate in the Faculty of Science and Agriculture at Charles Sturt University, in May 1997 a Doctor of Applied Science, *honoris causa* at Charles Sturt University, a Doctor of Science, *honoris causa* at the University of New South Wales, an Adjunct Professor of the Department of Linguistics at the Macquarie University and in December 1997 a Professorial Fellow, Department of Geomatics, The University of Melbourne.

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