Land Administration and Cadastral Trends – A Framework for Re-Engineering

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ABSTRACT

This paper is the second of two papers which look at the changing humankind-land relationship over the centuries, the resulting land administration and cadastral responses to this change and future trends. The first paper examines land administration and cadastral trends in the context of global drivers of sustainable development, the changing humankind-land relationship, globalisation, micro-economic reform and technology. It sets the scene for a new world order in land administration which takes a more integrated approach rather than the historic fragmented approach. This paper reviews the need for a new land administration vision and examines change management of land administration and cadastral systems in the context of the global drivers. This results in the development of a framework for re-engineering land administration systems. After discussing a land administration vision the paper reviews trends and issues in the context of this framework.

***Keywords and phrases**: Land administration, cadastre, cadastral reform, vision, spatial data infrastructures, spatial information management, GIS, WWW, IT, spatial hierarchy*

INTRODUCTION

Global drivers such as sustainable development, globalisation, micro-economic reform and technology are changing the way humankind relates to land. This changing relationship requires new land administration infrastructures and tools. As a result existing land administration and cadastral systems are being re-engineered. This paper is the second of two papers attempting to understand the changing humankind-land relationship and the resulting land administration and cadastral infrastructures required to support it.

The first paper (Ting and Williamson, 1999) is concerned with the changing humankind-land relationship over the centuries, with a focus on recent global drivers for change. It uses New Zealand as a case study in understanding the need for new land administration infrastructures. As a result of the global drivers, it concludes that societies will in future have to manage land in a different or revolutionary way, with land administration having to take a much broader and integrated view than was often the case in the past. The following section describes a new world order for land administration based on the first paper.

This second paper builds on the scenario to consider a new vision for land administration and develops a framework for re-engineering future land administration systems to achieve the vision. The paper also examines some of the trends and issues concerned with moving to a new land administration vision. Central to this paper is the over-riding principle that land administration and cadastral systems are a key component of the infrastructure that supports and facilitates the way that society interacts with land to ensure the sustainability of humanity.

A NEW WORLD ORDER

The global drivers identified above influence the development of the different land administration polices and models adopted by governments, with an obvious flow on to the private sector. These models and concepts can only be developed with a clear understanding of current land administration issues and trends. By its very nature, land administration focuses on land tenure and cadastral (land parcel related) issues. The land administration perspective includes understanding the changing humankind-land relationship, land tenure issues such as native title, institutional and administrative issues such as the relationship between infrastructures and the business systems they support, and technical issues such as those concerned with the use of the World Wide Web (WWW).

A review of the dynamic humankind-land relationship by Ting and Williamson (1999) shows that it may be classified into four broad phases:

- Human settlement during the agricultural revolution through to the feudal system, which tied human beings to land in a physical way. Land was the primary symbol and source of wealth. In this phase, the cadastral system's role was to publicly record ownership as well as for fiscal purposes.

- The Industrial Revolution began a process of breaking that strong physical tie to land by turning land into more of a commodity, albeit the most valuable commodity and primary source of capital. This environment gave birth to land markets and so cadastre took on another focus – a tool to support land transfer and land markets.

- The post-World War II reconstruction and the population boom saw an awareness of land as a scarce resource that was not sufficient for the needs of a growing world population which was becoming more mobile. With this came an interest in planning, particularly urban and regional planning. Planning in turn created another application for cadastre.

- The 1980s have seen a different twist in the concern for the scarcity of land. The focus has turned to wider issues of environmental degradation and sustainable development, as well as social equity. All of these issues have the probable effect of tempering short-term economic imperatives. Planning issues have widened to include more community interests and deepened to address more detailed issues of land use. This has created a growing need for more complex information about land and land use. The impact of these has been manifested in the desire for multi-purpose cadastres.

Many countries are in the course of making the transition from the third to the fourth phases. Apart from examining local or national legal, institutional, economic and social frameworks, the current era requires that nations take into consideration the global drivers such as sustainable development, globalization, micro-economic reform (privatization) and the information revolution.

Sustainable development, as exemplified by the internationally acclaimed instrument Agenda 21, brings environmental issues and social forces such as indigenous and women's rights into the realm of influence alongside and often in opposition to, traditional economic considerations. It is this dynamic which starts to bring land administration and land management into closer and even overlapping proximity.

Sustainable development is also linked to globalization. Globalization means the process of greater interconnectedness between societies and jurisdictions from a social, economic and political perspective, such that events in one part of the world have more potential to impact on peoples and societies in other parts of the world. A globalized world is one in which political, economic, cultural and social events become more interconnected.

The globalization of markets has in turn influenced micro-economic reform. This reform has translated into the radical down-scaling of government, privatisation of services and some policy functions, and the introduction of a competition and service-oriented philosophy into the remaining government activities. Some refer to this as the "user-pays" philosophy. Often this results in a tension with the "universal environment" and public good approach.

These tensions emphasise the need for complex and sophisticated decision-making which, in the context of micro-economic reforms, means not only in government but the private sector and wider community. Civil society demands a place in the framework of decision-making. Here, information technology and the information revolution have the potential to make the vision a reality. The WWW is just one example of the potential that exists to bring consultation and participation to a new level of effectiveness. Sustainable development, by its very nature, requires community involvement and ownership, whether we are referring to the local community or the global community. It is thus imperative that the legal and institutional structures adapt to facilitate these changes.

It is in the context of this new world order that the next generation of land administration systems will have to be developed. This new order lays the foundations and sets the parameters for these new systems which have to be much broader and integrated than the approaches of the past.

TOWARDS THE BATHURST DECLARATION

Land administration and cadastral systems are continually evolving as society's attitudes and relationship to land changes. As this relationship with land becomes more complex in terms of the ever increasing number and form of rights, responsibilities and obligations, our land administration information systems that support decision-making, primarily in support of sustainable development, must also adapt to remain relevant. The resulting land administration and cadastral reforms which have developed across many jurisdictions worldwide over the last 20 years, give an insight into the issues and trends in both land administration and supporting spatial information systems.

Land administration and cadastral systems can no longer rely on manual processes or traditional structures that supported individual economic or taxation imperatives in the past. Stand alone or isolated approaches that supported individual purposes where data and processes were maintained separately, such as land valuation and land titling, are not sustainable. They are being replaced by multipurpose cadastral systems where information about natural resources, planning, land use, land value and land titles, including Western and indigenous interests, can be integrated for a range of business purposes. As we move further into the information revolution, a clear vision of what land administration and cadastral systems might look like in a decade or so is becoming more urgent.

The United Nations and organisations such as the International Federation of Surveyors (FIG) have for many years undertaken studies to understand and describe land administration systems and particularly the cadastral component. The interest in land administration infrastructures has been growing over the last few years as a result of the changes necessitated by the global drivers mentioned above but also because of the fall of apartheid in Southern Africa and the changes from command to market economies in Eastern and Central Europe. A key component in most of these studies has been to develop a new land administration vision for a changing world and to explore the issues required to achieve such a vision.

The UN Regional Cartographic Conference (UNRCC) for Asia and the Pacific held in Beijing in 1994 passed a resolution to organise a joint UN-FIG Inter-Regional Meeting of Experts on Cadastre. The resulting meeting was held in Bogor, Indonesia, in March 1996, the primary objective of the meeting being "to develop a document setting out the desirable requirements and options for cadastral systems of developing countries in the Asia and Pacific region and to some extent globally". As a result of the success of the Bogor Declaration on Cadastral Reform (UN-FIG, 1996), the FIG presented the Declaration at two subsequent UNRCCs for Asia and the Pacific in Bangkok and for the Americas in New York, in 1997.

While the Bogor Declaration resulted in a valuable contribution to a better understanding of cadastral reform, the delegates to the meeting recognised its relatively narrow focus and acknowledged the lack of representation from a wide range of land related experts. As a result one of the recommendations from the Bangkok UNRCC was to organise by 1999 a global workshop on land rights, responsibilities and restrictions and suitable cadastral structures and systems

appropriate to the needs of governments for their sustainable development. This latter meeting was to take a broader view of land administration and would draw on a wide range of experts. Assistance was to be sought from the FIG to organise the meeting. This recommendation has resulted in the current Workshop and International Conference on Land Tenure and Cadastral Infrastructures for Sustainable Development jointly organised between the UN and the FIG. The major outcome will be the Bathurst Declaration. There was a recognition in the 1997 UN resolution that the 1999 initiative would build on the vision, guidelines and policies proposed in the previous UN-FIG Bogor Declaration.

The Bogor Declaration adopted the definition and description of a cadastre as set out in the FIG Statement on the Cadastre (FIG, 1995). Reference was also made to the two previous UN meetings of cadastral experts (in 1972 and 1985) and the Land Administration Guidelines prepared by the Meeting of Officials on Land Administration (MOLA, 1999) of the United Nations Economic Commission for Europe in 1996.

A central component of the Bogor Declaration is a cadastral vision of the future. This vision and the supporting guidelines, and cadastral reform options and principles have formed a starting point for the development of the Bathurst Declaration. Another input into the development of the vision for a future land administration infrastructure is the FIG report on future cadastral systems "Cadastre 2014" (Kaufmann, 1998 and Kaufmann and Steudler, 1998).

This ongoing work of the UN and FIG resulted in the objective of the Bathurst Declaration being:

> *To explore humankind-land relationships for the next millennium in the context of AGENDA 21 and the emerging global village. It will determine a broad vision and a set of guidelines for suitable cadastral structures and systems to support land management and in particular land administration to ensure sustainable development and environmental management. It will focus on the legal, technical and institutional infrastructure required to support such a vision. The workshop will recognise the trend for formal land tenure systems to move from a focus on ownership to one of land rights, responsibilities and restrictions.*

The workshop and conference, and the resulting Bathurst Declaration, are another step in the growing awareness of the importance of land administration and cadastral systems in support of sustainable development. This paper suggests a way forward for land administration systems which can build on the new Bathurst Declaration. The paper proposes a model to re-engineer land administration systems and then looks closely at two of the most important phases in the process - the development of a land administration vision and implementation issues.

LAND ADMINISTRATION AND CADASTRAL REFORM

The necessity for change in land administration and cadastral systems is highlighted in many reports and statements and is a growing focus for organisations such as the United Nations, the World Bank and the International Federation of Surveyors. The Bogor Declaration argues for change, documents a vision and describes the necessity for re-engineering systems. Cadastre 2014 describes a new vision for cadastral systems. The MOLA Land Administration Guidelines establish a framework for land administration reform with a focus on Central and Eastern Europe. More importantly land administration and cadastral systems world-wide are currently undergoing major changes. In understanding present trends it is useful to understand this change.

Unfortunately much change in the broad land administration area focuses on technology and does not take a broad view of land administration reform as identified in the first paper by Ting and Williamson (1999). It is useful to consider three related perspectives in implementing change in land administration. First is an appreciation of the global drivers for change which were mentioned previously. Next is an analysis of the impact of these drivers on the design of land administration systems, and particularly the cadastral component, which results in the land administration and cadastral environment from which new systems must evolve. This in turn identifies implementation issues with a focus on technical and administrative tools which support these trends and developments, such as spatial data infrastructures and the Internet. This hierarchy of perspectives is shown in Figure 1. This hierarchy is expanded in the framework for re-engineering land administration systems in Figure 2.

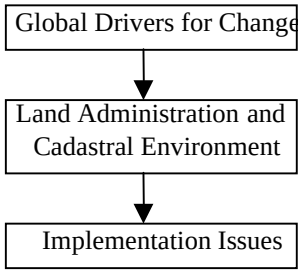

Figure 1. Hierarchy of Perspectives

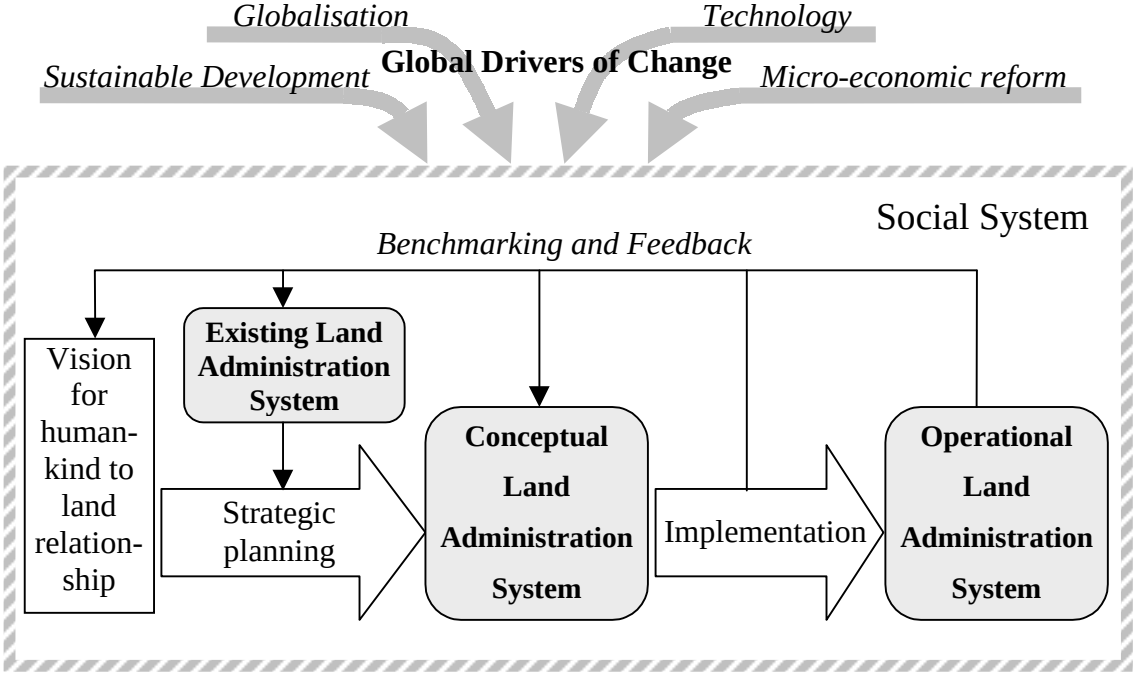

Figure 2. Framework for Re-engineering Land Administration Systems

In this framework global drivers impact on the whole social system which comprises the re-engineering process. The framework shows that through a strategic planning process, the vision of a new humankind-land relationship, together with the existing land administration system, results in the development of a conceptual land administration system. Through an implementation process an operational land administration system is developed. Through benchmarking and feedback, the vision and conceptual system will be continually refined. Some of the key strategic planning and implementation issues within the re-engineering process, such as the role of native title, the changing nature of spatial data infrastructures, understanding the business-infrastructure relationship in spatial information management, the use of the WWW and benchmarking processes, are discussed later in the paper.

One of the key steps in the re-engineering process, being the determination of the vision for the humankind-land relationship and the resulting conceptual land administration system, is discussed below.

DEVELOPING A LAND ADMINISTRATION VISION

Over the years a number of land administration or cadastral models or visions have been developed. Two of the most notable are described in the FIG Statement on the Cadastre (FIG, 1995) and the Bogor Declaration on Cadastral Reform (UN-FIG, 1996). Cadastre is defined in the Statement on the Cadastre as :

> *… normally a parcel based and up-to-date land information system containing a record of interests in land (e.g. rights, restrictions and responsibilities). It usually includes 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. It may be established for fiscal purposes (e.g. valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (e.g. for planning and other administrative purposes), and enables sustainable development and environmental protection.*

The Bogor Declaration on Cadastral Reform (UN-FIG, 1996) expanded this definition to state that future cadastres would:

- develop modern cadastral infrastructures that facilitate efficient land and property markets, protect the land rights of all, and support long term sustainable development and land management.

- facilitate the planning and development of national cadastral infrastructures so that they may fully service the escalating needs of greatly increased urban populations. These will result from the rapid expansion of cities that is already taking place and which is projected to continue into the 21st century.

This vision incorporated the concept of cadastral systems as infrastructures and highlighted the role of cadastres in the operation of land markets. While the Statement on the Cadastre was in reality a definition, the Bogor Declaration was

more concerned with strategic and implementation issues, albeit in the relatively narrow cadastral sense.

Williamson (1996) developed a 10 year land information management vision for the State of Victoria, Australia, which would be a central component of any future land administration system. It built on his involvement with the development of the Statement on the Cadastre and the Bogor Declaration in addition to it receiving valuable input from many colleagues. This vision took a more information systems view of modern land administration and cadastral systems. It is summarised as follows:

> *Simply within ten years all tiers of government, the private sector and the wider public will have controlled access to a standardised, complete, nation-wide, current, on-line land information system in real time, which is efficient, economically justified and compatible with other information systems.*

A more recent investigation of future cadastral systems is the FIG Cadastre 2014 vision (Kaufmann, 1998 and Kaufmann and Steudler, 1998). This was commissioned in 1994 by one of the Working Groups of Commission 7 (Cadastre and Land Management) as a 20 year vision. The final report was the result of a four-year process involving input from many countries world wide. Cadastre 2014 recognises the changing relationship of humankind to land, the changing role of governments in society, the impact of technology on cadastral reform, the changing role of surveyors in society and the growing role of the private sector in the operation of the cadastre.

> *Cadastre 2014 is defined as a methodically arranged public inventory of data concerning all legal land objects in a certain country or district, based on a survey of their boundaries. Such legal land objects are systemmatically identified by means of some separate designation. They are defined by either private or public law. The boundaries, the identifier together with descriptive data, may show for each separate land object the nature, size, value and legal rights and restrictions associated with the land object.*

Cadastre 2014 has made a valuable contribution to the understanding of future cadastral systems. However it did by design restrict its focus on cadastral systems and emphasised technological changes.

Another document which has influenced land administration and cadastral thinking over the last few years is the Land Administration Guidelines produced by the European Meeting of Officials on Land Administration (MOLA) for the UN Economic Commission for Europe (MOLA, 1999). The MOLA Guidelines took a wider view of land administration incorporating land registration, land valuation and planning, however by design they focused on land administration and cadastral reform in Eastern and Central Europe.

One result from all these initiatives is the trend for future land administration and cadastral systems to take a broader and more integrated view than in the past. The components of land registration, cadastral surveying and mapping, planning and land valuation, and their role in the operation of land markets, must all be considered as one integrated system where the common objective is sustainable development. A

result of taking such a broad integrated approach is that all rights, restrictions and responsibilities, often overlapping, relating to land must be considered in designing and managing a land administration system as shown in Figure 3. This results in the multi-purpose cadastral concept which has been promoted for the last couple of decades but is only becoming a reality in recent times. Another outcome is the way that land administration is being viewed as an infrastructure to support sustainable development.

As a result of the limitations of the previous initiatives and the urgent need to address issues of sustainable development, the UN and the FIG believed that the development of a new declaration on the relationship of land administration and cadastral systems to sustainable development was justified and timely. This has resulted in the Bathurst Workshop, the resulting Bathurst Declaration and the Melbourne Conference.

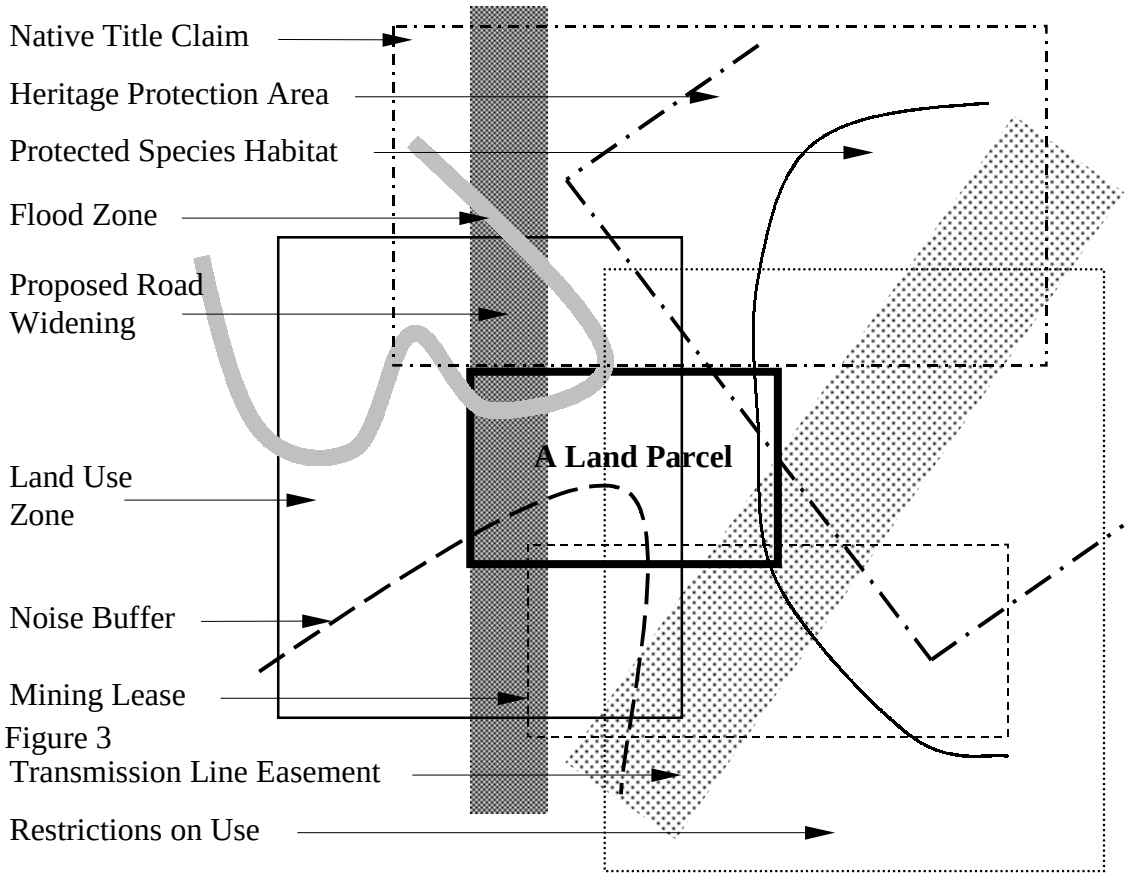

Figure 3

Figure 3: Schematic of overlapping rights, restrictions and responsibilities in a modern multi-purpose cadastre

STRATEGIC AND IMPLEMENTATION ISSUES

Whether governments are being pushed or pulled towards the above multi-purpose cadastral vision, a move in this direction is almost universal, especially in the developed countries. In moving towards this vision, land administration and cadastral

systems are being re-engineered as discussed in the framework described in Figure 2. This process highlights a range of strategic and implementation issues which should be considered in developing future land administration systems, although not all will apply to every system. These issues include policy, technical, institutional, administrative and legal components, even though it is often difficult to categorise them as one or another. The influence of these trends and changes are resulting in new rights, restrictions and responsibilities in land, new tenures, new processes and new institutional structures.

New technologies have dictated and influenced many changes in the development of land administration and cadastral systems, especially the information technology advances and the more specialised spatial information technologies. The GIS technologies for data management, manipulation, analysis and integration arguably have had the greatest impact on the spatial information environment, although in the future the communication technologies such as the WWW are rapidly becoming the focus of attention. These technologies are expected to be the norm for viewing, locating and using land related information in the years ahead.

Legislative reform appropriately follows policy development, technological advances and institutional reform and should be a support process in re-engineering land administration systems. Since legislation should simply be an expression of the implementation of policy adopted at a political level, it does not warrant investigation in this paper, even though its importance in land administration reform is critical. Unfortunately legislation is used as an excuse to inhibit land administration reform in some countries (UN, 1997).

Following are some of the land administration and cadastral trends and issues in which the authors and their colleagues are currently involved, which are part of or influence or result from the re-engineering process. The first issue is concerned with the evolving concept of spatial data infrastructures (SDIs). The business-infrastructure relationship is followed by a discussion of the hierarchy of SDIs, the need for partnerships in SDI development, the growing focus on national cadastral data sets in national SDIs and the spatial hierarchy issue. These are then followed by the difficulty of incorporating traditional or customary rights in “western” land administration systems, the complexity of the spatial component of cadastral systems and the impact of the WWW on land administration systems. Lastly issues such as evolving government, professional and educational institutions and benchmarking land administration systems are considered.

Understanding the business-infrastructure relationship in spatial information management

After studying the growth and utilisation (diffusion) of GIS in state governments (Chan and Williamson 1996, 1999a), Chan (1998) details and validates a business-infrastructure model that can better describe how and why agencies cooperate to develop a GIS. In this model, a corporate GIS is viewed as comprising inter-related mutual-

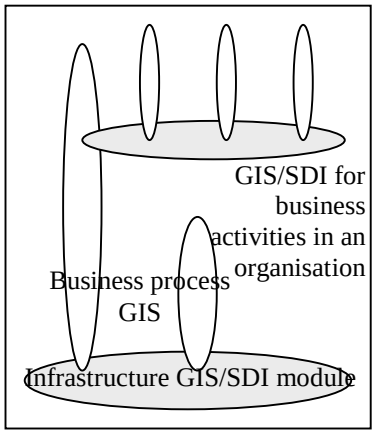

Figure 4. The business-infrastructure model.

supporting multi-levelled modules of business process GIS and infrastructure GIS in the context of the business/production activities of the organisation (Figure 4).

Based on this model, an SDI is disaggregated into a collection of modules of hierarchical infrastructure GIS (the shaded ovals). The business process GIS represents the GIS capabilities developed by the *users* (the clear ovals) that rely on the SDI modules to deliver the products and services needed by the geospatial information industry. This GIS may, in turn, nurture the development of new SDI modules, and link different SDI modules together.

The inherent relationships between the infrastructure and the business process in the business-infrastructure model provide a broad framework for any land administration system development.

The changing nature of spatial data infrastructures

Current spatial data infrastructures (SDIs) are in reality a sophisticated version of the systems that most developed nations have had for over 50 years. They are becoming an important component of any land administration infrastructure. Another development is the recognition that SDIs comprise people, a clearinghouse/access network, technical standards, an institutional framework and framework data. The spatial data infrastructures of the past were designed and driven primarily by the providers of the infrastructure. The last decade has seen rapidly expanding numbers of users of spatial data, which are resulting in a proliferation of spatial business systems. These are now influencing and demanding specific characteristics from SDIs. With the rapidly changing spatial information environment and the impact of such technologies as the WWW, GPS, high resolution satellite imagery, communication technologies and sophisticated decision support systems based on GIS technologies, these spatial data infrastructures will continue to change and develop.

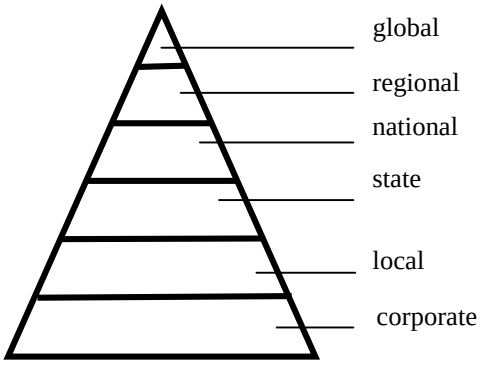

Figure 5. Hierarchy of SDIs

In exploring such changes it is useful to recognise that SDIs are now often being grouped into a hierarchy (Figure 5) comprising six levels of SDIs, namely, global, regional, national, state (also called provincial), local and corporate (Chan and Williamson 1999b). Ideally with compatible sets of SDIs, users working on issues at a higher level in the hierarchy can draw on data from SDIs in all other levels lower in the hierarchy (Rajabifard, *et al*. 1999). Again any jurisdiction embarking on the re-engineering of land administration systems should take this hierarchical view of SDIs into account.

Developing partnerships

Partnership refers to the association of two or more people as partners in the carrying on of a business with shared risks and profits. In this context it is generally

recognised that no one agency can develop a National SDI (NSDI) with the result that different national SDI coordinating agencies are encouraging NSDI development through partnerships (Federal Geographic Data Committee 1997, AUSLIG 1999). In the USA alone, over 50 major partnership initiatives have been established since 1995 on a thematic, state wide and regional basis. States like Victoria in Australia have recently achieved considerable success in developing strong partnerships with local government in providing the State's SDI. These SDIs, and particularly the cadastral component, are an essential component of future land administration infrastructures.

Australia has accumulated significant experience with the development of the cadastral component of its NSDI through a wide range of partnerships between public bodies and those between a public body and a private corporation (Mooney and Grant 1997, Williamson *et al.* 1998). Some are successful and some are not, but all are useful in understanding how partnerships can be better utilised in cadastral and NSDI development. The issues involved in establishing partnerships include standards, cost sharing, privacy, copyright and inter-state/inter-person rivalry. However, the Australian experience also suggests that where there is a need, there is always a solution. It is expected that the determining factors in an on-going research project into partnerships in SDI development will be the type of partnership, the objective, the business driver, organisation settings of the partners and leadership by visionary managers.

National cadastral systems

A move to create national cadastral systems in countries which are federations of states and territories raises many issues. The example of the development of the Public Sector Mapping Agencies (PSMA) national data set in Australia, based primarily on state and territory DCDBs, together with the commitment to a national competition policy, has raised the concept of national cadastral data sets. Such national cadastral data sets are key components of any future national land administration infrastructure. However it must be remembered that each state is responsible under the Australian Constitution for land and land administration, like many other countries which are federations, which results in each state and territory having slightly different land administration and cadastral systems.

One of the differences between the jurisdictions is that different states define parcel boundaries differently. In some states cadastral boundaries can move while in others they cannot. The result is that the concept of a land parcel in the different Australian jurisdictions is different. The major difference is that some jurisdictions permit adverse possession as to part of a parcel and some do not (this means in some jurisdictions a boundary may have moved and is not shown on the digital cadastral map). This difference can also significantly affect the operation of the local land market.

At one level it can be stated in Australia that while all the states permit adverse possession and the two Territories do not, the differing requirements within each state's own scheme must be recognised. For example the State of South Australia only permits adverse possession where registered land has been abandoned or perhaps informally transferred by the registered proprietor, and the registered

proprietor does not object to the proposed registration of the occupier as the new registered proprietor. If a focus is taken on adverse possession of part of a parcel, a situation which can affect the location of the boundary between adjoining parcels, a different conclusion may result. While the State of New South Wales permits adverse possession it does not allow adverse possession of less than a whole parcel. The State of Victoria on the other hand does, which is in line with traditional adverse possession of land not within the Torrens registration scheme (Park *et al.*1998, Park and Williamson 1999a and 1999b).

A single national cadastre in Australia is technically possible as illustrated by the PSMA mapping base (Mooney and Grant 1997) mentioned previously. The positive response from the spatial information industry towards such a product has been favourable, suggesting that a single national cadastre is also desirable. However a possible difficulty is the different approach of each jurisdiction to adverse possession of registered title land, and particularly to part parcel. If Australia decides to adopt common cadastral legislation, it appears that this "possible difficulty" could prove to be a stumbling block in moving towards a national cadastral system. Again this highlights the importance of a broader and more national view in undertaking the re-engineering of State and Territory land administration systems. In the past such changes were only ever considered within a single jurisdictional focus, however that parochial view may require modification.

The spatial hierarchy problem

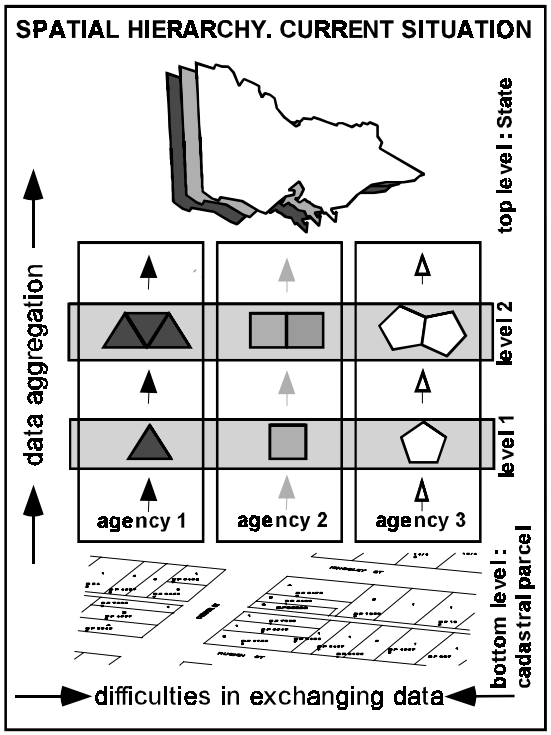

Figure 6. Current situation of managing spatial data among state agencies

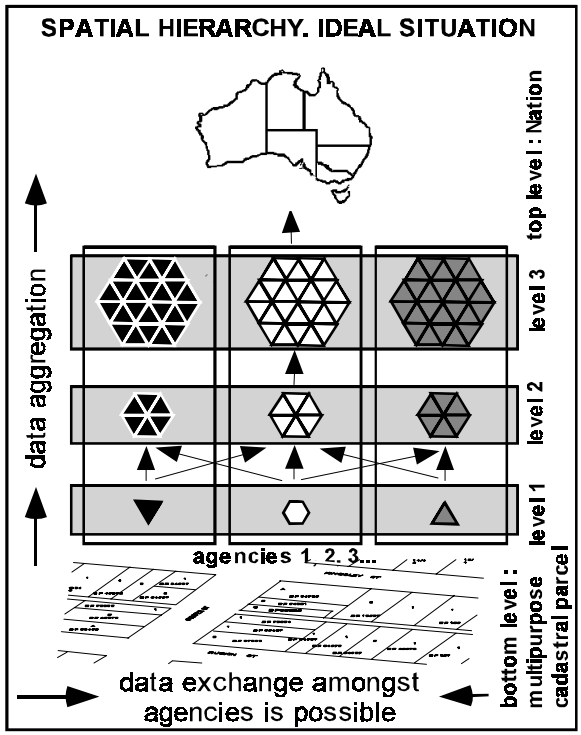

Figure 7. Ideal situation of managing spatial data among state agencies

With the advent of spatial business systems demanding more from spatial data infrastructures and the broader land administration and cadastral systems, problems with the "spatial hierarchy" are becoming an issue. The spatial hierarchy problem refers to the difficulties in exchanging, aggregating and analysing different data sets based on non-coterminous boundaries, as illustrated in Figures 6 and 7 (Eagleson, *et al*. 1999).

Figure 6 illustrates the current situation where each agency collects and aggregates data based on its own hierarchically structured boundaries. The bottom layer is the land parcel or cadastral map, a core component of a land administration infrastructure. Land parcels are recognised as indivisible units. This is common practice in most countries. As a result, data aggregation is possible within each agency but presents difficulties to the sharing of data between various agencies.

Research is being undertaken in Australia to examine trends in such organisations as the Australian Bureau of Statistics (ABS), health and social security departments, and Australia Post to explore the use of Hierarchical Spatial Reasoning (HSR) in assisting in the spatial hierarchy problem. Such an approach has been applied in different applications such as "way finding" for navigation systems (Car, 1997). The properties inherent in HSR theory make it suitable as the base for a re-organisation of spatial units under a common hierarchy. This research aims to apply the principles of HSR theory to the re-organisation of spatial boundaries. Figure 7 shows a model where all agencies share a common structure that enables better analyses using different data sets. By applying HSR to this problem, GIS will hopefully improve its capacity for data integration (one of the items on the agenda of GIS institutions such as the National Center for Geographic Information and Analysis (NCGIA) and the University Consortium for Geographic Information Science (UCGIS)).

Recognising that land administration systems are now providing an infrastructure for a much wider range of uses, any re-engineering of such systems should take the spatial hierarchy problem into account.

Integration of customary and traditional tenures into "western" land administration systems

The inclusion of indigenous interests in land has been recognised by the United Nations in Agenda 21 as important for maintaining and developing a land information system in support of sustainable development. This is a world trend with indigenous interests in land having been recognised and integrated to some degree within mainstream land administration systems, such as those in New Zealand, USA, Fiji, Papua New Guinea, and more notably the establishment of the Nunavut Territory in Canada by the Inuit people.

On the one hand the integration of diverse land tenures into one comprehensive land administration system is essential and inevitable, however it presents many difficulties which have been highlighted around the world. On the other hand the new spatial information technologies and the emerging multi-purpose cadastral systems offer much potential in assisting in solving the inevitable problems in developing the land administration infrastructures that jurisdictions which have to address this issue, will need over the next 10 years.

From an Australian perspective for example, the recent results from the High Court's decision concerning Mabo and Wik, and the inception and implementation of the *Native Title Act* 1993 highlight the issue. These decisions are driving the integration of two vastly different land tenure systems in Australia, namely traditional Aboriginal land tenure and the Australian Torrens system. The amalgamation must result in future modern multi-purpose cadastres in Australia being able to include native title interests while maintaining cultural integrity (Brazenor *et al.* 1999). The tensions inherent in amalgamating two different land tenure systems such as these present a challenge to any country in this situation which is embarking on land administration reform.

Understanding the complexity of cadastral systems and the maintenance of the spatial component

A cadastral system has two components: textual and spatial. Both are core components of any land administration infrastructure. The spatial component consists of cadastral maps, the geodetic framework and survey plans. Maintenance of this spatial component involves updating and upgrading of the 'proposed', 'current legal' and 'as built' spatial data layers of land subdivision activities through various means including the Internet (Effenberg, *et al.* 1999, Falzon and Williamson 1998, Phillips, *et al.* 1998, Polley, *et al.* 1997) as illustrated in Figure 8. The goal of the maintenance exercise is to provide a homogeneous statewide coverage of cadastral data with minimum maintenance duplication. As shown in Figure 8, the objective is not just a matter of updating the state digital cadastral map (often called a digital cadastral data base or DCDB) but of providing an updated digital environment for the effective functioning of the cadastral system.

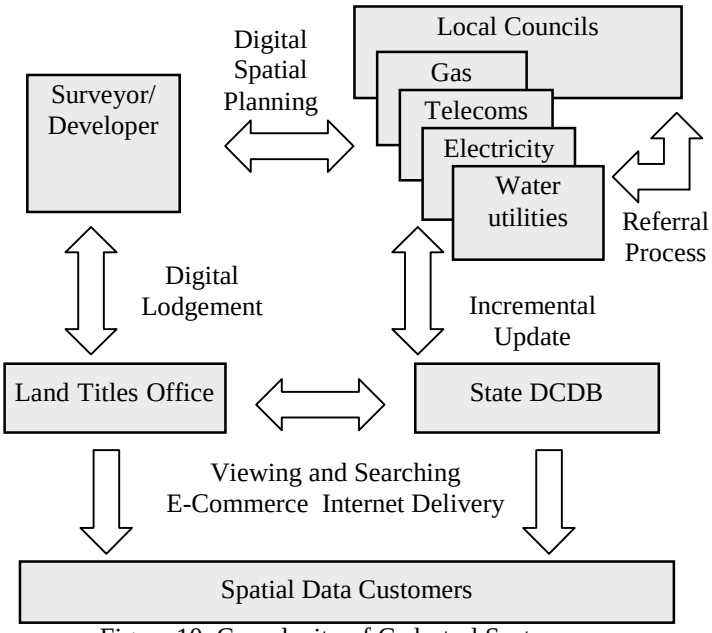

Figure 10. Complexity of Cadastral Systems

This digital view of the spatial component of the cadastre in particular reinforces the need for an integrated view when re-engineering land administration and cadastral systems, and highlights the complexity and inter-dependence of all the components and partners in a spatial data infrastructure.

Impact of the WWW and communications technologies

The WWW and communication technologies are having a major impact on the operation of land administration and cadastral systems. The use of GIS in land administration over the years, in both the natural resources and parcel based areas, has resulted in the proliferation of many large distributed spatial databases. Such spatial databases require efficient means of data management and access tools that intelligently guide users to the data. Metadata (data about data) and metadata engines are examples of intelligent spatial access tools, areas where there is considerable research being undertaken. Metadata provides users with information about the data prior to retrieving and using the data. A Metadata engine can use the metadata for searching and retrieving datasets from across the WWW (Phillips *et al*, 1998). The WWW is also often viewed as storage banks where spatial information can be stored and retrieved locally by Internet users. A prototype developed by Polley uses Java and the Computer Gateway Interface (CGI) language to facilitate a two-way flow of spatial data through the WWW (Polley, 1999).

The WWW is now seen as an alternative to delivering cadastral information from public bodies to the public. In fact some land administration organisations are seeing their whole delivery strategy based on the WWW. WWW servers and the emergence of Map Servers also facilitate the move towards the realisation of the multi-purpose cadastre concept described over 20 years ago and more recently in the Bogor Declaration on Cadastral Reform and Cadastre 2014. However it is only now, due to the technology, that the vision is becoming a reality.

Together with distributed databases, the WWW and Map Servers, a multi-purpose cadastre is expected to allow government agencies to overlay cadastral maps, title registers, planning and other vital land resources live and interactively in order to show the complete legal situation of the land to Internet users across the world (Majid *et al*,1999). In other words it is becoming possible to identify all rights, restrictions and responsibilities relating to land over the WWW. No doubt the WWW, together with advanced communication and information technologies, will continue to be one of the drivers for the future development of land administration infrastructures.

Evolving government institutions

Land administration and cadastral systems have continued to undergo re-engineering over the last 20 years in many developed countries and particularly during the last decade. As a result of the micro-economic reform driver, many governments are moving away from service delivery to focus on directing and setting policy in the land administration and spatial information environment. This is resulting in the growth of a vibrant spatial information industry in some jurisdictions.

At the same time as governments recognise the importance of land administration to sustainable development, government institutions have continued to evolve. A trend has been the amalgamation of all the land related information organisations into one

department, group or unit. A good example is Land Victoria in the Government of Victoria, Australia, but examples can be found world-wide.

An important development has been the emphasis in spatial information development at a national level in countries like Australia which are federations of states. In the past the only organisation with the ability to provide national spatial data was the Australian Federal Government. However as a result of its mandate, the Federal Government tended to focus on small-scale spatial data. With the growth of medium and large-scale digital data at a State and Territory level in Australia, usually based on the cadastre, users are demanding access to this data as an aggregated product at a national level. This has seen the growth of the previously mentioned Public Sector Mapping Agencies (PSMA) (Mooney and Grant, 1997), as an excellent example of the partnership concept in Australia, to provide these products.

Another outcome of these changing institutions has been a growing partnership between academic institutions and both government and the private sectors. With universities also having been significantly affected by micro-economic reform policies resulting in reduced government funding, universities are now providing much of the research and development to government in the broad land administration, cadastral and spatial data infrastructure areas, research which was previously undertaken in-house by government.

As land administration systems take on a more multi-purpose role the necessity for more integrated government institutions and stronger partnerships will increase.

Education and Professional structures

The land administration and spatial information revolution has influenced related education and professional structures in countries such as Australia over the last decade or so. These influences and resulting trends are relevant considerations when developing new land administration and cadastral systems. Professions such as surveying continue to evolve to accommodate the spatial information revolution, while endeavoring to maintain traditional services.

At the university level the impact on surveying has been significant. The surveying discipline has been transformed over the last decade. We have seen the adoption in Australia and internationally of the geomatics concept where the focus of the discipline is to design, build and manage the spatial dimension of the natural and built environment. Several programs like those at the Universities of Melbourne and New South Wales in Australia have become accredited engineering degrees.

At a professional level there have been ongoing discussions in several countries for an amalgamation of the spatial professions into one spatial information body.

An interesting development in Australia is the joint creation of a National Spatial Accreditation Authority by the spatial information industry and professional bodies. This is being coordinated by The Institution of Surveyors, Australia Inc. Such a move is considered essential in a de-regulated environment where traditional bodies like State and Territory Boards of Surveyors in Australia have come under threat as a

result of a national competition policy. At the same time as these developments are occurring, the whole question of the statutory control of spatial data is under review.

These issues should be considered when undertaking reform of land administration and cadastral systems.

Benchmarking *or* how does a government know if it has a good land administration system?

As governments are becoming cost conscious and as management practices such as quality assurance and international best practice are impacting on all government services, governments are questioning the efficiency of their land administration and cadastral systems to a greater extent. Simply put, how does a government or jurisdiction know if it has an efficient and effective land administration and cadastral system?

As a result of these trends, there has been research into the approaches and techniques in evaluating the success of these systems. On the one level there has been a lot of work in developing guidelines as to what constitutes a good system or what are the components of a good system. This has included the FIG Statement on the Cadastre, the UNECE MOLA Land Administration Guidelines, the Bogor Declaration on Cadastral Reform and the FIG Cadastre 2014 vision as examples. However none of these documents provided advice on how to evaluate the performance of a system.

While there is still no definitive approach to evaluating land administration and cadastral systems, there has been some work undertaken which is useful.

The first is the work by Commission 7 of the FIG which is responsible for cadastre and land management. Over the period 1994-98 the Commission undertook an international benchmarking exercise of 53 countries or jurisdictions world wide (Steudler *et al.*, 1997). This approach was adopted as the best way to evaluate the performance of cadastral systems. The study collected economic and statistical indicators about the size, activity and efficiency of each cadastral system so that an attempt could be made to crudely standardise the data so that it could be compared. The four-year exercise proved to be problematic since it was difficult to standardise many of the definitions and processes. However after much effort, international goodwill and collaboration some useful data was produced which is still proving of benefit to countries and jurisdictions for evaluating and improving their systems.

Another approach has been explored by Williamson and Fourie (1998) where they adopted rigorous case study methodologies from the social sciences to cadastral reform. Again while this approach does not specifically provide an approach to determining the performance of systems, it does provide a structured approach to evaluating cadastral systems.

Finally the work of Dale (1999) on developing a process to determine the performance of land markets in countries undergoing transition in Eastern and Central Europe is also useful. He has developed a land market model incorporating policy, legal and financial components. Within this framework a qualitative scoring

system is applied, with the ability to normalise the results. The result is a process to compare the development or efficiency of a land administration or cadastral system from one country to another.

CONCLUSION

In overviewing trends and issues in land administration and cadastral systems, two inter-connected papers have been prepared. The first by Ting and Williamson (1999) describes the humankind-land relationship and the global drivers which are influencing present land administration reforms. It set the scene for this paper which has attempted to look at the issues in re-engineering current land administration and cadastral systems to better meet the needs of the next millennium. The need for a vision based on a broader and more integrated approach is argued. In order for countries or jurisdictions to work towards such a vision a model for re-engineering land administration systems is proposed. The components of the framework are used to review issues and strategies based on the experience of the authors and their colleagues.

In discussing land administration and cadastral reform the paper has described the process leading to the Bathurst Workshop and Melbourne Conference on land tenure and cadastral infrastructures to support sustainable development. It outlines previous work by the UN and the FIG which is used as a basis for the workshop and conference. The two connected papers have attempted to provide a justification for the framework for the UN-FIG Declaration on Land Tenure and Cadastral Infrastructures for Sustainable Development as set out below:

- A future land administration and cadastral vision
- The dynamic relationship of humankind to land
- The role of land in sustainable development
- Tenure systems and land administration
- The interface between land markets, land registration, planning and valuation
- Food, water and land
- Re-engineering cadastral systems
- Recommendations for implementation

The implementation issues outlined in this paper have tried to highlight the complexity and inter-dependency of issues in the area of land administration, cadastral systems and spatial information management. They also highlight their multi-disciplinary nature. They have endeavoured to show that any land administration strategy at any level of government must take a broader approach than in the past by recognising a wide range of social, economic and

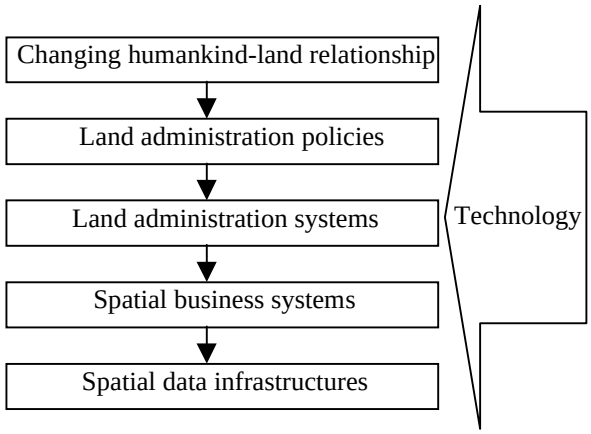

Figure 9. Developing spatial information management strategies

land related issues. A key outcome of such strategies is the development of land administration infrastructures and spatial information management strategies.

The development of these spatial information management strategies requires an understanding of the relationship between the changing humankind-land relationship, land administration policies, land administration systems, spatial business systems and spatial data infrastructures, while recognising the impact of technology across these dimensions (Figure 9). In this context, spatial data infrastructures will evolve to accommodate the business needs of land administration decision support systems and multi-purpose cadastres. An emphasis on business needs as distinct from infrastructure needs of spatial information will see a re-engineering of current SDIs as key components of future land administration systems.

In summary, sustainable development will be the focus for the changing humankind-land relationship into the next millennium. This will demand sophisticated land administration infrastructures in order to support the necessary decision-making. These in turn will require support from more generic information technologies integrated with spatial information technologies that can process and package data that is of sufficient quality, accuracy, relevance and inter-operability to the decision-makers. Herein lies the challenge that needs to be tackled in developing the next generation of land administration systems.

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NOTE: Most of the articles by Williamson and his colleagues can be found at <http://www.geom.unimelb.edu.au/research/publications/IPW_publ.html>