Role of Spatial Data Infrastructures in Managing Our Cities[1]

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SUMMARY

The aim of this presentation is to outline the role of spatial data infrastructures (SDI) in managing cities. The presentation will contain an overview on current status and application of SDI including:

- Institutional arrangements, information policy and legal frameworks needed to create and share data, information and tools within and between levels of government
- Respective roles of government, private sector, professional bodies and community groups in creating and managing SDI
- Implementing international best practice standards in SIM at all levels, including use of ISO/TC 211, OpenGeospatial® Consortium, etc.

Australia will be used as a case study of how SDI is used to support urban land planning; real estate management and development; environmental management; public safety; and social and economic infrastructure.

This material will be used to support subsequent discussion on the role of local, regional and national SDI in managing mega cities to help firm up the work program of FIG Working Group 3.2 over the next three years. These topics include:

- Identify institutional, policy and legal frameworks that can be incorporated in SDI to address mega city issues
- Identify specific technical innovations in SIM that can improve management of mega cities
- Roles and benefits to surveyors, government, associations engaged with spatial data and users of spatial data and spatial information

[1] This paper was presented as keynote address at the FIG Commission 3 2007 Annual Meeting and Workshop "Spatial Information Management Toward Legalizing Informal Urban Development", Sounio, Athens, Greece, 28-31 March 2007

1. INTRODUCTION

Geographically referenced information has become indispensable for numerous aspects of urban and rural development, planning and management. The increasing importance of spatial information has been due to recent strides in spatial data capture (especially satellite remote sensing), management (utilizing GIS and database tools) and access (witness the growth in web mapping), as well as the development of analytical techniques such as high resolution mapping of urban environments.

The concept of spatial data infrastructures (SDI) has been developed to encompass the efficient and effective collation, management, access and use of spatial data. SDI has been adopted in many countries around the world, notably at national level, but frequently found at sub-national levels based on regional or local government areas. SDI has been seen as a purely governmental mechanism and it is true that government agencies constitute the greatest collectors and users of spatial information. However, there is a clear trend to involve diverse user communities that incorporate elements of the private sector and non-governmental organisations to ensure that investments in spatial data development yield the greatest possible benefit.

> *Definition of SDI*
> An SDI comprises the people, policies and technologies necessary to enable the generation and use of spatially referenced data through all levels of government, the private and non-profit sectors and academia.

Developing and implementing an SDI should be seen as an integral component of a jurisdiction's overall social and physical infrastructure planning.

However, the development of an SDI is problematic. Key issues have been the diversity of data sources and management of spatial data, usually spread across a multitude of agencies and organisations focused on single mandates. A challenge has been to develop new institutional arrangements to allow implementation of appropriate integration of data, adoption of relevant data standards and meet a growing range of needs for spatial data products. These arrangements vary from choosing an existing agency to lead SDI development (such as the agency responsible for land administration), through formal coordinating committees to formation of a specialist "SDI" agency. The choice will be based on prevailing administrative, legal and social cultures found in a jurisdiction.

The role that SDI initiatives are playing within society is changing. SDIs were initially conceived as a mechanism to facilitate access and sharing of spatial data for use within a GIS environment. This was achieved through the use of a distributed network of data custodians and stakeholders in the spatial information community. Users however, now require the ability to gain access to precise spatial information in real time about real world objects, in order to support more effective cross-jurisdictional and inter-agency decision making in priority areas such as emergency management, disaster relief, natural resource management and water rights. The ability to gain access to information and services has moved well beyond the domain of single organisations, and SDIs now require an enabling platform to

support the chaining of services across participating organisations (from *The Role of Spatial Data Infrastructures in Establishing an Enabling Platform for Decision Making in Australia,* Williamson, Rajabifard and Binns, GSDI-9 Conference Proceedings, 6-10 November 2006, Santiago, Chile)

2. USING SDIS TO MANAGE CITIES

Applying spatial information can help to solve problems in cities. For example, Lagos Metropolis has emerged as one of the fastest urbanizing cities in the West African Sub-region. In the absence of a regular use of information management systems, limited effort had been made to keep track of change in the rapidly growing city for policy making in land administration. The ubiquitous energy radiated by the rapid urbanization rate in the area not only created unprecedented consequences by diminishing the quality of the environment but it raises serous implications for land management in the region. The factors fuelling the land crisis in the area which are not far fetched consists of socio-economic, ecological and policy elements. To tackle these issues in a mega city, up-to-date knowledge would be required to capture and analyze land information in order to control city's expansion as well as infrastructure development and make well-motivated choices in planning and (spatial) designs (from *The Applications of Geospatial Information Technology in Land Management: A Case Study of Lagos, Nigeria*, Albert Osei et al, GSDI-9 Conference Proceedings, 6-10 November 2006, Santiago, Chile)

City Governments are entrusted with the stewardship of land to ensure that it is equitably exploited amongst a diverse set of users without compromising the ability of future generations to meet their own needs for land. Decisions to support the sustainable development of this land, as a valuable and finite resource, merit a holistic approach to impact assessment. Many aspects and options need to be explored to arrive at an appropriate, objective decision. This can only be achieved if the decision makers, both city officials and citizens, have access to consistent and integrated information about land. A key element in providing this relevant land information is City-wide Land Information Management (LIM), the institutional and technical arrangements whereby information about all land and real property within a city are administered.

Cities currently manage considerable collections of land related information. However, the traditional separation of this information into different component themes (see Figure 1 below), combined with disjoint information management regimes, leads to a considerable loss in the value of the information as a resource. City-wide LIM provides the means to technically and institutionally integrate these component themes of land information into a truly corporate information resource. The figure below illustrates how City-wide LIM can add value by combining information concerning use, condition, value and tenure of land and disseminating this to the decision makers.

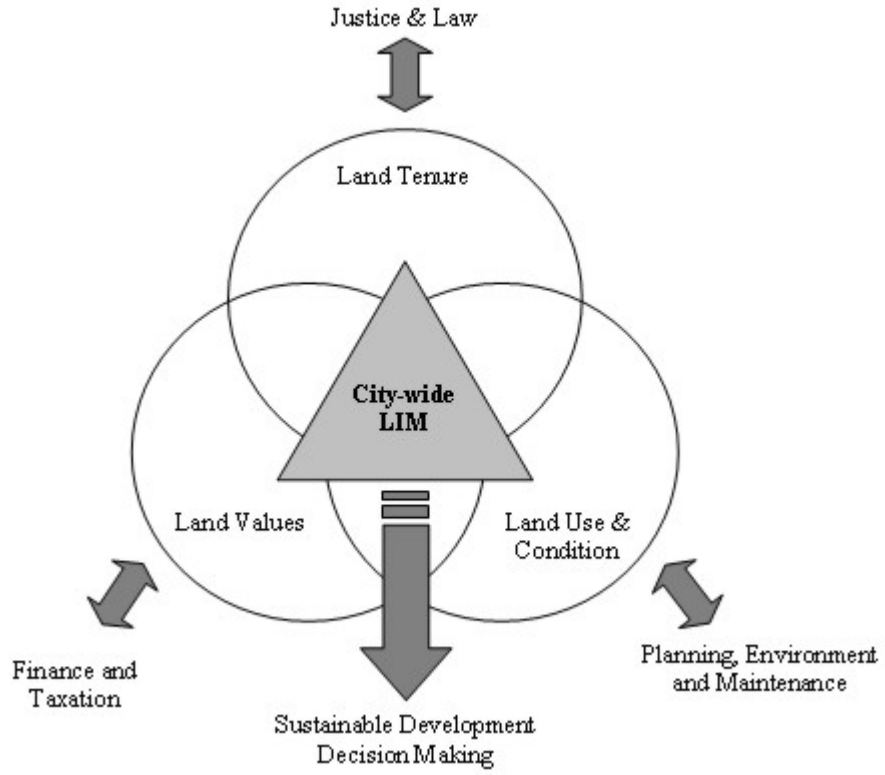

Figure 1: City-wide LIM Supporting Sustainable Development Decision Making (from FIG Publication No. 31 *Land Information Management for Sustainable Development of Cities: Best Practice Guidelines in City-wide Land Information Management*, 2002)

The Marrakech Declaration (FIG Publication No. 33) recommends the development of a comprehensive national land policy, which should include:

- Institutional and governmental actions required for providing good governance.
- Land administration infrastructures for steering and control of land tenure, land value and land use in support of sustainable land management.
- Tools for capacity assessment and development at societal, organisational and individual level.

This should in turn form the basis for sound administration at local level. While the focus has been on land administration, management of a city includes other factors, such as public safety. So, while an SDI should provide the basis for a good land administration system, it must also serve a range of city management processes not necessarily dependent on use of land. For example, the availability of a sound cadastral database covering spatial, legal and valuation systems is a key element of an SDI; other data sets not necessarily based on cadastral parcel are just as valid. Datasets can include census districts, administrative units defining communities and government agency services, road and utility service networks and natural feature boundaries.

There are a number of key issues faced by the growth of cities, which places severe strains on their management. Key issues that need to be addressed and possible use of spatial information are shown in the following table.

Issue	Use of spatial information	Examples
Environmental		
Land use planning	Describe spatial extent of allowable land uses	Land zoning maps
Impact of development	Describe land capability and sustainability	Terrain maps showing vulnerability to land slippage
Impact of climate change	Vulnerability to rising sea level and tidal surges	Flood prone land mapping and real-time weather mapping
Access to water	Location of dams and fresh and waste water reticulation networks	Catchment terrain maps
Pollution and hazards	Location of broad and point specific pollution and hazardous wastes	Inventory of properties where hazardous wastes are stored
Governance		
Land allocation	Describe pattern of current land use	Digital cadastral database
Access to serviced land	Current location of serviced land	Cadastral map overlaid by current aerial photography and utility service networks
Secure property rights	Spatial extent of existing property rights	Land titles register containing all rights, restrictions and obligations for each property
Community participation	Public access to cadastral, planning and environmental information affecting individuals and the community	Public display of proposed developments, land suitability and other maps
Fiscal sustainability	Comprehensive and accurate records of the extent of existing property rights and land use	Land valuations shown on cadastral maps
Public safety	Comprehensive data about roads, properties and hazards	Emergency dispatch system; bushfire models
Slum reduction	Location of vacant or under-utilised land and population growth predictions	Current aerial photography, predictive modeling of land use
Measuring performance	Land change over time	Land change mapping

Social and economic infrastructure		
Employment	Location of existing enterprises and land zoning for future business use based on predicted population growth	Maps showing land zoned for business use
Communal facilities	Location of land set aside for communal facilities	Street map showing location of communal facilities
Utility services	Location and attributes of fresh water, sewer, storm water, electricity and telephone networks	Cadastral maps showing utility services
Transport	Location and attributes of public roads	In car navigation device using up-to-date road network and GPS
External effects		
Rural sustainability	Location, size and productive capacity of rural properties	Satellite images of rural areas overlaid by cadastral boundaries
Access to raw materials	Location of sources of food and mineral production and transportation corridors for their movement to the city	Topographic mapping series

3. THE BROAD CONTEXT OF SDI

SDIs are more than a collection of spatial data sets. They are also more than a land administration system. SDI form an under layer of policies, administrative arrangements and access mechanisms to allow integration of data from various providers, systems and services to support end-to-end processes across organizational and technology boundaries within a defined jurisdiction.

Some trends in SDI development include:

- Most countries recognise the value of spatial capabilities and are developing SDI strategies at national and sub-national levels
- Key applications are disaster management, national security, natural resource management and land administration
- City and local governments are a growing user of spatial information for delivering community services
- Public use is growing through navigation and online services

While individual city governments are developing their SDI, experience shows that they are more effective if they:

- Implement international best practice (such as use of ISO and OGC standards)
- Use data from higher levels (such as regional cadastral database, utility and transport network data and national topographic database)
- Provide end-to-end processes merged with surrounding jurisdictions (such as regional planning processes and land use plans).

In fact, city SDIs should look like a microcosm of regional and national SDI, perhaps differentiated by use of higher resolution data.

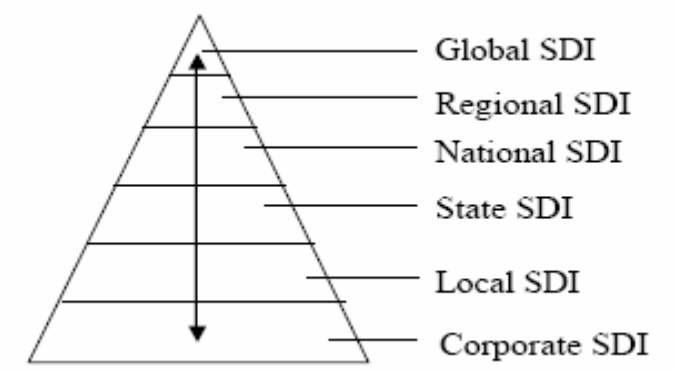

Figure 2: An SDI Hierarchy (from Prof Ian Williamson)

Experience in countries such as Australia shows that problems encountered in developing an SDI at any level include:

- Immature institutional arrangements and user/provider relationships
- Inconsistencies in the availability and quality of spatially referenced data
- Inconsistent policies concerning access to and use of spatially referenced data
- Incomplete knowledge about the availability and quality of existing spatially referenced data
- Lack of best practice in the utilisation of enabling technologies.

4. DEVELOPING AN SDI

The following development guideline is drawn from the Australian Spatial Data Infrastructure Action Plan 2002-2004.

SDI governance

Goal.	Holders of spatial data, service providers and users in government agencies, business enterprises, academic institutions and community groups are involved in implementation and use of the SDI.

The focus of SDI governance efforts is to improve institutional arrangements in support of the SDI. The key outcome to be achieved is the removal of barriers to access and use of spatially related data. Often, institutional arrangements are based on a cooperative approach supported largely by personal relationships, which while assisting with communication and action, can fall over when personnel changes occur. Therefore, there is a need to develop enduring

underpinning structures. The need to engage user communities and the emerging role of the non-government sector has highlighted the need for arrangements that take into account the balance between public and private sectors, data sources and data users.

The development of an SDI should be the means of brokering partnerships between diverse data providers and users, led by a lead organisation acceptable to all key stakeholders. It should also provide the opportunity to engage the local community, provide more open access to information and encourage participation in decision-making.

Data Access

Goal.	Spatial data users are able to find and access existing data sources and services with minimum impediments.

Mechanisms need to be provided for data sources and service providers to advise potential users about the availability of their spatial data and services. Mechanisms should include:

- Consistent policies and best practice procedures that minimise regulatory and administrative barriers to access (such as consistent data pricing, protection of privacy and intellectual property and mandating data management best practice standards and procedures)
- Tools such as directories and catalogues that assist users find and access existing spatial data and services
- Tools that assist users to access existing spatial data and services, such as over-the-counter services at local government offices, display of maps in public places and web portals
- Communication mechanisms to assist users to be heard on data access needs

Data Quality

Goal.	Users are able to easily ascertain the quality of existing spatial data and its fitness to meet their needs.

Availability of metadata is the key to providing users with documentation about data quality. There also needs to be use of best practices in spatial data management, including adoption and use of data quality documentation standards. In Australia, this has taken the form of:

- Data quality metadata records held by a distributed clearinghouse (40,000 records in the Australian Spatial Data Directory)
- A minimum set of SDI-endorsed data quality standards, especially ISO 19115 and ISO 19139 implemented in commercial software products
- Development of an SDI technical architecture and a Harmonised Data Model (HDM) and published best practice toolkits for local government

Interoperability

Goal.	Access to and combination of spatial data sources and services is made time and cost efficient for users through use of world's best practice interoperable technologies.

The availability of online Web Services models, Internet standards and spatial interoperability standards now allows digital data to be viewed and overlain using common web browsers. Australian governments support implementation and use of the open systems specifications promulgated by the OpenGeospatial® Consortium (OGC) and the World Wide Web Consortium (WWWC) in SDI, as part of the e-Government Interoperability Framework. Action can include:

- A collaborative partnership approach between the public and private sectors in providing interoperability;
- Identify the costs of implementing interoperability and how these can be shared;
- Promote adoption of interoperability specifications and technologies through targeted pilots, test beds and case studies which conform to world's best practice
- Promote development of reference implementations and geospatial web services in both the public and private sectors capable of supporting and using an interoperable environment.

Integratability

Goal.	Spatial data sources conform to common standards that enable integration with other data, where such integration enables efficient and effective solutions for users.

Just as important as interoperability, is the ability to integrate data to improve its usability. The true value of many datasets are realised when they are integrated with companion datasets to allow spatial analysis to occur. Standards relevant to the SDI in general should be focused on making individual data and systems fit/work together. Areas for integration need to be defined by user needs rather than because a standard exists. There is a need to consider privacy issues, as they can restrict some forms of data integration. Actions can include:

- Identify priorities and support development of consistent and integratable spatial data sets that meet demonstrated user needs
- Adopt common classification systems, spatial referencing and content standards, data models and other common models to facilitate data development, sharing and use of these data sets
- Encourage data providers to make priority data sets available through the SDI

5. MEASURING PERFORMANCE OF AN SDI

Area	Possible Indicators
Policy Level – *Policy*	• existence of a government policy for SDI • handling of intellectual property rights, privacy issues, pricing • objectives for acquisition and use of spatial data
Management Level – *Standards*	• standardization arrangements for data dissemination and access network • institutional arrangements of agencies involved in providing spatial data • organizational arrangements for coordination of spatial data • definition of core datasets • data modelling • interoperability
Management Level – *Access Network*	• access pricing • delivery mechanism and procedure • access privileges • value-adding arrangements
Operational Level – *Access Network*	• type of network • data volume • response time
Operational Level – *Data*	• data format • data capture method • definition of core datasets • data maintenance • data quality and accuracy
Other Influencing Factors – *People*	• number of organizations and people involved • opportunities for training • market situation for data providers, data integrators, and end-users
Performance Assessment	• degree of satisfying the objectives and strategies • user satisfaction • diffusion and use of spatial data and information • turnover and reliability

Figure 3: Possible Indicators for Evaluating SDIs (from Prof Ian Williamson)

6. FURTHER DISCUSSION

This material will be used to support subsequent discussion on the role of local, regional and national SDI in managing mega cities to help firm up the work program of FIG Working Group 3.2 over the next three years. Topics will include:

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BIOGRAPHICAL NOTES

Paul Kelly has extensive experience in the development of spatial information policy and operational management at both national and state government levels.

Paul has headed the national office of ANZLIC – the Spatial Information Council for Australia and New Zealand from 2001 to 2004 where he worked with key users of spatial information in natural resource management, emergency management, counter-terrorism and local government.

During an eclectic career, he has also been the Chief Information Officer of a New South Wales (NSW) natural resource agency and Deputy Surveyor-General of NSW.

He has degrees in surveying, geography, history and political science.

He is currently the Director of Spatial Strategies Pty Ltd, which offers advice on land administration reform and the strategic use of spatial information in government agencies and business enterprises. He has recently completed the Land Administration Strategy for Vietnam and the Spatial Information Strategy for the NSW State Government.

He is the chair of FIG Commission 3 Working Group 3.2 – Spatial Data Infrastructure for 2007-2010.

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