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SDI TO FACILITATE A SPATIALLY ENABLED SOCIETY

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ABSTRACT

The ability of society to meet sustainable development objectives is a complex and temporal process involving multiple stakeholders. This can be facilitated through the development of a spatially enabled society, where location and spatial information are regarded as common goods made available to citizens and businesses to encourage creativity and product development. This requires data and services to be accessible and accurate, well-maintained and sufficiently reliable for use by the majority of society which is not spatially aware.

With this in mind, many countries are developing Spatial Data Infrastructures (SDIs) to improve access, sharing and integration of spatial data and services, however, there are still many issues and challenges which need to be overcome in order to have a fully functioning SDI. For example, an integration mechanism, cooperation between the private, public and academic sectors and a development framework are essential to form the information infrastructure required to support a spatially enabled society.

This paper aims to introduce and discuss various challenges and issues associated in building a spatially enabled society. It also discusses the central role that an SDI plays in facilitating this as the enabling platform. This includes aspects of designing, creating and processes involved in development and governance of an SDI platform.

BIOGRAPHY OF PRESENTER

Andrew Binns is a Research Fellow and member of the Centre for Spatial Data Infrastructures and Land Administration at the University of Melbourne. He previously worked with the Cooperative Research Centre for Spatial Information (CRC-SI) investigating the development of Virtual Australia. He has also worked as part of a project team who looked into the development of a marine cadastre for Australia. His research areas include SDI development, Land Administration, Marine Cadastre and Marine Administration and Remote Sensing.

INTRODUCTION

The majority of government organisations and businesses currently under-utilise the spatial dimension of their information in which 80% of this information has a spatial dimension or location. One of the reasons for this under-utilisation is due to many issues regarding the storage and access of data in various jurisdictions concerned with custodianship, different jurisdictional responsibilities, different institutions, privacy and different legal and regulatory regimes, which all impact on the effective delivery of

spatial data. In order to address this, the concept of a Spatial Data Infrastructure (SDI) has been developed.

SDIs have become a crucial tool in facilitating how spatial data and spatial information systems are used. They allow the sharing of data, which enables users to save resources, time and effort when trying to acquire new datasets. Effective use of spatial information requires the optimisation of SDIs to support spatial information system design and applications, and subsequent business uses. The key challenge is how to develop an SDI that will provide an enabling platform in a transparent manner that will serve the majority of society who are not spatially aware.

Having said that, there are many parallels between the thinking that underlies the development of SDIs and the vision of spatially enabled society. SDI development, as it has emerged over the last fifteen years (Masser 2005), has often been dominated by the concerns of central governments usually without the participation of stakeholders from the sub national levels of government, the private sector and academia. SDIs have also been developed in many cases as a tool for the professional elite rather the population as a whole who are the main beneficiaries of spatially enabled society.

With these considerations in mind Masser *et al*. (2006) highlighted some challenges that must be overcome to make existing SDIs more appropriate for spatially enabling government and society. These include four strategic challenges arising out of this new environment (Figure 1). The first of these is the need for more inclusive models of governance given that SDI formulation and implementation involves a very large number of stakeholders from all levels of government as well as the private sector and academia. The second concerns the promotion of data sharing between different kinds of organisations. In some cases this may require new forms of organisation to carry out these tasks. The third challenge relates to the establishment of enabling platforms to facilitate access to spatial data and the delivery of data related services. The fourth challenge arises from the changes that are taking place in the nature of the users of spatial information in recent years. In place of the spatial professionals who have pioneered these developments an increasing number of end users will need some training in spatial thinking to make them more literate users. Consequently there are a number of new capacity building tasks to be undertaken in order to create a fully spatially enabled society.

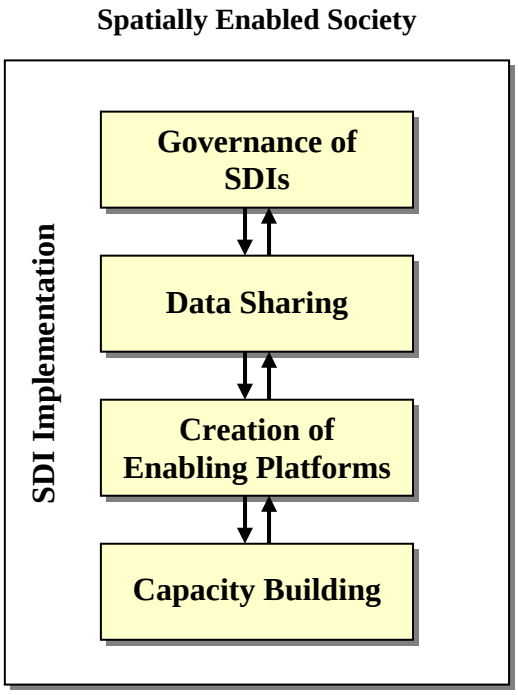

Fig. 1: Strategic Challenges
(Adopted from Masser *et al*, 2006)

This paper aims to introduce and discuss various challenges and issues associated in building a spatially enabled society. It also discusses the central role that an SDI plays

in facilitating this as the enabling platform. This includes aspects of designing, creating and processes involved in development and governance of an SDI platform.

WHAT IS AN ENABLING PLATFORM?

The development of an enabling platform for a country or a jurisdiction will enhance the capability of government, the private sector and the general community in engaging in systems based, integrated and holistic decision making about the future of that jurisdiction. Applications, tools, and different sorts of information would be available through the platform to build a view of, query and allow decisions to be based on, both the built and natural environments. This platform must also include the administration and institutional aspects of such features, enabling both technical and institutional (eg. policies) aspects to be incorporated into decision-making. This is an aspect of research identified as more challenging than complex technical issues (Rajabifard *et al*, 2005).

Further, an enabling platform is an infrastructure that supports a knowledge base to access information derived from a model of integrated datasets from different disciplines such as the natural and built environments. It can comprise of individual organizations or partners working as a collaborative network to deliver specialized products and services for various applications such as animal and disease control and counter terrorism, on the basis of common standards (like Open Geospatial Consortium - OGC) and business understanding, creating distributed functions within the organisations (Radwan *et al*, 2003). It can also support ready access to applications of spatial information to support decision making at different scales for multiple purposes. It could be viewed as an infrastructure linking data users and providers on the basis of the common goal of data sharing across jurisdictions.

The creation of an enabling platform for access to information and technology would help to lower barriers to access and use of spatial information and tools within the spatial information industry. This lowering of barriers will enable industries to concentrate on their core business objectives to greater effect, would reduce duplication of effort, reduce costs and encourage investment in capacity for generating and delivering a wider range of products and applications (Rajabifard *et al.* 2005).

SPATIALLY ENABLED SOCIETY

Societies can be regarded as spatially enabled ‘where location and spatial information are regarded as common goods made available to citizens and businesses to encourage creativity and product development’ (Wallace *et al*, 2006, 3). In this regard, the vast majority of the public are users, either knowingly or unknowingly, of spatial information.

Spatially enabled society consists of an overarching vision and a set of tools. The vision is to establish an enabling infrastructure that will facilitate the provision of the place or where or location to all human activities, and government actions, decisions and polices. The enabling infrastructure provides the set of tools combining technical, institutional, legal and policy aspects which can be used to assist the delivery of sustainable development at all levels of government and society. Such spatial enablement allows business transactions to be linked to a place or location and further facilitates the evaluation and analysis of relationships between people, business transactions and government.

A spatial enabled society including government is one that plans to achieve three broad goals as highlighted by Masser *et al.* (2006):

- More effective and more transparent coordination, where voters are able to access the spatial information they require to evaluate the choices made by elected decision makers.
- The creation of economic wealth through the development of products and services based on spatial information collected by all levels of government.
- The maintenance of environmental sustainability through the regular and repeated monitoring of a wide range of spatial indicators distributed throughout the world as a whole.

Realising this vision of spatially enabled society is dependent on the development of appropriate mechanisms to facilitate the delivery of data and services. These mechanisms should embody the following principles that are the foundation of the INSPIRE initiative that is currently being implemented by the European Commission (CEC 2004):

- Data should be collected once and maintained at the level where this can be done most effectively
- It should be possible to combine seamlessly spatial data from different sources and share it between many users and applications
- Spatial data should be collected at one level of government and shared between all levels
- Spatial data needed for good governance should be available on conditions that are not restricting its extensive use
- It should be easy to discover which spatial data is available, to evaluate its fitness for purpose and to know which conditions apply for its use (http://inspire.jrc.it).

The most highly developed mechanisms of this kind in operation for such purposes are the SDIs that are currently being developed in more than 70 different countries throughout the world (Crompvoets *et al*, 2004).

GOVERNANCE, DATA SHARING AND PARTNERSHIPS

SDI development over the past fifteen years has seen three main players emerge, being federal/national governments, sub-national governments and the private sector. Originally, National governments set spatial information and SDI policy through a top-down approach as well as leading in the building of the infrastructure. The involvement of sub-national governments and the private sector was not as well coordinated.

Current trends and SDI development however, especially within Australia, has seen the roles of the three major players changing to meet the needs of the focus on large-scale, people relevant data within SDIs. Although national government influence at a strategic and operational level has decreased, there is still a strong case for a strategic national government role in SDI coordination. The operational role of SDI development has now become the main domain of sub-national governments who produce large-scale land administration data. This data aids in collecting taxes, land use planning, the operation of land markets, road and infrastructure development and day-to-day decision making.

The private sectors operational role has also increased and they are leading the drive for greater access to people relevant data that is utilised to effectively undertake their role in society (Rajabifard *et al*, 2006a).

This new role in SDI development has seen it become necessary to think in terms of more inclusive models of SDI coordination and governance so that they are both understood and accepted by all stakeholders. These new models will need to be based on effective partnerships in order to facilitate data sharing across jurisdictional boundaries.

Partnerships have existed in government and business for many years. In some cases a partnership may be as simple as an informal arrangement to share a resource, for example a building or to provide an incentive to land development. In the context of developing SDIs however, there is a need for partnerships to consist of an ongoing formal relationship between jurisdictions (especially national, state and local government) to which each makes a defined contribution and from which each expect to receive benefits (McDougal *et al*, 2005). These types of partnerships, can be viewed as a pyramid of building blocks, displaying many hierarchical properties. This hierarchical system of SDIs can help to gain a better understanding of the political and administrative issues that impact SDIs. Local government SDI with their detailed data sets would form the base of the pyramid and global SDI with its more generic data sets would form the top of the pyramid. Another perspective of SDI put forward relates to understanding the inter-relationship between the levels of SDI and the areas of policy, fundamental datasets, technical standards, access network and people (Rajabifard *et al*, 2000).

This trend to expand efforts in developing SDIs through partnerships can be seen throughout countries developing SDIs, as data sharing is crucial to the success of SDIs. In the 1990s National SDI development took a broad-base approach to encourage cooperation among stakeholders to pool data assets. Based on this approach, an ideal SDI should have all datasets in the local SDI fully integrated. Constrained by existing technical and institutional arrangements, SDI developing agencies have focused on promoting adoption of common standards, as well as fast-tracking integration among certain strategic datasets through partnership arrangements (ANZLIC 1996, Jacoby *et al*. 2001). Partnerships are formed to create business consortia to develop specific data products or services for strategic users, by adopting a focussed approach to SDI development. This can include aspects of government/private sector partnerships, joint ventures, consortiums etc. that enable various players to create services and infrastructure that they could not create on their own.

It is also important to identify and understand the legal, economic, cultural and community issues as they help to better define and arrange data sharing relationships through the partnerships concept (Rajabifard *et al*, 2002). This is highlighted by Onsrud and Rushton (1995) who defined the issues involved in data sharing in the following way: ‘Sharing of geographic information involves more than a simple data exchange. To facilitate sharing, the GIS research and user communities must deal with both the technical and institutional aspects of collecting, structuring, analysing, presenting, disseminating, integrating and maintaining spatial data’.

The varying ways that partnerships and data sharing is carried out shows the myriad of challenges that spatial information communities face in developing effective SDIs. In

many cases, partnerships are already in place at a certain level. However, many other cases will require either major changes in existing organizational structures or the creation of new structures to facilitate data sharing activities within the framework of SDI development.

THE CREATION OF ENABLING PLATFORMS

Development of SDIs have played a major role in helping to form the concept of a spatially enabled platform. Initially SDIs were implemented as a mechanism to facilitate access and sharing of spatial data hosted in distributed GISs. Users however now require precise spatial information in real time about real world objects and the ability to develop and implement cross-jurisdictional and inter-agency solutions to priorities such as emergency management, natural resource management, water rights and animal, pest and disease control.

In order to achieve this, the concept of an SDI is moving to a new business paradigm, where SDI is emerging as an enabling platform to promote the partnership of spatial information organisations (public/private) to provide access to a wider scope of data and services, of size and complexity that is beyond their individual capacity.

SDI as an enabling platform can be viewed as an infrastructure linking people to data (Figure 2) through linking data users and providers on the basis of the common goal of data sharing. The benefits of SDI in enabling this sharing of information have been documented, however an SDI does not necessarily break down the barriers between jurisdictions. Just because different information can be gained about a state for example from different jurisdictional levels, does not mean that the information will necessarily be compatible (it may not be of the same accuracy or have the same specifications, utilize the same symbology, etc). There is now a need to move beyond a simple understanding of SDI and create a common rail gauge to aid in implementing initiatives that solve cross-jurisdictional and national issues.

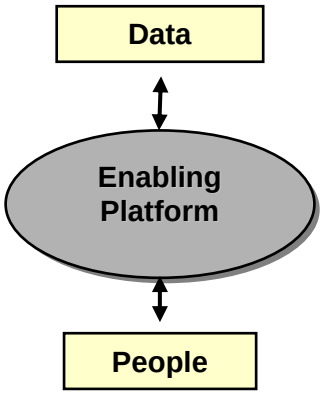

Figure 2: Connecting People to Data

The technical basis for delivery of enabling platform should be through an interoperability architecture based on distributed, custodial data management and open standards. This would provide uniform and consistently managed access to distributed web services operated by authoritative custodians. This architecture would allow initiatives to grow in an open environment that gives government and agencies the ability to operate in an integrated manner (Rajabifard *et al*. 2005). This creates an opportunity for a whole of government initiative to develop from the often-fragmented developments at different levels.

The ability to deliver the concept of spatially enabled platform however will also require an investigation of the way that data will be stored in the future. The ability to allow massive consolidation of spatial data sets across all jurisdictions may enable the creation of a seamless platform (which covers both land and marine environments), although there is the need to look closely at the advantages and disadvantages of both a

distributed data model verses a consolidated model. It will be important that the concept is based upon and takes advantage of the latest technologies, standards and metadata application in order to deliver an interoperable environment. One of the key objectives of SDI is to facilitate the interoperable environment through the ability to integrate multi-source datasets.

With this in mind, the enabling platform will be the main gateway to discover, access and communicate spatially enabled data and information about the jurisdiction and society. Such an entity can be enhanced so that it is possible to share in addition to data, business goals, strategies, processes, operations and value-added products. In this environment all types of organisations participating (including governments, industries, and academic) can gain access to a wider share of the information market ensuring more transparent and effective information coordination. This is done through organisations providing access to their own spatial data and services, and in return, becoming a contributor and hence gaining access to the next generation of different and complex services. The vision is to facilitate the integration of existing government spatial data initiatives for access and delivery of data/information. This integration would be based on common standards and business understanding and combines distributed functions provided by participating organisations to deliver services which are structured and managed in such a way that to be seen by third parties as a single enterprise.

Following this direction, in Australia for example, the development of an enabling platform called Virtual Australia is underway. The concept and delivery of Virtual Australia aims to enable government and other users from all industries and information sectors to access both spatial information (generally held by governments) and applications which utilise spatial information (developed by the private sector and governments). According to Rajabifard *et al*. (2006b), Virtual Australia is a vehicle from which both textual and spatial data are utilized to form a range of supported functions for those within the industry as well as non-spatial and non-technical user groups. Each state jurisdiction has a range of initiatives and functions being both used and created often in isolation from one another. The creation of Virtual Australia will help to modularize the development of SDI – creating services and functions that can be utilized at further levels up the information chain, including across jurisdictions, and by society as a whole. Although technical capabilities are important in the creation of a Virtual Australia, administrative and institutional aspects to its creation must also be researched and implemented if it is to be successful.

With this in mind, Virtual Australia is an enabling platform that supports the vision of spatially enabled government by providing a major point of discovery and communication to complete, correct and current information about the natural and built environment and related affordable spatial information applications, in a useable and readily available manner at anytime and in anyplace.

Another example is the Geospatial One-Stop (GOS) in the USA, which is one of three major initiatives (Federal Geographic Data Committee (FGDC), Geospatial One-Stop (GOS) and The National Map initiative) driving the development of a National SDI (NSDI) for USA. The GOS is one of 24 e-Government priorities that are aiming to make it easier, faster and less expensive for all levels of government and citizens to access spatial information (Ryan *et al*, 2004). From a policy perspective, it adds three unique benefits to the implementation of the NSDI including:

- Raising the visibility of the strategic value of geographic information
- Increasing federal accountability for geospatial data stewardship, and
- Establishing a collaborative model for an intergovernmental initiative.

The establishment of the GOS also gives the implementation of an NSDI a sense of urgency and importance. The GOS implements the basic elements of the NSDI by providing an Internet portal to facilitate data sharing and encourage decision support across all jurisdictional levels of the country. GOS will rely on the National Map as the underlying provider of base content for all other GOS supplied datasets. This gives the USA a base layer of fundamental data from which all other jurisdictional levels are able to work from. This type of initiative is also important in the creation of a seamless SDI between all jurisdictional levels as well as creating spatially enabled government vision.

Based on these examples, the creation of an enabling platform would lower barriers to access and use of spatial data, to both government and the wider community within any jurisdiction, and particularly to the spatial information industry. If barriers are minimised, then entities would be able to pursue their core business objectives with greater efficiency and effectiveness. In particular, industry would be able to reduce their costs, which would encourage investment in capacity for generating and delivering a wider range of spatial information products and services to a wider market.

CAPACITY BUILDING

In developing capacity building strategies it will be necessary to take account of the changes that have been taking place in the nature of the users of spatial information in recent years. In place of the spatial professionals who have pioneered these developments an increasing number of end users will need some training in spatial thinking to make them more literate users. According to the US Committee on Geography (National Research Council 2006) ‘spatial thinking is based on a constructive amalgam of three elements: concepts of space, tools of representation and processes of reasoning.’ As a research of their research, the Committee recommend that spatial thinking concepts should be taught formally to high school students to foster the universal spatial literacy that will be needed to exploit the opportunities that will be provided by spatially enabled governments. Similar spatial thinking development projects will also be necessary to enable adult users to develop these skills.

More generally capacity building is an important challenge for SDI implementation to spatially enable governments. SDI is still a fuzzy concept to many, with practitioners, researchers and governments adopting different perspectives depending on their needs and circumstances. Capacity building is a complex issue with the term capacity having many different meanings and interpretations depending on who uses it and in what context it is used. Therefore it is understandable that the development of appropriate strategies for capacity building for SDIs is unclear due to the application of a complex and unclear process to a fuzzy concept (Williamson *et al*. 2003).

Capacity is the power of something – a system, an organisation or a person to perform and produce properly. The conventional concept of capacity building has changed over recent years towards a broader and more holistic view, covering both institutional and country specific initiatives. As summarised by Williamson *et al*. (2003), capacity is seen as two-dimensional: capacity assessment and capacity development.

Capacity Assessment or diagnosis is an essential basis for the formulation of coherent strategies for capacity development. This is a structured and analytical process whereby the various dimensions of capacity are assessed within a broader systems context, as well as being evaluated for specific entities and individuals within the system.

Capacity Development is a concept which is broader than institutional development since it includes an emphasis on the overall system, environment and context within which individuals, organisations and societies operate and interact. Even if the focus of concern is a specific capacity of an organization to perform a particular function, there must nevertheless always be a consideration of the overall policy environment and the coherence of specific actions with macro-level conditions. Capacity development does not, of course, imply that there is no capacity in existence; it also includes retaining and strengthening existing capacities of people and organisations to perform their tasks.

There are different capacity factors that are important for the success of SDI implementation. These capacity factors are technological capacity, human capacity, and financial capacity. Some examples of capacity factors are: the level of awareness of values of SDIs; the state of infrastructure and communications; technology pressures; the economic and financial stability of each member nation (including the ability to cover participation expenses); the necessity for long-term investment plans; regional market pressures (the state of regional markets and proximity to other markets); the availability of resources (lack of funding can be a stimulus for building partnerships, however, there should be a stable source of funding); and the continued building of business processes.

The United Nations Development Program (UNDP, 1998) defines capacity as the power/ability of something – a system, an organisation or a person to perform and produce properly. According to this definition, capacity issues can be addressed at these three levels: the broader system/societal level; the entity/organisational level; and the group of people/individual level. These levels relate to their application of capacity in society.

Capacity building initiatives feature prominently in the GSDI Association's activities (Borrero 2002). Delegates at GSDI 5 in Cartagena in May 2001 welcomed the establishment of a multi million dollar Global Map/GSDI Grant programme by the President of ESRI, Jack Dangermond, in memory of the late Professor John Estes, the first chair of the International Steering Committee for Global Mapping. This programme provides a useful resource for national mapping organisation or spatial development organisations that are leading the effort to build national SDIs in their countries. More than 100 countries have so far benefited from these grants (www.gsdi.org). At GSDI 6 in Budapest the following year delegates also applauded the launch of Intergraph's own multi million dollar Open Interoperability Grant programme. This seeks to stimulate the use of open interoperability standards through its support for organisations who wish to build Web services using OGC standards as well as organisations who wish to publish their data in XML/GML file format. So far grants have been made to agencies as diverse as the East Midlands Development Agency in Britain, the city of Bochum in Germany and the Military Geographic Institute of Chile (www.gsdi.org).

Under the heading of capacity building the GSDI Association draft strategic plan lists training for those who may be coordinating SDI activities within a particular country, working with national and regional organisations to provide on site development and

training programmes throughout the world, and establishing an overall knowledge infrastructure (see also Stevens *et al*, 2004). Development research activities include the creation of a small grant programme to support SDI related research, the development of SDI research networks throughout the world and the creation of an online library of SDI reference material. The third round of GSDI small grant programme for 2006 was also a collaborative effort with the Urban and Regional Information Systems Association's GIS Corps. The fifteen projects selected from more than 70 applications in this round (www.gsdi.org) supported projects such as:

- A web based mapping workshop in Colombia
- The development of a biodiversity database in Congo
- A SDI workshop in East Timor
- An online database and clearinghouse in Niger
- Building the NSDI: technology working groups and policy development in the Philippines.

CONCLUSIONS

This paper has considered a number of strategic issues relating to the implementation of SDIs to spatially enable society. It discussed current development of spatial information initiatives and activities within different jurisdictions internationally outlining an overview of current practice and challenges with the aim to help move the vision of enabling platform towards the creation of a strategy and roadmap for the realization of SDI as a framework to spatially enable society through building institutional capacity amongst all sectors of the spatial information community.

Four strategic challenges that must be taken into account when implementing SDIs to spatially enable society were highlighted. The first of these indicates the need for new and more inclusive models of governance to enable the very large number of stakeholders from all levels of government as well as the private sector and academia to participate in the management of the processes of SDI implementation. The findings of the analysis also suggest that the emphasis has shifted away from the central government organisations that played a leading role in the initial development of SDIs towards sub-national government and private sectors in terms of SDI implementation.

The second challenge considered the strategic questions associated with data sharing between different kinds of organisation. The findings of the analysis suggest that data sharing on a massive scale will be needed for SDIs to become fully operational in terms of spatially enabled government. This level of data sharing is likely to require considerable changes in the organisational cultures of the participants and may require new organisational structures to effectively manage this process in some cases.

The third challenge relates to the establishment of enabling platforms to facilitate access to spatial data and the delivery of data related services. It can be viewed as an infrastructure linking people to data through linking data users and providers on the basis of the common goal of data sharing. Further, this infrastructure would be a vehicle from which both textual and spatial data are utilized to form a range of supported functions for those within the industry as well as non-spatial and non-technical user groups. The fourth challenge related to the capacity building issue which tasks to be undertaken in order to create a fully spatially enabled society.

In summary, the paper has discussed four strategic challenges that must be taken into consideration during the implementation of SDIs to support spatially enabled society. It shows some examples of the ways in which these challenges are being addressed in both research and practice. However, the scale of the efforts that will be required to overcome these challenges should not be under estimated.

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REFERENCES

ANZLIC (1996). National spatial data infrastructure for Australia and New Zealand, ANZLIC Discussion Paper, Commonwealth of Australia, http://www.anzlic.org.au/anzdiscu.htm, (Accessed November 1998).

Borrero, S. 2002. Taking advantage of best proved practices, *GIM International*, 16 (August), 8-11.

Commission of the European Communities, (CEC) 2004. *Proposal for a Directive of the European Parliament and the Council establishing an infrastructure for spatial information in the Community (INSPIRE)*, COM (2004) 516 final, Brussels: Commission of the European Communities.

Crompvoets, J., Rajabifard, A., Bregt, A. and Williamson, I.P. (2004) Assessing The Worldwide Developments Of National Spatial Data Clearinghouses. *International Journal of Geographical Information Science*, 18(7), 1-25.

Jacoby, J., Smith, J., Ting, L. and Williamson, I.P. (2002). Developing a Common Spatial Data Infrastructure between State and Local Government - An Australian Case Study. *International Journal of Geographical Information Science*, 16 (4), 305-322.

Masser, I. 2005. GIS worlds: creating spatial data infrastructures, Redlands CA ESRI Press.

Masser, I., Rajabifard, A. and Williamson, I. 2006. Spatially Enabled Governments through SDI Implementation, International Journal of GIS (Under Review), 2006.

McDougall, K., Rajabifard, A. and Williamson, I.P. (2005) Understanding the Motivations and Capacity for SDI Development from the Local Level. *Proceedings of FIG Working Week/GSDI-8*, Cairo, Egypt, 16-21 April, http://www.fig.net/pub/cairo/tech_programme.htm.

National Research Council 2006. *Learning to think spatially: GIS as a support system in the K-12 curriculum*, Committee on Geography, Washington D.C: National Academy Press.

Onsrud, H. and Rushton, G. (Ed.) 1995. *Sharing geographic information*, New Brunswick NJ: Centre for Urban Policy Research.

Radwan, M., Alvarez, A., Onchaga, R. And Morales, J. 2003. Designing an Integrated Enterprise Model to support Partnerships in the Geo-Information Industry, *MapAsia*, 2003.

Rajabifard, A., Binns, A. Masser I. and Williamson, I. 2006a. The role of sub national government and the private sector in future spatial data infrastructures, *International Journal of GIS*, 20 (7), 727-741.

Rajabifard, A., Binns, A. and Williamson, I. 2006b. Virtual Australia – Concepts and Principles, *Journal of Spatial Science*, 51 (1), 63-78.

Rajabifard, A. Binns, A., and Williamson, I.P. 2005. Creating an Enabling Platform for the Delivery of Spatial Information', *Proceedings of the Spatial Science 2005 Conference*, 14-16 September, Melbourne, Australia.

Rajabifard, A., Feeney, M.E. and Williamson, I.P. (2002). The Cultural Aspects of Sharing and Dynamic Partnerships Within an SDI Hierarchy. *CARTOGRAPHY*, 31(1), 21-32.

Rajabifard, A, Williamson, IP, Holland, P & Johnstone, G (2000), "From local to global SDI initiatives: a pyramid building blocks", *Proceedings of 4th GSDI Conference*, Cape Town, South Africa.

Ryan, B., DeMulder, M., DeLoatch, I., Carie, H. and Siderelis, K. 2004, A Clear Vision of the NSDI, Federal Geographic Data Committee Newsletter, 2004 Winter Edition.

Stevens, A., Thackrey K. and Lance, K. 2004. Global Spatial Data Infrastructure (GSDI): finding and providing tools to facilitate capacity building, *Proceedings 7th GSDI Conference*, Bangalore, India, 2-6 February 2004.

UNDP 1998. Capacity Assessment and Development. Technical Advisory Paper No.3. http://magnet.undp.org/Docs/cap/CAPTECH3.htm (accessed 13 April 2003).

Wallace, J., Williamson I., Rajabifard, A. and Bennet, R. 2006. Spatial information opportunities for government, *Journal of Spatial Science*, 51 (1), 79-100.

Williamson, I.P., Rajabifard, A. and Feeney, M. (Ed.) 2003. Developing Spatial Data Infrastructures: From Concept to Reality, Taylor & Francis, UK.

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