THE FUTURE OF SPATIAL DATA INFRASTRUCTURES

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ABSTRACT:

This paper addresses two central questions relating to the future of spatial data infrastructures (SDIs)

- Where have we got to now?
- Where should go from here?

The answers to the first question are to be found in a review of the main milestones of SDI development over the last two decades and a comparative evaluation of SDI experiences in different parts of the world which constitutes the first main section of the paper. The answers to the second question are inevitably more speculative in nature. With this in mind the second main section examines some emerging trends and explores some of the main strengths and weaknesses of current SDI practices in relation to the perceived opportunities and threats that are likely to emerge in the foreseeable future. The paper concludes with a discussion of four key issues that are likely to play a vital role in determining the future success of SDIs.

1. INTRODUCTION

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Before beginning the discussion, however, it is important to clarify was is meant by the term 'SDI'. A comprehensive definition which conveys some of the complexity of the issues involved can be found on the Global Spatial Data Infrastructure Association website (www.gsdi.org).

'A ...Spatial Data Infrastructure supports ready access to geographic information. This is achieved through the co-ordinated actions of nations and organisations that promote awareness and implementation of complimentary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the (national) and regional scale are not impeded in meeting their objectives.' (Author's italics)

The italicised sections of this rather complex definition show that there are four key concepts underlying SDIs. The first of these states that their overriding objective is to promote ready access to the geographic information assets that are held by a wide range of stakeholders in both the public and the private sector with a view to maximising their overall usage. The second concerns the need for concerted action on the part of governments to ensure that this overriding objective is attainable. The next part of this sentence gives some examples of the kind of actions that are required from governments. The third key element stresses the extent to which SDIs must be user driven. Their primary purpose is to support decision making for many different purposes and it must be recognised that many potential users may be unaware of the original purposes for which the data was collected. Finally the last sentence illustrates the wide range of activities that must be undertaken to ensure the effective implementation of a SDI. These include not only technical matters such as data, technologies, standards and delivery mechanisms but also institutional matters related to organisational responsibilities and overall national information policies as well as questions relating to the availability of the financial and human resources needed for this task.

2. WHERE HAVE WE GOT TO NOW?

2.1 SDI Milestones

The first SDI milestone dates back twenty years to the establishment of the Australian Land Information Council (ALIC) in January 1986 as a result of an agreement between the Australian Prime Minister and the heads of the state governments to coordinate the collection and transfer of land related information between the different levels of government and to promote the use of that information in decision making (ANZLIC 1992, p.1).

The second milestone was the publication of the Report of the British Government Committee of Enquiry on Handling Geographic Information chaired by Lord Chorley in May 1987 (Department of Environment, 1987). This set the scene for

much of the subsequent discussion about SDIs in the UK and elsewhere. The report reflects the committee's enthusiasm for the new technology: "the biggest step forward in the handling of geographic information since the invention of the map" (para 1.7), and also their concern that information technology in itself must be regarded as "a necessary, though not sufficient condition for the take up of geographic information systems to increase rapidly" (para 1.22). To facilitate the rapid take up of GIS the committee argued that it will be necessary to overcome a number of important barriers to effective utilisation. Of particular importance in this respect are the need for greater user awareness and the availability of data in digital form suitable for use in particular applications.

The third milestone occurred in 1990 when the United States Office of Management and Budget (OMB) established an interagency Federal Geographic Data Committee (FGDC) to coordinate the "development, use, sharing, and dissemination of surveying, mapping, and related spatial data."

Up to this point the term 'National Spatial Data Infrastructure' was not in general use although a paper was presented by John McLaughlin at the 1991 Canadian Conference on Geographic Information Systems in Ottawa entitled 'Toward National Spatial Data Infrastructure.' Many of the ideas contained in this paper were subsequently developed and extended by the United States National Research Council's Mapping Science Committee in their report on 'Toward a coordinated spatial data infrastructure for the nation' (National Research Council, 1993). This recommended that effective national policies, strategies, and organisational structures need to be established at the federal level for the integration of national spatial data collection, use and distribution. To realise this goal it proposed that the powers of the FGDC should be strengthened to define common standards for spatial data management and to create incentives to foster data sharing particularly among federal agencies.

The next milestone is the outcome of an enquiry set up by DG XIII (now DG Information Society) of the European Commission which found that there was a strong European wide demand for an organisation that would further the interests of the European geographic information community. As a result the first continental level SDI organisation in the world was set up in 1993. The vision of the European Umbrella Organisation for Geographic Information (EUROGI) was not to 'replace existing organisations but … catalyse effective cooperation between existing national, international, and discipline oriented bodies to bring added value in the areas of Strategy, Coordination, and Services' (Burrough et al, 1993).

The milestone that marks a turning point in the evolution of the SDI concept came in the following year with the publication of Executive Order 12906 signed by President Bill Clinton entitled "Coordinating Geographic Data Acquisition and Access: the National Spatial Data Infrastructure"(Executive Office of the President, 1994). This set out the main tasks to be carried out and defined time limits for each of the initial stages of the National Spatial Data Infrastructure. These included the establishment of a National Geospatial Data Clearing House and the creation of a National Digital Geospatial Data Framework. The Executive Order also gave the FGDC the task of coordinating the Federal government's development of the National Spatial Data Infrastructure and required that each member agency of that committee held a policy level position in their organisation. In this way the Executive Order significantly raised the political visibility of geospatial data collection, management and use not only among Federal agencies but also nationally and internationally.

One of the outcomes of this debate in Europe was the decision to hold the first of what subsequently became a regular series of Global Spatial Data Infrastructure conferences at Bonn in Germany in September 1996. This conference brought together representatives from the public and private sectors and academia for the first time to discuss matters relating to NSDIs at the global level.

After the second GSDI conference in Chapel Hill, North Carolina in 1997 the author carried out a worldwide survey of the first generation of NSDIs (Masser, 1999). This showed that at least eleven NSDIs were already in operation in various parts of the world by the end of 1996. What distinguished these from other GI policy initiatives was that they were all explicitly national in scope and their titles all referred to geographic information, geospatial data or land information and included the term 'infrastructure', 'system' or 'framework'. This first generation included relatively wealthy countries such as the United States and Australia as well as relatively poor countries such as Indonesia and Malaysia.

The rapid rate of NSDI diffusion after 1996 is highlighted by the findings of a survey carried for the GSDI (www.gsdi.org). These show that 49 countries responded positively to his questionnaire between 1998 and 2000: 21 of these came from the Americas, 14 from Europe, 13 from Asia and the Pacific and one from Africa. The number of positive responses to this survey is more than four times the number of first generation NSDI countries identified up to the end of 1996 Subsequent data collected by Crompvoets and Bregt (2003) suggests that as many as 120 countries may be considering projects of this kind. These figures must be treated with some caution as they do not necessarily imply that all these countries are actively engaged in SDI formulation or implementation. Furthermore it is also likely that many of them may be engaged in some aspects of SDI development without necessarily committing themselves to a comprehensive SDI programme. Nevertheless it is felt that the term 'SDI phenomenon' is a reasonable description of what has happened in this field over the last ten to fifteen years.

2.2 SDI Diffusion – A Global Overview

A comprehensive and consistent global evaluation of SDIs has yet to be carried out but there are encouraging signs of such activities at the regional level, particularly in Europe (see Masser, 2005, chap 3). The following section summarises the material that is currently available. These findings must also be treated with some caution as the nature of the sources and their content still varies considerably from region to region.

2.2.1 Europe: The development of SDIs has been studied extensively in Europe over the last five years. This is partly due to the interest of the European Commission in such activities that was expressed initially in the GI 2000 initiative and more recently in the INSPIRE programme. In the process the Commission has also funded a number of important studies in this field such as the Geographic Information Network in Europe (GINIE) project (Craglia et al, 2003). More recently the European Commission commissioned a series of 32 country studies of the state of play of SDI activities in all the European countries from the Catholic University of Leuven (http://inspire.jrc.it/state_of_play.cfm). The findings of these studies constitute a major resource for SDI research not only in Europe but also for the rest of the world.

On the basis of this research the authors of these studies have developed a useful typology of SDIs that is based on criteria based mainly on the coordination aspects of these initiatives. Matters of coordination are emphasised because 'it is obvious coordination is the major success factor for each SDI since coordination is tackled in different ways according to the political and administrative organisation of the country' (SAD, 2003). A basic distinction is also made between countries where a national data producer such as a mapping agency has an implicit mandate to set up a SDI and countries where SDI development has been driven by a council of Ministries, a GI association or a partnership of data users. A further distinction is then made between initiatives that do and do not involve users in the case of the former and between those that have a formal mandate and those that do not in the case of the latter.

According to the authors more than half the SDI initiatives in Europe are led by national data producers. This is particularly the case in the central and eastern European countries that have recently become members of the European Union (Craglia and Masser, 2002) and the Nordic countries. All the Nordic countries explicitly include data users in the coordination process whereas only a minority of former accession countries make provision for user involvement. However, not all these SDI initiatives are operational. This is the case in Greece and Luxembourg as well as several of the former accession countries.

The remaining countries have made other arrangements for the coordination of their national SDI activities. In two countries (Germany and Portugal) a government interdepartmental body has been formally mandated to create a national SDI which is now operational. In the Netherlands a national GI association (RAVI) has been encouraged by the government to take lead and it has succeeded in developing an operational national SDI.

2.2.2 The Americas: The findings of a survey of 21 countries in the Americas carried out in 2000 give a useful overview of the state of SDI development (Hyman et al, 2003). The overall impression that is created by this survey is one of a growing awareness of SDI concepts and approaches in the Americas in 2000, together with recognition that the main obstacles to be overcome in these countries were institutional rather than technical in nature. There was also some concern about the question of the resources that would be required for effective SDI implementation.

The findings of the survey highlight the range of different kinds of SDI initiatives that existed at that time. Formal mandates for the development and implementation of SDIs existed in only six out of the 21 countries. In the majority of cases, a single institute, normally the national mapping agency, or in some countries such as Mexico, the national mapping and statistical agency, was the lead organisation in these initiatives. In some other countries, the Ministries of the Environment, Science and Technology, and Transportation and Public Works acted as focal points. Generally these initiatives were restricted to central government although the utilities were involved in several countries together with the private sector. An interesting example of the latter is the Uruguay clearing house, which is managed by a private company under contract to the Ministry of Works. In most countries the basic data with reference to topography, transport, hydrology, land cover and administrative boundaries was available in digital form but there was often a lack of standardisation and harmonisation.

2.2.3 Asia and the Pacific: The Asia and the Pacific region is the largest and the most diverse region in the world. Its 55 countries contain 60 per cent of the world's population. They include some of the largest countries in the world as well as many small island countries in the Pacific with tiny populations. They also include countries from the Middle East, and the Indian sub continent, as well as south east and eastern Asia and Australia and New Zealand.

This diversity may also be the reason for the relative lack of regional studies of SDI diffusion of the kind described above for Europe and the Americas. Nevertheless, Rajabifard and Williamson (2003) estimate that somewhere between 20 and 30 per cent of countries in the Asia and the Pacific region are developing or have plans to develop national SDIs. This broadly confirms the findings of their earlier survey of regional fundamental data sets (Rajabifard and Williamson, 2000) when 17 out of the 55 members of the Permanent Committee for GI in Asia and the Pacific, or just under a third of the members, responded to their questionnaire. These were essentially national mapping agencies.

Within this region an obvious distinction can be made between developed and developing countries in terms of their needs and aspirations. Within the developing countries category a further distinction can be made between countries in the process of transition from a less developed to a more developed state, countries at an early stage of economic development, and the Pacific island nations. It can also be argued that developing countries face different challenges from those of developed countries. 'The main limitations are a lack of appreciation of what SDI can and cannot do, lack of resources and trained personnel, inefficient bureaucratic processes, lack of data, and lack of infrastructure' (Rajabifard and Williamson, 2003).

2.2.4 Africa: The Johannesburg World Summit on Sustainable Development in September 2002 stimulated several Africa wide studies on SDI related topics. These included a report entitled 'Down to earth: geographic information for sustainable development in Africa' prepared by the Committee on the Geographic Foundation for Agenda 21 on the US National Research Council (2002).

These studies build upon earlier work in the environmental field in Africa. A good example of this is the Environmental Information System Programme for Sub Saharan Africa that has played an important role in harmonising standards for data capture and exchange, coordinating data collection and maintenance and promoting the use of common data sets by the different agencies involved (www.EIS-Africa.org).

Kate Lance's (2003) overview of the current state of the art in SDI development in Africa highlights the diversity of SDI initiatives that have come into being over the last ten years and the role that has been played by international agencies of all kinds in facilitating the development of SDIs. This is particularly evident in the publication of an African version of the GSDI cookbook (2003) based on the efforts of GSDI, EIS Africa, the UN Economic Commission for Africa and the International Institute for Geoinformation Science and Earth Observation (ITC) in the Netherlands.

Lance also lists 21 national SDI initiatives that are currently under way in all parts of Africa. These include countries from both anglophone and francophone Africa. Her review also identifies some of the main problems facing SDI development on this continent. One of the most important of these is the

question of political support as very few of these initiatives have a legal status or enabling legislation to support their efforts and there are only a few countries where SDIs have achieved the status of funded activities with a budget from central government. Another particularly African problem is that of leadership. While national survey and mapping agencies are an important contributor to SDI development it is quite common in Africa to find that other entities have the political influence (and funding) that drives the initiatives.

2.2.5 Comparative evaluation: The SDI initiatives described above show the extent to which they come in all shapes and sizes with respect to population size, land area, level of economic development and distribution of administrative responsibilities.

There is also a basic difference within the group between Europe and the Americas on the one hand and Asia and the Pacific and Africa on the other. Most of the former are classified as either upper middle or high income by the World Bank whereas most of the latter are low income countries. These differences reflect the considerable gap that exists between these two parts of the world with respect to wealth and also, to a large extent, the resources that are likely to be available to implement SDI initiatives.

The driving forces behind these initiatives are generally similar: i.e. promoting economic development, stimulating better government and fostering environmental sustainability. This can be seen, for example, in India's national SDI, which sets out its objectives as follows

'The NSDI must aim to promote and establish, at the national level for the availability of organised spatial (and non spatial) data and multilevel networking to contribute to local, national and global needs of sustained economic growth, environmental quality and stability and social progress' (DOST 2002, para 8.0).

Other driving forces include the modernisation of government and environmental management. One of the main objectives of the Chile's SNIT is to modernise the way that territorial information is handled by government agencies and to create a collaborative scheme for its future management. Environmental concerns feature prominently in Africa in general and the starting point for the Ghana NAFGIM was a World Bank funded project carried out for the Environmental Protection Agency as part of the Ghana Resource Management Project.

eGovernment has also emerged as an important driving force in many recent cases. It features prominently in the Czech SDI that is linked closely to that country's overall national information infrastructure programme. Specific factors in certain regions may also act as a strong driving force in SDI development. This is particularly the case in the accession countries in central and eastern Europe. The initial development of the building blocks for SDIs in these countries was directly funded by the European Union through the Phare programme that was set up specifically to help these countries meet the requirements for EU accession. International donors, such as the World Bank, have also played an important role in SDI development in many Asian and African countries

The distinction between SDIs led by national data producers and those that are led by Councils of Ministries or partnerships of data users proposed by the Leuven study is a useful indicator of the status of a SDI. A formal mandate is particularly important where interagency bodies are involved as it defines their position and status with respect to government but, nevertheless, some advisory bodies enjoy de facto recognition without the need for a formal mandate. This is the case, for example, with respect to the Dutch national GI association (RAVI).

There are also marked differences between countries with respect to the range of substantive interests represented in the coordinating bodies and the extent to which stakeholders are directly involved. There is still a strong coordination dimension to the work of the US Federal Geographic Data Committee (FGDC). Although its composition is broad in scope, its formal membership is restricted to federal government agencies. The existing position in Australia is similar in some respects to that of the United States but more inclusive in terms of representation. The Australia New Zealand Land Information Council (ANZLIC) is essentially an umbrella organisation consisting of representatives from both the Commonwealth and State level government public sector coordination bodies. In contrast the lead Canadian agency, GeoConnections, has always been an inclusive organisation that seeks to bring together all levels of government, the private sector and academia. These interests are reflected in the composition of its Management Board and also in the membership of its committees. It sees itself as a catalyst for successful implementation. There is also a strong industry connection in the CGDI through the Geomatics Industry Association of Canada.

Somewhat surprisingly, given that are large number of low income countries are involved, questions of funding and resources do not feature very prominently in their discussion of SDI development. A notable exception is India which devotes a complete section of its National Spatial Data Infrastructure Strategy document to this matter. Where national data producers are involved as the lead agencies in SDI development it is likely that some of the costs will come from their own budgets. In Kenya, for example, the Survey of Kenya was able to insert the Kenyan SDI into the National Development Plan for 2002-2008. This means that the Ministry of Lands and Settlements has a mandate to invest staff time and resources into this initiative.

Other possibilities include international funding through World Bank and similar projects. Projects of this kind played an important role in setting up Ghana's National Framework for Geospatial Information Management and creating Nemoforum in the Czech Republic. Similarly, the Japan International Cooperation Agency was involved in the workshop that led to the creation of the Kenyan SDI. However, projects such as these generally have a limited life span whereas SDI development requires sustained efforts over a long period of time. This is one of the reasons why Kate Lance sees SDIs as a hard sell in regions such as Africa.

'SDI is a hard sell. It is a 'beast' of an initiative since it requires inter-institutional, cross sector, long term coordination - something that defies the administrative and budgetary structures in Africa, as well as the donor agencies' funding cycles' (Lance, 2003).

2.3 Achievements

From the above discussion it can be seen that a critical mass of SDI users in all parts of the world has come into being as a result of the diffusion of SDI concepts during the last ten to fifteen years. This provides the basic networks and channels for communication that are essential for the future development of the field. In the process regional bodies at the continental level

and global bodies have come into being to facilitate SDI development and promote a wide range of capacity building initiatives throughout the world. Alongside these activities there is a growing body of SDI related literature and research.

3. WHERE SHOULD WE GO FROM HERE?

3.1 Emerging Trends

Some emerging trends in thinking about SDIs have been explored by Rajabifard et al (2003). Their findings show that first generation of SDIs gave way to a second generation from about 2000 onwards. The most distinctive change that has taken place is the shift from the product model that characterised most first generation SDIs to a process led model of a SDI.

Database creation was to a very large extent the key driver of the first generation and, as a result, most of these initiatives tended to be data producer led. The shift from the product to the process model is essentially a shift in emphasis from the concerns of data producers to those of data users. The main driving forces behind the process model are the desire to reuse data collected by a wide range of agencies for a great diversity of purposes at various times. Also associated with this change in emphasis is a shift from the centralised structures that characterised most of the first generation of SDIs to the decentralised and distributed networks that are a basic feature of the WWW.

There has been also a shift in emphasis from SDI formulation to implementation over time. This is associated with the nature of multi level SDI implementation. Under these circumstances it is necessary to think in terms of more inclusive models of governance. In many cases these developments will also require new kinds of organisational structure to facilitate effective implementation.

3.1.1 The Multi Level Nature of SDI Implementation: The impression given by many national SDI documents is that they abide by the principle of 'one size fits all.' In other words they suggest that the outcome of SDI implementation will lead to a relatively uniform product. However there is both a top down and a bottom up dimension to the relationships between the different levels involved in national SDI implementation. National SDI strategies drive state wide SDI strategies and state wide SDI strategies drive local level SDI strategies. As most of the detailed database maintenance and updating tasks are carried out at the local level the input of local government has also a considerable influence on the process of SDI implementation at the state and national levels. The outcomes of such processes from the standpoint of a national SDI such as that of the US are likely to be that the level of commitment to SDI implementation will vary considerably from state to state and from local government to local government. Consequently the US NSDI that emerges from this process will be a collage or a patchwork quilt of similar but often quite distinctive components that reflect the commitments and aspirations of the different sub national governmental agencies.

This vision of a bottom up SDI differs markedly from the top down one that is implicit in much of the SDI literature. While the top down vision emphasises the need for standardisation and uniformity the bottom up vision stresses the importance of diversity and heterogeneity given the very different aspirations of the various stakeholders and the resources that are at their disposal. Consequently the challenge to those involved in SDI implementation will be to find ways of ensuring some measure of standardisation and uniformity while recognising the diversity and the heterogeneity of the different stakeholders. This will require a sustained mutual learning process on the part of all those involved in SDI implementation.

A particularly interesting example of multi level implementation in practice is the European Union's INSPIRE (Infrastructure for SPatial Information in Europe) initiative. This was launched in 2001 with the objective of making available relevant, harmonised and quality geographic information to support the formulation, implementation, monitoring and evaluation of Community policies with a territorial dimension or impact' (http://inspire.jrc.it). INSPIRE is seen as the first step towards a broad multi sectoral initiative which focuses on the spatial information that is required for environmental policies. It is a legal initiative that addresses 'technical standards and protocols, organisation and coordination issues, data policy issues including data access and the creation and maintenance of spatial information'. A draft Directive to 'establish an infrastructure for spatial information in the Community' was published in July 2004 (CEC 2004) and the European Environment Agency, together with Eurostat and the Joint Research Centre, are currently engaged in a process that should lead to its approval in late 2006 or early 2007. When approved, the governments of all 25 national member states will be required to modify existing legislation or introduce new legislation to implement its provisions within a specific time period.

3.1.2 More Inclusive Models of SDI Governance: Many countries are moving towards more inclusive models of SDI governance to meet the requirements of a multi level multi stakeholder SDI. Recent developments in the US and Australia, for example, show a marked shift in this direction. In the US the FGDC is considering the recommendations of its Future Directions Project regarding the creation of a new governance model that includes representatives of all stakeholder groups to guide the NSDI (FGDC 2005). This is supported by a joint FGDC/NSGIC (2005) initiative which aims to get all 50 states actively involved and contributing to the NSDI. Similar developments are already under way in Australia. The Australia New Zealand Land Information Council's proposals for an action plan (ANZLIC 2004) involve a new governance model that takes account of the balance between public and private sectors, data sources and data users. These developments will bring both these countries into line with Canada where the lead Canadian agency, GeoConnections, has always been an inclusive organisation that seeks to bring together all levels of government, the private sector and academia.

A good example that highlights the need for more inclusive models of SDI governance at the outset of a SDI initiative is the formulation of a GI strategy for Northern Ireland in the UK. Ordnance Survey of Northern Ireland and its parent ministry, the Department of Culture, Arts and Leisure, decided that a new approach was required to the development and implementation of geographic information policy in Northern Ireland (Masser, 2005, chap 4). It was decided to make use of the Future Search method to develop an initial GI policy agenda for the province. Weissbord and Janoff (2000) claim that Future Search is 'a unique planning meeting that meets two goals at the same time, 1) helping large diverse groups discover values, purposes and projects they hold in common, and 2) enabling people to create a desired future together and start working towards it right away.'

The Future Search process worked well at a special workshop involving all the main stakeholders at Lusty Beg, an island on a remote lough in Northern Ireland. The participants collectively created a mind map with 32 main trends and an even larger numbers of sub trends within these trends. In the process the following issues emerged as key elements in the common ground for a future strategy: the importance of creating an overall GI strategy for Northern Ireland, the need to facilitate access and promote awareness, and the importance of partnerships in realising these objectives. On the basis of this experience the participants set up a number of working groups to further develop Northern Ireland's GI strategy.

3.1.3 The emergence of new organisational structures: In many cases it is likely that the multi level nature of national SDI implementation will also require the creation of new kinds of organisation. These can take various forms. Masser (2005, chap 5) shows some of the different kinds of organisational structures that have already emerged in the US, Australia and Canada to facilitate national SDI implementation. This shows that at least five different types of partnerships are in operation. These range from the restructuring of existing government agencies to the establishment of joint ventures involving different combinations of the key stakeholders.

The simplest case is the merger of various government departments with responsibilities for various activities based on geographic information. The driving force for this kind of restructuring is typically the perceived administrative benefits to be derived from the creation of an integrated database for the agency as a whole. This can be seen in the creation of Land Victoria in 1996 in Australia which is the product of a merger of various state government entities with responsibilities for various aspects of land administration. The objective of this merger was to establish an integrated land administration agency with a shared geographic information resource for the State of Victoria.

An alternative strategy is to set up a special government agency outside the existing governmental structure with a specific remit to maintain and disseminate core datasets. Service New Brunswick in Canada is a good example of such a strategy. It is a Crown Corporation owned by the State of New Brunswick. It was originally set up to deal with matters relating to land transactions and topographic mapping for the Province as a whole. Since 1998 it has shifted its position to become the gateway for the delivery of a wide range of basic government services as well as national SDI implementation.

There are also some interesting examples of joint ventures between different groups of the stakeholders in SDI implementation. The simplest case is a data producer driven joint venture involving the Australian public sector mapping agencies that was originally set up in 1993 to create an integrated national digital base map for the 1996 Census of Population (www.psma.com.au). The driving force behind this partnership was the recognition the whole is worth more than the sum of the parts in that there are clear economic and social benefits for the nation to be derived through the assembly and delivery of national data sets from the data held and maintained by the consortium members.
The other two types of joint ventures involve more complex structures. Alberta's Spatial Data Warehouse is very much a data user driven initiative. It is a not for profit joint venture between key data users including the State itself, the local government associations and the utility groups to facilitate the continuing maintenance and distribution of four primary provincial data sets. From the outset the partners recognised that they did not either the expertise or the resources to maintain and disseminate the existing databases. Consequently they negotiated a long term Joint Venture Agreement with two private sector companies in 1999 to carry out these tasks. This covers the reengineering of the databases and also makes it possible to implement new pricing and licensing options.

Finally, initiatives such as the MetroGIS collaborative in the Minneapolis St Paul metropolitan region of the US bring together a large number of data producers and data users. Such initiatives are both more ambitious and more open ended in their potential for development than either of the other joint ventures. The distinctive feature of this initiative lies in its insistence on voluntary, open and flexible and adaptive collaborations which optimise the interdependencies between citizens and organisations.

3.2 SWOTs Analysis

3.2.1 Strengths: The most important strength of the SDI concept is the way in which it enables a diverse group of users to access a wide range of geo referenced data sets. The underlying rationale for SDIs is to maximise the use that is made of local, national and global geographic information assets and their success or failure is likely to be measured largely in these terms. In this way SDIs also make an important contribution to economic growth and job creation at the local, national and global levels as well as promoting more effective and transparent decision making in both the public and private sectors.

The second main strength is the degree to which the SDI concept straddles existing professional and administrative sectoral boundaries. It is a truly integrating concept that facilitates the use of local, national and global geographic information assets many times in many different applications. Recognition of the importance of integrating data from many diverse sources is already encouraging the merger of previously separate professional bodies in some countries. In Australia, for example, a Spatial Sciences Institute was set up in 2003 to bring together the professional disciplines of surveying, mapping, engineering and mining, surveying, remote sensing and photogrammetry (www.spatialsciences.org.au). At the global level a Global Spatial Data Infrastructure Association was set up in 2004 'to promote international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic and environmental issues of pressing importance' (www.gsdi.org). Its membership includes organisations of all kinds in both the public and private sectors as well as not for profit organisations and academia from all parts of the world.

The third main strength of the SDI concept is the way it has exploited recent developments in location based services and the Internet and the World Wide Web. The importance of the latter was recognised by the US Mapping Sciences Committee in their report on Distributed Geolibraries (National Research Council 1999, 31). In their view, 'the WWW has added a new and radically different dimension to its earlier conception of the NSDI, one that is much more user oriented, much more effective in maximising the added value of the nation's geoinformation assets, and much more cost effective as a data dissemination mechanism.

3.2 2 Weaknesses: Each of the strengths referred to above also brings with it its weaknesses. SDIs can only facilitate access to a wide range of users if radical changes take place in existing organisational cultures. To be effective SDIs require data sharing on an unprecedented scale. Some indication of the nature of the barriers that must be overcome is given in Uta Wehn de Montalvo's (2003) study of spatial data sharing perceptions and practices in South Africa from a social psychological perspective. This study utilises the theory of planned behaviour. This theory suggests that personal and organisational willingness to share data depends on attitudes to data sharing, social pressures to engage or not engage and perceived control over data sharing activities of key individuals within organisations. The findings of her analysis generally show that there was only a relatively limited commitment amongst those involved to promote data sharing in high profile initiatives such as the South African national SDI.

Similarly, the extent to which SDIs straddle professional and administrative sectoral boundaries may lead to problems in building up and maintaining a consensus among the stakeholders involved over time. The old adage that Rome wasn't built in a day is equally applicable to SDIs. The creation of SDIs is a long term process that may take years or even decades in some cases before they will be fully operational. Such a process is also dependent on sustaining political support and commitment for such initiatives. This is likely to present particular problems in some less developed countries where financial and human resources are scarce and governments may be politically unstable.

3.2.3 Opportunities: The most important opportunity is the growing public awareness of the potential for SDI development in an Information Society. This can be seen from the agenda for the UN World Summit on the Information Society in Tunis in November 2005. Key factors underlying this Summit are the extent to which the Digital Revolution is changing the ways people think, communicate and earn their livelihood and the need to bridge the digital divide between rich and poor both between and within countries (www.itu.int/wsis/). Because of the degree to which a large proportion of all data is geo referenced SDIs are likely to play a major role in the achievement of the Millennium Development Goals that the UN has set itself for improving the living standards of millions of people throughout the world.

Another important opportunity for SDIs arises from the growing pressure to make public sector information more readily available for reuse by the private sector. The rationale behind these debates in Europe is the recognition that the public sector is the largest single producer of information in Europe and that the social and economic potential of this resource has yet to be tapped. Geographic information held by public sector organisations has considerable potential for the development of digital products and services. With this in mind EU Directive 2003/98/EC sets out a framework for the conditions governing the re-use of public sector information (CEC 2003). The adoption of this Directive has important implications for the future development of the geographic information field in Europe because the measures that it contains are mandatory on all 25 national member states which had until July 2005 to incorporate them in their respective national legislation.

3.2.4 Threats: As was the case with respect to the strengths and weaknesses the opportunities created by the Information Society and public sector information debates also bring with them threats. There is already some concern that the GI/SDI sector will be swallowed up by these broader debates and lose its identity in the process. As a result some of the special qualities of geographic information may not be adequately considered in future applications. These include the questions such as those associated with transforming 3D information relating to the globe into two dimensions for display and analysis, the need to be to able to deal with multiple representations of the same data at scales varying from 1:1,000,00 to 1:500, and the voluminous sizes of geographic databases which can easily exceed one terabyte in size.

4. KEY ISSUES FOR THE FUTURE

In the light of the preceding analysis four sets of issues can be identified that will play a vital role in determining the future success of SDIs. These are listed below in order of priority.

4.1 Creating Appropriate SDI Governance Structures

Top priority must be given to the creation of appropriate SDI governance structures which are both understood and accepted by all the stakeholders. This is a daunting task given the number of organisations that are likely to be involved. In the US, for example, there are more than 100,000 organisations engaged in SDI related GIS activities. Under these circumstances it will not be possible in most cases to bring all the stakeholders together for decision making purposes but structures must be devised that keep all of them informed and give them an opportunity to have their opinions heard. The simplest solution to this problem is to create hierarchical structures at the national, state and local level for this purpose. As noted above, this kind of structure is already operational to some extent in Australia and is implicit in the proposals for a fifty states initiative in the US.

It also important in this respect that such governance structures should as inclusive as possible from the outset of a SDI initiative so that all those involved can develop a shared vision and feel a sense of common ownership of a SDI. Otherwise it may be difficult or even impossible to bring new participants into a SDI initiative at a later stage. This is likely to be a challenging task that may slow down the progress of the work in the short term but building up a base for future collaboration is an essential prerequisite for the long term success of the SDI.

4.2 Facilitating Access

Facilitating access is the second highest priority after developing appropriate governance structures because one of the biggest problems faced by users is the lack of information about information sources that might be relevant to their needs. Consequently, without appropriate metadata services which help them to find this information it is unlikely that a SDI will be able to achieve its overarching objective of promoting greater use of geographic information. There is also a very practical reason why the development of metadata services should be given a high priority in the implementation of a SDI. This is because they can be developed relatively quickly and at a relatively low cost. In this respect they can be regarded as a potential quick winner which demonstrates tangible benefits for those involved in SDI development.

The establishment of Web based metadata services that provide information to users about the data that is available to meet their needs. is also one of the most obvious SDI success stories. The

US Federal Geographic Data Committee Clearinghouse Registry, for example, lists nearly 300 registered users from the all over the world (http://registry.gsdi.org/server/status). In recent years the development of spatial portals has opened up new possibilities for metadata and application services (Tang and Selwood, 2005). As their name suggests, spatial portals can be seen as gateways to geographic information (GI) resources. As such they provide points of entry to SDIs and help users round the world to find and connect to many rich GI resources. These portals also allow GI users and providers to share content and create consensus.

4.3 Building Capacity

Capacity building is the next priority because SDIs are likely to be most successful in maximising the use that is made of local, national and global geographic information assets in situations where the capacity exists to exploit their potential. It must also be recognised that the creation and maintenance of a SDI is also a process of organisational change management. Consequently there is a need for capacity building initiatives to be developed in parallel to the processes of SDI development. This is particularly important in less developed countries where the implementation of SDI initiatives is often dependent on a limited number of staff with the necessary geographic information management skills. However, although much of the recent SDI discussion justifiably focuses on the need to need to devote considerable resources to capacity building in less developed countries (Stevens et al, 2004), it must also be recognised that there is still a great deal to done to develop GIS capabilities, particularly at the local level, in many more developed countries if the potential of a SDI is to be exploited to the full.

4.4 Making Data Interoperable

It may come as something of a surprise to find that matters relating to data interoperability come last in terms of priority for future SDI development. This is because the development and implementation of SDIs involves much more than database creation. This is clearly evident from the preceding discussion. It should also be noted that the potential for making data interoperable is heavily dependent on the specific institutional context of each country.

In countries where large scale topographic data sets are incomplete the creation of an national digital topographic database is also likely to be an expensive task that takes place over a relatively long period of time. In the meantime those involved in SDI development must exploit alternative information sources such as remotely sensed data in addition to conventional survey technology. A great deal can be done in this way without incurring the delays that are inevitably associated with conventional data base creation.

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