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Building SDIs – The Challenges Ahead

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Abstract

The spatial information vision for most countries is to create a virtual state where any spatial information is available to any user, any time and any place. This is a simplistic vision that presents many challenges, with the major challenge being the creation of a spatial data infrastructure (SDI) to support the vision. Importantly unless we can agree on a spatial information vision for each country, we cannot create a SDI vision.

SDI is a rapidly evolving concept with a resulting lack of definition and clarity. However it is generally agreed that SDIs comprise people, access issues, policies, standards and data issues with all presenting major challenges if SDIs are to mature and deliver the spatial information vision.

First, people are intimately involved with creating the capacity to design, build and maintain SDIs. With this in mind, there is relatively little attention to building the body of knowledge to increase SDI capacity. For example how many university courses in the spatial sciences include a course on SDI?

Second, access is dependent on capacity, policies, standards and data and a whole range of technologies. All these dependencies present challenges in the rapidly evolving ICT environment. For example the impact of the web, communications and positioning technologies, and data base technologies are changing our understanding of the SDI concept.

Third, while some excellent attempts have been made at developing SDI policies, or in many jurisdictions "spatial information strategies", most of the international focus and research has been on national initiatives that are only one level in the SDI hierarchy from corporate SDIs to global SDIs. The challenges in understanding the various levels and moving up and down the

SDI hierarchy as well as within levels are enormous but must be met if the SDI vision is to be a reality. Equally is the challenge of monitoring, evaluating and benchmarking SDIs – how do you know if you have an efficient and effective SDI?

Within individual countries a key challenge is how to incorporate large scale and people relevant data into the national SDI. In developing the SDI hierarchy, the trap that is easy to fall into is that SDI is just that, an infrastructure, and without users driving development it has no justification!

Fourth, while most people recognise the need for standards, there is also a recognition that standards can stifle growth and creativity. One of the most innovative SDI initiatives in Australia was the creation of a national large-scale cadastral map of the country for the 1996 census. This data set was build without standards and in fact once built established a de facto standard. If an attempt had been made to develop a standard first it would not have been built. However standards are necessary, with the work that goes into ISO and OGC being essential, but challenging.

Lastly, new technologies are making data collection, storage and management easier and more efficient with the result that many jurisdictions have data overload. The challenge is to develop and continue to refine metadata search engines and spatially enabled web tools - a spatially enabled Google? The problem is being compounded as countries complete the construction of large scale data sets such as cadastral, land use and road network data sets. Unfortunately these large scale people relevant data are usually at different levels in the SDI hierarchy (state or local government versus federal or national government) thereby presenting a range of other political and jurisdictional challenges.

While all these challenges are likely to be addressed in time in highly developed countries, there is a much bigger challenge facing the developing world. The question must be asked - what constitutes a SDI in a developing country that does not have the capacity of the developed world?

This paper will discuss these challenges and their impact on future SDIs.

Introduction

The spatial information vision for most countries is to create a virtual state where any spatial information is available to any user, any time and any place. However this is a simplistic vision that presents many challenges, with one of the major challenges being the creation of a spatial data infrastructure (SDI) to support the vision. Ironically whilst most SDI authorities will agree that SDIs should be user driven, there is little discussion on the spatial information vision for each country or what sort of information and communications technology (ICT) enabled society we wish to be. However unless we can agree on a spatial information vision for each country (or jurisdiction), it is almost impossible to create an appropriate SDI vision. Therefore our first

challenge is to clearly describe and articulate the type of society we want our SDI to support.

Since there is such lack of clarity in the form of the "virtual state" or the type of ICT-enabled society we wish to aspire to, it is not surprising that the SDI concept lacks definition and continues to evolve. However it is generally agreed that SDIs comprise people, access, policies, standards and data with all presenting major challenges if SDIs are to mature, achieve their potential and deliver the spatial information vision.

Scanning the SDI websites of the many countries that have now embraced the concept highlights the lack of clarity and direction in the evolution of SDIs. While there are some very good examples which are user driven and are focussed on providing access to spatial data and information, there are more which simply set out their SDI policies without a user focus. At a recent international SDI short course (which was held at the University of Melbourne on 19-21 November 2003 and which was supported by both the 16th United Nations Regional Cartographic Conference for Asia and the Pacific and the Permanent Committee for Geographic Information Systems and Infrastructure for Asia and the Pacific), SDI professionals were asked to search the web for particular examples of SDIs. It was surprising to many since this was the first time they had become users and it also surprised them to find out how difficult is was to use many of the SDI websites and their lack of user friendliness.

During the course it appeared that it was the national SDIs, which have a focus on medium to small scale data, which appear to lack a clear business case and are not openly user driven. Interestingly it is the SDIs at a state or provincial or local or city level which focus on large scale people-relevant data, such as land-parcel data, road networks, valuation and land use data, which appear to be of a much higher level of operational integrity, sophistication and relevance. It appears that these are more user driven. The challenge was again highlighted to ensure SDIs are clearly user driven and are based on a strong business case.

SDI challenges are discussed below under the five SDI components of people, access, policies, standards and data.

People

People are critical in providing the capacity or capability for a jurisdiction to design, build and maintain SDIs. However capacity building is not just about educating individuals but is concerned with building the capacity of the society to design, build and maintain SDIs. For example capacity is concerned with the rule of law and acceptance of government institutions where the SDI processes are compromised by such things as corruption and vested interests. Capacity is also concerned with the capacity of organisations and government departments as well as the capacity of individuals. Since the SDI concept is relatively new and continues to evolve there is not a large body of knowledge that can assist capacity building. For example how many

university courses in surveying, geomatics or spatial sciences around the world include a course on spatial data infrastructures?

Experts in SDI believe in its importance, however to many people SDIs are a technical activity of marginal relevance to supporting the economic development, environmental management and social stability within a country. This highlights the challenge the SDI community has in explaining the role of SDIs and promoting their use. Experience shows us that if we want to promote the SDI cause we need to tie it closely with current political user needs such as sustainable development, access to water, environmental degradation, economic development, food production, health, education, counter terrorism and emergency management.

Another example of lack of awareness or importance of SDI can be seen in the response to the recent international SDI short course mentioned above. While the course was a relative success with about twenty attendees from seven countries this could not be seen as an outstanding success even though the course was widely promoted. The SDI community has to ask the question as to whether the SDI concept is being taken seriously and supported, or is a lot of the support just rhetoric?

Whatever the reason there is no doubt that there is a major challenge for the SDI community to improve the capacity of institutions, organisations and individuals in understanding, accepting, designing, building and managing spatial data infrastructures.

Access

Access to useful data and information is dependent upon not only the availability of data but also the capacity of societies, organisations and people to use that data as well as the technologies, policies, standards and governance framework for accessing this data. All these dependencies present challenges in the rapidly evolving information and communications technology environment. For example developments in web technologies, super servers, virtual libraries, GRID computing, communications and positioning technologies, database design and the influence of clustered data base management software are driving the ever changing SDI concept.

Gaining access to useful data is also about knowing what data is available and the metadata concerned with that data. It is all about building clearing houses or virtual libraries of available spatial data sets.

The major challenges in access to spatial data concern the inter-operability of data. However inter-operability can be considered at various levels where the institutional level of interoperability focuses on data integration and access from the perspective of standards, policies, institutions, capacity, and legal and regulatory frameworks.

The syntax level of inter-operability considers issues concerned with the spatial data information framework architecture and addresses the computer

science, ICT and data base components of the SDI. It includes a detailed scientific and technological understanding in data base design, clustered data base management software, GRID computing and web access technologies.

The semantic level of inter-operability considers issues of accessing spatial data, cognitive engineering and usability. It places data into the user's context, and translates data between contexts. The challenge facing the SDI community is not just about building clearinghouses or virtual libraries or virtual databases, but also in making the access systems user friendly. Making the data user friendly involves an understanding of the different uses and types of data and includes a detailed understanding of spatial data ontologies.

Another dimension of access is to what extent the access environment or infrastructure supports intelligent decision-making. Data by itself is not particularly useful unless it can be turned into information and in turn knowledge, which can then lead to better decision-making. Users also wish to visualise spatial data as a means of assisting the decision making process, however this can require accessing sophisticated visualisation tools as part of decision support systems. Should the SDI incorporate or facilitate access to spatial decision support systems (SDSS)? There is a huge challenge in building the links between data and better decision-making, the ultimate goal of SDI.

Unfortunately many of the clearinghouses or virtual libraries that are available have been developed by providers of data and are often not user friendly. As mentioned the lack of user friendliness of clearing houses was identified at the recent international SDI short course where it came as a surprise to data providers and the developers of clearing houses that a large number of these systems are not user friendly.

Policies

While some excellent initiatives have been undertaken at developing SDI policies in many jurisdictions' "spatial information strategies", most of the research and international focus has been on national SDI initiatives which is only one level in the SDI hierarchy from corporate SDIs through to local, state, national, regional and global SDIs. In fact an overview of current websites on spatial data infrastructures would indicate that there has been a great deal more activity and success at the state or provincial level rather than the national level in developing spatial data infrastructures.

Whatever the emphasis, one of the key challenges in developing spatial data infrastructures is understanding the various levels of infrastructure where the ability is required to access data from within one level as well as across levels. As such the development of policies, which facilitate access to data through the SDI hierarchy and not just within one level are enormous but must be met if the SDI vision is to be a reality.

Within countries a key challenge is how to incorporate large-scale people relevant data into a national SDI noting that the concept of a land parcel or property for example is often different in different states within the same country. This could include ownership or valuation data which might be held at a state or provincial level, or street address, property or land use data which might be held at a local government level, or data held at a corporate level such as the structures, rules, and rights, restrictions and responsibilities pertaining to multi-unit developments (strata or condominium developments).

In developing the SDI hierarchy, a trap that is easy to fall into is that SDI is just that, an infrastructure, however without users it has no justification! Again this was highlighted at the recent SDI short course where it was noted that a number of SDI initiatives in countries are driven with a provider focus rather than a user focus.

In order for SDIs to operate there are a whole range of other policies and institutions that have to be put in place. For example policies must be determined on privacy, intellectual property, copyright and pricing. For example a critical challenge is balancing privacy and security with utility of data, or whether a jurisdiction adopts a public good economic model for data pricing or a commercial model or a combination. At the same time there are a whole range of policy decisions to be made with regard to the institutional arrangements and governance framework that support both the development and maintenance of the SDI.

Another challenge is to distinguish between the roles of data sponsors and data custodians. This involves determining the role of government and the private sector in SDI development and maintenance.

Finally one of the most important challenges is knowing whether a jurisdiction has an efficient and effective SDI. This involves methodologies for monitoring, evaluating and benchmarking SDIs. It involves assessment at the strategic, management and operational levels of development. Without these processes if it very difficult to justify further investment in a SDI. Quality assurance tells us that if you cannot measure something you cannot improve it.

There is no doubt that the challenges associated with determining appropriate and workable policies in support of SDI are central to achieving the SDI vision – simply building SDIs is not just a technological challenge although in some quarters it is perceived as such.

Standards

While most people recognise the need for standards, there is also recognition that in some circumstances standards can stifle growth and creativity. The challenge is to achieve a balance between the development and enforcement of standards and the encouragement of growth of spatial data infrastructures. For example ICT developments in data base design, clustered data base management software, GRID computing and web access technologies are so

powerful that they have the potential to re-invent SDI. Inevitably these technological developments will run ahead of standards with the result that there will always be a challenge in maintaining a commitment to the adoption and development of standards while wishing to capitalise on the latest technology.

There are now a wide range of standards that are supporting and facilitating the growth of spatial data infrastructures. In particular ISO and OGC (Open GIS Consortium) standards are key groups that support the broad area of access to spatial data and more particularly interoperability between distributed data sets. However the more traditional view that SDIs are all about linking distributed silos of data by web technologies is now being challenged by the power of ICT.

At the same time a growing area of importance are the standards concerned with the fitness for use of spatial data as well as quality issues including the visualisation of data uncertainty.

Quite often standards have evolved and been developed after systems have been put in place. A good example of this in the area of SDI was the creation of a national large-scale cadastral map for Australia that was used as the basis of the 1996 Census. The data set comprised over 10 million land parcels from seven different jurisdictions and to a large extent was built without standards. However the end result in effect became a standard for the Australian Spatial Data Infrastructure (ASDI). A similar development phase is occurring currently in Australia where a geo-coded national address file (GNAF) is being developed for the nation. While a lot of effort has gone into designing GNAF the end result will be a standard in its own right that will provide the basis for creating and refining standards in this area.

Simply if the vision of a virtual jurisdiction is to be a reality, then standards need to be developed and used such that all spatial data sets are SDI compliant. This is an enormous challenge.

So while standards are essential, especially to facilitate interoperability within an SDI context, getting the right standards that facilitate development and do not limit it, is a challenge.

Data

The 1980s and 1990s focussed on the establishment of spatial databases and spatial data collection, usually as separate data silos. Most developed countries have now moved past this phase of building the first generation of spatial data infrastructures while at the same time new technologies have made data collection easier and more efficient. Often the result is now data overload, not lack of data. As a result a challenge is to continue to refine metadata search engines, clearing houses, spatially enabled web tools and data mining capabilities in order to search and identify appropriate data sets. This is a major challenge. To date we do not have any spatially enabled web

tools such as a spatially enabled Google. Sophisticated data mining requires a detailed understanding of the ontologies of spatial data, as well as the access technologies.

With the explosion in the amount of spatial data and the ability to combine data from different data sets, there is a much greater awareness of the potential and power that data integration provides as well as the resulting privacy issues. Managing these often conflicting objectives in a major challenge in its own right.

One of the major challenges in improving interoperability is fragmentation of data between non-coterminous boundaries such as often occurs with census boundaries, postcodes, local government areas and school districts for example. If these boundary units do not match or cannot be easily integrated it is very difficult to convert the data into structures and formats that can be exchanged, integrated and fully utilized by all users.

As discussed above a challenge is to build clearinghouses or virtual spatial data libraries that have intelligence and can assist the user to not only identify appropriate data but also identify appropriate tools to turn that data into information and knowledge. As a result the future challenge will be the development of tools to assist in better decision making rather than simply accessing data in its own right.

The problem of data over load is being compounded as jurisdictions complete the construction of large-scale data sets such as cadastral, land use, street address and road network data sets. Unfortunately these large-scale people-relevant data are often at different levels in the SDI hierarchy (corporate, local or state government versus federal and national governments). They often represent a wider range of political and jurisdictional challenges.

At the same time the wider community is starting to recognise the power of “location” in business systems and in better decision-making. The result is that a great deal more data at a corporate level rather than at a local government or state level is now being made available with a spatial context or location. For example governments and the public increasingly want to know all the rights, restrictions and responsibilities that apply at a particular location – again this is an enormous challenge.

Another challenge facing the developers of spatial data infrastructures is driven by a recognition that economic, environmental and social activities do not cease at the water’s edge. In fact some of the most sensitive areas in any jurisdiction are in the coastal zone. The result is that SDI developers have to accommodate both marine and land-based data sets seamlessly into their systems. This presents significant challenges since marine data has historically resided in individual information silos and has been divorced from land-based administration.

Developed and Developing Countries

While all these challenges are likely to be addressed or at least acknowledged in highly developed countries, there is a much bigger challenge facing the developing world. The question must be asked – what constitutes a spatial data infrastructure in a developing country that does not have the capacity of their developed counterparts?

Unfortunately most of the discussion with regard to the development of spatial data infrastructures centres on the use of the latest systems and technologies primarily based in the developed world. To a significant extent most SDIs have been established in the developed world and may not be relevant to the developing world.

The challenge facing the developing world is to institute spatial data infrastructures much more quickly, efficiently and at lower cost than developed countries. The reality is that in the developed world it has usually taken twenty to thirty years or even 100 years to establish the appropriate spatial data sets that are now residing in state-of-the-art SDIs. But the reality is that even these data sets are only the first generation with many of them lacking integrity and completeness. For example there is only a limited number of countries that have complete digital cadastral databases or property databases across their nation (none in North America for example and only a few in Europe).

In the case of Australia, while the first generation of these data sets has been developed, the data sets still have gaps and lack completeness. For example not all privately owned land is included in the cadastral system in some states since there is a residual of parcels based on what is called “Old-system title” which was phased out with the introduction of the Torrens System in the mid 1800s. At the same time roads and many other public lands are not uniquely identified in some states in an integrated system, nor are mining rights and many other rights, restrictions and responsibilities. So while the developed world still has a major challenge to refine their data sets and systems, the developing world has an even greater challenge, however these countries cannot wait 100 or even 50 years to build their systems.

Simply the challenges facing the developing world are enormous. They not only have a lack of digital data, they have a lack of hard copy data. On the other hand geographic information systems and associated project-specific spatial data sets are growing dramatically in developing countries in an ad hoc manner. This could be the biggest challenge facing developing countries to ensure there is a common focus for the huge amount of effort and activity that is going on in this area, often in an uncoordinated manner.

In addition the difficulty is compounded by a lack of capacity as mentioned previously and a lack of policies.

It could be a useful exercise for the Global Spatial Data Infrastructure organisation to recommend what are the most basic steps required in a

developing country in order to create a spatial data infrastructure. For example the establishment of a geodetic control network using satellite positioning technology together with a common base map at a large scale for urban areas and a medium to small scale in rural areas. Importantly the establishment of a common base map, which is used by all organisations in a country and which could be made freely available to all, will need to over come many political and institutional challenges in developing countries and will confront many traditional vested interests.

Lastly a broad land policy, that incorporates a spatial data infrastructure component that collectively is linked to a nation's information and communications technology strategy, is a fundamental need as a basic building block. It would be a useful exercise at GSDI 7 to see how many countries attending have a national land policy?

As a result of the enormous problems confronting developing countries in establishing SDIs and that they have the most to gain from the development of SDIs, I encourage GSDI to take up the challenge to determine what constitutes a spatial data infrastructure for countries at different stages of economic and social development.

Conclusion

This paper has attempted to discuss the challenges that face any jurisdiction within the spatial data hierarchy in designing, building and managing spatial data infrastructures. In considering these challenges I have used the accepted components of a SDI, being people, access, policies, standards and data, and have considered the challenges within the SDI hierarchy ranging from corporate through to global SDIs. I have concluded by also focussing these challenges on the developing world.

Finally I would like to conclude by discussing what I see as arguably the biggest challenge facing the SDI community in both developing and developed countries - that is how to describe and promote the benefits of SDI in order to seek support and investment in their creation. I believe the challenge is not to focus on the term "SDI", which to many people is simply a technological tool with little interest. The challenge for the SDI community is to focus on outcomes and on areas where the adoption of a SDI is critically important in ensuring the success of such activities as environmental management, economic development, counter terrorism and emergency management.

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