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Some Priorities for SDI Related Research

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SUMMARY

The paper outlines some priorities for SDI related research based on the findings of the author's forthcoming book on SDIs. It highlights some of the trends in SDI thinking that emerge from the analysis with reference to four key themes: SDI diffusion, evolution, implementation, and hierarchy.

Some Priorities for SDI Related Research

Ian MASSER, United Kingdom

1. THE SPATIAL DATA INFRASTRUCTURE PHENOMENON

Given that more than half the world's countries claim that they are involved in some form of spatial data infrastructure (SDI) development (Crompvoets et al 2004) the term 'SDI phenomenon' seems an appropriate one to describe the events that have taken place over the last ten to fifteen years in this field. A forthcoming book by the author (Masser 2005) provides an overview of these developments. Its primary focus is on the policy options and the institutional structures that have been come into being in the process of formulating and implementing SDI initiatives. The overall scope of the book is world wide in nature although particular attention is given to developments in four countries that can be regarded as among the acknowledged leaders in the field: Australia, Canada, the United Kingdom and the United States.

Four main themes are explored in some detail in the book. These are:

- the diffusion of SDIs
- the evolution of SDIs
- the implementation of SDIs
- the hierarchy of SDIs.

The diffusion of SDIs throughout the world is explored with particular reference to the diffusion of innovations model developed by Everett Rogers (1995). The findings of this analysis highlight some of the main features of the innovators/early adopters who pioneered SDI development and the contrasts between them and the early majority that followed them. Given that it may take many years or even decades before these SDIs become fully operational, and the institutional context in which they are developed may change substantially during this time, the evolution of thinking about SDIs is explored in some detail with reference to the experiences of the United Kingdom over the last ten years. The rest of the book considers some aspects of the hierarchy of SDIs that is coming into being throughout the world. Some of the experiences of the United States, Australia and Canada with respect to the multi level implementation of SDIs at the state and local levels are examined. Then the processes of institution building that have taken place at the regional/continental and global levels respectively are considered with reference to the European Umbrella Organisation for Geographic Information (EUROGI) and the Global Spatial Data Infrastructure Association.

This paper summarises some of the main findings of the analysis. Its main objective is to put these findings into a broader perspective and to identify issues that would benefit from further research. The discussion highlights some of the trends in SDI thinking that emerge from the analysis and then focuses on the four main themes that were identified in the introduction to the book: ie SDI diffusion, evolution, implementation and hierarchy.

2. SHIFTS IN SDI DEVELOPMENT

The innovators/early adopters described in Masser(1999) constituted the first generation of national SDIs and the development of the second generation of SDIs began around 2000 as the early majority gained momentum (Rajabifard et al 2003). There is an important shift in emphasis from the first to the second generation both in technological terms and also with respect to the key themes of SDI development. The shift in technological emphasis is due to the opportunities opened up by the development of the Internet and the World Wide Web. The US Mapping Sciences Committee in their report on Distributed Geolibraries (National Research Council 1999, 31) acknowledged this shift saying that '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.'

Table 1 Shifts in SDI development

From a product to a process model

From data producers to data users
From database creation to data sharing
From centralised to decentralised structures

From formulation to implementation

From coordination to governance
From single to multilevel participation
From existing to new organisational structures

Some of the current trends in thinking about SDI development are summarised in table 1. Rajabifard et al (2003) argue that the most distinctive feature of the second generation of SDIs is the shift that has taken place from the product model that characterised most of the first generation to a process 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 national SDIs to the decentralised and distributed networks that are a basic feature of the WWW.

There is also a shift in emphasis from SDI formulation to implementation over time. This reflects the shift from single level to multi level participation within the context of a hierarchy of SDIs. Under these circumstances it will be necessary to think in terms of more inclusive

models of governance. These developments may also require new kinds of organisational structure to facilitate effective implementation.

3. THE DIFFUSION OF SDIs.

Although more than half the world's countries claim that they are involved in some form of SDI development, these claims need to be treated with some caution until they have been backed up by factual evidence as it is likely that there is an element of wishful thinking in some of them. The findings of the state of play study carried out the Spatial Applications Division of the University of Leuven for the European Commission (SAD 2003), for example, suggest that only a handful of European countries have anything like a full blown SDI and most of these initiatives can better be described as 'SDI like or SDI supporting initiatives.' Furthermore, the fact that some countries have reported that they are engaged in some aspect of SDI development does not necessarily mean that this will translate into a fully operational SDI over time.

The most obvious SDI success can be measured in the establishment of clearinghouses and portals to disseminate metadata. The FGDC Clearinghouse registry, for example, lists nearly 300 registered nodes from the US and other countries (<http://registry.gsdi.org/serverstatus/>). Similarly, Maguire et al (2005) claim that there are on average 5622 user visits per week to the US Geospatial One-Stop portal site in April 2004. However, it is not enough to report that clearinghouses have been established without including some information on their usage and the arrangements that have been made for their continuing upgrading and maintenance. For example, the findings of a number of surveys carried out at different points in time by Crompvoets and his colleagues (2004) suggest that the use that is being made of some of these metadata services may be declining over time rather than increasing and that this is due to unsatisfactory arrangements for continuing site management.

While considering the extent to which the diffusion of innovations model is an appropriate one for the study of SDI diffusion it is worth noting that SDIs generally fit the definition of an innovation as 'an idea, practice, or object that is perceived as new by an individual or unit of adoption' (Rogers 1995,11). However, while the characteristics of the innovators, early adopters and early majority of SDIs show most of the features described by Rogers, it will be interesting to see whether this is the case for the late majority and laggards.

It should also be noted that the diffusion of innovations model has been criticised for its pro innovation bias (Rogers 1993). This can also be seen in the statements that are made in connection with SDI development which constantly stress its positive impacts in terms of promoting economic growth, better government and improved environmental sustainability. These and other similar claims need to be rigorously examined in further research.

In the process more attention should be given identifying possible negative impacts arising out of SDI development. A useful example of this kind of work can be found in the four brave new GIS worlds scenarios that were developed by Wegener and Masser (1996). Their trend, market, big brother and beyond GIS scenarios are easily translatable into the SDI field as can

be seen from the Mapping Science Committee's Future of spatial data and society project (National Research Council 1997).

It is not always easy to define with any precision the moment in time when the idea was adopted. In some cases, there is a gradual transition from existing practices into a SDI. This happened, for example, in Australia and Finland where there was a tradition of SDI like thinking before the SDI itself formally came into being. In other cases the position is complicated by differences in the terminology that is used to describe SDI like activities. When, for example, does a national GI system become a SDI?

Some of these problems can be resolved by developing more systematic ways for describing and classifying SDIs. The typology developed by the Leuven group (SAD 2003) as a result of their EU wide state of play study is a step in the right direction, even though, in its current version, it gives rise to some ambiguities and overlaps in practice. However, this typology only takes account of the approach that has been adopted towards coordination and it may be worthwhile extending it to incorporate other variables.

Another matter that needs consideration in future SDI diffusion research is the extent to which cultural factors are likely to influence SDI adoption. An interesting example of this kind of research is van de Toorn and de Man's (2001) analysis of the role of culture in SDI development. This draws upon the four dimensional model developed by Hofstede (1997). As a result of extensive empirical research Hofstede found that national cultures varied with respect to four main variables: power distance (from small to large), uncertainty avoidance (from weak to strong), masculinity versus femininity, and collectivism versus individualism. In a SDI environment van der Toorn and De Man argue that cultures where there are large power distances are likely to use SDI to reinforce the hand of management whereas those with small power distances will welcome their data sharing and accountability properties. Similarly, masculine cultures will be interested in SDIs because of their capacity to contribute to the visible achievements whereas feminine cultures will welcome their networking and relationship building properties.

4. THE EVOLUTION OF SDIs

The old adage that Rome wasn't built in a day is equally applicable to SDIs. The creation of SDIs is a long term task that may take years or even decades in some cases before they are fully operational. This process is likely to be an evolving one that will also reflect the extent to which the organisations that are involved reinvent themselves over time. Rogers (1995, 16-7) defines reinvention as 'the degree to which an innovation is changed or modified by a user, in the process of its adoption and implementation.' He also notes that, while some innovations are difficult or impossible to reinvent, others are 'more flexible in nature, and they are reinvented by many adopters who implement them in different ways.' The degree of reinvention involved in GIS implementation in British local government led Campbell and Masser (1995, 109-110) to conclude that

'the meaning of a technology such as GIS was constantly being reinvented at both the organisational and individual scales. This has important implications for studies of

diffusion as it would appear that innovations such as GIS embrace a wide range of perceptions. These differences in emphasis are likely to lead to tensions and problems which will complicate the implementation process. It is also likely that such systems will be used to undertake activities not originally anticipated by their inventors.'

There are clear parallels between these findings and SDI evolution. Given that SDI implementation is likely to take place over a long period of time when the technologies are also changing, together with the external political and institutional circumstances that surround a SDI, it may be necessary to distinguish between two levels of reinvention in this case. The first of these concerns the processes needed to initially adapt the notion of a SDI to the local or national context to take account, for example, of the impacts that the allocation of administrative responsibilities and the style of government will have on the form of SDI development in each case. The second relates to processes that are involved in its evolution over time in response to changing political, institutional and technological circumstances.

Given the extent to which SDIs can be expected to change over time it will be necessary to set up research procedures to ensure that their progress is systematically monitored. Longitudinal studies will form an important part of this research strategy. To facilitate research of this kind it will also be necessary to ensure that key documents are not lost when they become out of date. This is particularly a problem in SDI research which relies to a great extent on grey literature in the form of unpublished reports and memoranda. As a result it is heavily dependent on materials obtained from web sites that are also changing constantly over time. This is already a matter of concern in some countries and the author's analysis of the UK NGDF experience (Masser 2005, chapter 4) was made more difficult by the fact that many key documents are no longer readily available following the closure of the NGDF website in 2001.

5. THE IMPLEMENTATION OF SDIs

Some of the most challenging research questions are posed by the need for multilevel stakeholder participation in SDI implementation. The scale of these operations in large countries such as the US is massive given that more than 80,000 public bodies alone are involved in some way. This task is made even more difficult by a governance model that is based largely on consensus building and the extent to which coordination bodies such as the FGDC in the US and ANZLIC in Australia lack the powers to enforce their strategies or to impose sanctions on unwilling participants.

It must also be recognised that the 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 is to find ways of ensuring some measure of standardisation and uniformity while recognising the diversity and the heterogeneity of the different stakeholders. This will involve a sustained mutual learning process on the part of all those involved in SDI implementation.

Data sharing among the participants on an unprecedented scale will be needed for SDIs to become fully operational in practice. This level of data sharing is likely to require considerable changes in the organisational cultures of the participants. Onsrud and Rushton (1992, 1) define the issues involved in data sharing in the following terms,

'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.'

For this reason there is a pressing need for more research on the nature of data sharing in a multi level SDI environment. The studies that have been carried out by Zorica Nedovic-Budic and Jeffery Pinto (1999a and b) and Nedovic-Budic et al (2004) in the US provide a useful starting point for work in other parts of the world. The two earlier studies focus mainly on the motivations for data sharing, the coordination process and the costs of coordination whereas the more recent analysis of the responses of 245 respondents to a survey questionnaire provides some interesting quantitative indicators of the interactions mechanisms involved and the motivations of the respondents. Similarly, the findings of Harvey's (2002) survey of local governments in Kentucky demonstrate the complexity of the networks involved in collaborative environments of this kind.

Another example of this kind of research is 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 quantitative analysis generally bear out the relationships postulated in this theory and give valuable insights into the factors that determine the willingness to share spatial data. They also show that there is only a relatively limited commitment amongst those involved to promote data sharing in high profile initiatives such as the South African national SDI whose successful implementation is dependent on a high level of spatial data sharing.

More attention also needs to be given to research that identifies the types of organisational structure that facilitate data sharing. Given the importance of these matters for SDI development and implementation, Warnest et al (2003) have argued that it may be useful to examine how matters of this kind have been dealt with in the management literature. The work of Child and Faulkner (1998) on cooperation strategies and Lendrum's (2003) partnering handbook, for example, may be helpful in future discussions of SDI implementation.

6. THE HIERARCHY OF SDIs

Hierarchy does not necessarily imply a top down command structure when used in connection with SDI development. There is a bottom up as well as a top down dimension in SDI

development and implementation. It also showed that in many cases national bodies such as the FGDC work directly with local bodies without reference to the state level. Similarly, it should be noted that the absence of SDI initiatives at one level of the hierarchy does not necessarily inhibit their development at other levels. France is a particularly good example of a country that has no national SDI initiative but a number of well developed sub national initiatives (see, for example, Roche and Humeau 1999).

From a research perspective it may be worthwhile exploring hierarchy theory in greater depth in the context of SDI development. Rajabifard (2002), for example, has made use of hierarchical reasoning in his work on SDI structures. He has also identified three properties of hierarchies that give some useful insights into these structures:

- the part - whole property which describes the degree to which higher level entities can be subdivided into lower level parts,
- the Janus effect which relates to the relationships that an element has with the levels above and below it, and
- the near decomposability property which describes the nesting of systems within larger systems and the extent to which the interactions between the different systems decrease in strength with the distance between them.

It is also important to bear in mind that different levels of the SDI hierarchy perform different tasks. The role of bodies at the regional and global levels is primarily to foster SDI development by disseminating information about current developments and best practices to the levels below them whereas local SDIs are primarily concerned with the operational needs of day to day decision making. Despite these differences all levels of the hierarchy are involved to some extent in the dissemination of information between the various levels. National level bodies perform a similar task with respect down to sub national and upwards while regional bodies and state level bodies do the same with respect to local ones.

These activities involve some measure of capacity building and it is therefore worth looking at the notion of capacity building in more detail. The term 'capacity building' can be used to include human resource development, organisational change and societal transformation (see, for example, Pauknerova et al 2003). Nevertheless to some people it means essentially the training of SDI technicians and managers although this definition is sometimes extended to include the education of politicians and the general public outside the geographic information industry (Hopkins 2004).

To others, including those involved in SDI development, it is necessary to take a much broader view of capacity building. If the term 'environmental management' is replaced by 'SDI development' in the quotation below it can be seen as a useful definition of some of the key strategic capacity building tasks involved in SDI implementation.

'The contemporary view of capacity building goes beyond the conventional perception of training. The central concerns of environmental management - to manage change, to resolve conflict, to manage institutional pluralism, to enhance coordination, to foster communication, and to ensure that data and information are shared - require a broad and holistic view of capacity building.'
(<http://nrm.massey.ac.nz/changelinks/capacity.html>).

Such a view is synonymous with organisational learning This standpoint is reflected in the African Capacity Building Foundation's approach which argues that 'capacity building should not only involve the creation of new human and institutional capacity, but also the effective utilisation of existing capacity as well as the retrieval and regeneration of hitherto lost or decaying capacity.' (www.abfc-pact.org).

However, it is also important to bear in mind that capacity building activities, like SDI development itself, can have a negative as well as a positive impact. This is particularly the case with some projects in less developed countries. Fukuda-Parr et al (2002), for example, have shown how technical cooperation programmes can adversely affect the development of local organisations as a result of two mistaken assumptions:

'The first is that it is possible simply to ignore existing capacities in developing countries and replace them with knowledge and systems elsewhere - a form of development as displacement rather than development as transformation. The second assumption concerns the asymmetric donor recipient relationship - the belief that it is possible ultimately for donors to control the process and yet consider the recipients to be equal partners.'

7. CONCLUSIONS

The findings of this analysis highlight the diversity of topics that need to be investigated in future SDI related research. These draw heavily on concepts from economics, geography, management and social science. Research activities of this kind are essential to facilitate more informed SDI developments in the future.

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BIOGRAPHICAL NOTES

Ian Masser retired from the position of Professor of Urban Planning at ITC in September 2002 after four and a half years service. Prior to that he was Professor of Town and Regional Planning at the University of Sheffield for nearly 20 years. He currently holds the positions of Visiting Professor in the Faculty of Geographical Sciences at the University of Utrecht, the Centre for Advanced Spatial Analysis at University College London and the University of Melbourne. He was the Founder Chairman of the Association of Geographic Information Laboratories in Europe (AGILE) from 1998 to 1999 and President of the European Umbrella Organisation for Geographic Information (EUROGI) from 1999 to 2003. He was also President of the Global Spatial Data Infrastructure Association from September 2002 to February 2004.

Educated in geography and town planning at Liverpool University Professor Masser received his PhD in 1975 and was awarded a LittD in 1993 by the same University for his contributions to the fields of planning methods, information management and comparative studies. These three interests feature prominently in his research activities. From 1986-1991 he was national coordinator of the UK's Economic and Social Research Council's Regional Research Laboratory initiative and he co-directed the European Science Foundation's GISDATA scientific programme from 1992 to 1997. His publications include seventeen books and over 250 contributions to conference proceedings, books and major journals.

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