Directions for the Future of SDI Development

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Abstract

Understanding the role of Spatial Data Infrastructure (SDI) is important to acceptance of the concept and its alignment with spatial industry objectives. Much has been done to describe and understand the components and interactions of different aspects of SDIs and their integration into the transactions of the spatial data community. However, what fails to be received through these perceptions, is that the role SDI plays is by necessity greater than the sum of individual components of SDI and stakeholder groups.

SDI is fundamentally about facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community. To this end, the authors propose that the roles of SDI have been pursued through different approaches: product-based and process-based. Both approaches have value, but contribute to the evolution, uptake and utilisation of the SDI concept in different ways. They provide different frameworks for dealing with SDI mandates for the objectives of spatial data access and sharing.

This paper reviews the nature and concept of SDI, including the components, which have helped to build understanding about the importance of an infrastructure to support the interactions of the spatial data community. Several examples of how SDIs have been described are offered to aid understanding of their complexity. The need for descriptions to represent the conflict between the role and deliverables of an SDI and thus contribute to a simpler, but dynamic, understanding of the complexity of the SDI concept, are postulated. The transition between the understanding of SDIs from product-based to process-based approaches is investigated, with a review of the positions taken by current SDI initiatives throughout the world. A model of how these approaches provide a framework to meet the mandates of the relevant jurisdictions is proposed, and factors contributing to the success of such positions in the future are discussed.

Introduction

There has been a significant evolution in the approach taken to the implementation and support of spatial data frameworks over the last decade, especially in developed countries. There is increasing recognition that the benefits being returned to communities by investing in such infrastructure include development of a spatial information marketplace, economic development, social stability, reduced resource disputes, improved environmental management, and subsequent dealings within the land administration system.

This has resulted in a worldwide impetus for communities to begin thinking more strategically about their geographic information needs, collection, management and the resources needed to deliver these to wider audiences. These communities usually use different ways of enhancing and strengthening their strategies on managing spatial data assets. However, their common objectives have resulted in the development of the Spatial Data Infrastructure (SDI) concept at different political/administrative levels. SDI is fundamentally about facilitation and coordination of the exchange and sharing of spatial data between stakeholders in the spatial data community, and it constitutes dynamic partnerships between inter- and intra-jurisdictional stakeholders.

The principal objective for developing SDI for any political/administrative level, as highlighted by Rajabifard *et al.* (1999), is to achieve better outcomes for the level through improved economic, social and environmental decision–making. The role of SDI is to provide an environment in which all stakeholders, both users and producers, of spatial information can cooperate with each other in a cost-efficient and cost-effective way to better achieve organisational goals. SDIs have the potential to increase employment and new business opportunities for the geographic information industry, and promote widespread use of the available spatial data sets, which are essential to optimise spatial technology support for decision-making processes.

Short through longer-term visions have been adopted for SDI initiatives, to address the needs of participating communities over the next decade and beyond. Some have achieved little beyond their initial good intentions, whilst others have built up considerable experience in formulating and implementing SDI initiatives. In countries, such as Australia, Canada and the United States, there is a growing body of published material describing different aspects of SDI development and implementation, including future strategic plans.

Much has been done to describe and understand the components and interactions of different aspects of SDIs and their integration into the transactions of the spatial data community. There is still, however, a need for descriptions to actually represent the discrepancies between the role and deliverables of a SDI and thus contribute to a simpler, but dynamic, understanding of the complexity of the SDI concept. To this end, the authors propose, that the roles of SDI have been pursued through two different approaches: product-based and process-based models, which contribute to the evolution, uptake and utilisation of the SDI concept in different ways. In this paper the transition between the understanding of SDIs from product-based to process-based approaches is investigated, with a look at the positions taken by current SDI initiatives throughout the world. A model of how these approaches provide a framework to meet the mandates of the relevant jurisdictions will be proposed, and factors contributing to the success of such positions in the future will be discussed.

SDI – the nature, components and global drivers

The design of any SDI requires understanding the nature of the concept, the contributing components and the impact of global drivers. Apart from rapid advances in information and communication technologies, the need to define the concept of SDI is justified by drivers such as globalisation, sustainable development, economic reform, political unrest and war, urbanisation, environmental awareness and human rights (Williamson 2000). Moreover, it is the needs of the user community that will drive SDI development in the future. These present

significant influences on the changing spatial data relationships within the context of SDI jurisdictions. Reliable information infrastructures are needed to record environmental, social and economic rights as well as provide spatial data to facilitate appropriate decision-making and support conflict resolution. These drivers in turn effect the resulting spatial data industry environment and SDI vision, in particular partnership concepts.

There has been a trend for countries to expand or consolidate their effort in developing SDIs through partnership. In the 1990s national SDI development took a broad-base approach to encourage cooperation among stakeholders to pool data assets. Based on this approach, an ideal SDI should have all data sets in the corporate SDI fully integrated. Constrained by existing technical and institutional arrangements, SDI developing agencies have focused on promoting adoption of common standards, as well as fast-tracking integration among certain strategic data sets through partnership arrangements (ANZLIC 1996). Partnerships are formed to create business consortia to develop specific data products or services for strategic users, by adopting a focussed approach to SDI development.

Coleman and McLaughlin (1998) identify four different perspectives of SDI, which provide an insight to the spatial data environment. These perspectives were developed to represent the varied directions of SDI initiatives, as shaped by the participant stakeholders, namely, spatial data supplier, technology supplier, spatial data and technology users and the collection of all three. Coleman and McLaughlin (1998) also point out that these groups interact widely with one another, suggesting that the SDI environment be made up of these interacting stakeholder groups.

Different views of SDI can also be derived from different countries' approach to the understanding and development of SDIs. The Federal Geographic Data Committee (FGDC 1997) defines the United States' National SDI as an umbrella of policies, standards, and procedures under which organisations and technologies interact to foster more efficient use, management, and production of geospatial data. It further explains that SDIs consist of organisations and individuals that generate or use geospatial data and the technologies that facilitate use and transfer of geospatial data. The Australian and New Zealand Land Information Council (ANZLIC 1998) define a national SDI as comprising four core components: an institutional framework, technical standards, fundamental datasets, and clearing house networks.

After reviewing the varied roots and values underlying the vision of SDIs, including those cited, Coleman and McLaughlin (1998) defined the Global SDI as encompassing the policies, technologies, standards and human resources necessary for the effective collection, management, access, delivery and utilisation of geospatial data in a global community. The principal objective of developing an SDI is to provide an appropriate environment in which all stakeholders, both users and producers, of spatial information can cooperate with each other in a cost-efficient and cost-effective way to better achieve their targets. In this context, Coleman and McLaughlin (1998) regard the Australian and New Zealand Land Information Committee (ANZLIC) definition of SDI as data-centric, that is not taking into consideration the interactions between the suppliers and users of spatial data, which is a key driving force in SDI development. This data-centricity also applies to the Asia-Pacific SDI development by the Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP 1998), which adopts the same four components as ANZLIC (ANZLIC 1996), applying them at a regional SDI level. People are an important component of SDIs, in addition to the four basic components identified for the Australian and Asia-Pacific SDIs. The interaction of the spatial data users and suppliers and any value-adding agents in between drive the development of any SDI. For this reason the formation of cross-jurisdictional partnerships have been the foundation of SDI initiatives supported to date.

People are the key to transaction processing and decision-making. All decisions require data and as data becomes more volatile human issues of data sharing, security, accuracy and access forge the need for more defined relationships between people and data. The rights, restrictions and responsibilities influencing the relationship of people to data become increasingly complex, through compelling and often competing issues of social, environmental and economic management. Facilitating the role of people and data in governance that appropriately supports decision-making and sustainable development objectives is central to the concept of SDI.

Viewing the core components of SDI as policy, access network, technical standards, people (including partnerships) and data, different categories can be formed based on the different nature of their interactions within the SDI framework. Considering the important and fundamental role between people and data as one category, the second can be considered the access network, policy and standards – the main technological components. The nature of the second category is very dynamic due to the rapidity with which technology develops and the need for mediation of rights, restrictions and responsibilities between people and data change (Figure 1). This suggest, an integrated SDI cannot be composed of spatial data, value-added services and and-users alone, but instead involves other important issues regarding interoperability, policies and networks. This in turn reflects the dynamic of the whole SDI concept. This is an issue which also highlighted by Groot and McLaughlin (2000). According to Figure 1, anyone (data users through producers) wishing to access data sets must go through the technological components.

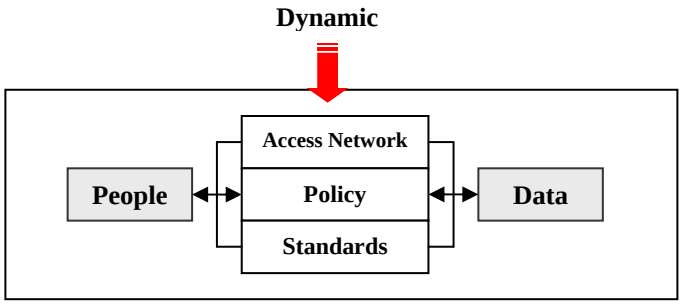


Figure 1: Nature and relations between SDI components

There are numerous approaches taken through varying SDI initiatives for the relationships defined between people, data and the initiative's objectives. One approach has been the development of strategic partnerships. The influence of the level of SDI and the focus for the technical components have an important influence on the approach taken for aligning components towards the development of SDIs.

The Product and Process-based Approaches

As the emphasis in business processes changes focus from product quality to decision quality (Watson 1996), a similar transition is taking place in the development of infrastructure. SDI development strategies can be characterised as having both product and process emphases. The role these different emphases play in SDI development can be fundamentally important to the capacity of the initiative to facilitate the desired objectives.

Making the transition from an industrial to a post-industrial society based on knowledge and services, the key determinant of success is likely to shift from product quality to decision quality (Watson 1996). In an industrial society, decision quality is critical because it precedes product quality. Yet, definition and understanding of technology, business processes and innovation diffusion have often developed as a result of adopting the metaphor of production processes and product-oriented deliverables in research in different disciplines (for examples see Alford 1993, Chan and Williamson 1996, 2000). In contemporary business environments successful organisations will be those able to make high quality decisions quickly. Decision quality has always been important, it just becomes more so in a knowledge and service based society.

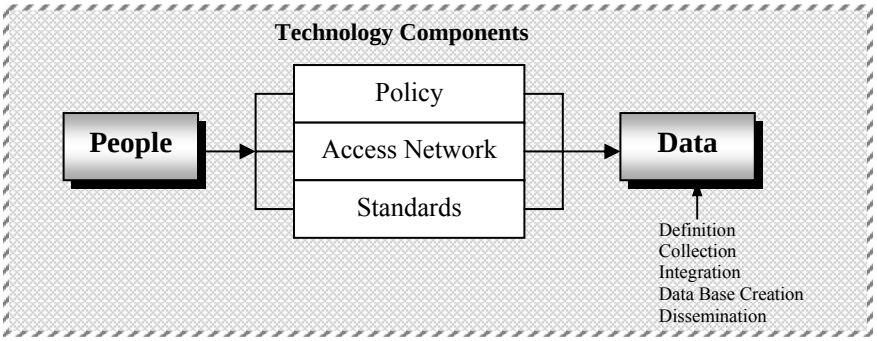
The competing importance of achieving product and decision quality in business processes is also present in product and process-based approaches evident in SDI development strategies. Coleman and McLaughlin (1998) acknowledge the two frameworks from the origins of early infrastructure definitions in the telecommunications

sector. The approaches focus on the "conduit", or alternatively the "content", defining the infrastructure, and the balance between "technology-push" and "demand-pull" from within the participant industry (Coleman and McLaughlin 1998). Whilst the competing foci are of relative importance to each other, the balance of SDI development to date has been on *content* formation and preliminary access agreements, evolving within short-term frameworks or on a project-by-project basis and thus taking on product-based characteristics.

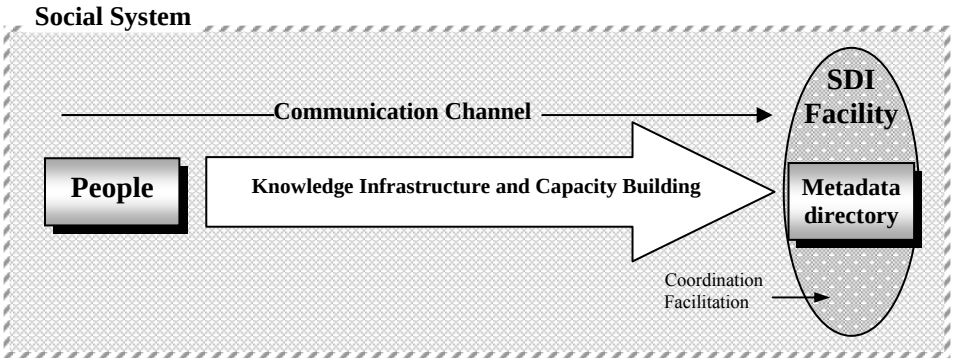
The deliverables expected from SDI initiatives have frequently had more to do with aligning the access networks, policies and standards for particular stakeholders or databases, than establishing *conduits* or long-term process-based spatial data-people networks. The partnership strategies employed in facilitating such networks have been successful within several government departments (Jacoby 2000). The authors' propose the future of SDI lies in addressing the balance between the competing foci in SDI development toward an emphasis on process-based facilitation for participant initiatives for spatial data sharing. Whilst ongoing *content* development, a product-based approach, is essential to complement process-based facilitation, the differing roles of each in the development of SDIs is becoming more important for longer-termed commitments to and investments in SDIs.

Based on the strategies, aims, objectives, and status of individual SDI initiatives in different political/administrative levels, both product-based and process-based approaches can be identified in contemporary SDI development, as illustrated in Figure 2. The initial thought of the existence of these two approaches, is based on Masser (2000), where he presented the implications for access within National SDI initiatives.

The product-based model, outlined in Figure 2A, represents the main aim of an SDI initiative being to link existing and upcoming databases of the respective political/administrative levels of the community. Chan *et al.* (2001) provides a detailed description of the production aspect of SDIs in terms of spatial data, value-added services and end-users, describing the chain of spatial data flow in the environment of multiple 'production lines'.



A) Product-Based Model



B) Process-Based Model

Figure 2: Product and Process based models for SDI development

The process-based model, Figure 2B, is the second approach possible for SDI development. This model presents the main aim of an SDI initiative as defining a framework to facilitate the management of information assets. In other words, the objectives behind the design of an SDI, by any coordinating agency, are to provide better communication channels for the community for sharing and using data assets, instead of aiming toward the linkage of available databases.

The process-based model emphasises the communication channel of knowledge infrastructure and capacity building, which is illustrated in detail in Figure 3. According to this figure, an SDI initiative can proceed by following certain steps towards the creation of an infrastructure in which to facilitate all parties of the spatial data community in the cooperation and exchange of their data sets.

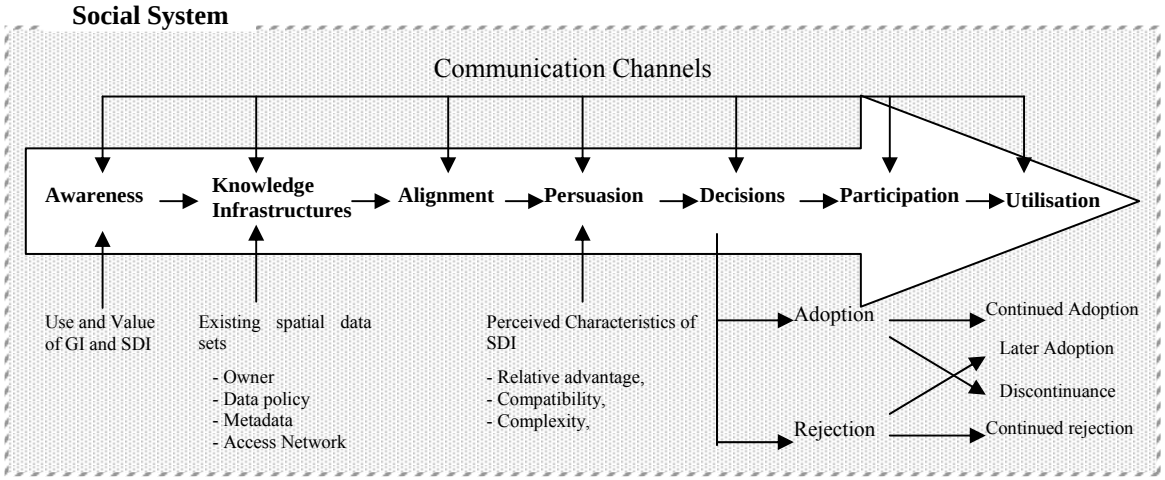


Figure 3: Process-based model for SDI development (based on Roger's Innovation-Decision Process 1993)

For taking full advantages of this approach, it is important to understand the social system of the community or jurisdiction in which this approach is supposed to be executed. The social system as defined by Roger (1993), is a set of interrelated units that are engaged in joint problem solving to accomplish a common goal. The importance of this condition is that the characteristics of an innovation, like an SDI, as perceived by the members of a social system, determine its rate of adoption. The social system definition then becomes particularly influential when an innovation is developed and implemented within different communities, due to different characteristics of each community. The characteristics of the social system strongly influence the approach taken to the development of an SDI initiative. The understanding of the social system can help selection of an appropriate approach to SDI development

SDI development using a process-based model, in its adoption among spatial data communities, obeys the S-shaped diffusion curve found by Coleman *et al.* (1966 cited by Roger 1993), that characterised the behaviour of earlier and later adopters of an innovation (Figure 4). This is reflected in the degree of support in different SDI initiatives as they develop. For example, after six years of development the Asia-Pacific SDI is

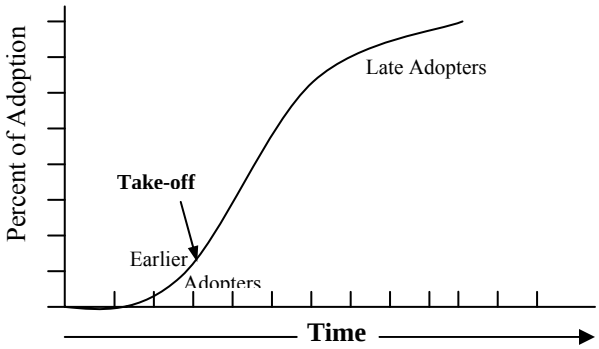


Figure 4: S-Shaped Diffusion Curve (Adopted from Coleman *et al.* 1966)

still only in an early stage of adoption according to the proposed Diffusion curve (Mohammed 1999). There are many issues and challenges faced by SDI development initiatives throughout the world (Onsrud 1998, Masser 1998, Mohammed 1999) including the compatibility of the visions and expectations for a SDI and the development model selected, which justify the need to improve understanding about the alternative approaches that may be adopted whilst learning from current development experiences.

The different characteristics of social systems, or communities, adopting the SDI concept can be attributed to a number of variables, including the different cultures of the communities. However, the objectives behind cooperation toward SDI development are still to take advantage of common interests toward achieving certain goals. These characteristics can be seen as very similar to the organisational objectives of people working together with common interests toward achieving organisational goals. Although SDI stakeholders do not necessarily conform to the formal structure of an organisation, the motivating concepts behind cooperation toward SDI development apply at global and regional levels, as much as to individual countries, states and corporations in an SDI hierarchy, despite the more voluntary nature of the cooperation than in a formal organisational structure.

Therefore, taking an organisational approach can direct and inform on the role of the social system in approaching individual SDI development strategies. The development model adopted for SDI initiatives influence the roles individual SDIs play within an SDI hierarchy as well as in the broader context of the spatial data community. Linking the development models adopted, to the roles each SDI will eventually play in an SDI hierarchy, to achieve defined organisational (or super-organisational) objectives, presents an opportunity to demonstrate the complexity, flexibility as well as the dynamic nature of the concept of SDI. A framework proposing how the relationships between SDI hierarchy, organisational structure and different models of SDI development could enable the SDI concept to meet the mandates of the relevant jurisdictions is described below.

Relationships between SDI Hierarchy and different Models of SDI Development

According to Petch and Reeve (1999), most organisations, regardless of their particular spheres of activity, develop broadly similar organisational structures with three different tiers constituting operational, management and executive roles. This structure is often represented as an organizational pyramid.

The base of the organisational structure is the operational level where production processes take place. The middle organizational tier is composed of managers, researchers and administrators whose tasks include monitoring the performance of the operational level, researching the external environment of the organisation, and preparing policy options for the highest organisational tier. This highest organisational tier consists of decision-makers that determine the strategic direction of the organisation. All three organisational tiers are applicable to every SDI hierarchy level. However, by characterising each SDI level by the dominant organisational structure, the authors aim to simplify the understanding of the relationship between development models for SDI hierarchy levels.

The organizational pyramid model has found its way into textbooks in a wide range of subjects from sociology, geography, economics and business to management (Petch and Reeve 1999). Its relevance here is that each layer of the organisational structure has distinctive information requirements and hence demands support from a distinctive level of SDI. It is thus possible to classify different levels of an SDI hierarchy (which is made up of inter-connected SDIs at corporate, local, state/provincial, national, regional (multi-national) and global levels), according to the roles played within different political/administrative levels and their similarities to the organisational structure, as illustrated in Figure 5.

According to this figure, and based on the nature of SDIs, any multi-national SDI (regional or global), can be considered similar to the strategic tier of an organisational structure. An SDI at a national level has resemblance to both managerial and strategic tiers, depending on the political system of the nation. If the nation is a federated system of states/provinces, then more advantage can be taken from adopting a process-based model to develop a National SDI. Non-federated nations can select between SDI development models to optimise advantage.

The local and state levels of an SDI hierarchy are similar to the operational tier of an organisational structure. Both these levels of SDIs are producing data and are thus forming data belonging to higher levels of an SDI hierarchy. However, state level SDIs can play more important roles in a federated system of government, where due to the power and responsibilities of states, state-level SDIs can emulate management or operational organisational tiers, or both, for the entire state. Both management and operational tiers take product-based approaches due to their key roles in data development. Only the strategic tier and Nations with federated systems are suggested here to adopt the process-based model of SDI development. The main reason multinational and federated nations can take more benefit from using a Process-based model is because of the voluntary nature of SDI participation in these levels of an SDI hierarchy.

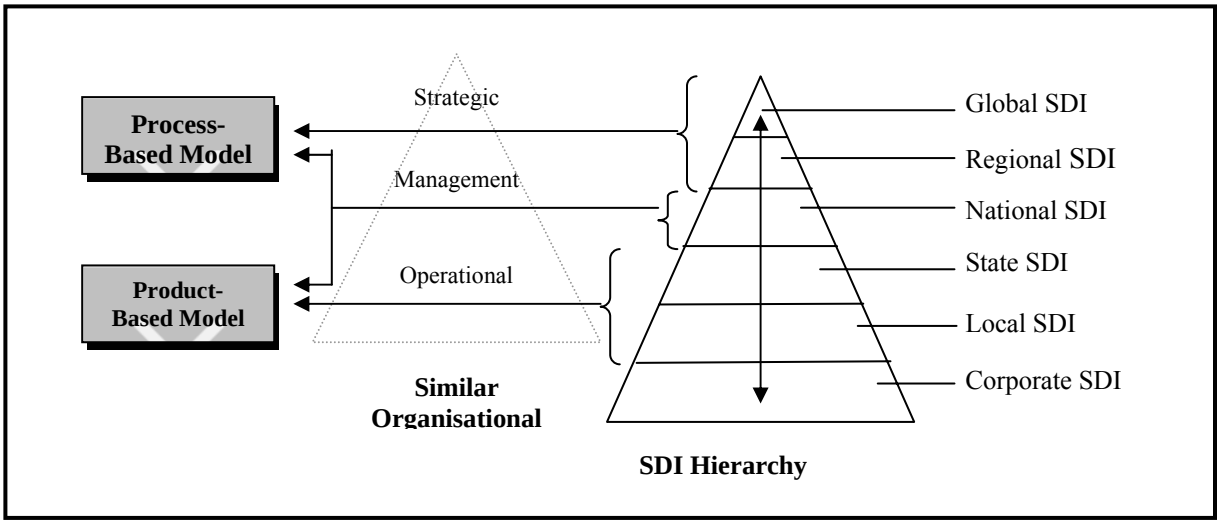


Figure 5: Relationships between SDI Hierarchy and different Model of SDI development

Assessment of Current SDI Initiatives

The criteria used to investigate the development models of SDIs inform on the roles the SDI will play in an organisational sense as well as within the spatial data community. The main criteria for discussing the development of any SDI initiative include the motivations for the development, expected outcomes, management of the development, membership of the development, the measures of progress, the primary political/administrative function of the development, as well as the time-frame commitment of development. As a broad-brush assessment of the approach taken by SDI initiatives these criteria provide a framework against which any initiative can be defined as product or process-based. Whilst there is no exact formula for belonging to one or the other model of development, the alignment of criteria towards achieving product-based or process-based objectives is generally quite specific. Approaches within each of the criteria might include the following examples:

motivations for the development :	integrating existing data with the aim to develop a common fundamental database within a spatial data community, or establishing the links between people and data to facilitate exchange and sharing within a spatial data community
expected outcomes :	an SDI database/warehouse, data-exchange agreement, or an active directory linking data and people
management of the development :	implementation or coordination
membership of the development:	participatory, representative, compulsory or voluntary
measures of progress:	punctuated deliverables, or ongoing establishment and maintenance of a framework or conduit for spatial data for a community
political/administrative function:	intra-jurisdiction, inter-jurisdictional, inter- and intra-jurisdictional
time-frame commitment:	project-oriented, short-term and long-term planning.

There are currently many SDI initiatives established and operating for different political/administrative levels, which have pursued different development models. The following table (Table 1) illustrates the status of some of these current SDI initiatives, and has been prepared mainly from baseline information provided by Onsrud (1998) on the nature and characteristics of SDIs. These initiatives have been classified as product-based or process-based against the discussed criteria. Table 1 illustrates the predominance of a product-based approach to SDI development by current SDI initiatives. Communities adopting process-based SDI development are principally European, with France, Northern Ireland, the United Kingdom and Sweden taking composite approaches with differing emphases on the balance between product-based and process-based initiatives within their SDI development strategies.

Table 1: Current SDI Initiatives displaying product-based or process-based models principally (√) or partially (~)

SDI Community	Product-Based Model	Process-Based Model	SDI Community	Product-Based Model	Process-Based Model
Australia	√		Kiribati	√	
Canada	√	~	Macau	√	
Colombia	√		Malaysia	√	
Finland	√		The Netherlands	√	~
France	~	√	Northern Ireland	~	√
Germany	√		South Africa	√	
Greece	√		Sweden	√	~
Hungary	√		UK	~	√
India	√		USA	√	
Indonesia	√		ANZLIC	√	
I.R of Iran	√		Asia-Pacific (PCGIAP)	√	
Japan	√		Europe (EUROGI)		√

Until now most initiatives have taken a product-based development approach potentially due to a lack of alternative options and awareness of the use and advantages of alternative approaches characterising the development-coordinating SDI community. One example is the regional-level SDI development pursued by the PCGIAP. The PCGIAP approach to SDI development reflects a product rather than process-based model. The PCGIAP's vision for the Asia-Pacific Spatial Data Infrastructure (APSDI) is of a network of databases, located throughout the region, that together provide the fundamental data needed to achieve the region's economic,

social, human resources development and environmental objectives (PCGIAP 1998). Those distributed databases may, in the future, be linked electronically so that they appear, to the user, as a virtual database, but they will also be linked together in a number of other important ways such as linked by the implementation of inter-governmental agreements on data sharing.

On the other hand the regional-level SDI development pursued by Europe reflects a process rather than product-based development. The European equivalent of the Asia-Pacific PCGIAP Regional initiative, the European Umbrella Organisation for Geographic Information (EUROGI), was formed in 1994 with support from the European Union IMPACT program. The mission of this organisation is to promote, stimulate, encourage and support the development and use of geographic information and technology at the European level and to represent the common interest of the geographic information community in Europe (GI2000 1995).

However, parallel to EUROGI, the European Commission (EC) initiated a consultative process at the end of 1994 to confront spatial data issues at a pan-European level (European Commission 1995). The EC's goal was to set up a framework within which a regional European Geographic Information Infrastructure (EGII) could be defined and established across all European Union (EU) member states. Wide consultation was held throughout 1995 and 1996 and a draft Communication document, "GI2000: Towards a European Policy Framework for GI", was produced and further debated during 1997 (Longhorn 2000). 'GI2000' presented the status regarding European GI as one sector of a much wider information market, citing European strengths, weaknesses, barriers to greater uptake and use of GI and the potential for increased market growth if such barriers could be removed. Taking such an approach was possible with a different agency, Multipurpose European Ground Related Information Network (MEGRIN), in conjunction with Comité Européen Responsables de la Cartographie Officielle (CERCO), working specifically on the creation of the European spatial databases, and seems to have influenced the approaches to SDI development pursued by other European countries. The current organisational changes between agencies working on the creation of the European datasets, including MEGRIN and the CERCO (to form one entity), have been to make it increasingly easier for member nations to create and share European datasets.

European nations in particular have a greater frequency of taking composite product-process approaches to SDI development compared with nations in any other region. These demonstrate national SDI development initiatives taking advantage of the combined benefits of operating at both managerial and operational levels, to complement the more strategic focus of regional European SDI development (Figure 5). SDI development initiatives taking composite product-process approaches are able to balance the advantages drawn from both, enabling the SDI initiatives to be more versatile. An initiative predominantly adopting a process-based approach may fast-track development by establishing working-groups addressing particular *content* issues or responsible for the establishment of specific SDI components, which adopt a product-based approach.

Some SDI development initiatives have in recent times begun to manifest characteristics of both having made an initial or partial commitment to addressing the essential balance between the approaches, or being in a transitional stage - developing a more process-based approach having had product-based origins. Reference to such an adaptation of current SDI development directions is being made to the FGDC's prospective SDI strategies. An FGDC change in direction, as part of the ongoing process of refining SDI development, can be interpreted in terms of the FGDC aligning themselves more with a strategic organisational approach to better achieve the objectives desired for the level of SDI in which they predominantly operate.

The USA was one of the first countries to engage in National SDI development for its spatial data community (Tosta 1999). The initiative progressed especially rapidly after the Executive Order from the President's Office

was issued in 1994 (Executive Order 1994). However, following more than six years of coordination and implementation of the US National SDI by the FGDC, and efforts from other committees, such as the Mapping Science Committee (MSC), the development of the US National SDI is still challenged by lack of support from some member states and is faced with many implementation difficulties. Many documents have been published regarding the FGDC's achievements and activities including their SDI development strategies. Inability to persuade different states to align themselves to form the requisite components of a National SDI for the US is just one example of the persistent difficulties. Another is the different stages of development achieved by the different states.

The difficulties faced by the FGDC can be analysed from different angles. Firstly, the USA is a nation of federated states where each state has its own political and administrative power. Secondly, the effects of the advancement of technologies on the evolution of the SDI concept has placed increased need for awareness of the role of technology in SDI development. Thirdly, the organisational position of the FGDC, as the coordinating committee responsible for SDI development in the US, is problematic. The FGDC is currently under the jurisdiction of the US Geological Surveying organisation (USGS) which is itself a provider of very specific data sets for the US. This USGS organisational structure contradicts the need for independent coordination of the varied data-providing agencies required within the scope of a NSDI for the US.

As a result of some of the difficulties discussed, at the end of 1999, the FGDC started to develop a new GeoData Organisational initiative for the geospatial data community. The aim of the initiative is to create a self-governing entity to distribute authority and responsibility among a growing network of organisations with an interest in the creation, distribution and use of geospatial data and information. This new strategy perhaps shows that the FGDC is moving from a product-based to a process-based approach to SDI development in order to neutralise difficulties arising from existing approaches.

Australia, like the US, have started a transition from product to more process-oriented SDI development to address some of the challenges faced by SDI development, particularly at a national level, under the influence of a federated political system. Australia, whilst predominantly displaying product-based approaches to SDI development (also noted by McLaughlin and Coleman 1998) has recently recognised the value in taking a facilitation role for SDI development rather than that of implementation of a specific data product by itself. Based on the initial aims for Australian SDI Development (ANZLIC 1991, 1996) the difficulties of coordinating many individual efforts toward SDI development, including the various stages achieved by Australian states, and awareness of the value and vision of SDI development have made the objective of alignment difficult to achieve. Whilst product-based approaches to data set assembly and sharing were the focus of SDI development from 1991-1996 (ANZLIC 1996) a transition toward process-based development has been initiated through a clearinghouse initiative- the focus of an ANZLIC workshop in March 2000 (ANZLIC 2000). More recent efforts toward ANZLIC pursuing a role of coordination have resulted in ANZLIC delegating the task of integrating and sharing different jurisdictional data sets to the Public Sector Mapping Agency (PMSA) in cooperation with the private sector. This is emphasised by the reported vision of the PMSA as " the coordination, assembly and delivery of…national data sets from fundamental databases held by member agencies" (PMSA 2000).

The difficulties faced by the US and in Australia in the development of a national SDI which precipitated their change in strategies are not unique and manifest in different ways for other SDI initiatives throughout the world, which face the same challenges to achieving their future development and implementation phases. These challenges occur more when the political structure of a nation is a federated system as well as at the multinational level, which in both cases rely on voluntary participation. By selecting an appropriate model for SDI development, depending on the jurisdictional level of an SDI communities, may be better able to address

and overcome some of the development difficulties currently faced. Moreover, as suggested by Groot and McLaughlin (2000), the top-down approach from the political level must be accompanied with any SDI initiative in which to making stakeholders sensitive to the longer term benefits of an SDI and involving them in the development of standards.

Conclusions

Based on the strategies, aims, objectives, and status of individual SDI initiatives in different political/administrative levels of an SDI Hierarchy, this paper introduced two models as a new vision on SDI development, namely a product-based and process-based model. According to these models, an SDI initiative is considered to be a product-based model if the main aim of the initiative is to link existing and upcoming databases of the respective political/administrative levels of the community. However, if the main aim of an SDI initiative is to define a framework to facilitate the management of information assets, the initiative is considered to be a process-based model. Further, it is suggested that a process-based approach needs to be raised within a defined or acknowledged social system. Both approaches have value, but contribute to the evolution and uptake/utilisation of the SDI concept in different ways. They provide different frameworks for dealing with intra-jurisdictional mandates for the objectives of spatial data access and sharing.

Current SDI initiatives are assessed and analysed using the proposed models for SDI development. According to the results of this analysis a predominance of product-based models of SDI development are adopted by current SDI initiatives. This eventuates from a lack of awareness of alternative options and advantages of each of the two approaches for SDI development. Appropriately adopting the product-based and process-based models for SDI development will provide a framework in which to meet the mandates of the relevant SDI jurisdictions. Factors informing on the success of the different development models for SDIs are also discussed.

Finally, the paper presented the relationships between SDI hierarchy and different SDI development models through drawing similarities to the objectives of SDI development to a model of organisational structure. According to this relationship, any SDI initiative belonging to the higher levels of SDI hierarchy (especially multi-national SDIs) is able to take more benefit using a process-based model of SDI development. A process-based model may be better able to overcome some of the challenges facing SDI initiatives persisting with a product-based approach, especially in the voluntary domains of SDI initiatives at higher levels.

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