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INSPIRE: An Innovative Approach to the Development of Spatial Data Infrastructures in Europe

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ABSTRACT

First-generation spatial data infrastructures (SDIs) were product oriented and focused on databases. Second-generation SDIs are more process oriented and emphasize partnerships and stakeholder involvement. Nevertheless, most spatial data infrastructures are still led by public-sector organizations, with limited involvement by the private sector or society at large and the involvement of user groups often sporadic and poorly organized. INSPIRE, a spatial data infrastructure for Europe, is innovative in two respects: (1) it is based on existing resources at the national and subnational levels, and (2) it engages user communities and geographic information stakeholders by organizing them in spatial data interest communities. This approach poses challenges at both technical and organizational levels but also offers important opportunities for sustainability.

INTRODUCTION

Development of spatial data infrastructures (SDIs) across the world has shifted from the first generation, which was product oriented and focused on the development or completion of databases, to the second generation, which is more process oriented and emphasizes partnerships and stakeholder involvement. With respect to coordination activities, which are crucial to the development and management of an SDI, the first generation was largely led by the national mapping agencies while the second generation has seen an increasing role of organizational models which are often independent of the mapping agencies and seek to be more representative of the stakeholder communities.

Despite the shift from a product-centered to a process-centered approach, most spatial data infrastructures are still led by public-sector organizations, with limited involvement by the private sector or society at large and often sporadic and poorly organized involvement of user groups. The spatial data infrastructure for Europe INSPIRE, proposed by the European Commission, is innovative in two respects: (1) it is based on existing resources at the national and subnational levels, and (2) it engages user communities and geographic information stakeholders by organizing them in spatial data interest communities. This approach poses challenges at both technical and organizational levels but also offers important opportunities for sustainability.

The paper describes the nature of SDI initiatives and the shift from first- to second-generation SDIs; evaluates the findings of a recent survey of SDIs in 32 European countries; examines the development of INSPIRE with a focus on spatial data interest communities; and discusses opportunities and challenges.

THE CHANGING NATURE OF SDIs

SDI developments have been well documented by Masser (1999, 2005), Williamson et al. (2003), Craglia et al. (2003), Vandenbroucke (2005), and Crompvoets and Bregt (2003). While there are many definitions of SDIs, a useful framework is the one put forward by Rajabifard et al. (2003) (figure 1), which places particular emphasis on the dynamic relationship between data, people, and technology-policy standards. The authors argue that the relationship between these categories is dynamic because communities require access to different sets of data mediated by the ever-changing technology. The interactions among these components in turn put new demands on rights, restrictions, and responsibilities enshrined in policy, as there is a constant need for interpreting and responding to political and technological changes and new user needs, which may have been unforeseen at the initial stage of development. While information systems that respond to clearly defined tasks and user groups within organizations have well-documented challenges (Jirotka and Goguen 1994; Dittrich et al. 2002), additional challenges exist for SDIs because their Internet-based nature makes identifying user communities and responding to their needs more difficult. This is also why coordination is so critical. Without effective coordination, different components—reference data, metadata, clearinghouses—may be in place without a cohesive whole.

International experiences in 2002 and 2003 (Craglia et al. 2003, p. 240) indicated that coordination is one of the most important aspects in the development of an SDI. Coordination involves:

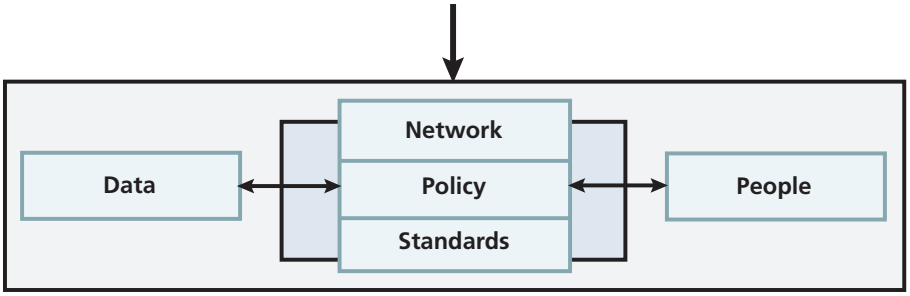

Figure 1. SDI components.
Reprinted from Rajabifard et al. 2003 with permission of Taylor and Francis Books.

- Leadership
- Mediating interagency conflicts
- Sustaining political support
- Selling the benefits to multiple audiences
- Providing technical guidance and enforcement of common standards
- Raising awareness and disseminating the results

In addition, coordination can also play a very useful role in identifying gaps or inconsistencies in the legal and organizational framework, and suggesting remedial action to the government. This is particularly important as the legal framework within which SDIs operate is strongly affected by many other policy areas, such as Public Sector Information legislation, Freedom of Information, international conventions (e.g., Aarhus), competition law, and so on. Moreover, all these areas of policy may have some variation not only at national but also across subnational levels.

The more dynamic the social, political, and technological environment in which the SDI is embedded and the more distributed the framework upon which it is built, the greater the need for coordination.

A complementary perspective for analyzing the importance of coordination comes from a review on the diffusion of SDIs and their evolving nature in responding to social and technological changes. Masser (2005) uses the classical diffusion model originally put forward by Rogers, who defines diffusion as "the process by which an innovation is communicated through channels over time among the members of the social system" (Rogers 1995). This model takes the form of a bell-shaped curve, with innovators and early adopters at the beginning of the process, followed by an early majority, late majority, and laggards at the tail end. Masser argues that the 11 SDIs he reviewed in 1998 represent the group of innovators and early adopters: Canada and the United States in North America; Qatar, Indonesia, Japan, Australia, and Korea in Asia; and the Netherlands, Portugal, and United Kingdom in Europe. In spite of their differences in size, wealth, scope, and organization, this group was defined as representing the first generation of SDIs, characterized as having a specifically national focus, an emphasis on the development of databases, and often (but not always) leadership provided by national mapping agencies.

The transition towards the second generation of SDIs, or the early majority in the Rogers model, is placed by Rajabifard et al. (2003) around the year 2000, when a consolidation of the SDI community (the social system in Rogers' definition) took place with the establishment of a series of international conferences, the publication of shared experiences in the SDI Cookbook, and the strengthening of channels of communication that enable diffusion. The second generation of SDIs is characterized by an increasing recognition of geographic information stakeholders within society. Hence, the emphasis moves from the development of products toward a process involving partnerships, agreements, and a broader set of applications. Instead of being led by data producers, second-generation SDIs use organizational models designed to be representative of the different stakeholders. It could be argued that the sharing of experiences and consolidation of technologies and standards such as ISO and OGC have also freed newcomers from having to worry about technology and enabled them to pay more attention to the institutional and organizational arrangements. Table 1 summarizes the key features of the two generations of SDIs.

Comprehensive studies of SDIs in 32 European countries were conducted by the University of Leuven in 2003, 2004, and 2005 with funding from the European Commission. In his overview of the 2005 results, Vandenbroucke identified the following key features:

1. Increasing regional and local contributions to national SDIs
2. Greater involvement of stakeholders other than the main data producers
3. Increasing adoption of international standards and specifications (ISO, OGC) and availability of Web-based services and portals

Characteristic	First generation	Second generation
Nature	Explicitly national	Explicitly national in a hierarchical context and therefore more flexible for cross-jurisdictional collaboration
Goal	Integration of existing data	Establishing linkages between people and data
Expected outcome	Linkage into a seamless database	Knowledge infrastructures, interoperable data and resources
Participants	Mainly data providers	Cross-sectoral: data providers, integrators, users
Funding	Mainly no specific or separate budget	Mostly included in national mapping programs or having separate budget
Coordinating agency	Mainly national mapping organizations	More independent organizational committees/ partnership groups
Public awareness	Low at the beginning, then growing gradually	High
Capacity building	Very low	Communities are more prepared to engage in ongoing activities
Number of SDI initiatives	Very low	High
Model	Predominantly product based	Increasingly process-based or product-process hybrid
Relationship with other SDI levels and international initiatives	Low	High
Value measurements	Productivity, savings	Holistic sociocultural value versus the expense of not having an NSDI

Table 1. Key features of the two generations of SDIs.

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Vandenbroucke also notes that "the large majority of countries do not yet have an integrated approach in which the tasks for building and maintaining the NSDI are well defined and divided amongst the different stakeholders" (page 12) and that "one of the conclusions that can be drawn . . . is that clear mandates for building (parts) of the components of the NSDI are often lacking or that some mandates are rather fuzzy in relation to the NSDI" (page 1).

Vandenbroucke classifies the countries surveyed into two groups. In the first group, a national data provider (national mapping and/or cadastral agency) is the officially mandated or *de facto* leading organization for the establishment of the NSDI, with a further subdivision based on whether users are involved. In the second group, NSDI initiatives are led by a council of ministries or administrative departments, by a (nongovernmental) GI association, or by a partnership of data users; this group is further subdivided on the basis of the presence of a formal mandate for SDI coordination (*ibid.,* page 15).

This classification mirrors to a large degree the two generations identified by Masser (2005) and Rajabifard et al. (2003). We can reclassify the 32 European countries in Vandenbroucke's study into 3 groups of similar sizes: first generation (data producer led, users not involved), second generation (user led), and intermediate (users are involved but do not lead the process).

While the generational view is helpful for understanding the evolution of SDIs and the new challenges, Rogers himself recognized the pro-innovation bias of his model, in other words, the tendency to assume a linear transition between one stage and the next. This is clearly not the case for infrastructures such as SDIs, which are embedded in social and political processes. For example, the Portuguese infrastructure launched on the Internet in 1995 experienced very limited progress for almost five years due to budgetary constraints and a reorganization of the coordinating structures (Juliao 2005). Similarly, the United Kingdom SDI (classified as first generation by Masser [1999]) has suffered setbacks and is now fragmenting, with independent strategies for Scotland, Wales, and Northern Ireland and with England struggling to define its own strategy due to lack of political leadership (Masser 2005). Even in the United States, which was seen by many as a leading example, particularly because of the high-level political commitment in President Clinton's Executive Order, progress has been difficult at times. Engaging state and local jurisdictions as well as the private sector in the development of a truly national SDI has been particularly problematic (Urban Logic 2000; National Research Council 2001). For example, Harvey and Tullock (2003) report that almost half of the local organizations contacted did not know about the national SDI and did not rely on any standard for their geospatial activities. The authors conclude that a data-centric approach is unlikely to succeed and that much more emphasis is needed on establishing and supporting social networks.

The above review of the literature indicates that the changing nature of SDIs requires greater involvement of stakeholders and user communities, not just from the public sector but also from the private sector and society at large. More effort is therefore needed in building and maintaining social networks, understanding needs, evaluating effects on society, and delivering results to heterogeneous user groups with often conflicting objectives. Addressing coordination and social contextualization challenges in the multicultural and multilingual context of Europe is particularly difficult and requires a fresh approach as discussed below.

INSPIRE

INSPIRE is a directive establishing the legal framework for setting up and operating an Infrastructure for Spatial Information in Europe based on spatial information infrastructures in European Union member states. The purpose of INSPIRE is to support the formulation, implementation, monitoring, and evaluation of European Community environmental policies. The component elements of INSPIRE include:

- Metadata
- Key spatial data themes and services
- Network services and technologies
- Agreements on sharing and access
- Coordination and monitoring mechanisms
- Process and procedures

The general background of INSPIRE was described by Annoni and Craglia (2005) at GSDI-8. Despite significant progress, major barriers remain:

- Inconsistent data collection: spatial data are often missing or incomplete, or the same data are collected by different organizations
- Inadequate documentation: description of available spatial data is often incomplete
- Incompatible datasets: datasets often cannot be combined with other datasets
- Incompatible geographic information initiatives: the infrastructures for accessing spatial data often function in isolation only
- Barriers to data sharing: cultural, institutional, financial, and legal barriers prevent or delay the sharing of spatial data

From the outset of this initiative it was recognized that, to overcome some of the barriers highlighted above, it would be necessary to develop a legislative framework requiring member states to coordinate their activities and agree on a minimum set of common standards and processes. This required wide support of member states for the objectives of INSPIRE. Therefore, a very collaborative process was put in place to formulate the INSPIRE proposal. This process involved the establishment of an expert group composed of official representatives from all member states and working groups composed of experts in environmental policy and geographic information to formulate proposals and forge consensus. The groups agreed to base INSPIRE on the following key principles:

- Spatial data should be collected once and maintained at the level where this can be done most effectively
- It must be possible to seamlessly combine spatial data from different sources across the EU and share it between many users and applications
- It must be possible for spatial data collected at one level of government to be shared between all levels of government
- Spatial data needed for good governance should be available without restrictions on extensive use
- It should be easy to discover which spatial data is available, to evaluate its fitness for purpose, and to know which conditions apply for its use

Ten words and phrases used by the Commission that are not used in the Council draft	Ten words and phrases not used by the Commission but used in the Council draft
Accessibility Commercial activities Common licensing Competition Decision 1692/96/EC25[a] Distortion Focuses[AG1] Harmonized specifications Requisite Rights of use	Apply charges Click licences Corresponding fees Cost-benefit Excessive costs Limit sharing Payment Precondition Reciprocal Viability
[a]European Transport Networks	

Table 2. Comparison between the Council and Commission versions of INSPIRE.
Courtesy of Christopher Edward Henry Corbin.

Following three years of intensive consultation among the member states and their experts, a public consultation, and assessment of likely impacts (see http://www.ec-gis.org/inspire), the European Commission adopted the INSPIRE proposal in July 2004 (CEC 2004). The European Parliament expressed its favourable opinion on the Commission's proposal in June 2005 and introduced clarifying amendments. The European Council in January 2006 introduced limitations to the data-sharing arrangements put forward by the Commission. An analysis of the original proposal and the one adopted by the Council (Corbin 2006) (table 2) clearly showed the difference in emphasis between the two, demonstrating once more that SDIs are strongly embedded in a political process, in which public-sector organizations are funded in different ways in different member states.

A compromise agreement between the Council and European Parliament was reached in November 2006, and the directive was approved in February 2007. The Joint Research Centre of the European Commission and Eurostat have been coordinating the drafting of the implementation rules envisaged by the directive.[1]

Implementation rules are needed for each of the key components of the infrastructure: metadata, data specifications and harmonization, network services, data and service sharing, and monitoring and reporting. Given the political context of the proposal, the drafting of implementation rules requires not only a high level of technical competence but above all the participation and engagement of all the key geographic information stakeholders in Europe. To organize this process, two mechanisms have been put in place. The first is engaging national and subnational European organizations that already have a formal legal mandate for the coordination, production, or use of geographic and environmental information. The second is facilitating the self-organization of stakeholders, including both data providers and users of spatial data, in spatial data interest communities (SDICs) by region, societal sector, and thematic issue. SDICs should naturally form strategic partnerships—public-public, public-private, and private-private—to align the demand for spatial data and services with the necessary investments.

The central role played by SDICs in the development of implementation rules consists of:

- Identifying and describing user requirements (understood as being in line with environmental policy needs, as opposed to "maximum" requirements beyond the scope INSPIRE and beyond realistically available resources)
- Providing expertise to INSPIRE drafting teams
- Reviewing proposed implementation rules
- Developing, operating, and evaluating pilot implementation projects
- Developing initiatives for guidance, awareness raising, and training

In addition, legally mandated organizations (LMOs) play a central role in reviewing and testing proposed implementation rules and in assessing potential costs and benefits.

An open call was announced on March 11, 2005 for the registration of interest by SDICs and LMOs, which were also asked to put forward experts and reference materials for preparing implementation rules. By April 29, 2005, the INSPIRE Web site recorded the following registrations:

- Spatial data interest communities: 133
- Legally mandated organizations: 82
- Proposed experts: 180
- Referenced materials: 90
- Identified projects: 91

The majority of LMOs are national in character and dominated by producers of reference data (figure 2). SDICs, on the other hand, characterize themselves primarily as research organizations and GIS coordinating bodies, with each SDIC bundling together many organizations representing different viewpoints and interests.

An example of a regional SDIC is GDI NRW, which is a nonprofit initiative of the state of North Rhine–Westphalia, Germany, in which representatives from the business, government, and science communities work together in a public–private partnership as geoinformation providers, enablers, brokers, and users. GDI NRW has more than 100 members, including various state authorities in North Rhine–Westphalia (land surveying office, geological survey, ministry of the environment, etc.), about 20 local authorities, several research institutions, and multiple companies.

SDICs organized by thematic issue include the European Soil Bureau Network (ESBN), the European environment information and observation network (EIONET), and the European Meteorological Infrastructure (EMI).

ESBN was created in 1996 as a network of national soil science institutions to collect, harmonize, organize, and distribute soil information for Europe. Soil information is used to address leaching of agrochemicals, deposition of heavy metals, disposal of waste, degradation of soil structure, risk of erosion, immobilization of radionuclides, water levels at catchments, assessment of suitability and sustainability for traditional and alternative crops, and estimation of soil stability.

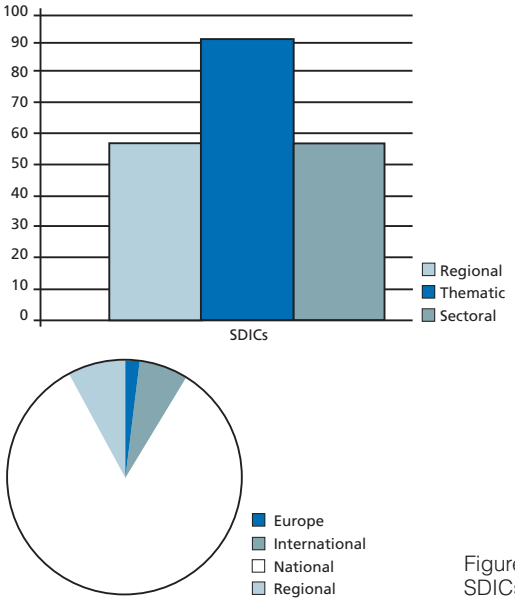

Figure 2. Key features of registered SDICs and LMOs.

EIONET was established in 1990 and aims to provide timely and accurate data, information, and expertise for assessing the state of the environment in Europe and the pressures acting upon it. EIONET connects the European Environment Agency (EEA), a number of European Topic Centres, and a network of about 900 experts from over 300 national and regional environmental agencies in 37 countries.

EMI is an operational infrastructure established by the European National Meteorological Services to deliver information services to decision makers, customers, and users throughout Europe. EMI is part of the World Meteorological Organization's telecommunication system for the European region.

The above examples show not only the thematic breadth of the SDICs but also the extent to which INSPIRE needs to build on existing infrastructures and interact effectively with their architectures, technologies, standards, protocols, and organizational frameworks.

Whereas the communities described above already existed, the INSPIRE open call also led some organizations to create new groups of interest or to join existing ones. As a consequence, user groups not previously considered by data producers in strategic decisions now have greater influence in defining priorities and needs.

With the growing awareness of INSPIRE, the numbers of SDICs and LMOs increased to 160 and 98, respectively, as of March 2006 and the numbers of registered projects and reference materials almost doubled.

Of significant interest is the high number of experts (180) proposed by the SDICs and the LMOs. Considering that the experts are not paid by the European Commission but are supported instead by the organizations and communities that nominated them, these figures indicate strong support of INSPIRE.

From the large pool of experts available, 70 were selected with the goal of balancing the perspectives of data producers, users, and solution providers from the

private sector. With the advice of member state representatives, teams for drafting implementation rules for the following 5 areas were established: metadata, data specifications, network services, data and service sharing, and monitoring and reporting. From the time they began their work in October 2005, the teams have been setting an example of how European Union legislation can be developed with stakeholder contributions.

Several aspects are particularly important in understanding the work of the drafting teams. First, each expert represents a community of interest and therefore has the responsibility to bring to the table the expertise, expectations, and concerns of this community. Second, each drafting team has to reach out to all the thematic communities that are addressed by INSPIRE. This is no small undertaking, as the proposed directive covers more than 30 different data themes which are the responsibility of multiple national, regional, and local agencies across 27 countries. In comparison, the U.S. NSDI defined only 7 framework themes—geodetic control, orthoimagery, elevation, transportation, hydrography, governmental units, and cadastral information—for each of which a designated federal agency takes the lead in data collection and management. The European Union has no supranational institutions in charge of data collection.

The drafting teams have a difficult task in collecting and summarizing reference material, seeking common denominators and reference models, and developing recommendations which satisfy user requirements without imposing undue burden on organizations responsible for data collection and management. Seeking compromise between different requirements and perspectives is crucial to the work of each drafting team. Last but not least, the drafting teams have ownership of their work. They make recommendations and submit them for review to all the registered SDICs and LMOs and the representatives of the member states. Only after all reviewer comments have been taken into account does the European Commission submit a proposed implementation rule to public consultation.

The complexity of this participatory approach is certainly innovative not only for SDIs but for European Union public policy in general. The resulting consensus-based policy and a strong network of stakeholders will be instrumental in the implementation of this distributed SDI.

ANALYSIS AND CONCLUSIONS

First-generation SDIs were product oriented. Process-based initiatives emphasizing partnerships, social networks, and multisectoral collaboration are more common today.

INSPIRE has engaged hundreds of stakeholder organizations across Europe in the drafting of the legislative framework. Involving all interested parties from the very beginning and giving them a role in shaping the infrastructure is in line with best practices and the literature on participatory approaches (Arnstein 1969; Thomas 1996), which emphasize the advantages of real empowerment over mere tokenism. Moreover, a network of stakeholders representing different regions and thematic areas will contribute to INSPIRE's sustainability. The wide-ranging project also faces complex challenges. As with other European legislation, INSPIRE development is a long process, spanning some 15 years from inception to full implementation. Sustaining the momentum, mediating the different

interests, coordinating the activities, managing the expectations, and delivering meaningful value to all the stakeholders is a very complex undertaking, particularly in the constantly changing political and technological environment.

In addition to internal organizational challenges (SDICs and LMOs), INSPIRE must also develop effective organizational and technical relationships with existing national and subnational SDIs; other important European initiatives such as e-government, thematic information networks, and infrastructures such as those of the International Hydrographic Organization and the World Meteorological Organization; and global initiatives such as GSDI and GEOSS (Global Earth Observation System of Systems) (http://earthobservations.org/). This will require coordination, identification of synergies, harmonization of data and practices, and interoperability of services.

Last but not least, the drafting of INSPIRE implementation rules needs to balance changing technologies, practices, and requirements across the different geographic and thematic layers with the need to encode agreements into legal text, backed up where necessary by European (CEN) or international (ISO) standards and industrial specifications. The tension between the need to accommodate change and retain flexibility and the need to "freeze" practices and agreements into standards and legislation characterizes all information infrastructures (Hanseth and Lyytinen 2005), but the complexity of the participatory process and the multiplicity of actors, languages, and cultures make these conflicting pressures particularly important for INSPIRE to balance effectively.

In conclusion, we have emphasized the importance of building a modern spatial data infrastructure through a combination of bottom-up participatory approaches across multiple stakeholder communities and careful coordination backed up by a legal framework. Creating a broad social network with empowered stakeholders and building on existing infrastructures, professional practices, and agreements are central features of INSPIRE. This approach entails multiple challenges, which we are striving to address together with our partners.

ENDNOTE

1. A directive is a piece of legislation defining general principles and objectives and allowing member states to determine their own means of reaching these objectives through national legislation. Implementation rules, in contrast, specify technical details mandated by the Commission for all member states to ensure the coherent implementation of the directive.

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