A SHOWCASE OF SPATIAL DATA INFRASTRUCTURES AND RELATED TECHNOLOGIES

UWE JASNOCH*
Intergraph Deutschland GmbH,
Reichenbachstr 3, 85737 Ismaning, Germany

Abstract. This chapter first gives a rational perspective why spatial data infrastructures are getting more and more importance. Different application fields and necessary services are introduced. The chapter tries to clean-up with the misleading usage of SDI, denoting concepts, technologies and implementations. Afterwards, it embraces on existing and necessary technologies – especially data harmonization. Data harmonization is a crucial element in sharing pan-national data. Examples are given showing working applications of these technologies in different organizations. Finally, critical question about future and missing parts of SDI are stated.

Keywords: Spatial Data Infrastructures, Interoperability, Data Harmonization.

1. Introduction and Background

Geographic information is vital to making sound decisions at local, regional, and national government levels, and it is applicable to several different areas, such as:

- Border security, primarily at the national government level.
- Emergency management, involving prevention planning, monitoring, and analysis of natural disasters and large public events.
- Infrastructure management for water and wastewater systems, transportation systems, city services (garbage, snow, parks), field equipment, and some utility systems.

* Dr.-Ing. Uwe Jasnoch, Intergraph (Deutschland) GmbH, Reichenbachstr. 3, 85737 Ismaning, Germany; e-mail: uwe.jasnoch@intergraph.com

R. De Amicis et al. (eds.), *GeoSpatial Visual Analytics: Geographical Information Processing and Visual Analytics for Environmental Security*,

- Land information management, including cadastre, forestry, agriculture, natural resources, urban planning, environmental protection, and economic development.
- Mapping and cartographic production, primarily at the regional and national government level.
- Public services (e-Government), including businesses and citizens purchasing government information, accessing government information, and requesting services.

The above areas are just a few examples where decision makers are benefiting from geographic information, coupled with the associated spatial data infrastructure (SDI) that supports information discovery, access, and use of this information in the decision-making process. The examples also clearly indicate the importance of collaboration between organizations – interoperability for spatial data and publication of spatial information.

Figure 1 illustrates the relationships of data access in an end-to-end resource discovery, evaluation and access paradigm, forming the fundamental for each SDI activity. Successive iterations of resource discovery via a metadata catalogue, followed by resource evaluation (such as Web mapping) lead to data access either: direct as a data set or indirect via a data access service.

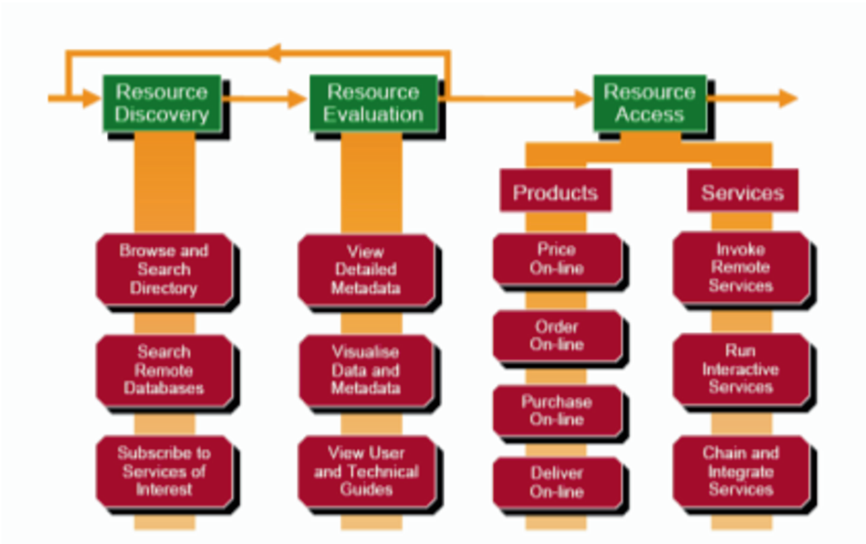

Figure 1. Geospatial resource access paradigm (Nebert, 2004).

From a software technology point of view, services are the heart of the spatial data infrastructure. These services embrace the following areas:

- Human-interaction Services (Portal Services) – Client services for the management of user interfaces, graphics, multimedia, and presentation of compound documents.
- Model/Information Services (Data and Catalogue Services) – Services for the management of the development, manipulation, and storage of metadata, conceptual schemas, and datasets.
- Workflow/Task Services – Services supporting specific tasks or work-related activities conducted by humans. These services support the use of resources and product development involving a sequence of activities or steps that may be conducted by different persons.
- Processing Services – Services that perform large-scale computations involving substantial amounts of data.
- System Management Services – Services for the management of system components, applications, networks, user accounts, and user access privileges.
- Communication Services – Services for encoding and transfer of data across communications networks.

Geospatial information, however, is an expensive resource, and for this reason, appropriate information and the resources to fully use this spatial information may not always be readily available, particularly in the developing world. Many national, regional, and international programs and projects are working to improve access to available geospatial data, promote its reuse, and ensure that additional investment in spatial information collection and management results in an ever-growing, readily available and useable pool of geospatial information. Also included in such initiatives is an emphasis on harmonizing standards for spatial data capturing and exchange, the coordination of data collection and maintenance activities, and the use of common data sets by different agencies.

For Europe, the European Commission has recognized that the availability of relevant and standardized geospatial information is a vital prerequisite for efficient political action. As such, they set up the Infrastructure for Spatial Information in Europe (INSPIRE) initiative (http://inspire.jrc.it/home.html) to coordinate activities to improve utilization of geographic information on a European level. This initiative provides a European legal standard, which, as envisaged, took effect in 2007, and will regulate the structure of a European geospatial data infrastructure (European Spatial Data Infrastructure – ESDI) by using the national geospatial data infrastructures of the European Union members.

The next chapter will give some hints for the philosophy and architecture of an SDI.

2. Philosophy and Principle Architecture for SDI

To become a node in an SDI, organizations must first accomplish several key steps:

- Identify the related parties and persons.
- Identify and define the process which is to be supported by the infrastructure.
- Identify the spatial resources and empower them with appropriate technology.
- Identify the needs of the infrastructure and outline how to meet those needs.

These steps make it clear that applying only software and hardware is not sufficient to become a node of an SDI. Indeed, becoming a well-respected node requires the implementation of a fully empowered solution covering all different aspects of processes, organization, infrastructure, and software.

From a technology point of view, being a node in an SDI requires different technologies for:

- Providing interoperable services
- Consuming interoperable services
- Structuring geospatial data according to determined models
- Publishing/displaying the geospatial data

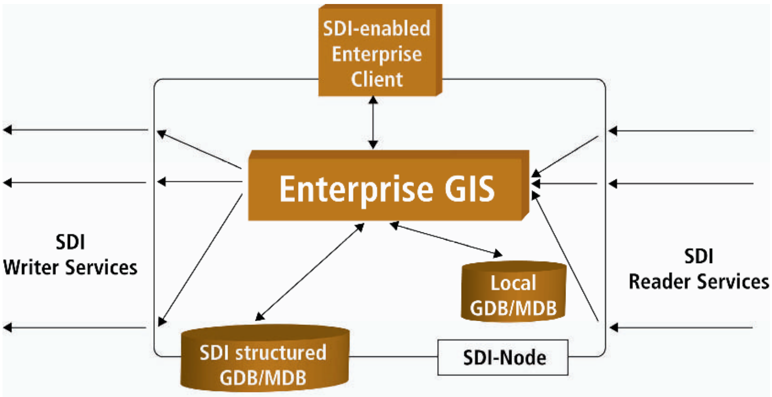

Figure 2. Principle architecture of an SDI node.

This leads to architecture for storing, reading, writing, and displaying data in an SDI-technology manner, as shown in Figure 2. Enterprise GIS includes all the existing geospatial software and infrastructure available in this node.

The mission, from the technical point of view, is to set up an SDI technology, which gives users a customizable turnkey solution. The major objective for this technology is to fulfil the core requirements of sustainability, interoperability, and flexibility.

Sustainability is important, as it pertains to the upcoming changes in related standards. The solution must be open for users to adapt the new versions in an easy-to-modify manner. Interoperability relates to the usage of standards. Model inherent, SDI is a network theme where different players each have their own role. Interoperability of data and services is reached through the use of standards. Flexibility applies to different solution characteristics. The solution must be easy to integrate into an organization's environment, adopt its security policies, and adapt to its corporate standards.

Flexibility and scalability also refer to the needs of different kinds of users. From municipalities to nations or even pan-national organizations, all must realize the node of an SDI in an appropriate scale and manner, each with their different requirements in services and scales. For example, a state or nation SDI node has a strong demand for harmonizing the data provided by services to generate a homogeneous "picture" of geospatial data, whereas a municipality's needs relate more to acquiring metadata for geospatial data.

3. Data Harmonization: A Special European Dimension

To use a very abstract image, the spatial information landscape resembles the seas around Antarctic or Antarctica filled with icebergs. Icebergs are not swimming on top of the sea; actually 90% of their compound is below the surface.

The same is true for the variety of spatial information sources. A vast amount of collected geographical information is not accessible or even not detectable by potential users.

Making spatial data searchable and accessible is only the first step. The second step to exploiting digital geographic information is the ability to seamlessly combine spatial information sources – that is where data harmonization or the standardization of data comes to the fore.

According to INSPIRE, data harmonization is a "process of developing a common set of data product specifications in a way that allows the provision of access to spatial data through spatial data services in a representation that allows for combining it with other harmonized data in a coherent way." This process also includes agreements about coordinate reference systems, classification systems, application schemas, etc. Notwithstanding, it is common understanding within INSPIRE that a total "data harmonization" across all EU nations is not achievable due to a variety of reasons. The challenge is to find solutions for a "virtual harmonization" that allows data providers to stay with their grown and established data specifications and data models but that also supports data users that need a "common geo data language" in Europe.

Data harmonization is also the common denominator of two ongoing EU projects. HUMBOLDT is funded by the 2005 GMES call and aims at enabling organizations to document, publish and harmonize their spatial information, thus contributing to the implementation of the European SDI according to the INSPIRE Directive. GIS4EU is part of the eContentPlus program and it is targeted to making digital content in Europe more accessible, usable and exploitable.

Within HUMBOLDT, data harmonization is understood as "creating the possibility to combine data from heterogeneous sources into integrated, consistent and unambiguous information products, in a way that is of no concern to the end-user".

The data harmonization process(es) from a given source to a certain target, should be examined from two perspectives: one is the target definition aspect and the other is the technical harmonization aspect itself.

Within INSPIRE, the target definition aspect comprises the work of the Data specification teams. For each data theme defined in the INSPIRE Annexes, a common target (data model) is defined. This specification of a target is based on expert decisions and is applicable for data sources that cover the same theme, for instance transportation networks or administrative units.

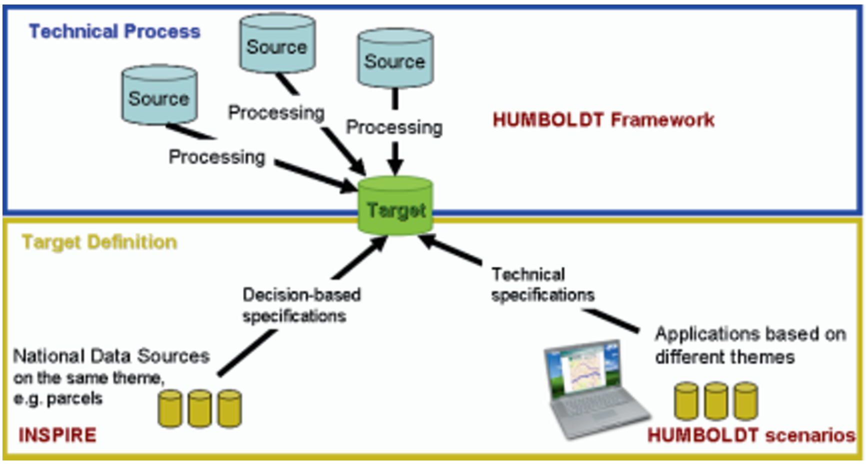

Figure 3. HUMBOLDT – data harmonization aspects (Giger, 2008).

The technical harmonization aspect comprises the actual harmonization processes, for instance the transformation between different Coordinate Reference Systems, as shown in Figure 3.

As a legal framework followed by technical implementation rules, INSPIRE has got high impact on both projects. The Drafting Team on data specifications identified 20 aspects of data harmonization that need to be tackled. Based on findings of the RISE (Reference Information Specifications for Europe) project, INSPIRE defined 20 components of data harmonization, as shown in Figure 4. The theoretical 21st component could be the computational models (process models) together with their constraints and parameters.

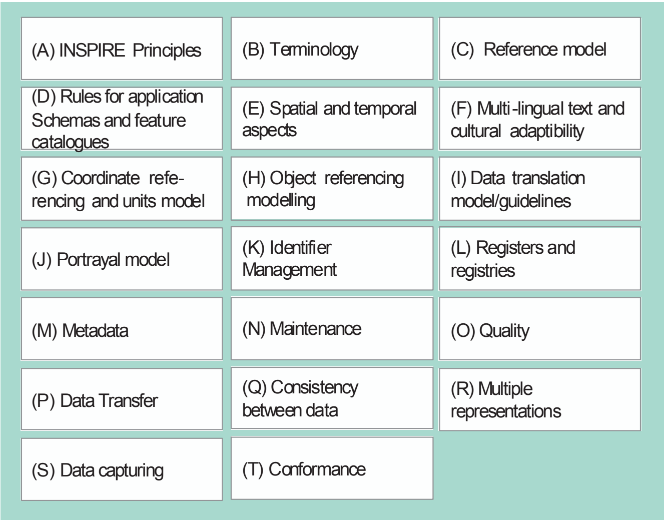

Figure 4. Twenty components of harmonization (according to INSPIRE, 2007, p. 23).

But before one gets lost in the variety of aspects, the basics of data harmonization shall be addressed: data model harmonization which is also referred to as schema mapping. The Model Driven Architecture (MDA) as promoted by the OMG (Object Management Group) proves to be the most promising approach. Figure 5 gives an impression of schema mapping idea. The conceptual schema could be an UML-model or even a textual description, mappings between the source and target model could be provided by an application expert.

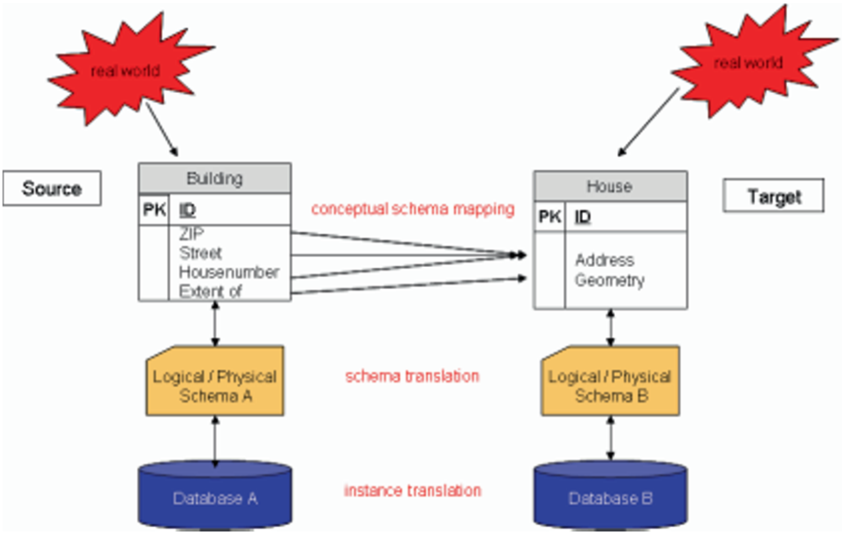

Figure 5. Model driven architecture, abstract view (according to OMG group).

4. Examples for Spatial Data Infrastructures

Several government agencies and organizations around the world have experienced success with solutions. The examples below showcase organizations that have successfully implemented and are enjoying the benefits of spatial data infrastructure technology.

4.1. SITGA – GALICIA, SPAIN

As a result of the demands generated by the District Development Plan of Galicia (PDC), Galicia created a land planning and management tool at the local and district government levels. This, known as the Territorial Information System of Galicia (SITGA), compiles socioeconomic, physical, and infrastructural data from a variety of sources.

SITGA's many responsibilities include developing GIS applications for system users and publishing cartographic maps in different scales. SITGA stores Galicia's geospatial data in a catalog located on different servers, enabling other government municipalities of the region to access this information as needed. Conversely, this process can prove laborious, requiring too much time to push this data to the different servers. SITGA's objective is to provide users with as much geographic information as possible while allowing them to access this information from other servers and applications through the use of international standards.

The main objectives of the project were:

- Create a user-friendly environment to facilitate geospatial data management.
- Make spatial data commonly available, based on international standards.
- Share resources and procedures with other regional government municipalities.
- Introduce GIS functionalities to decision makers.

SITGA decided to implement a Web-based solution with two levels of access: an intranet for technicians of Galicia's regional government and an Internet site for other interested users and communities. Based on their past experience with Intergraph GeoMedia software, SITGA partnered with Intergraph (Spain) to develop the Web solution. Intergraph used GeoMedia WebMap Professional as the basis for the solution. GeoMedia WebMap Professional enables the manipulation of valuable geographic information, allowing SITGA to create custom dynamic, open, and scalable Web mapping applications on the fly.

Figure 6. SITGA's new Web-based solution.

SITGA's new Web-based solution (see Figure 6) allows users to easily retrieve spatial data relating to the Galicia region. Users can access a database with basic and thematic cartography at different scales, as well as an aerial and satellite images stores. The solution also incorporates various services such as CSW, WFS-G, WMS, and WFS.

Through their new Web-based solution, SITGA now has an easy-to-use cartographic server complete with a wide array of services needed to manage a large amount of cartographic information. By promoting the development of online information services in the government of Galicia, this solution is a major step toward creating an entire Galician Spatial Data Infrastructure.

4.2. STATE OF BADEN-WUERTTEMBERG

The Survey Administration of State of Baden-Wuerttemberg is responsible for the collection, update, and dissemination of all geospatial base data, such as cadastre, topographic data, and analogues or digital maps for the whole state, which has about 11 million inhabitants and an area of 36,000 km², making Baden-Württemberg the third largest state in Germany.

The state office has been running a geoportal known as GEODIS for data dissemination since 1998, based on Intergraph GeoMedia WebMap technology for online ordering and selling of their geospatial data. Due to a new German wide standard data and process model on cadastre and topography, the entire structure for production, storage, and dissemination needed to be updated. Additionally, new responsibilities in the field of SDI were granted to the state office. Consequently, it serves as an active node in the national SDI (called GDI-DE) and for the INSPIRE directive of the European commission.

To fulfil these new challenges, updates and extensions of the existing geoportal environment to the new standards and upcoming needs of INSPIRE and GDI-DE wherever necessary. A new database for product generation and Web Services based on a new German wide data model was implemented. This is integrated into the existing SAP-connected e-shop system by a rich set of services. The state office decided to extend their system with several OGC® services for data delivery, including WMS, WFS, and WCS. Additionally, the system provides metadata based on the OGC® Catalogue Service – Web Standard. For local searches, a Gazetteer Service, using OGC® WFS-Gazetteer profile, helps users find the information they need. As official geospatial data in Germany is subject to a charge, the functionality for secured services fulfils a critical task. It protects the data services from unauthorized use and tracks how services are being used by authorized users. It also integrates with a privilege management and SAP-based accounting system.

The resulting new GEODIS geoportal of the Survey Administration of State of Baden-Wuerttemberg serves as an innovative node in the expanding European SDI, and it helps to optimize the processes of data discovery and delivery to Baden-Württemberg, Germany, and Europe.

5. SDI: Brave New World?

While in the beginning the specifications of the Open Geospatial Consortium were far ahead existing solutions and the demands of the customers, situation has changed. A couple of necessary documents are still in the standardization and discussion pipe urgently demanded from the market.

Especially service and content monitoring and protection is to be named. As shown in the example of Baden-Wuerttemberg, there is an urgent demand for higher valued services.

To protect data owner services from illegal usage, secured services with the following protection methods for rights management are necessary:

- User authentication:
    - User name and password (as parameter of HTTP-header)
    - IP address of the caller
- User authorization:
    - Access rights on feature classes/layers
    - Access rights on geographic extent (bbox)
    - Time-based access rights

As part of an SDI, each participating node should have a clear understanding of its serving capabilities. To be a reliable part of an external value chain, these nodes will be "confronted" with Service Level Agreements (SLA), which guarantees a certain level of quality of the services. The service provider must have valid, up-to-date information about its services for this to be successful. Classical operational monitoring tools alone are not sufficient. Furthermore, monitoring the content is also essential, especially whenever these services are connected to a billing system. These monitoring functionalities seem to be very valuable:

- Events logging:
    - No response from resource
    - No connection
    - Incompatible version of request and grounding service
- Performance measurements:
    - Number of calls/s
    - Average service response time
- Content logging:
    - Requested layers
    - Requested spatial extend
    - Requested feature objects

In terms of Enterprise Application Integration (EAI) or Service Oriented Architectures (SOA), the transport protocol is also an issue. OGC® services typically relay on the http post/get paradigm, while EAI and SOA are typically looking for Simple Object Access Protocol (SOAP) bindings.

Last but not least, how many infrastructures there are within the spatial data infrastructure? Today, talking about SDI most often leads to a discussion of software technology aspects. Despite this valuable discussion, hardware and networks and their operation do play an important role in the game too.

6. Conclusions

This chapter clearly highlights the benefit of using SDI technology for collaboration and distribution of geospatial data. In some regions around the world, providing data is enforced by law, and there is a strong demand for sharing geospatial data from business perspective as well. In terms of interoperability, this technology helps to streamline processes and improve efficiency. To summarize, the technology for cooperation and collaboration, denoted as SDI technology brings a lot of opportunities and also challenges. Even with these tools in hand, open issues have to addressed and closed very soon, especially data harmonization and security.

Acknowledgement

I would like to thank Mrs. Breu from Intergraph Germany, for providing the valuable input concerning the data harmonization, as well as the European Commission, which funds the projects Humboldt and GIS4EU.

References

Giger, C., 2008, Online reference: http://www.ecgis.org/Workshops/inspire_2008/presentations/InspireConference_HUMBOLDT_WS_Giger.pdf

INSPIRE, Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community.

Nebert, D. D. (ed.), 2004, *The SDI Cookbook*, GSDI – Global Spatial Data Infrastructure, Needham, USA. Available at: http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf