Towards The Implementation of the European Spatial Data Infrastructure – Getting the Process Right

Lars Bernard, Alessandro Annoni, Yannis Kanellopoulos, Paul Smits
Joint Research Centre, Institute for Environment and Sustainability
I-21020 Ispra, IT
{lars.bernard|alessandro.annoni|yannis.kanellopoulos|paul.smits}@jrc.it

SUMMARY

There is wide agreement about the urgent need to start implementing the European Spatial Data Infrastructure (ESDI). First prototypes prove the technical feasibility of already available specifications and standards to realize distributed geodata bases and distributed geoinformation services that form the technical foundation upon which the ESDI must be built. This paper discusses the current technical obstacles and sketches the next steps needed to speed up the implementation the ESDI in reality.

KEYWORDS: *European Spatial Data Infrastructure (ESDI), Geoinformation Services (GI Services), ESDI-Portal, Technical Guidelines*

INTRODUCTION

The implementation of Spatial Data Infrastructures (SDI) is one of the current main topics in the geoinformation arena. Technical prototypes show the benefits of distributed but interconnected geodata managing and geoprocessing, to enable easy access to up-to-date geoinformation (CGDI 2001, Bernard 2002, Riecken et al. 2003). However, SDI that are really operational, offering an every day support of geoinformation accessing and processing do still hardly exist. This is true for regional and national SDI solutions and is even more so for trans-national or global SDI approaches.

One of the reasons why large-scale implementations of SDI are not common practice is that the realisation of an SDI, like any other infrastructure, requires more than just the technical means. The term infrastructure refers to the institutional arrangements, policies, and funding mechanisms that make the infrastructure sustainable. At the same time political support is needed to trigger the required changes in the current systems. This political support is now emerging at various levels and with various degrees of intensity, often sustained by the awareness that SDI are a means of improving efficiency in governmental processes, leading to considerable savings and benefits for the citizen.

With the *Infrastructure for Spatial Information in Europe* (INSPIRE) and the *Global Monitoring for Environment and Security* (GMES) initiatives, the political will to work towards the realisation of an ESDI is growing. At the same time collaborative processes on consensus building for GI interoperability (notably ISO/TC211 Geographic Information, OpenGIS Consortium, and CEN/TC287 Geographic Information) have reached a stage where they provide a solid framework for further SDI standardisation in Europe and beyond.

It is in this context that this paper will address some of the existing obstacles that hinder the implementation of an ESDI today and will show the approaches that are currently undertaken, to proceed in the realization of the ESDI.

BITS AND PEACES EXIST - THE GLUE IS STILL MISSING

The ESDI technically grounds on the paradigm of distributed, interoperable geoinformation services (GI Services). Interoperability should be guaranteed by the OpenGIS Consortium (OGC) implementation specifications and the ISO/TC211 standards that describe the required service interfaces and encoding rules. An overview is given in the OpenGIS Reference Model (Buehler 2003). Existing approved implementation specifications cover the areas of portrayal services (i.e. cartographic mapping services), geodata access (i.e. coverage and feature services), querying geodata, encoding geodata (i.e. the GML geographic mark-up language), coordinate transformations, and cataloguing of geodata and GI Services (i.e. geo-metadata and catalogue services).

These existing specifications ensure the important basic conformity on the usage of network protocols, the encoding of exchanged geodata and the calling conventions and capabilities that have to be fulfilled by the GI Services, which claim to be in *compliance* with the specifications. Moreover the existing standards offer basic rules on how to model domain specific information (i.e. how to *profile* the given encodings) that is transported using the interoperable GI Services.

However, any specific kind of agreement about the content of the sent and received service calls does not fall into the scope of these specifications. But these kinds of agreements and contracts are crucial to enable a SDI that allows for the future transparent chaining of GI Services in to support the ad-hoc building of applications in a multi-purpose manner.

A workshop on Regional SDI (RSDI) in Europe conducted at the Joint Research Centre in January 2003 clearly showed a lack of additional guidelines to really achieve interoperable - in the sense of *ad-hoc plug-and-play-able* – GI Services. Although most of the RSDI, presented by their technical experts, completely follow the current OGC implementation specifications and ISO Standards, an ad-hoc chaining of cross border GI Services was not possible. A first analysis identifies five main issues:

Issue 1: A complete set of mature implementation specifications serving as a foundation for the needed GI Services in a SDI is still missing. The implementation specifications currently available to realize a Web-based SDI cover the topics: portrayal, feature access, coverage access, feature encoding and geodata cataloguing (see http://www.opengis.org).

Issue 2: Tools for conformance testing of implemented GI Services are to be further developed. Full compliance with the given implementation specifications is important and adequate conformance testing tools and certification mechanisms must be further developed. The OGC CITE initiative (Magazine 2003), supported by the Open Group, is an important step in this direction

Issue 3: Additional agreements to shape the exiting implementation specifications according to the needs of interoperability in a common SDI are missing. Even the compliance to the implementation specifications (as addressed above) does not guarantee that two separate GI Services can be linked into a common application to supplement each other.

Issue 4: Related to the above-mentioned issues is the lack of reference implementations (possibly open source). Potential reference implementations of services are emerging but need to be linked with the certification mechanisms identified under issue 2. Reference implementations should serve as templates for the development of additional services.

Issue 5: Unexpected barriers for interoperable services will emerge that the GI interoperability community needs to be prepared for (e.g. security issues; IT bottlenecks).

Taking the example of Web Catalogue Services and Web Map Services as the most prominent GI Services, both widely considered as the two core services to be realized in the initial development step of a SDI, these issues should be illustrated.

Linking Web Catalog Services

Catalogue services are assumed to be the typical starting access point of future SDI users. Users should be provided with adequate support in both, exploring the geodata populating the SDI and finding the GI Services available to operate on this data. The catalogue concept that is currently most accepted in geoinformatic applications relies upon structured metadata-bases and therefore differs to the underlying concept of most internet search machines (e.g. google, yahoo, etc.) that basically - of course in a very elaborated manner - follow a free text search approach.

With the (draft) standards ISO 19115 and ISO 19119 the ISO/TC211 describe metadata schemata for geodata and for GI Services, respectively and become more and more implemented worldwide. However, a stable implementation specification to describe the interfaces to Web Catalog Services (WCatS) that can deal with metadata for geodata and GI Services is still missing (Note that catalogues that are capable to manage service metadata are also often referred as registries). So this falls into the category of the *Issue 1* mentioned above. A discussion paper developed in a *testbed*-manner by a coordinated action of a Regional SDI shows in a first draft how to combine and extent the available ISO/TC211 standards and OpenGIS specifications to realize a WCatS implementation specification (Voges and Poth 2002). A recently organized OGC working group is combining this expertise with other experiences to come up with a stable OpenGIS WCatS implementation specification. Taking this specification as already implemented the following problems will most likely remain:

- Beside the fact that *metadata* has been a geoinformatic research and development topic for more than a decade now, it still lacks tools that support the creation and the maintenance of metadata in as far as possible automatic manner. Thus these tasks - if ever really fulfilled – today mainly require tedious and therefore error-prone manual work.
- A commonly agreed concept to define unique identifiers on features or feature collections, which at least allows checking for similarity of geodata-sets, acquired from different sources, is still missing.
- The current ISO metadata schemata do not support bidirectional links between geodata and GI Service metadata, to indicate for instance which GI Services apply to a given geodata-set and vice versa. Moreover extension of the schemata might be necessary e.g. to allow an appropriate description of spatio-temporal geodata (e.g. temporal resolution of time-series) or of GI Services (e.g. the capabilities and bindings). The future incorporation of service metadata schemata like the *Web Service Description Language* (http://www.w3.org) for GI Services may be a first step towards a solution.
- Widely accepted pan-European, multilingual thesauri to support a shared vocabulary for the description of geodata do not yet exist. Especially research currently undertaken to reach semantic inoperability might benefit from such a base for a shared vocabulary (Bernard et al. 2003, Kuhn and Raubal 2003).

Linking Web Map Services

Worldwide a permanently increasing number of OpenGIS compliant Web Map Services (WMS) is available and usable, mostly free of charge. The OpenGIS *WMS Cookbook* (Kolodziej 2003) supports the installation of WMS by offering guidelines on how to realize a WMS using either free software or commercially available tools. Additionally a set of free available WMS-clients offer the possibility to explore the existing WMS. That way it is easy to prove interoperability between a WMS and WMS-client that have been developed independently and without a common application background. Once you start this experiment, you might also experience, that not every WMS corresponds to every WMS-client (or vice versa) as the term interoperability may indicate. This is mainly caused by the *Issue 2* mentioned above: a lack of conformance testing. This topic is addressed by the *Conformance & Interoperability Test & Evaluation* project (CITE), currently undertaken to develop tools to enable conformance test of GI Services that claim conformance to the WMS specification (see http://www.opengis.org). However, assuming that this problem has been solved it is very likely that problems will still persist in connecting different WMS - for instance to create a pan-European map from various distributed WMS - within a single WMS-client. These problems result from *Issue 3*. In terms of the considered WMS, it lacks agreements such as:

- The Spatial Reference Systems (SRS) offered by the various WMS. Several WMS can only interoperate having at least one SRS as a common denominator.
- How to treat multilingualism, e.g. in style and layer names.
- The scale hints used for Maps being offered, or even more complex the scale hints given for different layers representing different scales. The WMS specification gives a general rule but no explicit reference on how to treat different scales.
- The names and the hierarchy to be used for the offered layers. Without addressing the far more complex problems of semantic interoperability general suggestions on naming and ordering conventions of different map layers are not yet established.
- On some basic principles of cartographic styling. As most of the current WMS do not fully support the *Styled Layer Descriptor* specifications, a remote controlled styling of the advertised map layers is not yet feasible, thus leading to colourful patchworks of adjacent map layers served from different WMS or resulting in visually hardly to interpret overlays formed out of layers coming from various WMS.

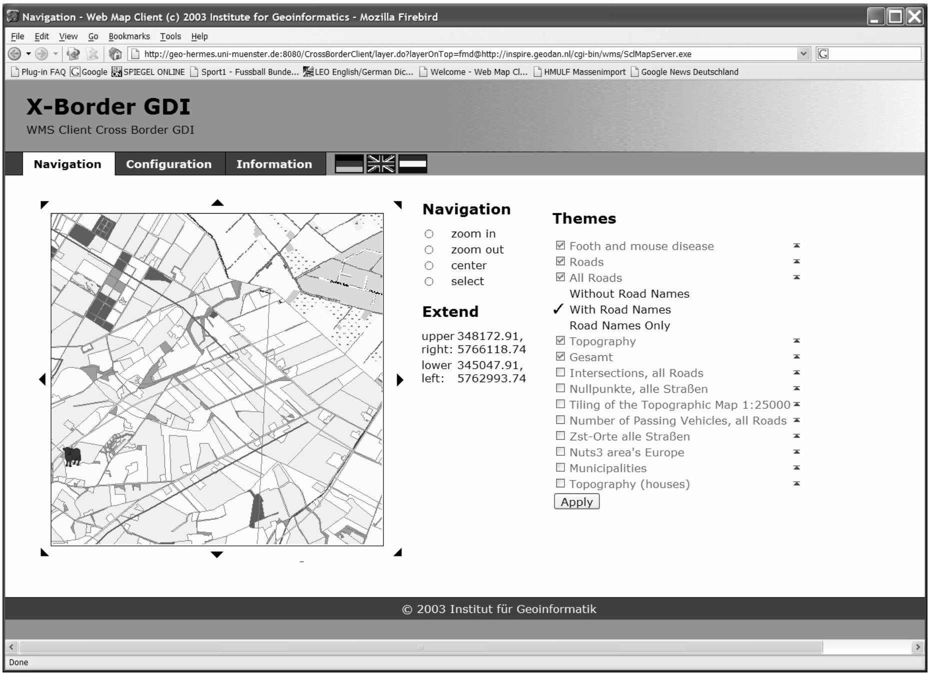

Figure 1: Screenshot of a Cross-Border WMS-client (OpenGIS Version 1.1.0 compliant) capable to combine several WMS and includes support for WMS which use the SRS recommended by INSPIRE and may additionally offer a XML-coded translation table to enable multilingualism.

These issues are not yet addressed by documents like the *WMS Cookbook* (Kolodziej 2003) or the *SDI Cookbook* (Nebert 2001). A feasibility study to discover the technical implications of a Cross-Border SDI (Riecken et al. 2003) resulted in some first pragmatic approaches to tackle the first two problems mentioned in the above bullet list. The study suggests, that each WMS should at least support the SRS that are recommended in the INSPIRE position papers (Annoni et al. 2001, Smits 2002) and defined an addition to the WMS implementation specification to support multilingualism by simply offering a translation scheme for the name- and metadata-entries provided by a WMS (Figure 1). The *GiMoDig* project (http://gimodig.fgi.fi) funded by the European Commission elaborates an approach towards a Global Schema for pan-European Mapping (Illert and Afflerbach 2003) that herein may serve as a starting point to tackle the second and fourth problem mentioned above.

A PRAGMATIC APPROACH

Technology is changing, and all the areas of technology relevant to SDIs are in continuous development. The incorporation of future developments must be viewed from a user perspective. In order to accommodate changes in standards and specifications which are judged useful today, the Joint Research Centre of the European Commission is coordinating the creation and maintenance of the draft INSPIRE Technical Guidelines. Following the lessons presented in this paper, this work clearly needs to benefit form practical experiences, and thus it is intended to incorporate the expertise of various ongoing and upcoming SDI implementation projects and also to use some of these projects as kind of *Testbeds* or *Pilots* to enhance the evolving guidelines. The development of the ESDI Portal represents one of these *Pilots*.

The Glue - Guidelines

In the framework of the INSPIRE, two sets of guidelines are foreseen: the INSPIRE Technical Guidelines, and the INSPIRE Cookbook for Spatial Interest Groups.

The INSPIRE Technical Guidelines will be a living document providing all the necessary details, and is to evolve into the authoritative reference for the implementation of the INSPIRE. A first draft of the INSPIRE Technical Guidelines will be based on the INSPIRE Architecture and Standards Position Paper (Smits 2002) and therefore especially address *Issue 3* mentioned earlier in this paper.

In addition to the technical guidelines, which will have a generic character, a Cookbook for Spatial Interest Groups will be created. This cookbook is to provide guidance to the network of spatial interest groups in issues that go beyond the purely technical issues. Examples include templates for data licenses and best practice in data documentation.

A point of reference - The ESDI Portal

Most of the problems already discussed in this paper have also been encountered during the implementation of a prototype version of the European Geo-Portal. The vision of the EU Portal is to allow users to discover, understand (in their natural language), view and obtain the data they want, for just that part of the country they are concerned about, without needing to know the details of how the data are stored and maintained by independent organizations. Thus, the Geo-Portal is an online access point to a collection of geodata and GI services across European countries and across various level of jurisdiction. The Portal does neither store or maintain the data nor host the GI Services; rather, these resources are distributed in many servers across Europe and each server is maintained by the agency or organization that is responsible for the data in the server.

The prototype version of the EU Geo-Portal (http://eu-geoportal.jrc.it) currently includes the following functionalities:

- Metadata Search — The Metadata Search functionality allows users to search for metadata in the metadata catalogue of the Portal by providing spatial, thematic, temporal, or keyword search criteria. Search may also be performed through appropriate data categories defined according to INSPIRE data themes and categories. A mapping to the ISO 19115 defined categories has been made. Note that the Portal currently also applies the ISO 19115 and in some cases FGDC schemata to describe both geodata and GI Services (here mainly WMS).
- Search Results — The Search Results, return metadata records that match the user's search criteria. From the Search Results, it is possible to access the referenced services (WMS, download, etc) or applications if available online.
- Map Viewer — The Map Viewer allows users of the Portal to browse, navigate, and query map data and combine and view multiple OpenGIS WMS.

The search facilities provided by the portal are not yet based on distributed catalogue services but rather on a centralised catalogue compiled by individual metadata records in an XML format. The reason(s) for this being that as has also been mentioned earlier in this paper, include the lack of appropriate specifications for interfaces to WCatS, and the complexity in implementation of a WCatS supporting distributed search. Furthermore the lack of standards for the encoding of the ISO metadata and the variety of schemata as well as domain specific profiles add to the confusion and further delays the development of metadata and catalogue services.

In the context of connecting distributed catalogue services in a seamless way it is worth noting some of the difficulties encountered and may be attributed to Issues 1 & 3 mentioned before. Lack of support of specific or common projection systems may impede the visualisation of more than one WMS at a time while no provision of information concerning the scale a specific dataset is supplied with, may result in unpredictable results. Finally depending on the WMS client that one is using these problems may or may not be revealed

Other problems that have been encountered concerning the data themselves such as geometric problems, matching of features such as roads, rivers etc, different levels of accuracy, data models etc. are not the scope of this paper and therefore are not discussed.

The process – Thematic European, national, and cross-border projects

Following the pragmatic approach, further development of standards and specifications and the actual implementation of the components that together constitute the ESDI are to be done in the framework of projects. This will result in a combined top-down and bottom-up approach. On the one hand there will be the INSPIRE Position Papers, the early version of the INSPIRE Guidelines, and the results of *CEN/TC287 - Geographic Information* constituting a top-down approach, while on the other hand the user-driven, bottom up, approach ensures that technical solutions are proposed that effectively address real needs within clustered user communities ("Geospatial Interest Groups").

Pilot projects like thematic cross-border projects are an important means for building application schemas; at a later stage and only if necessary, universal schemas can be devised. This approach is complicated enough. It will have to deal with the complexity in semantics, multi-lingual issues, while at the same time addressing the information flow in support of relevant "*business processes*" from local to global levels. This will involve many issues, from a supportive IT infrastructure to data sharing, which will have to feed back in to both the INSPIRE Technical Guidelines and INSPIRE Guidelines for Spatial Interest Groups, bridging the top-down and bottom-up approaches.

CONCLUSION

SDI being based on the currently available set of ISO standards and OpenGIS implementation specifications evolve all over Europe and show first application examples that prove that the concept of distributed GI services and geodata bases offers a promising path to follow. The paper highlights and illustrates the issues that have to be tackled on the way forward towards the implementation of an ESDI. It enrols the idea of INSPIRE Guidelines that will be developed to provide a general framework for the ESDI implementation. The guideline development will follow the idea of a spiral process proved by reference implementations and therefore be undertaken in close linkage to SDI implementation projects where the implementation of an ESDI-Portal is one first example.

BIBLIOGRAPHY

Annoni, A, C. Luzet, E. Gubler & J. Ihde, Eds., 2001. Map Projections for Europe, European Commission.

Bernard, L, 2002. Experiences from an implementation Testbed to set up a national SDI. In: M Ruiz, M Gould & J Ramon (Eds.). 5th AGILE Conference on Geographic Information Science 2002, Palma de Mallorca: 315-321.

Bernard, L. , U. Einspanier, S. Haubrock, S. Hübner, W. Kuhn, R. Lessing, M. Lutz & U. Visser, 2003. Ontologies for Intelligent Search and Semantic Translation in Spatial Data Infrastructures. Publikationen der Deutschen Gesellschaft für Photogrammetrie und Fernerkundung(6): 451-462.

Buehler, K, Ed. 2003. OpenGIS Reference Model, OpenGIS Consortium.

CGDI, 2001. The Canadian Geospatial Data Infrastructure (CGDI) - Access Technical Services Manual. GeoConnections, Ottawa, Ontario.

Illert, A & S Afflerbach, 2003. GiMoDig - Report on Global Schema. German Federal Agency for Cartography and Geodesy.

Kolodziej, K, Ed. 2003. OpenGIS Web Map Server Cookbook, OpenGIS Consortium.

Kuhn, W. & M. Raubal, 2003. Implementing Semantic Reference Systems. In: M. Gould, R. Laurini & S. Coulondre (Eds.). 6th AGILE Conference on Geographic Information Science 2003, Lyon: 63-72.

Magazine, Directions, 2003. http://www.directionsmag.com/press.releases/index.php?duty=Show&id=6236

Nebert, D, Ed. 2001. Developing Spatial Data Infrastructures: The SDI Cookbook, Version 1.1, Global Spatial Data Infrastructure, Technical Comittee.

Riecken, J., L. Bernard, C. Portele & A. Remke, 2003. North-Rhine Westphalia: Building a Regional SDI in a Cross-Border Environment / Ad-Hoc Integration of SDIs: Lessons learnt. 9th EC-GI & GIS Workshop ESDI, June 25-27 2003, Coruña, Spain

Smits, P., Ed. 2002. INSPIRE Architecture and Standards Position Paper.

Voges, U & A Poth, Eds., 2002. GDI NRW Testbed II - Catalog Services für GeoDaten und GeoServices. Version 1.0., GDI North-Rhine Westphalia.