

## **Reverse engineering SDI: Standards based Components for Prototyping**

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### **Introduction**

Multiple organisations from INSPIRE at European level to national and regional bodies have spent considerable time and effort over the past few years debating optimal SDI architectures, which depend to some degree on the maturity (availability) of standards documents and standards-based components. After several years lamenting the lack of completed standards and components, there is now a healthy offer which allow SDI developers to prototype the three basic technology components of a SDI: 1) metadata collection and publication, 2) catalogue and registry services, and 3) web mapping servers and clients. In this paper we deliberately ignore that fact that the political and institutional aspects of SDI creation are in fact the toughest challenges, and we instead focus on the role technologists play in facilitating politicians' decisions regarding how to go forward, or at times whether or not to even begin.

We distinguish two classes of SDI project. The on-going NorthRhine Westfalia pilot project is an excellent example of how a rather large collection of companies and public institutions created standards-based components according to a well-defined project architecture (reference model, see Münster 2001). However, it would seem that many regional SDIs across Europe have not defined (or at least have not published) such consensus-driven architecture. Several nascent SDI projects within Spain are good examples of this second class of SDI, where significant interest exists yet a common model or architecture does not. The authors of this paper represent a collaborative team of academic technologists who have developed a set of prototype components in order to demonstrate the possible capabilities of various scales and types of SDI. Beginning with technology pilots might be considered putting the cart before the horse, but we have witnessed how this can serve to spark interest in interagency collaboration --it becomes easier to convince people of what is possible-- which then facilitates creation of the political pressure necessary to make the architectural planning happen. We see this methodology as essentially reverse-engineering the SDI creation process, again, normally a top-down political approach.

### **SDI Components**

Implementation of a Spatial Data Infrastructure is fraught with important and interesting political and institutional challenges, for which no single formula exists, however the technological picture has become quite clear during the past year or so. As is the case of the INSPIRE initiative, we adopted (earlier) the Digital Earth Reference Model (DERM) designed by technicians who are both NASA contractors and active OGC and ISO/TC211 representatives. The DERM document (see NASA 2001) nicely synthesizes the multiple options regarding standards and components to be implemented, and distills the potentially endless array of options into the simple graphic below. We have utilized a translated version of this diagram to explain to politicians that the SDI is really quite simple, consisting of basically three components: reference data repositories, metadata catalogues and user services (primarily web mapping), connected in a service chain initiated by an end-user via a no-cost web browser. Using the

graphic it is not difficult to map these “new” concepts back to more easily understood client-middleware-server (3-tier) concepts that many politicians understand. The basic message we have been able to communicate is that *although there are many options (and confusion certainly exists), in the end there are only 3 components to be developed, and we know how to acquire or create each of these, today!* This message is reinforced through demos; preferably with the politicians’ own data sources.

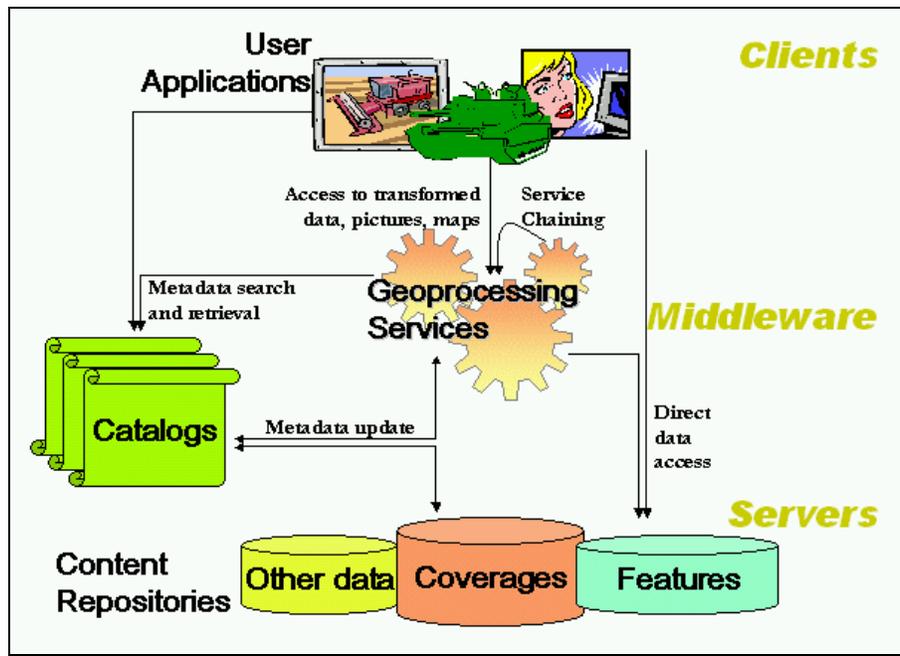


Figure 1. Digital Earth Reference Model (DERM); NASA (2001).

### Document availability

Most organisations have programmers on staff that are capable of creating the necessary components, or certainly of configuring available components, albeit with a little consulting guidance on the side to smooth out the rough areas. These components are defined in a series of technical documents, and one of the prime reasons cited for delay in implementing SDI components is that people (implementers) are waiting for the definitive version of a particular standards document to become public. A prime example is the ISO 19115 standard on geographic information metadata. While it is certainly true that the ISO *de jure* standardisation process is a slow one, we can confidently suggest two things:

- 1) once an ISO/TC211 standard document reaches DIS (Draft International Standard) status, it is very mature and essentially ready to be implemented or relied upon;
- 2) the ISO/TC211 process is streamlining its throughput, to the point where new standards can theoretically emerge publicly within 12 to 18 months.

Furthermore, this apparent access barrier has not stopped commercial enterprises such as ESRI, Intergraph, Ionic Software, etc. from implementing 19115 capabilities based on the DIS version, and neither should it stop SDI implementers in the public sector. This particular standard is, as of this writing, in about as stable a condition as can be, given that it is still awaiting the ceremonious passage from *Draft* to *International Standard* status. We underscore: 19115 is ready to be implemented now; the minor editorial changes it might experience in the final days before the aforementioned passage, are likely to be trivial and will NOT disrupt any on-going SDI initiative. Therefore, our group (specifically Univ. Zaragoza) has created and demonstrated Java applications for creating ISO 19115 metadata and storing it in Access or Oracle databases. Other open solutions are emerging as well (and will be published at the

[www.gsdi.org](http://www.gsdi.org) website), and in addition the major GIS vendors will within 12 months ship products that output this format. (We should warn creators/users here that metadata creation need not be tied to any current GIS platform; generic solutions abound.)

A related concern is how to gain access to ISO/TC211 Draft International Standards. DIS documents are not available (or for sale) on the ISO website because they are not yet approved standards. They are, however, available via ISO/TC211 national liaison members (normally at NMAs) and through the OGC liaison Cliff Kottman (in the case of OGC members). Furthermore, it should not come as a surprise that older drafts<sup>1</sup> may be found on the web, using *Google* and other search engines. Although the GI community is still not satisfied with the ISO document accessibility policy, we can state from our experience that any organisation seriously considering their implementation, should have no problem accessing relevant DIS documents through the aforementioned liaison channels. In addition, we suggest OGC membership as a key investment in SDI development, as membership opens doors facilitating access to a wide array of on-going technology development: the public can only directly access *approved* OGC and ISO specifications and certain drafts, whereas members may access the entire in-progress archive and essentially get a several-month head start. Several public institutions --Ordnance Survey, United Nations and FGDC to name but three--have recently joined or increased OGC membership level in order to gain increased access to the OGC knowledgebase and decision making process.

## Catalogues and Services

We do not consider reference data repositories here, and we have already mentioned metadata creation, which we consider an issue no longer open to debate regarding formats or standards. A related part of the second SDI component, is the catalogue service, a tricky one because on one hand a mature OGC specification exists (version 1.0), while on the other hand rumours of impending "stateless catalogue services" (advanced web services) are widespread and have caused some implementers to sit back and wait. Our recommendation is to implement 1.0 immediately, because we believe (and so does INSPIRE) that access to reference data is of immediate priority! This access (to multiple distributed sources) is facilitated only via a working catalogue service, and we see no reason to leave end users "unconnected" because we, as technologists, are waiting on the latest-greatest innovation from the IT world. The NRW pilot has implemented a (OGC-conformant) catalogue service based on 1.0, and our research group has done the same (albeit at version 1.1, which cannot be conformance tested as the test does not yet exist), as shown in figure 2. Now is the time to connect metadata repositories (in relational databases) to users via current catalogue service technology.

The third SDI component, what we term end-user services, was previously termed "web mapping". These services have now expanded beyond presenting users with pictures of maps (e.g. GIF/PNG), to include (OGC) Feature servers for vector data, Coverage servers for continuous field-based data, and soon other geospatial processing and portrayal services. As far as including direct views of geodata within an SDI, implementers have several possibilities. One is to modify the Minnesota Map Server (<http://mapserver.gis.umn.edu/>), which publishes its source code and is compatible with OGC WMS specification 1.0. A related method is to follow the WMS cookbook, published by International Interfaces at <http://www.intl-interfaces.net/cookbook/WMS/index.html>. Finally, the WMS documentation is sufficiently complete to allow for the creation of basic (and open) web mapping clients such as that shown in figure 3.

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<sup>1</sup> One example is an old draft of 19115.3 (metadata) at <http://www.standardsinaction.org/gismetadata/>.

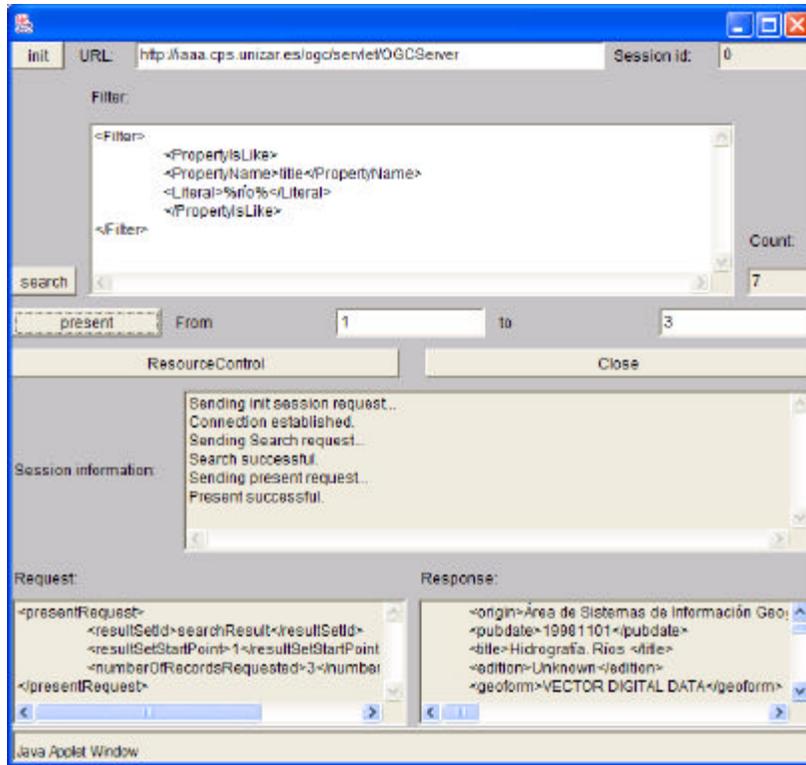


Figure 2. A prototype OGC Catalogue Service client, consulting a version 1.1 (draft) Catalogue Server for information on rivers (ríos). Note: an end-user application would reformat the XML output to create an appealing results web page.

We would be remiss not to mention that several GIS vendors now support the WMS 1.0 or higher specification for serving maps, including the products by ESRI, Intergraph, Ionic, Geodan, Cadcorp, SICAD, etc. (the latter 4 European companies; the entire list at <http://www.opengis.org/cgi-bin/implement.pl>). Caution should be taken, however, to determine just how open each commercial map server is to the use of OGC WMS protocols instead of its native protocol, and to the integration with other SDI components.

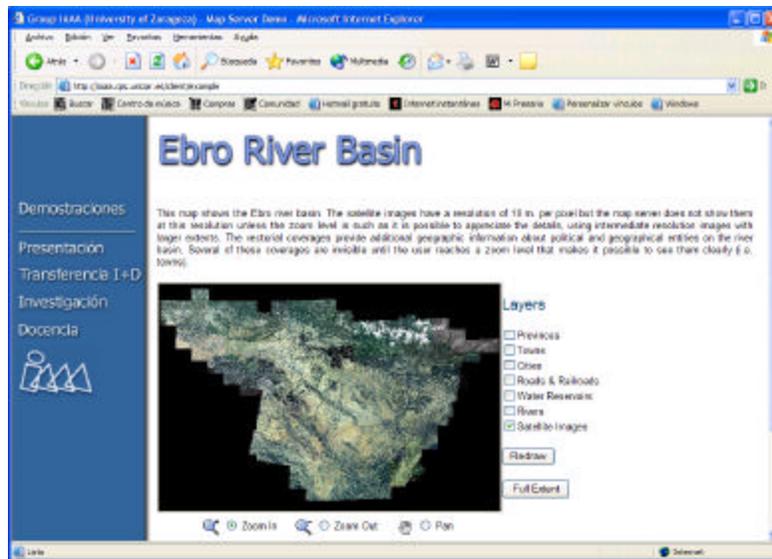


Figure 3. Basic WMS client

More complex user services such as the coverage and feature servers mentioned, will come onto the market within 12 months, as they are just now emerging from the Open Web Services initiative (which has served as a greenhouse for these technologies). Again, OGC members already have access to these draft technologies, and our group has implemented much of it, in order to offer more complete and diverse demos to our politicians, who will hopefully support future generations of regional and national SDIs.

### Reverse engineering a SDI

In conclusion we finally cycle back to our title. Reverse engineering: *The process of analysing an existing system to identify its components and their interrelationships and create representations of the system in another form or at a higher level of abstraction* ([www.dictionary.com](http://www.dictionary.com)). This seems to describe well our objective within a three-year technology research project funded by the Spain Ministry of Science and Technology, described in Bernabe et al. (2001): study what technology components are currently available and in use, and combine them to create pilot applications. If a particular region currently lacks a cogent SDI policy and architecture, it may just be that the relevant politicians have not seen clear demonstrations of what is possible today employing accessible, open, standard software components. We should also add that INSPIRE has certainly lived up to its name in our case, as the large shadow cast by this European initiative, has served to inspire politicians in Spain, who are now more confident regarding the possibilities for creating SDIs which are sustainable; the methods we are using are supported by INSPIRE, and *vice versa*.

### Future directions

Speculating where technological development will head during the coming years is always subject to unexpected "Big Bangs" (such as the sudden appearance of the WWW). Barring such radical disruption, it would seem that Web Services-based development will dominate the horizon for the coming years. (We note that if WS live up to their potential, and hype, they will in fact constitute a big bang.) This prediction is grounded in the on-going and planned initiatives within OGC (Open Web Services) and related interoperability organisations such as Object Management Group ([www.omg.org](http://www.omg.org)) and the OpenGroup ([www.opengroup.org](http://www.opengroup.org)), all aimed at the controlled application of web services technologies emerging from within the wider IT community. It should be noted that while we foresaw the advent of these simplified XML and HTTP-based services (see Gould 99) we did not know until very recently what they would be called or in what form they would appear. Web services will change the implementation of catalogue and registry functionality, as well as the way in which users "find" and "bind" them to their own applications, however we continue to recommend immediate implementation of current solutions (e.g. OGC Catalogue

Spec 1.0/1.1) and anticipate the emergence of a wide offer of migration solutions. In fact, our own research agenda will aim in this very direction. Another interesting direction for investigation in the SDI field (especially in Europe) will be tools to represent and exploit multilingual and cross-disciplinary ontologies (Mata et al, 2002): the key to semantic interoperability.

## Acknowledgements

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**ESDI: A Work in Progress**  
**Wednesday 3rd July 2002**

**Opening Plenary: ESDI, A Work in Progress (Chair: J. Meyer-Roux)**

Public Sector Information: A Perspective from the National Mapping Agencies (*R. Kirwan*)

Does Any Real European SDI Exist? The Practical Approach (*V. Slaboch*)

Financing Spatial Data as Infrastructure: Underwriting and Leveraging Co-Investments  
*(B. Cahan)*

INSPIRE (*M. Vanderhaegen*)

**Data Policy (Chair: M. Craglia)**

Harmonizing Data Policy: Challenges and Opportunities (*N. Land*)

Data Dissemination and Pricing Policy for Spatial Data at the Surveying and Mapping Authority of the Republic of Slovenia  
*(I. Ažman)*

Data Policy and Legal Issues Relevant to the Delivery of INSPIRE (*S. Carlyle*)

**Spatial Planning (Chair: M. Salvemini)**

GIS in a Knowledge Domain: Bringing GIS to Operational Integration in Spatial Planning  
*(D. Moore)*

Mapping and Modelling the Impact of Land Use Planning and Management Practices on Urban and Peri-Urban Landscapes in the Greater Dublin Area (*M. Critchley*)

Metainformation System: MIDAS as an On-Line Catalogue of Geodata of Public Administrations in the Transformation Process (*E. Pauknerová*)

MIDAS: A Tool for Public Administration Transformation Support (*J. Ruzicka*)

**Common Reference Data (Chair: P. Prendergast)**

INSPIRE Working Group on Reference Data and Metadata: A State of the Art (*D. Rase*)

Harmonisation of European Road Data: How to Create Large Scale Interoperability between National Databases (*U. Sandgren*)

Development of a pan-European Database of Rivers, Lakes and Catchments, in Support of the Needs of Environmental Policies (*J. Vogt*)

Cadastres & Agro-Environment (*R. Waters*)

**E-Government (Chair: B. McCormack)**

The Design and Implementation of a Community Based, Public Participation Geographic Information System for South County Dublin (*P. Haughey*)

GI for the Governance of Local Authorities. Critical Aspects and Technical Solutions  
*(M. Salvemini)*

The Ordnance Survey Ireland E-Commerce System (*C. Bray*)

The Importance of Geography: Better Information for Tackling Social Exclusion  
*(S. Chainey)*

**Poster Session (Chair: A. Munro)**

[EFIS: A Prototype European Forest Information System \(EFIS Project\)](#)

[European Territorial Management Information Infrastructure: A Contribution to the Definition of Europe's Future in Spatial Data Infrastructure Activities \(ETeMII Project\)](#)

[Recent E-Government Oriented Activities in the Newly Associated States and the Impact of EU-Funded Projects \(P. Fabian\)](#)

Access to Environmental and Cartographic Information (S. García)

Awareness, Training and Education in Interoperable OpenGeomatics-Based-Services: The BOW Approach to Open GeoData Infrastructures and Open Cross Border cooperation in Euro-Regions (F. Hoffmann)

[Spatial Distribution of Cancer and Material Deprivation in the Republic of Ireland: A GIS-Based Analysis \(V. Kelly\)](#)

[The Spatial Data Infrastructure Brandenburg, Germany \(P. Köhler\)](#)

[The Nature-GIS IST Project \(Nature-GIS Project\)](#)

[Using GIS to Regional Analysis of Basin Sustainable use under Water Framework Directive \(D. Pereira\)](#)

META: Development of Land Registration at the County Level (A. Podolcsák)

[An Approach for SDI Modelling and Visualization \(B. Rachev\)](#)

ECO GEOWATER: European Conference and forum to link GEO and WATER Research (G. Saio)

[Distribution of Spatial Data \(S. Vreçar\)](#)

[Mapping the Determinants of Spatial Data Sharing \(U. Wehn de Montalvo\)](#)

**ESDI: A Work in Progress****Thursday 4th July 2002****Plenary Session: ABGI (Chair: C. Corbin)**

[An Overview of the GINIE Project \(M. Craglia\)](#)

[EUROGI \(I. Masser\)](#)

The Recommendations from the GINIE Data Policy Workshop (F. Salgé)

ABGI (C. Corbin)

**SDI Analysis (Chair: P. Smits)****Public Access (Chair: D. Rizzi)**

Coupling GI-Services with Business Information Services: Experiences with a NSDI (*K. Senkler*)

Comparative Analysis of NSDI (*A. Annoni*)

Problems and Challenges in INSPIRE Impact Analysis (*M. Wachowicz*)

From Interoperability to Infrastructure (*C. Luzet*)

Public Access to Locally Important Environmental Information: Current Status and Future Needs (*P. Prendergast*)

GIS for NATURA2000: Example of the Need for a European Spatial Data Infrastructure (*D. Vandenbroucke*)

Addressing the Spatial Data Market: Implementation of The OGC Web Map Service Standard (*P. Daugbjerg*)

GETIS: The Road Towards Europe-wide Geo-processing Framework (*D. Piekny*)

### **SDI (Chair: M. Vanderhaegen)**

Towards a GI Infrastructure for Mine Action in S.E. Europe (*B. Jagarinec*)

RSIP: Building the Polish Component of the INSPIRE Framework at a Regional Level (*A. Sambura*)

Presentation on Implementing Structures and Funding Working Group from INSPIRE (*A. Vertanen*)

Ground Level SDI, Building up a Common Municipality Data Transfer Interface (*M. Arponen*)

### **Examples of EC GI Projects (Chair: J-F. Dallemand)**

Innovative Developments in GI Technology for Environmental Applications: A Contribution to E-ESDI (*L. Raynal*)

Quality of Geographic Information: Ontological Approach and Artificial Intelligence Tools in the REV!GIS project (*R. Jeansoulin*)

RURBAN: Optimizing Resource Allocation for RURal and urBAN Infrastructure Works via Spatial Database Technology (*O. Luca*)

BASIC: Building, Assessing and Standardising Information on the Atlantic Coasts (*V. Cummins*)

Challenges and Barriers to Environmental Decision Making: A Perspective from the MULINO Project (*J. Mysiak*)

### **Architecture and Standards (Chair: I. Kanellopoulos)**

Infrastructure for Spatial Information in Europe: Architecture and Standards (*P. Smits*)

Reverse Engineering SDI: Standards-based Components for Prototyping (*M. Gould*)

The OGC University Program: Conceptual Definition (*C. Kottman*)

### **Education (Chair: K. Rybaczuk)**

The INTERNET FOR GIS Project (*I. Compte*)

Project Geolab: Training with GIS at Secondary Schools (*P. Julião*)

Transboundary GI Education in the EC: Considerations and Potentials (*J. Thurston*)

Developing Multi-scale, Multi-context  
Databases Through the Semantic Integration  
of Heterogeneous Datasets (*M. Kavouros*)

Foundations of E-Learning Environments for  
Thematic Mapping (*H. Voss*)

**ESDI: A Work in Progress  
Friday 5th July 2002**

**Closing Plenary: ESDI (Chair: R. Kirwan)**

Polish Spatial Data Infrastructure: From the Concept Towards its Implementation  
(*E. Wysocka*)

The Regional Atlas of Southeast Europe: A Case Study for the Significance of Spatial Data  
for the Development of a Region (*U. Boes*)

The Ordnance Survey Digital National Framework: An Infrastructure for Joined up  
Geography (*V. Lawrence*)

**ESDI: A Work in Progress (Chair: A. Annoni)**

The PSI Directive proposal & Information Society Technologies in the 6th Framework  
Programme (*D. Rizzi*)

Environmental Applications & Services: GI-related IST Activities in FP5 & FP6 (*E. O'Neill*)