Main Page

From The SDI Cookbook

Welcome to the SDI Cookbook

The following contains the text of the book, broken down by chapter.

Each chapter is then broken into subsections.

SDI Cookbook

Chapter 1

From The SDI Cookbook

Contents

Chapter One: The Cookbook Approach

Introduction

At the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, a major resolution was passed to focus on reversing the impacts caused by environmental deterioration. The Agenda 21 resolution establishes measures to address deforestation, pollution, depletion of fish stocks, and management of toxic wastes to name a few. The importance of geographic information to support decision-making and management of these growing national, regional, and global issues was cited as critical at the 1992 Rio Summit, and by a special session of the United Nations General Assembly assembled in 1997 to appraise the implementation of the Agenda 21. In 2003, a landmark effort was made to illustrate the capabilities, benefits, and possibilities of using online digital geographic information for sustainable development at the World Summit on Sustainable Development in Johannesburg, South Africa.

Geographic information is vital to making sound decisions at the local, regional, and global levels.Crime management, business development, flood mitigation, environmental restoration, community land use assessments and disaster recovery are just a few examples of areas in which decision-makers are benefiting from geographic information, together with the associated infrastructures (i.e. Spatial Data Infrastructure or SDI) that support information discovery, access, and use of this information in the decision-making process. However, information is an expensive resource, and for this reason appropriate information and the resources to fully utilize this 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 spatial data, promote its reuse, and ensure that additional investment in spatial information collection and management results in an evergrowing, readily available and useable pool of spatial information. This is true of many initiatives even if they are not actually labelled as "SDI initiatives". An example of this is the Environment Information System Program in sub-Saharan Africa (EIS-SSA). An emphasis on harmonising standards for spatial data capture and exchange, the co-ordination of data collection and maintenance activities and the use of common data sets by different agencies may also feature in such initiatives, although these activities by themselves do not constitute a formal SDI.

In regions characterised by an availability of geographic information, in combination with the power of Geographic Information Systems (GIS), decision support tools, data bases, and the World Wide Web and their associated interoperability, the way better-resourced communities address critical issues of social, environmental, and economic importance is changing rapidly. However, even in the new era of networked computers, the social habits of the past continue to prohibit users from finding and using critical geographic information. This can lead to either the abandoning of a proposed project, or to unnecessary – and expensive - recapture of existing geographic information. In many agencies there is still the lost opportunity to reuse incidental digital geographic information collected for other purposes.

There is a clear need, at all scales, to be able to access, integrate and use spatial data from disparate sources in guiding decision making. Our ability then, to make sound decisions collectively at the local, regional, and global levels, is dependent on the implementation of SDI that provides for compatibility across jurisdictions that promotes data access and use.

Only through common conventions and technical agreements will it be easily possible for local communities, nations and regional decision-makers to discover, acquire, exploit and share geographic information vital to the decision process. The use of common conventions and technical agreements also makes sound economic sense by limiting the cost involved in the integration of information from various sources, as well as eliminating the need for parallel and costly development of tools for discovering, exchanging and exploiting spatial data. The greater the limitation on available resources for SDI development, the greater the incentive for achieving alignment between initiatives to build SDI.

The development of a "cookbook" is envisaged as a means to clarify the SDI definition and to share the current experiences in building SDI implementations that are compatible at many scales of endeavour. This cookbook is intended to be a dynamic document available in printed and digital form, to include "recipes" or recommendations on developing these infrastructures from a local, even non-governmental, scale through global initiatives.

Scope of This Cookbook

This SDI Implementation Guide or Cookbook, through the support of the Global Spatial Data Infrastructure community, provides geographic information providers and users with the necessary background information to evaluate and implement existing components of SDI. It also facilitates participation within a growing (digital) geographic information community known as the Global Spatial Data Infrastructure (GSDI).

To enable builders of SDI to make use of and build on existing SDI components in a way which makes their endeavors compatible with the efforts of other SDI builders, this GSDI Cookbook identifies:

- existing and emerging standards,
- open-source and commercial standards-based software solutions,
- supportive organisational strategies and policies and
- best practices.

Working within a common framework of standards and tools based on these standards also makes it possible to maximise the impact of the total available resources for SDI creation through future co-operation -- e.g. we develop this, you develop that, and then we share. Although proprietary or project-based solutions for information sharing continue to exist, the adoption of consistent geospatial data sharing principles will in general provide a better solution for information dissemination, through publishing geospatial data using the Internet and computer media. In an increasingly "global community", there is a need to ensure that transnational implementations and common knowledge bases are available. Ultimately, these SDI activities should improve collaboration within the geospatial data industry and make the benefits derived from the use of geographic information part of everyday life for all.

Spatial Data Infrastructures

The term "Spatial Data Infrastructure" (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia and by citizens in general.

The word infrastructure is used to promote the concept of a reliable, supporting environment, analogous to a road or telecommunications network, that, in this case, facilitates the access to geographically-related information using a minimum set of standard practices, protocols, and specifications. The applications that run "on" such an infrastructure are not specified in detail in this document. But, like roads and wires, an SDI facilitates the conveyance of virtually unlimited packages of geographic information.

An SDI must be more than a single data set or database; an SDI hosts geographic data and attributes, sufficient documentation (metadata), a means to discover, visualize, and evaluate the data (catalogues and Web mapping), and some method to provide access to the geographic data. Beyond this are additional services or software to support applications of the data. To make an SDI functional, it must also include the organisational agreements needed to coordinate and adminster it on a local, regional, national, and or trans-national scale. Although the core SDI concept includes within its scope neither base data collection activities or myriad applications built upon it, the infrastructure provides the ideal environment to connect applications to data – influencing both data collection and applications construction through minimal appropriate standards and policies.

The creation of specific organisations or programs for developing or overseeing the development of SDI, particularly by government at various scales can be seen as the logical extension of the long practice of co-ordinating the building of other infrastructures necessary for ongoing development, such as transportation or telecommunication networks.

The Global Spatial Data Infrastructure

Just as SDI programs of necessity involve the alignment of scarce resources for achieving success, so too it is necessary to ensure that the SDI initiatives develop in harmony with each other in order to maximise the impact of these programmes. In reality, many initiatives are working in isolation, not necessarily developing in harmony with others and consequently unable to reap the benefits of working together.

Anyone who is involved in a project of which spatial information forms an integral part and who intends leaving a legacy of spatial data or tools to exploit the data that lasts beyond the period of funding for the project is, by definition, participating in some of the fundamental elements required by an SDI. As coordination between such organisations expands, these projects very often lay the foundations on which initiatives formally dedicated to the establishment of SDI can then build. See Chapter 9 for specific case studies.

At a global scale, the most prominent examples of formal SDI programs are on a national scale. Most of these are driven by the national or federal government (e.g. the NSDI in the USA, the SNIG in Portugal, Australia's ASDI, Malaysia's NaLIS, South Africa's NSIF, Colombia, or the multi-national INSPIRE Initiative in Europe), but there are exceptions such as the Uruguay Clearinghouse and NGDF in the United Kingdom, which have largely been driven by the private sector. In most cases the need for wide participation in the development of lasting, useful SDI is acknowledged, and so private-public partnerships are encouraged. The beneficiaries of SDI are generally seen to derive from the public and private sectors, academia and non-governmental organisations, as well as individuals. Federal countries are often able to build their national SDI programs on SDI programs being driven by provincial or state governments (e.g. the ASDI of Australia). Regional SDI initiatives often arise out of existing multilateral structures (e.g. the Permanent Committee for GIS Infrastructure in Asia and the Pacific was formed through the UN Regional Cartographic Conference for the Asia-Pacific region).

Distribution

This GSDI Cookbook wiki is intended to be a "living" and dynamic document that can be updated as new principles and technologies are adopted. Distribution of this Cookbook is intended primarily via the World Wide Web, although electronic copies will also be made available on other physical media such as PDF, CD-ROM and printed copy for audiences that are not well connected to the Internet at this time.

Should you be reading this via the World Wide Web and wish to obtain a soft or hard copy, please contact the GSDI secretariat, at www.gsdi.org .

Contributors

Contributions to this GSDI Cookbook are indeed global and are intended to satisfy many different categories of participants. This was a deliberate choice, in order to ensure that the Cookbook represented various perspectives from around the globe, to ensure both that the collective global experience and existing resources would be represented in the Cookbook, and that its applicability could truly be global. The migration of the cookbook to a wiki environment is a logical extension of this idea, allowing contributions to be provided on an ongoing basis.

The cookbook will be periodically revised by selected and nominated editors to create a concise version that can be published as a electronic and paper document. This will allow outreach to people with an interest in SDI development who may not have ready access to the wiki version.

Organisation

Each chapter is organised into three major sections that correspond to levels of detail and application:

- The first section in each chapter establishes the background, context, and rationale for the subject suitable as general orientation for all readers, but targeted for managers and end-users
- The second section addresses the design architecture of organisations, roles, and software systems that are intended to interact
- The third section addresses the implementation with review of existing standards, protocols, and software as appropriate

Each chapter is approximately 10 to 20 pages in length with links to other relevant documents. Use-case scenarios and illustrations are featured in some chapters as inset boxes to further build understanding. Most chapters have a set of recommendations placed in a summary. Terminology used in this document, as well as guidance on how to standardize terminology, is presented in Chapter 10.

Case studies are intended to provide for local or regional relevance and interpretation. The document style not intended to be overly technical, however contributors have provided references to more detailed and comprehensive technical information where possible.

Finally, no manual of this type can claim to provide all the answers to suit all variations that may exist among implementations of national spatial data infrastructures. The goal is to provide enough common guidance to allow adjacent SDIs to exchange information easily through the adoption of common principles, standards, and protocols. This cookbook does provide a basic set of guiding principles that have been successful for establishing compatible Spatial Data Infrastructures, and are supported by the Global Spatial Data Infrastructure to promote successful decision-making for issues of local, regional, and global significance. As mentioned in the preceding section, if you feel that you have a contribution to make to the cookbook, or a question that you feel ought to be answered in the cookbook, please contact the GSDI Technical Working Group.

Cookbook Overview

The following sections provide an introduction to the content of each chapter. This is provided to help readers decide where to begin their exploration. Some users may already be fluent in geographic information systems but are unfamiliar with the tenets of Spatial Data Infrastructures (SDI). They may wish to start with the next chapter on SDI and GSDI. Others may already have extensive databases that are ready to be published on the World Wide Web. By starting in Chapter Two, they can learn how to catalogue and serve information about their data holdings in standard-based ways.

Chapter 2: Geospatial Data Development: Building data for multiple uses

In Chapter 2, you will learn about the development of standard and non-standard spatial data themes or layers for use in a trans-national or global context. The development of consistent reusable themes of base cartographic content, known as Framework, Fundamental, Foundation, or Core data is recognized as a common ingredient in the construction of national and global SDIs to provide common data collection schemas.

Chapter 3: Metadata: Describing geospatial data

In Chapter 3, you will learn how geospatial data are documented with metadata, what relevant standards exist, and how to implement them in software. Metadata are a key ingredient in supporting the discovery, evaluation, and application of geographic data beyond the originating organisation or project.

Chapter 4: Geospatial Data Catalogue: Making data discoverable

Geospatial data that are stored for use in local databases can often be used in external applications once they are published. In this chapter, the concepts and implementation of geospatial data catalogues are presented as a means to publish descriptions of your geospatial data holdings in a standard way to permit search across multiple servers.

Geospatial data catalogues are discovery and access systems that use metadata as the target for query on raster, vector, and tabular geospatial information. Indexed and searchable metadata provide a disciplined vocabulary against which intelligent geospatial search can be performed within or among SDI communities.

Chapter 5: Geospatial Data Visualization: Online Mapping

The primary view of geographic data has historically been through maps. In the context of SDIs, it is increasingly useful to provide mapped or graphical views of geospatial data through online mapping interfaces. This can satisfy many of the needs of novice or browse users of data without requiring download of the full data. Although it is not a replacement for direct data access, it satisfies a broad requirement for public interaction with geospatial information.

Assuming that data are being used for their correct purpose and at an appropriate scale (the Fitness for Purpose concept), maps can quickly portray a large amount of information to the inquirer. The rise of the Internet and in particular the World Wide Web has allowed information providers to harness this technology to the conventional stove-pipe GIS systems and data warehouses. This chapter describes current best practice in on-line mapping, and the results of the OpenGIS Consortium in realising simple inter-operability through a public web mapping specification that is also a draft ISO International Standard.

Chapter 6: Geospatial Access and Delivery: Open access to data

Once spatial data of interest have been located and evaluated, using the Catalogue and online mapping techniques described in previous chapters, access to detailed geospatial data in its packaged form is often required by advanced users or application software. Access involves the order, packaging and delivery, offline or online, of the data (coordinate and attributes according to the form of the data) specified. Finally, exploitation is what the consumer does with the data for their own purpose. This chapter walks through examples of data access and delivery that are recognized elements in a full-service SDI.

Chapter 7: Other Services

Web mapping services and Catalogue services are described as new, maturing technologies in earlier chapters. Additional services that extend functionality over the Web by combining data from sources described in Chapter 6 are described here. The application of special services, and service chaining, hold great promise in realizing true Web-based GIS interactions on data in support of decision making.

Chapter 8: Legal Issues and Economic Policy

Several legal issues arise when implementing information infrastructures, including SDIs. Typical are intellectual property rights (IPR) governing access to and use of spatial data, which includes copyright, patenting of software and algorithms, and database protection, in those jurisdictions where such protection exists in law. Privacy regulations if spatial data is used to identify individuals, commercial confidentiality and liability issues also arise. The chapter also reviews the several cost-benefit analysis (CBA) methodologies that have been used to justify the cost of creating SDIs, at sector, national and regional levels.

Chapter 9: Outreach and Capacity Building: Creating a community

The establishment of a Spatial Data Infrastructure at an organisational or national level requires an understanding of the requirements and responsibilities of the members of the community. This chapter discusses, with examples, the elements required for building and sustaining a geospatially-enabled community.

Chapter 10: Case Studies

One of the best ways to articulate the benefits of developing and using a spatial data infrastructure is to highlight the success stories that have emerged at the local, national, regional, and global levels. This chapter provides detailed accounts, or case studies from around the world that put into perspective the value of compatible SDI's and partnerships in making better decisions regarding the increasingly complex environmental, economic, and social issues that face our communities today.

Chapter 11: Terminology

This chapter provides an overview on how SDI organizations may wish to standardise their terminology; it also contains a glossary of terms used elsewhere in this document with appropriate citations. The abundant use of terms and acronyms in this highly technical field requires such a terminology reference.

Chapter 2

From The SDI Cookbook

Contents

Chapter Two: Geospatial Data Development: Building data for multiple uses

Editor: open

Context and Rationale

In the times of traditional ‘mapping’, collection and distribution of geographic information used to be highly centralised, or controlled by powerful government monopolies. This pattern was established since the beginning of the history of mapping, and lasted for centuries, until very recent times. It was a necessity that had never been challenged due to the heavy costs and technology associated with traditional mapping and to the long time-scales of mapping projects that often extended over several decades. Also, maps were not necessarily a consumer product, but were considered part of the national/local assets – data mainly used by the government, for defense, taxes, planning and development.

Thus the governments determined the collection of the information in specific types and formats required for its intended applications. Applications did not vary much across borders, and therefore a similar range of products was developed in many countries. These include:

- Cadastre, cadastral maps (scales from 1:100 to 1:5 000)
- Large scale topographic maps for urban planning and development (scale from 1:500 to 1:10 000)
- National ‘base maps’ (medium scale, 1:20 000 to 1:100 000)
- Small scale maps (1:100 000 and smaller)

Most, if not all, other mapping products and projects would use these main ‘basic maps’ as a template, as a common reference, and for building upon this ‘basic information’ the thematic data and applications that were required. Thus national interoperability was achieved. Moreover, needs across borders being very comparable, national products across borders were also quite similar, and if edge-matching was not always evident, anyone from country 'A' would be able to read and use a paper map from country 'B with no special effort required. Thus tacit cross-border interoperability also existed.

GIS technology has changed all that, particularly with the development of desktop GIS. Usage and type of applications is now incredibly diverse. GI has become a mass-market product on its own or is found integrated in hard- and software solutions. Nearly anyone can create their own maps, thanks to the use of desktop mapping, GIS, GPS surveying, satellite imagery, scanning and intelligent software. The old monopoly is shaken.

GIS technology is been employed in many different areas and in newer fields of applications, as computer hardware and GIS software applications provide improved capabilities at reduced cost. However, the overall cost of developing geospatial data required to support GIS applications remains relatively high compared with the hardware and software required for GIS. In addition, GIS users tend to develop their own data sets, even if there are existing geospatial data sets available for them, because:

- they may not know available existing data sets that could be appropriately used for their applications; or access to these data sets is difficult
- they are not used to sharing data sets with other sectors and/or organisations; and
- existing geospatial data sets stored in a certain GIS system may not be easily exported to another system.

These problems arise from the fact that existing geospatial data sets have been poorly documented in a standardised manner. Consequently, there have been duplicate efforts in geospatial data development, which sometimes hinders further dissemination of GIS applications in local, national, regional and global circumstances.

As a result, the new era of GIS is still characterised by:

- many actors involved in data collection and distribution
- a proliferation of GI applications, product types, and formats
- duplication as a consequence of the difficulties to access the existing data, and the highly specific quality of the data collected
- increasing difficulty in the exchange and use of data that came from different organisations

Core-, Reference-, Base-, Fundamental-data, and other similar terms are often used, and generally understood … until one tries to define what concept(s) they cover, or until one tries to define the related specifications.

Most GIS applications employ a limited number of common geospatial data items, including geodetic control points, transportation networks, hydrological networks, contour lines and so forth. These items are common to many GIS applications and provide keys for the integration of other and more specialized thematic information. They represent the content found in most traditional base-maps, or in modern technology and terminology, in most GI databases and products. Does that mean that these items are the ‘core’? What about postal addresses? What about cadastral parcels?

The concepts of ‘core-data’ and of ‘reference-data’ relate to two quite different perspectives. But fortunately they may result in the definition of very similar specifications. Let’s start with ‘reference’. The primary reference for cartographers is the geodetic and levelling networks that give the surveyors the physical links to a co-ordinate system. Of course, this has recently and dramatically changed with satellite positioning technologies, but the principle remains that the primary reference is what gives access to geodetic coordinates. We are not really concerned with this type of reference here, because it is generally not a part of the Geographic Information that is used in GIS applications, but rather its background. Very often it is even not visible.

If geodesy is the reference for the cartographer and the surveyor, the ‘reference’ of the GI user is generally more closely related to the real world. It includes concrete themes, such as infrastructure – roads, railways, power-lines, settlements, etc, or physical features – terrain elevation, hydrography, etc. It includes also less tangible features that have nonetheless a significant role in human life: administrative boundaries, cadastral parcels, gazetteer, postal addresses, etc. All these features are keys that allow one to relate, to ‘refer’, external information to the real world, through the media of its GI representation. Therefore they may be considered as comprising a reference for the GI user -- the ‘reference data’.

A different perspective presides over the conceptual approach of the ‘core data’. The core being the heart, the central part, the fundamental part, it may be also considered as being the common denominator of all GI data sets, being so because being used by most applications. We can see that this perspective can bring the specifications of the core very compatible with those deriving from the concept of the ‘reference data’. Therefore, let’s not lose ourselves in academic debates, and let’s keep here a simple practical view and terminology.

‘Core data’ when used here, will mean “a set of Geographic Information that is necessary for optimal use of most GIS applications, i.e. that is a sufficient reference for most geo-located data.” The relevance of this definition can of course be questioned, and will need to be improved. Let’s adopt it only for the sake of understanding the following chapters. One obvious necessary accommodation to the above definition, is that the specifications might be scaledependent. Core, then, may refer to the fewest number of features and characteristics required to represent a given data theme.

We have seen before that the GIS revolution has resulted in a democratisation of GI, but also in a key problem that is the non-interoperability of the GI produced with the new technologies. We propose that the concept of the ‘core data’ is one instrumentality to help improving interoperability, thus increasing GI usability and reducing expenses resulting from the current duplications.

Interoperability complications exist at different levels, and they can be found in four main types:

- cross-border : edge matching between different data sets
- cross-sector : data sets created for different sector-based applications
- cross-type : e.g. raster- vs. vector-data
- overlap : same features coming from different sources and process

Resolving the related issues will need a mix of three ingredients -- the technology, the adoption of a common concept of ‘core data’, and of course the political support that will help resourcing the necessary key implementations.

The concept of the core aims at sharing the core data sets between users in order to facilitate the development of GIS. Each data item may be provided by a different data provider. Such data providers produce data through their daily businesses including road management, urban planning, land management, tax collection, and so forth. Although there may be many data providers, the data sets they provide must be integrated to develop core data sets. Once these core data sets are shared between data users, each user does not have to develop the core data by oneself, and can avoid duplicated efforts of core data development. Consequently, by sharing the cost of developing the core data, data development cost can be minimised and shared between users.

Much more than at the time of data set creation, the benefits of the ‘core data’ concept will be revealed when updating. Since these core data sets are developed by those who produce the data through their daily businesses, they are updated most frequently. Therefore, the users are assured of using up-to-date core data sets. In addition, these data producers develop most detailed geospatial data with high quality based on their business requirements. Another benefit of using core data sets lies in the fact that these commonly used core data sets enable the users to easily share other geospatial data with other users.

Achieving Benefits

In order to achieve those benefits described in the previous section, those data producers who develop and maintain geospatial data sets through their daily businesses are to distribute their data to the public. Once distributed, GIS users can collect and integrate them in their own GIS applications. Such data sets would provide GIS users with the most up-to-date and highest quality data sets publicly available. Hence the users have to spend only a minimum amount of cost for the core data in their GIS applications.

Global Map is one illustration of ‘core' data sets conceived in a global or at least multi-national environment. The Japanese Geographical Survey Institute took an initiative in 1992 to develop a suite of global geospatial data (Global Map) to cope with the global environmental problems. The goal is to involve national mapping organisations to collaboratively develop global geospatial data sets. By incorporating national mapping organisations of the world, the collected information would be most up-to-date and assured of being free of national security issues. The Global Map could be considered as an initial implementation of the concept of a suite of ‘core data’ for GSDI in concert with similar framework data sets at regional and national levels.

It is important to recognize that Core data, as represented by Global Map and other national initiatives, do not comprise the only data available within a national or global SDI. SDI capabilities enable the documentation and service of all types of geospatial data, such as local scientific or engineering projects, regional or global remote sensing activities, and environmental monitoring. Although SDIs as infrastructure enables access to all these types of information, special consideration is given in this chapter to document issues associated with data of high reuse potential that may be served by SDIs at local, national, or global levels as traditional base map themes.

Organisational Approach

At the national level, common spatial data are often defined through community and/or national agreements on content, known as "framework" or "fundamental" data in various national SDIs. In the Australian Spatial Data Infrastructure (ASDI), Fundamental describes a dataset for which several government agencies, regional groups and/or industry groups require a comparable national coverage in order to achieve their corporate objectives and responsibilities. In other words, fundamental data are a subset of framework data. Similar concepts exist in other countries with similar terms, and most identify general themes of interest as "framework" information, for they provide a framework of base, common-use geospatial information onto which thematic information can be portrayed. An organisation interested in implementing spatial data that will be compatible with local, regional, national, and global data sets, must identify, and potentially reconcile different framework designations across their geographic area of interest.

The framework is a collaborative effort to create a common source of basic geographic data. It provides the most common data themes geographic data users need, as well as an environment to support the development and use of these data. The framework's key aspects are:

- specific layers of digital geographic data with content specifications
- procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and
- institutional relationships and business practices that encourage the maintenance and use of data.

The framework represents a foundation on which organisations can build by adding their own detail and compiling other data sets. Existing data content may be enhanced, adjusted, or even simplified to match a national or global framework specification. This is helpful for the purpose of exchange.

Framework Leverages the Development of Needed Data

Thousands of organisations spend billions of dollars each year producing and using geographic data. Yet, they still do not have the information they need to solve critical problems. There are several aspects to this problem:

- Most organisations need more data than they can afford. Frequently, large amounts of money are spent on basic geographic data, leaving little for applications data and development.
- Some organisations cannot afford to collect base information at all. Organisations often need data outside their jurisdictions or operational areas. They do not collect these data themselves, but other organisations do.
- Data collected by different organisations are often incompatible. The data may cover the same geographic area but use different geographic bases and standards. Information needed to solve cross-jurisdictional problems is often unavailable.
- Many of the resources organisations spend on geographic information systems (GIS) go toward duplicating other organisations' data collection efforts. The same geographic data themes for an area are collected again and again, at great expense. Most organisations cannot afford to continue to operate this way.

Framework initiatives will greatly improve this situation by leveraging individual geographic data efforts so data can be exchanged at reasonable cost by government, commercial, and nongovernmental contributors. It provides basic geographic data in a common encoding and makes them discoverable through a catalogue (See Chapter 4) in which anyone can participate. Using Web mapping and advanced, distributed GIS technology in the future, users can perform visual cross-jurisdictional and cross-organisational analyses and operations, and organisations can funnel their resources into applications, rather than duplicating data production efforts.

There are many situations in which the framework will help users. A regional transportation planning project can use base data supplied by the localities it spans. Government agencies can respond quickly to a natural disaster by combining data. A jurisdiction can use watershed data from beyond its boundaries to plan its water resources. Organisations can better track the ownership of publicly held lands by working with parcel data.

Geographic data users from many disciplines have a recurring need for a few themes of basic data. While these layers may vary from place to place, some common themes include: geodetic control, orthoimagery, elevation, transportation, official geographic names (gazetteer), hydrography, governmental units, and cadastral information. Many organisations produce and use such data every day. The framework provides basic content for these data themes, and by defining a common schema, it can also provide a common means of information exchange and value-adding.

By attaching their own geographic data — which can cover innumerable subjects and themes — to the common data in the framework, users can build their applications more easily and at less cost. The common data themes provide basic data that can be used in applications, a base to which users can add or attach geographic details and attributes, reference source for accurately registering and compiling participants' own data sets, and a reference map for displaying the locations and the results of an analysis of other data.

National and global frameworks are a growing data resource to which geographic data producers can contribute. It will continually evolve and improve. In practice, the content model of many framework layers may be simple enough that, as a collection target, at certain scales, it could be made available at virtually no cost. Content providers exist already in the United States to take and extend free government data with valuable additional attributes of value, e.g. marketing and demographic information. The core information itself may be given away for free, but extended information that are anchored to the geometry may have high current value that declines over time, and may re-enter the public domain after its proprietary nature expire. Thus commercial providers of information benefit through anchoring to a common framework system and cross-referencing with other attributes held by other organisations; consumers benefit in acquiring the framework core geometry, feature definitions, and base attributes as a by-product of the more advanced data set.

Who are the actors in framework data development?

- users and producers of detailed data, such as utilities
- users of small-scale, limited geographic data, such as street networks, statistical areas, and administrative units;
- data producers who create detailed data as a product or a service;
- data producers who create low-resolution, small-scale, limited themes for large areas;
- product providers who offer software, hardware, and related systems; and
- service providers who offer system development, database development, operations support, and consulting services.

Non-profit and educational institutions also create and use a variety of geographic data and provide GIS-related services. They cover the full spectrum of data content, resolution, and geographic coverage. Depending on the organisation’s activities, data use may range from highresolution data over small areas, as in facility management, to low-resolution data over wide areas, as in regional or national environmental studies.

Organisations build national and regional framework efforts by coordinating their data collection and development activities based on intersecting interests within a community. The bounds of this community, however, given the diversity of types of organisations and individuals involved, needs to be non-exclusive and open to innovative contributions, exchanges, and partnerships. The framework should be developed by the entire community, with organisations from all areas playing roles. For some, the framework will supply the data they need to build applications. Others will contribute data, and some may provide services to maintain and distribute data.

Some organisations will play several roles in framework development, operation, and use. The framework will take many years to develop fully, but useful components are being developed continuously.

Implementation Approach

The ISO TC 211 Geomatics standardisation activity is working on two related areas of endeavour that will greatly assist in the global specification of content models and feature models for framework and non-framework data. These include ISO 19109 - Rules for application schema, and 19110 - Feature cataloguing methodology. In the networked world, the ability for software to interact with geographic information outside an organisation is virtually non-existent except where public agreements exist for data structures (also known as a content model or schema) and the features being mapped. The ISO standards mentioned above provide a basis for the description of these packages of information that would enable access to a distributed network of framework data services. Implemented through specific encoding methods such as Geography Markup Language (GML), ISO 19136 Coupled with catalogue for discovery (See Chapter 4) populated with metadata (See Chapter 3), the ingredients are coming together for a configurable deployed architecture.

The scope of ISO 19109 is defined as "… the rules for defining an application schema, including the principles for classification of geographic objects and their relationships to an application schema." In principle, using the Unified Modeling Language (UML), software applications that provide access to geospatial data, such as framework, would be defined in a consistent way so as to improve sharing of data between applications and even allow for real-time interaction between applications. Expressing the encoding of an application schema using GML is a new technique to formalise the packages of information being exchanged between providers and users of spatial data.

Before one can allow software to reliably access mapped features stored in remote data systems, there must first be a common understanding about the nature and composition of the objects being managed. ISO 19109 includes guidance principles for classifying geographic objects. The usefulness of any information is reduced when the meaning is unclear, especially and commonly across different application domains. If different classifications are defined using a consistent set of rules, that ability to map one classification to another and retain the meaning will be greatly increased. This is also known as the semantic translation of one representation of an object in one system, for example a road or river segment, to that in another.

These rules will be used by geographic information users when classifying geographic objects within their applications and when interpreting geographic data from other applications. The rules and principles could also be used by geographic information system and software developers to design tools for the creation and maintenance of classification schemes.

Very closely related to the schema definition of ISO 19109 is the standard proposing a feature cataloguing methodology, ISO 19110. It is intended to define the approach and structures used for an information provider to store the identity, meaning, representation, and relationships of concepts or things in the real world as they are managed in online systems. A feature catalogue, then, acts as a dictionary for feature types or classes that can be used in software. The definition of a single international, multilingual catalogue would have tremendous value.

Whether this catalogue was used in all applications or only used as a neutral form when moving data from one application to another, it could simplify the problem of mapping the catalogue of one application to the catalogue of another. However, the feasibility of such a task is in question and will be investigated as a part of this work item in the TC 211 work group. The cataloguing task will use the input from the Rules for Application Schema work item and cannot be completed before that item is completed.

Publishing an application schema with a feature catalogue for a given data set of common interest can provide the basis for framework data definitions of use to global, regional, national, and local data. Done carefully, schemas and feature catalogues could be similarly constructed for existing framework-like data in order to enable discussion among participants, and transformation of content into conforming framework data sets.

Several national projects have been undertaken to build standardised framework data content and/or encoding. A project to develop framework specifications in Switzerland, known as InterLIS, has had marked success with this approach. Common definitions of data layers exist as target specifications that are matched to various degrees by participant organisations. As a result, software that is designed to interact with the InterLIS application model will work against data sets from different sources and organisations. The application framework is designed to be a scalable one to allow the participation of minimal data sets with lesser application functionality and more complex data sets with maximal application functionality. The Master Map of the Ordnance Survey in the United Kingdom and the Framework Data Content Standards under development in the United States are also documented as abstract application schemas and include GML encoding guidance to facilitate the exchange of data and development of applications that support the published models.

Common Identities of Real World Objects

In many framework implementations, there will not be necessarily one authoritative geometric representation of a feature in the real world. Several national systems have proposed the use of a common or permanent feature identifier to be associated with the object in the real world so that different representations and attributes of that object on maps can be cross-referenced. Having well-known identities of features established with a coding system within a community greatly assists in the association of attribute information to real-world objects where such attributes may not reside in a GIS or spatially-enabled data base. Also, multiple representations of real world objects may be linked to the identity code, to provide views of an object that is changed over time or that has different degrees of spatial resolution at different scales of data collection or representation. This becomes a logical model for organizing related geospatial information.

The management of a common or "permanent" feature identity needs to be undertaken within the community with permission granted to certain participant organisations to create or adjudicate these identities. In Canada, there is an effort to create a data alignment layer of wellknown features or intersections of features to help vertically integrate spatial data from different sources. These features and intersections will have published identifiers, some sense of positional accuracy, and source information. In the United States, the National Hydrography Data set includes a permanent feature identifier for segments of river and water bodies between points of confluence. In other national, regional, and global settings, agreement on management and assignment of feature identifiers -- building upon a sound feature cataloguing approach -- will be essential in building up compatible framework data across political boundaries.

Candidate National Framework Categories

A variable number of data layers may be considered to be common-use and of national or transnational importance as "framework" data. Framework layers commonly nominated in national context include:

- cadastral information
- geodetic control
- geographic feature names
- orthoimagery
- elevation
- transportation
- hydrography (surface water networks)
- governmental units

It is likely for this list to grow as custodians of data identify and promote their data as necessary to increasingly advanced applications and user environments.

Candidate Global Data Categories

The Global Mapping concept was articulated by the Ministry of Construction of Japan as a response to the United Nations Conference on Environment and Development held in Brazil in 1992. Agenda 21 is an action program drawn up by the conference, and it clearly makes the case that global baseline spatial data is important to society's interaction with the environment. The Global Mapping Project, also known as Global Map, is addressing the compilation of suitable spatial data products from existing international and national sources. This provide a public set of reference data at trans-national to global scales to assist decision-makers and society in depicting global environmental concerns.

Progress is being made in selecting and enhancing these general purpose spatial data layers originally based on VMAP Level 0 (also known as Digital Chart of the World) for vector themes, Global Land Cover Characteristics Database from the U.S. Geological Survey (USGS) for land cover, land use and vegetation, and the 30-second GTOPO30 product also hosted by the USGS. Global Map Version 1.0 specifications for data organisation were adopted at the International Steering Committee for Global Mapping (ISCGM) meeting held in conjunction with the Third GSDI Conference in Canberra, Australia in November 1998. As of February 2000, 74 countries are participating in the collection or aggregation of large-scale map products to update and package the above data sources.

Recommendations

The development of common data specifications is an arduous task to undertake by oneself or by a single organisation. For the development of the GSDI the following recommendations are made:

- ***The Cookbook authors recommend that interested parties participate in or be aware of existing framework initiatives at the sub-national, national, and international scale.***

Data appropriate to a given type of geospatial analysis will require information at a range of resolutions and degrees of detail.

The Cookbook authors recommend that Global Map specification be adopted for trans-national applications requiring land cover/use, vegetation, transportation, hydrography, administrative boundaries, populated places, and elevation data.

The global map content specification defines a simple content model with a small number of feature types and attributes suitable for the construction of base cartography at regional scales. Evaluate the level of detail with respect to a given GIS or mapping application. It may require extension to suit your base requirements.

- ***The Cookbook authors recommend that Core and non-Core data be modeled and shared in the designs of national SDIs using emerging ISO standards by following the rules for application schema, publishing a feature catalogue, and standardising the encoding of the data.***

The ISO 19109 and 19110 draft standards and the use of GML per ISO 19136 formalise the description and encoding of features and feature collections for individual applications that can facilitate the proper access and transformation of geospatial data held in online systems in near real time. This extends the capabilities of the individual in working with dynamic information held in distributed locations, as will be discussed in Chapter 6 in greater detail. National and global framework data, as well as non-framework data will be made more accessible and semantically correct through such technologies.

References and Linkages

Harmonised Data Manual - The Harmonised Data Model (Australia) http://www.icsm.gov.au/icsm/harmonised_data_manual/harmonised_data_model.htm

Framework Home Page, U.S. Federal Geographic Data Committee http://www.fgdc.gov/framework/framework.html

Geospatial One-Stop Framework Standards Development (U.S.) http://www.geo-one-stop.gov/Standards/index.html

Global Map Specifications - Version 1.1 http://www.iscgm.org/html4/index_c5_s1.html#doc13_3741

Interlis Project Home Page (Switzerland) http://www.interlis.ch/content/index.php

GSDI Cookbook, Version 2.0 25 January 2004 Page 23

Ordnance Survey Master Map in GML http://www.g-intelligence.co.uk/webadmin/data/files/36.pdf

Chapter 3

From The SDI Cookbook

Contents

Chapter Three: Metadata -- Describing geospatial data

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This document has been developed from input by FGDC, EUROGI, ANZLIC and NGDF and is predominantly based on the various sources cited at the end of the chapter.

Introduction

We often hear the phrase "information is power," but with increasing amounts of data being created and stored (but often not well organised) there is a real need to document the data for future use - to be as accessible as possible to as wide a "public" as possible. Data, plus the context for its use (documentation, metadata) become information. Data without context are not as valuable as documented data. There are significant benefits to such asset management:

- Metadata helps organise and maintain an organisation's investment in data and provides information about an organisation's data holdings in catalogue form
- Coordinated metadata development avoids duplication of effort by ensuring the organisation is aware of the existence of data sets
- Users can locate all available geospatial and associated data relevant to an area of interest
- Collection of metadata builds upon and enhances the data management procedures of the geospatial community
- Reporting of descriptive metadata promotes the availability of geospatial data beyond the traditional geospatial community
- Data providers are able to advertise and promote the availability of their data and potentially link to on line services (e.g. text reports, images, web mapping and ecommerce) that relate to their specific data sets

A number of studies have established that although the value of geospatial data is recognised by both government and society, the effective use of geospatial data is inhibited by poor knowledge of the existence of data, poorly documented information about the data sets, and data inconsistencies. Once created, geospatial data can be used by multiple software systems for different purposes. Given the dynamic nature of geospatial data in a networked environment, metadata is therefore an essential requirement for locating and evaluating available data. Metadata can help the concerned citizen, the city planner, the graduate student in geography, or the forest manager find and use geospatial data, but they also benefit the primary creator of the data by maintaining the value of the data and assuring their continued use over a span of years. Over thirty years ago, humans landed on the Moon. Data from that era are still being used today, and it is reasonable to assume that today's geospatial data could still be used in the year 2020 and beyond to study climate change, ecosystems, and other natural processes. Metadata standards will increase the value of such data by facilitating data sharing through time and space. So when a manager launches a new project, investing a small amount of time and resources at the beginning may pay dividends in the future.

Context and Rationale

The word metadata shares the same Greek root as the word metamorphosis. "Meta-" means change and metadata, or "data about data" describe the origins of and track the changes to data. Metadata is the term used to describe the summary information or characteristics of a set of data. This very general definition includes an almost limitless spectrum of possibilities ranging from human-generated textual description of a resource to machine-generated data that may be useful to software applications. More recently, the term metadata has even been applied to services as a description of published service characteristics.

The term *metadata* has become widely used over the past 15 years, and has become particularly common with the popularity of the World Wide Web. But the underlying concepts have been in use for as long as collections of information have been organised. Library catalogues represent an established variety of metadata that has served for decades as collection management and resource discovery tools. The concept of metadata is also familiar to most people who deal with spatial issues. A map legend is one representation of metadata, containing information about the publisher of the map, the publication date, the type of map, a description of the map, spatial references, the map's scale and its accuracy, among other things. Metadata are also these types of descriptive information applied to a digital geospatial file. They're a common set of terms and definitions to use when documenting and using geospatial data. Most digital geospatial files now have some associated metadata. In the area of geospatial information or information with a geographic component this normally means the What, Who, Where, Why, When and How of the data. The only major difference that therefore exists from the many other metadata sets being collected for libraries, academia, professions and elsewhere is the emphasis on the spatial component - or the where element.

The Benefits of Metadata

Metadata helps people who use geospatial data find the data they need and determine how best to use it. Metadata benefit the data-producing organisation as well. As personnel change in an organisation, undocumented data may lose their value. Later workers may have little understanding of the contents and uses for a digital database and may find they can't trust results generated from these data. Lack of knowledge about other organisations' data can lead to duplication of effort. It may seem burdensome to add the cost of generating metadata to the cost of data collection, but in the long run the value of the data is dependent on its documentation.

Metadata is one of those terms that is conveniently ignored or avoided. However there is an increasing recognition of the benefits and requirement for metadata for our data as we continue to increase the use of digital data. Whereas cartographers rigidly provided metadata within a paper map's legend, the evolution of computers and GIS has seen a decline in this practice. As organisations start to recognize the value of this ancillary information, they often begin to look at incorporating metadata collection within the data management process.

Organisational Approach

Levels of Metadata

There are different levels that metadata may be used for:

- Discovery metadata - What data sets hold the sort of data I am interested in? This enable organisations to know and publicise what data holdings they have.
- Exploration metadata - Do the identified data sets contain sufficient information to enable a sensible analysis to be made for my purposes? This is documentation to be provided with the data to ensure that others use the data correctly and wisely.
- Exploitation metadata – What is the process of obtaining and using the data that are required? This helps end users and provider organisations to effectively store, reuse, maintain and archive their data holdings.

Each of these purposes, while complementary, requires different levels of information. As such organisations should look at their overall needs and requirements before developing their metadata systems. The important aspect is for agencies to establish their business requirements first, the content specifications second and the technology and implementation methods third.

This is not to say that these levels of metadata are unique. There is a high degree of reuse of the metadata for each level and an organisation will design its metadata schema and implementation based on its business needs to accommodate these three requirements.

Discovery Metadata is the minimum amount of information that needs to be provided to convey to the inquirer the nature and content of the data resource. This falls into broad categories to answer the "what, why when who, where and how" questions about geospatial data.

What - title and description of the data set. Why - abstract detailing reasons for the data collection and its uses. When - when the data set was created and the update cycles if any. Who – originator, data supplier, and possibly intended audience. Where - the geographical extent based on latitude / longitude, co-ordinates, geographical names or administrative areas. How – how it was built and how to access the data.

The broad categories are only few in number to reduce the effort required to collect the information whilst still conforming to the requirement to convey to the inquirer the nature and content of the data resource.

Online systems for handling metadata need to rely on their (metadata is plural, like data) being predictable in both form and content. The level of metadata detail that will be documented is dependent on the type of data held and the methods that it is being accessed and used. Different types of data (e.g. vector, raster, textual, imagery, thematic, boundary, polygon, attribute, point, etc.) will require different levels and forms of metadata to be collected. However there is still a high degree of compatibility between most of the metadata elements required.

Similarly, organisations will manage their data in mission-defined ways. Some organisations manage information as a data set, tiles of data sets, series of data sets, or manage the information down to the feature level. Again there is still a high level of compatibility between the levels of metadata required, particularly as the data is cascaded from the feature level to the data set or data series level.

Thus, not only can metadata content vary according to purpose; it can also vary according to scope of the data being defined. Discovery metadata usually, but not exclusively, relates to collections of data resources or data set series that have similar characteristics but relate to different geographic extents or times. A map series is the commonest example but it can equally be applied to statistical surveys. More detailed metadata may be applied to a collection or series but may apply to an individual data set (e.g. one map tile). Transfer metadata applies exclusively to that transfer.

Exploration metadata provides sufficient information enable an inquirer to ascertain that data fit for a given purpose exists, to evaluate its properties, and to reference some point of contact for more information. Thus, after discovery, more detail is needed about individual data sets, and more comprehensive and more specific metadata is required. If the data are transferred as a single data set then quite specific and detailed metadata is needed possibly down to the feature, object or record level. Exploration metadata include those properties required to allow the prospective end user know whether the data will meet general requirements of a given problem.

Exploitation metadata include those properties required to access, transfer, load, interpret, and apply the data in the end application where it is exploited. This class of metadata often includes the details of a data dictionary, the data organisation or schema, projection and geometric characteristics, and other parameters that are useful to human and machine in the proper use of the geospatial data.

These roles form a continuum in which a user cascades through a pyramid of choices to determine what data are available, to evaluate the fitness of the data for use, to access the data, and to transfer and process the data. The exact order in which data elements are evaluated, and the relative importance of data elements, will not be the same for all users.

Linkages between geospatial data and metadata

Until recently, metadata have been created or derived with little or no automation. In fact, it is only with the recent development of metadata standards, and the development of metadata software based on these standards, has the consistent management of metadata been given any consideration by those collecting geospatial data. With an increased focus of incorporating geospatial data into corporate information systems, the development of an international standard for metadata, and the OpenGIS catalogue service specifications, new versions of commercial GIS software are now facilitating a close linkage between geospatial data and metadata.

Regardless of style of metadata, there is nominally one collection of properties or metadata associated with a given data set or feature collection. The 1:1 rule expresses the notion that a discrete resource should have a discrete metadata record. Although it seems simple enough, it isn't always so neat because resources are often not so discrete. For example, should each photograph in an article have its own record? How do you manage collections of articles? Can the collection be thought of as a resource? What about multi-media objects? Thus, one of the first tasks in metadata management is the identification of the data product or entity to be documented.

Metadata may exist at the collection level (e.g. satellite series), at a data product level (an image mosaic), at a data unit level (a vector data set), a group of features of a given type (certain roads), or even at a specific feature instance (a single road). Regardless of the level of abstraction, these associations of metadata to data objects should be maintained.

In practice, most metadata are currently collected at the data set level, and a metadata entry in a catalogue refers the user to its location for access. Increasingly sophisticated providers of geospatial data are including metadata at other levels of detail so as to preserve information richness. Metadata standards such as ISO 19115 allow different levels of metadata abstraction, and catalogue services will also need to accommodate this richness without confusing the user in its complexity.

Metadata Standards

Why use Standards?

Ideally, metadata structures and definitions should be referenced to a standard. One benefit of standards is that they have been developed through a consultative process (with other "experts") and provide a basis from which to develop national or discipline-oriented profiles. As standards become adopted within the wider community, software programs will be developed to assist the industry in implementing the standard. The consistency in metadata content and style is recommended to ensure that comparisons can be made quickly by data users as to the suitability of data from different sources. This means for example when comparing metadata about property or hazardous waste there is an indication of the dates to which the information refers or if comparing metadata about different map sources the relevant scales are shown. Without standardization, meaningful comparisons are more difficult to derive without reading and learning many metadata management styles.

Predictability is also encouraged through conformance to standards. However the problem has been that there are a number of “standards” in use or development. Detailed metadata standards that provide for an exhaustive definition of all aspects of various types of geospatial data are currently under preparation by a number of bodies, as are profiles of these standards as reference models to be adopted for international use.

Geospatial Metadata Standards

Considerable debate across the world centres on metadata and those characteristics that should be chosen to best describe the data set. There are discussion groups, seminars and conferences and quantities of paper generated in the debate about the subject. Standards have been generated by a number of organisations all designed to ensure that a degree of consistency exists within a given application community.

Three main metadata standards exist or are in development that are of broad international scope and usage and provide detail for all levels of metadata mentioned earlier:

The Content Standard for Digital Geospatial Metadata, U.S. 1994, revised 1998 http://www.fgdc.gov/

In the USA the Federal Geographic Data Committee (FGDC) approved their Content Standard for Digital Geospatial Metadata in 1994. This is a national spatial metadata standard developed to support the development of the National Spatial Data Infrastructure. The standard has also been adopted and implemented in the United States, Canada, and the United Kingdom through the National Geographic Data Framework (NGDF) and its successor the AGI. It is also in use by the South African Spatial Data Discovery Facility, the Inter-American Geospatial Data Network in Latin America, and elsewhere in Asia.

A CEN Pre-standard adopted in 1998 http://forum.afnor.fr/afnor/WORK/AFNOR/GPN2/Z13C/indexen.htm

In 1992 the Comité Européen de Normalisation (CEN) created technical committee 287 with responsibility for geographic information standards. A family of European Pre-standards have now been adopted including 'ENV (Euro-Norme Voluntaire) 12657 Geographic information - Data description - Metadata'. CEN TC 287 was reconvened in 2003 to address the development of European profiles of ISO TC 211 standards.

A number of national and regional initiatives have also developed metadata standards. These include initiatives managed by The Australian and New Zealand Land Information Council (ANZLIC) and two completed European Commission financed projects (LaClef and ESMI) now being assimilated by the INSPIRE project. These initiatives have taken similar approaches in promoting a limited set of metadata (described as "Core Metadata" or "Discovery Metadata" that organisations should use, as a minimum, to improve the knowledge, awareness and accessibility of the available geospatial data resources.

ISO 19115 (International Standard) and ISO 19139 (Draft Technical Specification)

An ISO standard for standard metadata was published and approved in 2003 (http://www.isotc211.org)[1]. The ISO standard was derived from inputs from the the various national bodies and their implementations of the respective metadata standards assisted by metadata software. Indeed, most of the existing standards already have a great deal in common with each other, and a robust international discussion has ensured that the ISO standard has accommodated most of the various international requirements. ISO 19115 provides an abstract or logical model for the organization of geospatial metadata. It does not provide for rigorous compliance testing as there is no normative guidance on formatting the metadata included in the standard. A companion specification, ISO 19139, standardises the expression of 19115 metadata using the Extensible Markup Language (XML) and includes the logical model (UML) derived from ISO 19115. In North America, work is beginning to create a North American Profile of Metadata based on ISO 19139 for Canada, the United States, and Mexico. This will allow for the compliance testing of metadata files using XML.

Metadata also forms an important part of the OpenGIS Abstract Specification. The OpenGIS Consortium (OGC) http://www.opengis.org is an international membership organisation engaged in a co-operative effort to create open computing specifications in the area of geoprocessing. As part of its draft 'OpenGIS Abstract Specification' OGC has adopted ISO 19115 as the abstract model for metadata management within the consortium. OGC is working closely with FGDC and ISO/TC 211 to develop formal, global spatial metadata standards. At their plenary meeting in Vienna, Austria in March 1999, ISO/TC 211 welcomed the satisfactory completion of the co-operative agreement between the OpenGIS Consortium and ISO/TC 211 and endorsed the terms of reference for an ISO/TC 211 / OGC co-ordination group.

Each of the initiatives is promoting the standards and use of discovery metadata as a foundation of their respective metadata directory initiatives. This discovery metadata provides sufficient information to enable an inquirer to ascertain that existence of data fit for purpose exists and to reference some point of contact for more information. If, after discovery, more detail is needed about individual data sets then more comprehensive and more specific metadata is required. It is possible that organisations may wish to develop metadata at different but complementary levels - at one level discovery metadata for external use and for in-house / internal use more detailed metadata. And to avoid duplication of effort those elements common to both are flagged. These guidelines have been developed with recognition of the importance of more extensive metadata required for data management and each of the organisations is promoting the adoption of ISO Metadata Standard.

General Metadata Standards

Other standards exist in the broader topic of metadata that do not specifically apply to geospatial information. These conventions are listed here for informational purposes. They may be useful references for linking or integrating non-geospatial resources into a geospatial framework.

The Dublin Core is a metadata element set intended to facilitate discovery of electronic resources. Originally conceived for author-generated description of Web resources, it has attracted the attention of formal resource description communities such as museums, libraries, government agencies, and commercial organisations.

The Dublin Core Workshop Series has gathered participants from the library world, the networking and digital library research communities, and a variety of content specialists in a series of invitational workshops. The building of an interdisciplinary, international consensus around a core element set is the central feature of the Dublin Core. The progress represents the emergent wisdom and collective experience of many stakeholders in the resource description arena. Dublin Core metadata is specifically intended to support general-purpose resource discovery. The elements represent one community's concepts of core elements that are likely to be useful to support resource discovery. Unfortunately, the formal use of the Dublin Core metadata model does has not always recognized the inclusion of qualified elements such as “Coverage.” This metadata element thus may contain text that represents a date or time, a description of a place name or time period, or coordinates, without a means to declare what type of content is present in the text element. As such, the Dublin Core unqualified elements are inadequate for even basic geospatial resource description and discovery, though they may be applied to web and library resources with a loose geospatial definition. Qualified Dublin Core elements can be derived from more detailed metadata models (such as ISO 19115) and can support discovery of lightly documented ancillary information such as books, reports, and other Web objects of potential interest to geospatial investigations.

The Spatial Data Transfer Standard (SDTS) and the Vector Product Format (VPF) Digital Exchange Standards (DIGEST) were developed to allow the encoding of digital spatial data sets for transfer between spatial data software. Both of these standards support the inclusion of metadata elements in an exchange, but remarkably have not until recently considered support for standardised the encoding of relevant geospatial metadata standards in their export or archival formats.

While other general-purpose metadata standards exist, it is recommended that a comprehensive geospatial metadata standard should be used to document geospatial data. It is easier to produce simplified metadata from a more robust collection of metadata, but it is impossible to do the opposite. Eventually, the integration of data content and exchange standards will converge with those in metadata content and exchange so that spatial data encoding efforts will provide a comprehensive solution for archive and documentation.

Implementation Approach

Who should create metadata?

Data managers tend to be either technically literate scientists or scientifically literate computer specialists. Creating correct metadata is like library cataloguing, except the creator needs to know more of the scientific information behind the data in order to properly document them. Don't assume that every professional needs to be able to create proper metadata. They may complain that it is too hard and they may not recognise the benefits. In this case, ensure that there is good communication between the metadata producer and the data producer; the former may have to ask questions of the latter to collaboratively develop adequate documentation.

The form for maintaining metadata will depend on a number of factors:

- the size of the data holdings,
- the size of an organisation and
- the patterns of data management within an organisation

If the metadata holdings are fairly modest, then it has been the convention to store the metadata in discrete documents by using any available software (e.g. word-processor, spreadsheet, and simple database). Historically, organisations have built up folders of single documents that may be in either paper or digital formats. Many organisations will start to investigate the use of more complex systems as they realise the benefit of the metadata, and as they gain greater data holdings and start to provide broader access to the data.

Indeed many organisations will start with a basic audit of their data holdings that will alert them of the vast wealth of data that they possess and where it is being used, replicated or improved across the organisation. As the data holdings become larger and the access to the data becomes distributed, then organisations would look at more advanced methods for maintaining metadata of their data holdings. These advanced tools may consist of commercial or selfdeveloped forms based systems that may also form part of the operational GI systems to extract aspects of the metadata automatically from the data itself.

How does one deal with people who complain that it's too hard? The solution in most cases is to redesign the workflow rather than to develop new tools or training. People often assume that data producers must generate their own metadata. Certainly they should provide informal, unstructured documentation, but they may not need to go through the rigors of fully structured formal metadata. For scientists or GIS specialists who produce one or two data sets per year it may not be worth their time to fully learn a complex metadata standard. Instead, they might be asked to fill out a less- complicated form or template that will be rendered in the proper format by a data manager or cataloguer who is familiar (not necessarily expert) with the subject and well-versed in the metadata standard. If twenty or thirty scientists are passing data to the data manager in a year, it is worth the data manager's time to learn the complex metadata standard. With good communication, this strategy complements the existing combination of software tools and training.

The first data set documented is always the worst. The other aspect to "It's too hard" is that documenting a data set fully requires a (sometimes) uncomfortably close look at the data and brings home the realisation of how little is really known about its processing history.

"Insufficient time" to document data sets is also a common complaint. This is a situation in which managers who appreciate the value of GIS data sets can set priorities to protect their data investment by allocating time to document it.

Spending one or two days documenting a data set that may have taken months or years to develop at thousands of dollars in cost hardly seems like an excessive amount of time.

These 'pain' and 'time' concerns have some legitimacy, especially for agencies that may have hundreds of legacy data sets which could be documented, but for which the time spent documenting them takes away from current projects. At this point in time, it seems much more useful to have a lot of 'shortcut' metadata rather a small amount of full-blown metadata. So what recommendations can be made to these agencies with regard to a sort of 'minimum metadata' or means to reduce the documentation load?

In some operations, small amounts of metadata, or “notes” are collected sporadically during the data processing flow. These hints can then be assembled more readily later into a clear statement of the history and processing of the dataset. This can present a less daunting task at the end of a project as most of the details are already documented, a little at a time. Increasingly, GIS and image processing software are capable of collecting and reporting quantitative metadata that can be filled-in for the user rather than expecting human input. These procedures can amount to significant savings in overall time and effort over a single manual metadata preparation process at the conclusion of a project.

Don't invent your own standard. Select a supported international standard wherever possible. Try to stay within its constructs. Subtle changes from an international standard such as collapse of compound elements may be costly in the long run - you won't be able to use standard metadata tools and your metadata may not be directly exchangeable or paresable by software.

Don't confuse the metadata presentation (view) with the metadata itself. There is a temptation to lump form and content into the same bin (e.g. "What I see in my database is what I print"). However, the ability to differentiate the contents of the metadatabase (the columns or fields) from its presentation (writing formatted reports) is now commonplace in desktop database software packages. This allows users to consider more flexibly how to present what information.

There are typically three forms of metadata that should be recognized and supported in systems: the implementation form (within a database or software system), the export or encoding format (a machine-readable form designed for transfer of metadata between computers), and the presentation form (a format suitable to viewing by humans). By recognizing the connections between these dispositions of metadata, one can build systems that support mission requirements, standard encoding for exchange, and permit many “report” views of the metadata to satisfy the needs and experience of different user constituencies.

The Extensible Markup Language (XML) provides two solutions to this metadata problem. First, it includes a capable markup language with structural rules enforced through a control file to validate document structure. Second, through a companion standard (XML Style Language, or XSL), an XML document may be used along with a style sheet to produce standardised presentations of content, allowing the user to shuffle field order, change tag names, or show only certain fields of information. Used together XML and style sheets allow for a structured exchange format and for flexible presentation. Thus, a metadata entry can be rendered in many ways from the same, single structured encoding.

XML is a widely accepted encoding methodology with international software support. It is supported by a lot of software, both free and commercial. However, the metadata-producing community doesn't have much experience using it to solve problems yet. Through reference implementations of software and experimentation, local Spatial Data Infrastructures can share their successes and failures in applying this new technology to fullest community benefit.

Consider data granularity. Can you document many of your data sets (or tiles) under an umbrella parent? Prioritise your data. Begin by documenting those data sets that have current or anticipated future use, data sets that form the framework upon which others are based, and data sets that represent your organisation's largest commitment in terms of effort or cost.

Document at a level that preserves the value of the data within your organisation. Consider how much you would like to know about your data sets if one of your senior GIS operators left suddenly in favour of a primitive lifestyle on a tropical island.

How do I create metadata?

First, one should understand both the data you are trying to describe and the standard itself. Then one must decide how you to encode the information. Historically, one creates a single text file for each metadata record; that is, one disk file per data set. Typically a software program is used to assist the entry of information so that the metadata conform to the standard.

Specifically:

- Define exactly what data packaging is to be documented.
- Assemble information about the data set.
- Create a digital file containing the metadata, using a standard format whenever possible
- Check the syntactical structure of the file. Modify the arrangement of information and repeat until the syntactical structure is correct.
- Review the content of the metadata, verifying that the information describes the subject data completely and correctly.

A digression on conformance and interoperability

The various metadata standards are truly content standards. They may not dictate the layout of metadata in computer files. Since the standard is so complex, this has the practical effect that almost any metadata can be said to conceptually conform to the standard; the file containing metadata need only contain the appropriate information, and that information need not be easily interpretable or accessible by a person or even a computer. This is the case even with the ISO 19115 International Standard.

This rather broad notion of conformance is not very useful. Unfortunately it is rather common. To be truly useful, the metadata must be clearly comparable with other metadata, not only in a visual sense, but also to software that indexes, searches, and retrieves the documents over the Internet. To accomplish this, there are several encoding standards that specify the content of a metadata entry for exchange between computers, For real value, metadata must be both parseable, meaning machine-readable, and interoperable, meaning they work with software used in services such as the FGDC Clearinghouse through OpenGIS Catalogue Services. Fortunately, the companion ISO 19139 Technical Specification provides normative guidance in the form of an annotated XML Schema Document (XSD), and by example, as to how the metadata must be structured as XML for validation and exchange.

Parseable

To *parse* information is to analyse it by disassembling it and recognising its components. Metadata that are parseable clearly separate the information associated with each element from that of other elements. Moreover, the element values are not only separated from one another but are clearly related to the corresponding element names, and the element names are clearly related to each other as they are in the standard.

In practice this means that your metadata are usually arranged in a hierarchy, just as the elements are in the standard, and they must use standard names for the elements as a way to identify the information contained in the element values.

Interoperable

To operate with metadata service software, your metadata must be readable by that software. Generally this means that they must be parseable and must identify the elements in the manner expected by the software.

There is a general consensus that metadata should be exchanged in Extensible Markup Language (XML) conforming to a Document Type Declaration (DTD) or, even more rigorous, its more modern successor, the XML Schema Document. Support for XML in parsing and presentation solutions is widespread on the Web and is presumed in current draft standards of the ISO TC 211 and OpenGIS specifications.

What software is available to create and validate metadata?

No tool can check the *accuracy* of metadata. Moreover, no tool can determine whether the metadata properly include elements designated by the Standard to be conditional, or 'mandatory if applicable.' Consequently, some level of human review is required. But human review should be simpler in those cases where the metadata is known to have the correct syntactical structure.

Software cannot be said to conform to the Standard. Only metadata records in a given encoding form can be said to conform or not. A program that claimed to conform to the Standard would have to be incapable of producing output that did not conform. Such a tool would have to anticipate all possible data sets. Instead, tools should assist you in entering your metadata, and the output records must be checked for both conformance and accuracy in separate steps. At best one can describe or anticipate compatibility testing among software components.

Issues in Implementation

Vocabularies, Gazetteers and Thesauri

When searching for information, the inquirer may not find any references based on the words used to describe the information sought. This problem can be overcome by use of a thesaurus. In the context of metadata and other electronic documents, a thesaurus is a tool for the organisation and retrieval of information in electronic materials. It allows data to be indexed and retrieved in a consistent manner. It permits the display of hierarchies of concepts and ideas, leading the user, whether as indexer or information seeker, to define his or her search in terms that are most likely to lead to the retrieval of relevant information.

For example, it will allow improved information retrieval by providing successful searching on synonyms - if the user enters the term "farming" the thesaurus will find the term "agriculture". Hierarchies of meaning can be shown - the term "Great Britain" may retrieve data indexed with that term but could also expand the search to retrieve data on England, Wales and Scotland which have been indexed under those three terms. The term "meals on wheels", although in a hierarchy of terms related to food, could also be linked to concepts relating to personal social services and to the different categories of recipients and a user can elect to follow and retrieve these related terms. Consistent searching for metadata will be achieved if all those who prepare metadata use the same thesaurus.

Minimum collaboration with users during the definition and implementation phases: a user-friendly focus is needed

For a non-professional user, finding the information wanted is very difficult. Even if 'Help' or 'Tutorial' can be found in some metadata services, it is not very easy to understand what to do and where to type. Efforts must be made to explain what to ask for and to develop user-friendly and multi-lingual interfaces. If it takes too much time to understand how to react to metadata services, users will not stay long and will immediately complain! A dictionary, multilingual thesauri or catalogues with keywords, should be provided to users to ensure that the same vocabulary is used. One of the most important things is to develop services that are not technology dependent and technology driven. Projects must be done in collaboration with users (who must first be identified).

User-expected content

Given the complex metadata models deployed, we can be reasonably certain that the metadata that is now presented from catalogue services is almost always more than is expected by end users. It seems that the current tendency is to propose a complex database approach that seems to be very 'data producer oriented'. One can imagine that users are more interested in examples and benefits on how to use the proposed data sets than a detailed description of its structure and content. This can be accomplished through special presentations of metadata.

It is important to separate the content of spatial metadata with its means of presentation. Through applications such as the Extensible Markup Language (XML), documents with extensive detail can be rendered through different style sheets from one content source into many presentation forms suitable to different audiences. Further work on developing presentation methodologies is required to simplify the burden of understanding metadata by all.

Metadata for applications

There is a tendency to adapt the metadata structure and content to applications, for example, electronic commerce or data management within an organisation. Metadata that is created to satisfy a real need, rather than because it is seen as something that should be done in the general interest, is more likely to be well-written and maintained.

The OpenGIS Consortium and ISO TC 211 have developed metadata structures and fields to describe software interfaces, exposed as "services" for external use. ISO 19119 describes the structure of services metadata to help intelligent software, through brokers known as service catalogues, to discover available services that could ultimately be chained together to form new composite operations. The World Wide Web Consortium and Oasis XML groups have specified service and resource discovery mechanisms that exploit a published set of metadata fields. Two of these efforts are known as the ebXML with its Registry Information Model (ebRIM) and the Universal Description, Discovery, and Integration of Web Services (UDDI). The suggested interaction between ebXML, ISO metadata, and OGC catalogue service interfaces is being harmonized in OGC Catalog Services Version 2.0.

A geographic information product identification mechanism

There is no current mechanism to provide identification numbers (ID) to the different GI products produced and offered to users. This missing element is a very important issue for those who are implementing in parallel a metadata service and an e-commerce solution.

To make the e-commerce of GI a reality a study on how a GI numbering system could be organised and implemented and by whom should be made. This system could be similar to the ones used for other products, such as books. It would be extremely helpful if the Global Spatial Data Infrastructure activity could develop initial guidance on the technical and political issues involved in establishing a data product identifier system that will work globally on digital and non-digital geospatial information.

Incentives for metadata development

The impressive list of incentives which includes financial resources, knowledge and expertise, standard and tools provided by the FGDC (U.S. Federal Geographic Data Committee - http://www.fgdc.gov) to stimulate the creation and maintenance of metadata content and services within the concept of the Clearinghouse appeared to be a key success factor of the U.S. metadata initiative. It is important that national and regional governments evaluate, recognize, and provide such incentives to metadata builders and managers. Some have started – France, Canada, Australia, Spain, Ethiopia, the United States and other countries develop and provide free software and to metadata builders. It is anticipated that the widespread adoption of the ISO 19115/19139 metadata standards will further encourage the development of an international base of free and commercial tools around a common standard.

Envisage legislation for public sector metadata content

In countries where legislation is the main engine for creating new or adapting existing public sector activities, new laws may be needed to encourage or require the collection and distribution of standards-based metadata by the GI public sector and by commercial enterprises that collect geospatial data for the public sector.

Recommendations

- ***The Cookbook authors recommend that you don't invent your own standard. Adopt or build a national profile of the ISO 19139 Technical Specification based on the abstract ISO 19115 metadata standard.***

Standards are very expensive to create and build implementations for. National standards should be adopted with the intention of supporting the ISO 19115 metadata content standard and its companion, Technical Specification ISO 19139, when it becomes available. This will provide the greatest interoperability rewards in a global environment.

- ***The Cookbook authors recommend that you prioritise your data.***

Begin by documenting those data sets that have current or anticipated future use, data sets that form the framework upon which others are based, and data sets that represent your organisation's largest commitment in terms of effort or cost. Framework layers and special, unique layers of great interest should be adequately documented for use within your organisation and by those on the outside. Of course, all published data warrant documentation this way, but through setting priorities you will know what work you have ahead of you.

- ***The Cookbook authors suggest collecting metadata a little at a time.***

For detailed metadata such as FGDC and ISO, an enormous amount of possible information can be collected. Although all fields are never filled in, it provides an opportunity to store specific properties in their correct location within the standard structure. This facilitates their storage and discovery in catalogues (See Chapter 4). If certain types of metadata are collected during the data collection process as part of the current workflow, then many 20-second notes can amount to a substantial story later on. This type of information cannot be easily collected after the fact.

- ***The Cookbook authors recommend the development of a coordinated spatial data product identifier system for use globally***

The GSDI Technical Working Group with policy assistance from the Steering Committee should develop initial guidance on the technical and political issues involved in establishing a data product identifier system that will work globally on digital and non-digital geospatial information. Uniquely identifying metadata records themselves is a practice from the library community in which a single metadata record may be shared to reflect its availability in many locations.

- ***The Cookbook authors suggest that research into a common thematic classification system for geospatial data be conducted by the Technical Working Group of the GSDI.***

Whereas ISO TC 211 is developing general specifications and methodologies, and the OpenGIS Consortium is building software interfaces, no convened global organisation is known to be co-ordinating a common classification system for geospatial data. As a result, the use of competing thematic thesauri make distributed search difficult.

References and Links

Chenez, Christian and Gaël Kermarrec, "On-going Metadata Initiatives in Europe", 1999, 5th EC-GIS Workshop, Stresa, ITALY http://www.eurogi.org/geoinfo/publications/5thgeo.html

Metadata Home Page, US Federal Geographic Data Committee http://www.fgdc.gov/metadata/metadata.html

Metadata Home Page Australia and New Zealand Land Information Council http://www.anzlic.org.au /infrastructure_metadata.html

Metadata (MetaGenie) Home Page UK Association for Geographic Information (AGI), http://www.askgiraffe.org.uk /datalocator/metadatatool.html

Reference Data and Metadata, INSPIRE Initiative, European Commission, http://inspire.jrc.it/about/reference.cfm

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[1] *In 1994 the International Standards Organisation created technical committee 211 (ISO/TC 211) with responsibility for Geoinformation/Geomatics. They are finalizing a family of standards; this process involves a working group, the development of one or more committee drafts, a draft international standard, and finally the international standard.*

Many common work items now exist between the OpenGIS Consortium and ISO TC 211 that will lresult in OGC specifications being balloted as International Standards or Technical Specifications.

Chapter 4

From The SDI Cookbook

Contents

Chapter 4: Geospatial Data Catalogue: Making data discoverable

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Introduction

An increasing volume of information is now considered critical to everyday decision making in modern society -- a large portion of this information is essentially related to "place" in the context of position on the Earth. As more online information includes some geographic context, the ability to describe, organise, and access it has become increasingly difficult. The ability to discover and access geographic data resources for use in visualisation, planning, and decision support is a requirement to support societies at the local, regional, national, and international levels. Common solutions have been developed and will be described in this Chapter by evaluating organisational approaches, comparing definitions of community, identifying common architectural solutions, and sharing a base of techniques that are implemented in available noncommercial and commercial standards-based software.

This Chapter presents the concepts, current practices, and designs for geospatial data discovery. It is intended as a guide to those interested in the management, development, and implementation of compatible discovery services in environments where the cross-domain publication of geographic information is desired. Organisational issues and roles are presented that are critical to the understanding and maintenance of the services within a larger spatial data infrastructure. The principles described herein can be interpreted and applied in a range of information management conditions from non-digital collections of map information, through small digital catalogues, to integrated repositories of data and metadata. Relevant standards and software are identified for evaluation and application.

Context and Rationale

Although the Internet is becoming the world's largest repository of knowledge, its navigation is hindered by the lack of a surrogate and comprehensive catalogue. As a result, one is delivered tens of thousands of candidate documents in response to a reasonable query from today's search engines. Fortunately, geographic information frequently has signatures of location in the form of coordinates or place names and even may have a reference date or time associated with the data. These metadata provide a key to a solution that can and does operate in an international context.

The library has long formed the primary metaphor for accumulation and management of knowledge about people, places, and things. Since the construction of the ancient library in Alexandria, Egypt to its modern day equivalents, libraries have employed classification systems, specialisation, and discipline to information in all forms. A central feature in this virtual library – and a critical part to its navigation and use – is the catalogue. In the context of geospatial information management, we use the descriptions of geospatial data, or metadata, as described in Chapter 2 as the common vocabulary to frame the structured fields of information that we seek to manage and to use in search and retrieval. These metadata elements are stored and served through a user-accessible catalogue of geospatial information.

Support of a discovery and access service for geospatial information is known variously within the geospatial community as "catalogue services" (OpenGIS Consortium), "Spatial Data Directory" (Australian Spatial data Infrastructure), and "Clearinghouse" and the "Geospatial One-Stop Portal" (U.S. FGDC). Although they have different names, the goals of discovering geospatial data through the metadata properties they report are the same. For the purpose of consistency within this document, these services will be referred to as "catalogue services." Further integration of these services with web mapping, live access to spatial data, and additional services can lead to exciting user environments in which data can be discovered, evaluated, fused, and used in problem-solving. Whereas this chapter will focus on finding spatial data and services, combination of the practices described here with those in other chapters can expand the capabilities of your spatial data infrastructure.

Distributed Catalogue Concepts

The Catalogue Gateway and its user interface allows a user to query distributed collections of geospatial information through their metadata descriptions. This geospatial information may take the form of "data" or of services available to interact with geospatial data, described with complementary forms of metadata. Figure 4.1 shows the basic interactions of various individuals or organisations involved in the advertising and discovery of spatial data. The boxes are identifiable components of the distributed catalogue service; the lines that connect the boxes illustrate a specific set of interactions described by the words next to the line.

A user interested in locating geospatial information uses a search user interface, fills out a search form, specifying queries for data with certain properties. The search request is passed to the Catalogue Gateway and poses the query of one or more registered catalogue servers. Each catalogue server manages a collection of metadata entries. Within the metadata entries there are instructions on how to access the spatial data being described. There are a variety of user interfaces available in this type of Catalogue search in various national and regional SDIs around the world. Interoperable search across international Catalogues can be achieved through use of a common descriptive vocabulary (metadata), a common search and retrieval protocol, and a registration system for servers of metadata collections.

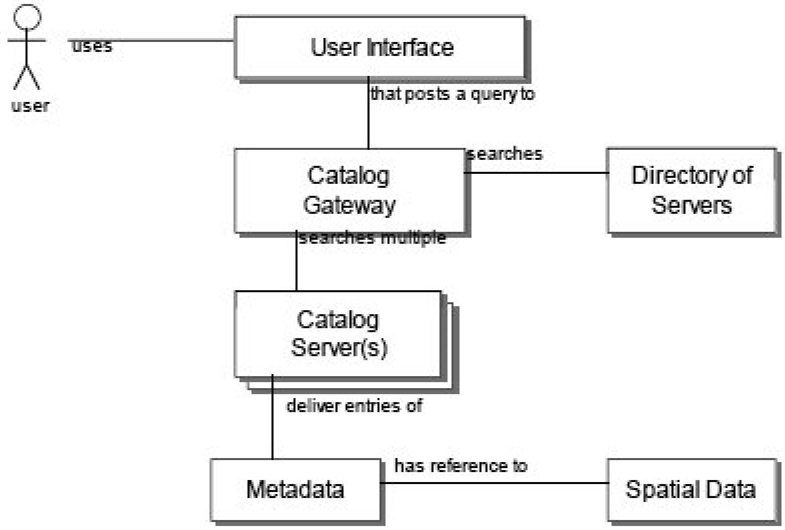

Figure 4.1 - Interaction diagram showing basic usage of distributed catalog services and related SDI elements from a user point of view.

The Distributed Catalogue environment is more than just a catalogue of locator records. The Distributed Catalogue includes reference and/or access to data, ordering mechanisms, map graphics for data browsing, and other detailed use information that are provided through the metadata entries. This metadata acts in three roles: 1) documenting the location of the information, 2) documenting the content and structures of the information, and 3) providing the end-user with detailed information on its appropriate use. A traditional catalogue, as found in the modern library, provides only locational information. In the era of digital data, the edges between the data or services and the catalogue can become blurred and permit the management of extended information called metadata that can be exploited by computer software and human eyes for many uses.

Organisational Approach

Who are the individuals or actors involved in the publication and discovery of geospatial information? By defining the roles and responsibilities that these actors play, one can understand the essential functions that human or computer-assisted services should be able to conduct in the interest of resource discovery for the GSDI.

Terminology:

Data Set - a specific packaging of geospatial information provided by a data producer or software, also known as a feature collection, image, or coverage.

Metadata - a formalised set of descriptive properties that is shared by a community to include guidance on expected structures, definitions, repeatability, and conditionality of elements.

Metadata Entry - a set of metadata that pertains specifically to a Data Set.

Catalogue - a single collection of Metadata Entries that is managed together.

Catalogue Service - a service that responds to requests for metadata in a Catalogue that comply with certain browse or search criteria.

Catalogue Entry - a single Metadata Entry made accessible through a Catalogue Service or stored in a Catalogue.

Service Entry - the metadata for an invokable service or operation, also known as operation or service metadata.

Roles

Figure 4.2 shows interactions between the Actors, the functions they perform, and the objects they interact with. The illustration uses Unified Modeling Language (UML) notation to picture processes from a functional point of view.

Originator of the Metadata Entry -- The responsibility of this Actor is to generate conformant metadata elements packaged so they accurately reflect the contents of the information being described. The role and credentials of the person responsible for the creation of this metadata may vary among organisations. In some situations the originator may be the scientist involved in building the data set being described. In others, the originator may be a contractor or second party who was directed to create the data or the metadata based on some project requirements, or it may be a generic description created by a production-oriented organisation without mention of the names of individuals involved in its creation. Given the rarity of metadata still, it is also a common practice for a third party to interpret or derive a metadata entry from available information where formal metadata has not yet been created.

Contributor to the Catalogue -- The responsibility of this Actor is to provide one or more conformant metadata entries to a Catalogue. Metadata entries may be delivered in proper format, derived from other formats, or developed from information stored in data and software systems. S/he interacts with the management functions of the Catalogue Service that permit a metadata entry to be entered, updated, deleted, or to assign levels of access or viewing privilege.

Catalogue Administrator -- The responsibility of the catalogue administrator is to manage the metadata for access by the Users. The maintainer or keeper of the metadata may be the same as the contributor, it may be a collecting organisation acting on the authority of an entire organisation (e.g. librarian or web site content manager), or it may be a different party who has acquired metadata in some form and is providing public access to it. The Custodian authorises access to the Catalogue Service for Management functions including entry, update, or deletion, manages authorisation details, and may perform some quality assurance evaluation on entries. The Custodian may also manage external (client) access to the Catalogue if it is not publicly accessible.

Catalogue User -- The responsibility of this user is to define criteria by which geographicallyrelated information could be located and used through use of Browse categories or posing a fielded or full-text query. This user may or may not be GIS-literate, but with the Internet is likely to not be familiar with or possess GIS or image processing software. This User may have a weak understanding of geography. Another common method of catalogue access may be through a program to discover and work with Catalogue information. The interaction occurs at the software level and assumes a documented interface (e.g. application programming interface) for submitting requests to and receiving responses from a Catalogue.

Gateway Manager -- the responsibility of the manager is to develop, host, and maintain the distributed search capabilities within the user community. This may also include management of or contribution to a directory of servers (registry) that participate in the national or regional SDI.

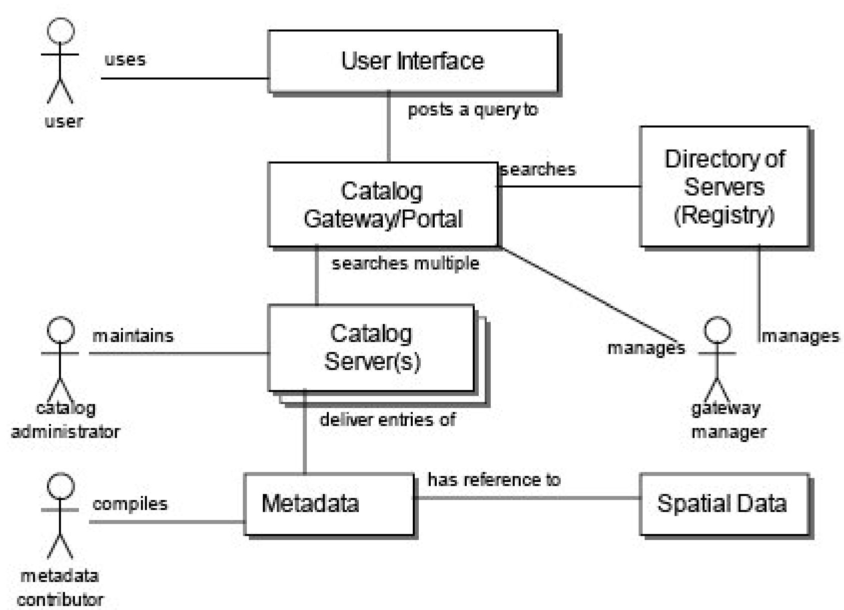

Figure 4.2 - Interaction diagram showing basic usage of catalog services and related SDI elements.

Using the actors from Figure 4.2 as described in the text, the following sections will describe the organisational or operational management requirements for distributed catalogue services compatible with the GSDI based on the following areas of interest

Catalogue Service development Catalogue gateway and access interfaces Registering participants

Each section will include a Use Case to focus on the roles and actions that should be considered in creating a discovery component of your SDI.

Catalogue Server/Service Development

The Distributed Catalogue services assume some degree of distributed ownership and participation. Similar activities on the Internet have taken a fully centralised approach to metadata management by placing all metadata in an index on one server, or in several replicated servers. In an increasingly dynamic data management environment, the synchronisation between detailed metadata and such an index becomes increasingly difficult. This problem is experienced on a daily basis when conducting searches on Web search engines and getting a “404: File not found” error when a document has been moved or changed. In addition we are seeing a migration toward treating metadata and data as interrelated and even being managed together within a single database. To duplicate this metadata in an external index can be costly and invites problems with synchronisation of the data, its metadata, and the externally indexed metadata. Organisations who already manage spatial data and are interested in publishing it are often the most capable candidates for publishing and maintaining the metadata. Metadata co-located with data on a server tend to be more current and detailed than metadata published to an external index (harvested and indexed off-site).

The construction of a catalogue service capability for geospatial information is built upon on the commitment to collect and manage some level of geospatial metadata within an organisation. The following Use Case scenario describes the publishing of a metadata entry.

A **contributor of metadata** receives the description of a new spatial data set developed by other professional staff. This metadata is generated in a transferable encoding format to allow exchange of the metadata without loss of context or information content. This metadata entry is passed to a **catalogue administrator** for consideration and loading to the catalogue. The **catalogue administrator** applies any acceptance criteria on the quality of the metadata as required by the organisation. If the metadata are acceptable it is inserted into the catalogue. The **catalogue administrator** then updates the catalogue to reflect the new entry as available for public access. This data set is now considered advertised because its metadata provide a searchable and browseable record of its background, its temporal and spatial extent, and many other searchable characteristics.

There are several models for where Catalogue services might be installed within or among organisations. Generally speaking, a catalogue server is usually installed at the level of organisation appropriate to the nature of the data or metadata, the organisational context or mandates, and the level at which a catalogue can be operationally supported.

Consortium Approach -- The consortium model is one where a single metadata catalogue is built and operated at one location and is shared by multiple organisations with a common discipline or geographic context. Metadata are exported from contributors and are forwarded to the common site where they may be evaluated, loaded, and made publicly accessible. This model may work well where there are personnel and computer access constraints and a shared service provides or extends outreach. The consortium approach also encourages collaboration between participants in building a collective data and metadata resource base across the organisations. The liabilities of this approach may include managing complexity and contributions from many sources and being sure that metadata provided stay synchronised with the data being described. Data might not be co-located with the catalogue service but may be referred to at contributor locations. Corporate Approach -- The corporate model assumes that all metadata are forwarded within an organisation to a single service at which time corporate issues of quality, publication, style, and content may be evaluated. This model allows personnel and networking resources to be focused on developing and managing a single service and computer within an organisation. Some degree of policy must be established within the organisation for the collection and propagation of the metadata to the corporate host. This model is well-suited to organisations who may be restricted to providing a single public access computer for security reasons. The liabilities of this approach may include managing contributions from many sources within the organisation and being sure that metadata provided stay synchronised with the data being described. Data may be co-located with the catalogue service or may be referred to at contributor locations.

Workgroup Approach --The workgroup model assumes that a service would be established at each place within an organisation where data are collected, documented, managed, and served. This follows the trend on the Internet in which virtually anyone on a connected network can be considered a "publisher" of information. The workgroup model also assumes that the individuals and groups most closely associated with the collection and revision of the information are also involved in its catalogue and service. This can lead to a high degree of synchronisation between the data and their metadata -- in some cases, data and metadata warehouses could be completely integrated. The liabilities of this approach may include technical expertise in catalogues at the local level and coordination issues across a given organisation.

Because of the nature of the distributed catalogue and its ability to search many servers, all of the suggested models listed are equally viable. In fact, close reading of the model descriptions will show that they represent a continuum of organisational choices that vary in complexity, governance, and the degree of integration with the data being described.

Alternative Approaches

The operational design of a distributed catalogue as described above, depends in large part on the ability for clients to use the proposed services. Globally, access to computers and communications networks supporting Web applications is still available to a small minority of the population. While this is changing in almost all regions through providing community public access points, building and subsidizing network construction and interconnection, the distributed catalogue may not be well suited to conditions in many developed and developing countries where the Internet is not yet common or bandwidth is lacking. There are two solutions that have been prototyped and are suitable for public information access in such environments.

For organisations and clientele who have limited access to computers or networks, metadata can be reprocessed and printed and distributed as paper catalogues. Printing and distribution costs may be significant but a wide audience can be reached through public libraries and organisations interested in using spatial data in decision making. Synchronisation with current data content and holdings in such paper catalogues may also be an issue. Paper distribution of catalogues can always be considered a supplement to digital information service methods.

If Internet services are present and available to the public but network bandwidth within the region of interest is limited, individual catalogues may wish to support harvesting of metadata from remote sites in "mirror" catalogues, or “metadata caches”. A good example of this would be for supporting regional data discovery across multiple servers in different locations whose connections are low-speed. If each catalogue posted its metadata in a Web-accessible directory, a crawler or harvester program could retrieve and index metadata from other sites into a regional or replicate index. This methodology is being demonstrated in the United States to provide a single synchronized point of access to metadata that are fetched from a small to moderate number of sites. Note that this still suggests that the combined collection itself is still behind a server with a common interface, but potentially fewer standing servers are required in this architecture. At the extreme end of this design one could envision a few large metadata repositories with common search interfaces. Primary concerns about the scalability of this approach include supporting extremely large searchable metadata indexes and the synchronization of the indexes with remotely held metadata and data. It is not likely that this approach would scale to support a single global collection of metadata using current technologies although Web search engines are capable of such searches but lack geographic awareness.

In environments where both data providers and clients have access to computers but not reliable networks, the creation of CD-ROM or DVD media with searchable metadata (and perhaps even data) is another outreach mechanism. Creation of digital media with metadata and data will be of greatest benefit where standard metadata and data approaches are followed, and a catalogue (software and data) could be placed on the media to minimise the cost of deployment where a catalogue already exists.

These alternatives should be viewed as approaches that supplement the catalogue services recommendations described in this Chapter until such time as the information is accessible to the majority of intended clients via the Internet. Use of the catalogue services will immediately enable international academic, commercial, and governmental use of such information for regional analysis issues.

Catalogue Gateway and Access Interface Development

Within a given geographic or discipline-based community, the need will exist to build relevant search capabilities that facilitate intuitive search across many servers. This problem can be divided into two related parts that must interrelate -- a user interface (*Search/Browse Interface, fig 4.2*) and a query distributor (*Catalogue/Gateway Portal, fig 4.2*). When performed across the Internet, these functions may be logically deployed in different locations although they tend to be coupled together in server-based or client-based search solutions.

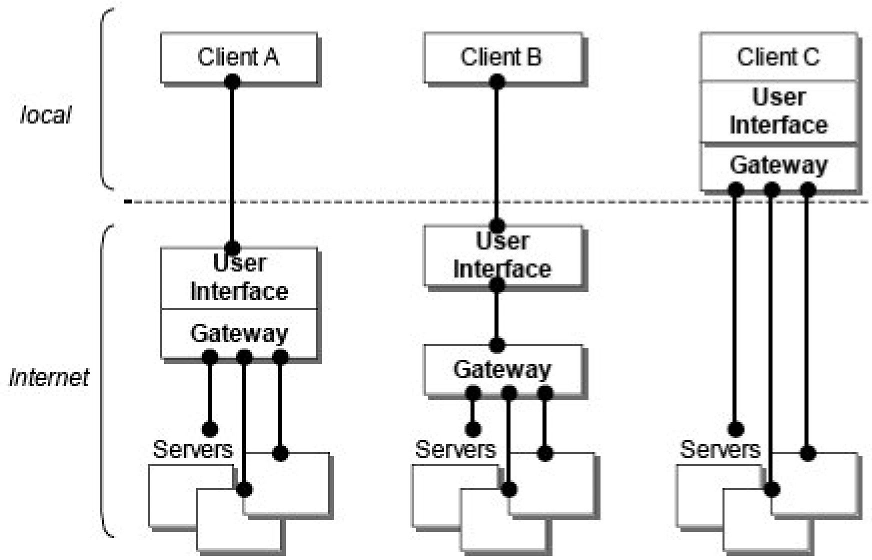

Figure 4.3 - Configuration options for Gateway and User Interfaces to Distributed Catalog

Figure 4.3 shows the possible configurations of a catalogue gateway and the user interface. Client A accesses a user interface that is downloaded (as forms or an applet) from a host on the Internet that is also managing multiple connections to servers. Client B is accessing a user interface from a location that is different from that of the Gateway supporting the construction of customised user interfaces for a community. Client C is a client-side "desktop" application that is fully self-contained and includes the user interface and distributed query capabilities for direct connection to remote servers. What is not known on this diagram is the dependence on or reference to a registry or Directory of Servers, as shown in Figure 4.2, which is further explained in the next section. All three styles of interaction are known to exist in various SDIs. Because they all depend upon distributed catalogue servers the three approaches are fully compatible.

Two styles of interaction are known to exist in Web search interfaces that are equally well applied to distributed catalogue access. The first style is query in which the user specifies search criteria for search using simple to advanced interfaces. The second style is a browse interface in which the user is presented with categories of information and selects paths or groupings, often in hierarchical form, to traverse.

The search approach to interaction with distributed catalogues can provide extra precision for advanced users in selecting spatial data of interest. It often is implemented in iteration to discover what effects individual parts of a query have on the pattern of results returned. The browse approach has great appeal to novice users who may wish to navigate by reference without knowing proper search words or fields *a priori*. The challenge of constructing and supporting browse mechanism across a global collection of servers is the work required in building and supporting a universal vocabulary for classification and its hierarchy or word space, known as an ontology. As this service lies at the intersection of many disciplines of interest, the construction of a single classification system is an extremely daunting and improbable task. Intelligent classification systems that are run externally on collections using neural networks, Bayesian probablitiies, and other estimates of "context" may be available in the coming years to help users navigate through heterogeneous geospatial information.

A Use Case scenario for a query user is as follows:

1. A User uses client software to discover that a distributed catalogue search service exists. 2. User opens the user interface and assembles the query elements required to narrow down a search of available information. 3. The search request is passed to one or more servers based on user requirements through a gateway function. The search may be iterative, repeating or refining queries based on new interactions with the user. 4. Results are returned from each server and are collated and presented to the User. Types of response styles may include: a list of "hits" in title and link format, a brief formatting of information, or a full presentation of metadata. Visualisation of multiple results may also be available through display of data set locations on a map, thematic groupings, or temporal extent. 5. User selects the relevant metadata entry by name or reference and selects the presentation content (brief, full, other) and the format (HTML, XML, Text, other) for further review. 6. User decides whether to acquire the data set through linkages in the metadata. By clicking on embedded Uniform Resource Locators (URLs) the user can directly access online ordering or downloadable resources, whereas distribution information lists alternate forms of access.

A User Case scenario for a browse user is as follows:

1. A User uses client software to discover that a distributed catalogue search service exists. This may be done through a search of Web resources, a saved bookmark, reference from a referring page, or word-of-mouth referral. 2. User opens the user interface and selects the parameters required to narrow down a search of available information based on topics/subjects, organisations, geographic location, or other criteria. Parameters are usually grouped into hierarchies for the user to navigate. 3. Requests are made to each server through a distributed request mechanism. 4. Results from each server are collated and presented to the User. Form of organisation of results is controlled by the user interface and gateway collaboration to present a uniform result space. 5. User selects the relevant metadata entry by name or reference and selects the presentation content (brief, full, other) and the format (HTML, XML, Text, other) for further review. 6. User decides whether to acquire the data set through linkages in the metadata. By clicking on embedded Uniform Resource Locators (URLs) the user can directly access online ordering or downloadable resources, whereas distribution information lists alternate forms of access.

Registering Catalogue Servers

The nature of distributed catalogues requires that the knowledge of the existence and properties of any given catalogue participating in a community be known to the community. In support of GSDI concepts, the need for a dynamic and comprehensive directory of services including catalogue servers is ever more important. The directory of servers concept allows an individual catalogue operator to construct and register service metadata with a central authority. This registry is then a searchable catalogue in its own right so that software may discover suitable catalogue targets based on their predominant geographic extent, descriptive words or classification, country of operation, or organisational affiliation, among other properties. Already national listings of compatible catalogue servers have been built, but the operation of a global network of catalogue servers within GSDI will require that a common directory of servers be built and managed to assure current content, distributed ownership, and authoritative reference to servers.

The features of the directory of servers may include:

- One descriptive entry per service collection (server metadata)
- Ability for a donor to contribute or update a record in the directory
- Ability to validate access to a server, as advertised
- User browse access of online server metadata
- Software search access of server metadata
- Management of active/inactive records, accessibility statistics

Several national distributed catalogue activities support management services for server-level metadata and contain references to servers predominantly in their country. The GSDI now sponsors a global directory of catalogue servers for all countries to utilise, with delegation of authority made to participating countries to manage and validate host information for their servers (http://registry.gsdi.org/registry) but it does not provide for the cataloguing of all service types at this time. The UDDI (http://www.uddi.org) offers the potential of a public, replicated “universal business registry” hosted by IBM, Microsoft, and SAP, that could be used by SDI publishers to advertise the existence of their services. Research into the use of the UDDI as a service directory for the GSDI is underway.

Relevant Standards

The GSDI distributed catalogue has been designed with maximum reliance on existing technologies and standards. Because of this, existing software can be re-utilised or adapted to support geospatial information without requiring special investment in new technologies. Key standardisation efforts in access to catalogues are found in the ISO 23950 Search and Retrieve Protocol, the OpenGIS Consortium Catalogue Services Specification Version 1.0, and relevant standards or "recommendations" of the World Wide Web Consortium (W3C).

ISO 23950, also known as ANSI Z39.50, is a search and retrieval protocol developed initially in the library community for access to virtual catalogues. Key features of the ISO 23950 protocol include:

- Support of registered public "field" attributes for query across multiple servers where they may be mapped to private attributes
- Platform-independent implementation over TCP/IP using ASN.1 encoded protocol data units
- Ability to request both content (known as Element Sets or groups of ‘fields’ such as Brief or Full) and presentation format (Preferred Syntax, e.g. XML, HTML, text)
- GEO (Geospatial Metadata) Profile with registered implementation guidance for current FGDC and ANZLIC metadata and soon to include ISO 19115 metadata elements

The use of a generalised query protocol on ISO 23950 permits a migration from national forms of metadata to future forms being developed through international consensus under ISO Technical Committee 211 and their draft metadata standard 19115. Even though the metadata standard will change, the GEO Profile specifies the meaning of search fields in a way they can be mapped to multiple metadata schemas where compatible elements exist. Under the GEO Profile search of international metadata can be achieved today across collections in the United Kingdom, the United States, Africa, Canada, Latin America, and Australia in a single search, even though different underlying local metadata models exist.

The OpenGIS Consortium published a Catalogue Services Specification in 1999 that provides a general model for geospatial data discovery through a catalogue that includes management, discovery, and data access services. These general services are described for implementation in the OLEDB, CORBA, and ANSI Z39.50 (ISO 23950) environments. The management functions include the ability to specify interfaces for creation, entry, update, and deletion of metadata entries to a catalogue. The discovery functions include the ability to search for and retrieve metadata entries from a catalogue with embedded references within the formal metadata to on-line data access, where available. The access functions support extended access to or ordering of spatial data based on references established in the metadata. Only the discovery functions are deemed mandatory in the Catalogue Services implementations; guidance is provided for implementation of optional management and access (really ordering) in interoperable ways.

At the OGC meeting in Southampton, U.K., a common catalogue services approach was presented and demonstrated that built upon the essential search and retrieval model of ISO 23950. Initial implementation specifications in Version 1.0 of the Catalogue Services Specification were submitted for CORBA, OLEDB, and ISO 23950. Distributed parallel search across these different protocols was demonstrated through an extension of commerciallyavailable gateway software.

A Web-based HTTP Protocol Binding for Catalogue search is being published in Version 2.0 of the OGC Catalogue Service Specification. OGC Testbed activities have shown the popularity of the HTTP-based approach to catalogue services that still applies the basic tenets of ISO 23950. Known variously as the “Stateless Catalog” and the “Web Registry Service” this protocol binding will be known as the “Catalogue Service – Web (CS-W)” and will complement the CORBA and ISO 23950 bindings defined in Version 1.1.1.

The International Standards Organisation (ISO) has a Technical Committee, TC 211, dedicated to the standardisation of abstract concepts relating to geospatial data, services, and the geomatics field in general. The International Standard for metadata (ISO 19115) provides a comprehensive vocabulary and structure of metadata that should be used to characterise geographic data. The companion Technical Specification ISO 19139 defines the encoding of this metadata. The development of national and discipline-oriented profiles of ISO 19139 will facilitate exchange of information using common semantics and syntax.

The World Wide Web Consortium (W3C) is a group of implementing organisations interested in developing common specifications, known as "recommendations' for wide support on the Web. One key set of recommendations and work items focus on the Extensible Markup Language (XML), a markup language specifically geared to encoding structured content of information. Companion topics include the XML-Schema activity, working on defining the schema and data types for XML documents and XML-Query -- at present only a design activity for a request syntax for XML-structured documents. The XML 1.0 Recommendation is in general use now, and is seeing wider application in the geographic software field as an increasingly richer means to encode and transfer structured information of all types. XML-Schema has recently been approved by the W3C and supports more rigorous validation of XML files.

Implementation Approach

The development of operational distributed catalogue services has been taking place in a number of countries including the United States, Canada, Mexico, Australia, and South Africa as primary examples. The software systems used to implement the ISO 23950 and Web based services has been developed largely through governmental support, resulting in both open source and commercial software solutions. The evolution of protocols and industry practices are difficult to predict, but this section provides a review of available solutions.

Let's review a technical use case scenario for access to a distributed catalogue:

1. A User uses client software to discover that a distributed catalogue search service exists. This may be done through a search of Web resources, a saved bookmark, reference from a referring page, or word-of-mouth referral. 2. User opens the user interface and assembles the parameters required to narrow down a search of available information. 3. The search request is passed to one or more servers based on user requirements through a gateway service. The search may be iterative, repeating or refining queries based on new interactions with the user. 4. Results are returned from each server and are collated and presented to the User. Types of response styles may include: a list of "hits" in title and link format, a brief formatting of information, or a full presentation of metadata. Visualisation of multiple results may also be available through display of data set locations on a map, thematic groupings, or temporal extent. 5. User selects the relevant metadata entry by name or reference and selects the presentation content (brief, full, other) and the format (HTML, XML, Text, other) for further review. 6. User decides whether to acquire the data set through linkages in the metadata. By clicking on embedded Uniform Resource Locators (URLs) the user can directly access online ordering or downloadable resources, whereas distribution information lists alternate forms of access.

The Distributed Catalogue is implemented using a multi-tier software architecture that includes a Client tier, a middleware or “Gateway” tier, and a server tier, as is illustrated in Figure 4.4.

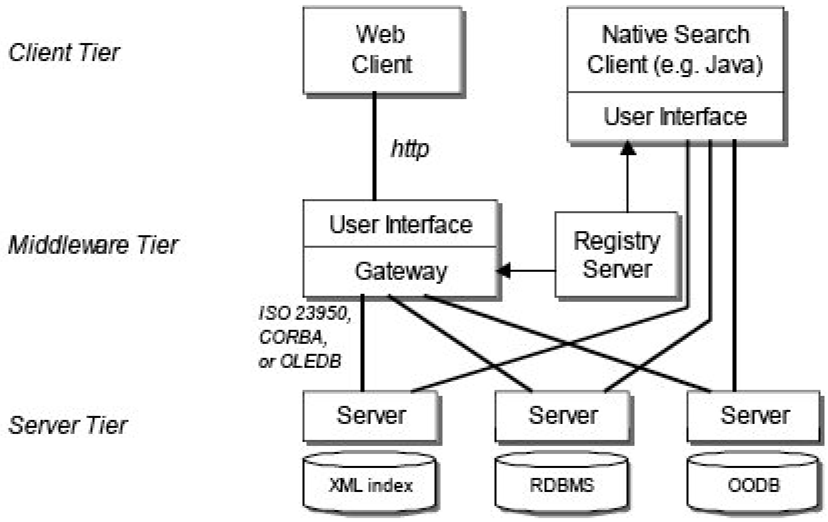

Figure 4.4 - Implementation view of distributed catalog services

The client tier is realised by a traditional Web browser or a native search client application. The Web browser uses conventional HyperText Transport Protocol (HTTP) communications, whereas the native search client uses the ISO 23950 protocol directly against a set of servers. It is possible to also collapse this multi-tier architecture into two tiers where middle-tier functionality is present in the client.

The middle tier in the architecture includes a World Wide Web to catalogue services protocol gateway. A Gateway effectively converts an HTTP POST or GET request into multiple catalogue service clients that run either in series or in parallel. Gateway solutions provide parallel distributed search of multiple catalogue servers from a single client Web session. At present, Gateways have been installed in the U.S., Canada, Mexico, South Africa, Australia to provide regional points of access. The forms and interfaces installed at each are identical, and each hosts parallel search of all servers. In order to track a large number of Distributed Catalogue servers, a list of known, compatible servers called a Directory of Servers or Registry must also be managed. This service contains server or collection-level metadata that can itself be searched as a special catalogue. In this way, an intelligent one pass search of eligible servers can be performed instead of requiring the user to select servers from a list, or to have all queries passed to all servers.

At the bottom tier of the service architecture are the catalogue servers. These servers can be accessed using the GEO Profile of the ISO 23950 protocol, although CORBA implementations also exist. The GEO Profile of ISO 23950 is available to implementors in the geospatial community as an extended set of the traditional bibliographic fields that can be searched. GEO includes geospatial coordinates (latitude and longitude) and temporal fields in addition to freetext (e.g. search for the word anywhere in the metadata entry). ISO 23950 servers may be implemented on top of XML document databases, object-relational, or relational database systems in which structured metadata are stored for search and presentation.

The ISO 23950 protocol was selected for use in the Distributed Catalogue for several reasons. First, the library catalogue service community existed with relevant software and specifications that could be enhanced for geospatial search. By adopting compatible terms, library catalogues can be searched with GEO catalogues. Second, the ISO 23950 protocol specifies only client and search behavior and does not specify the native data structures or query language used to manage the metadata behind the server. Abstraction of query allows for a public query on “well known” fields that can be translated at each server into local equivalents. This lets one keep current database structures and names but supports alternative access through this geospatial public "view," expressed in XML or HTML reporting forms. This common search functionality across hundreds of servers is a prerequisite to distributed search. It allows for local database management autonomy yet supports federated search. Third, the protocol is independent of computer platform. ISO 23950 search clients and servers exist for many types of UNIX and Windows platforms, and Java libraries are available for additional client and server programming.

This separation between local and public metadata search fields has allowed for the ISO 23950 search of many different types of metadata collections that support the GEO Profile, even though they may not support the same metadata model.

For example, The Australia and New Zealand Land Information Council (ANZLIC) metadata contains different tag names than FGDC metadata in the US. Through standard translation tables in the server, search against ANZLIC's "Data Set Name" field is associated with "Title" (the query labels this as attribute number 4) in the registered public fields. As a result, Australian catalogue servers can be searched through the FGDC Clearinghouse Gateways but return metadata records of a different structure. The same approach could be applied to other community metadata services, such as those employed by the Directory Interchange Format (DIF) files used in the space and global change disciplines or other metadata standards with similar content. Ideally, metadata formats should be delivered in such a structure that they could be converted or translated for consistent presentation, even if they come from different communities. The Extensible Markup Language (XML) and translator software is starting to enable the transformation of different XML documents in different schemas.

Catalogue Server/Service Development

To encourage widespread participation in the Clearinghouse, catalogue service software has been developed under direction of the FGDC and other coordination organisations around the world. Reference implementations of software exist to provide a free or low-cost example of metadata management and Distributed Catalogue service that can be quickly implemented. The software can also be used as reference by commercial developers to test anticipated functionality and interoperability and to develop value-added products.

A catalogue service that participates in a distributed catalogue should fulfill the following requirements:

- Support of a standard protocol (ISO 23950 preferred) for search and retrieval on an Internet-accessible server. When conformance testing for OGC Catalogue Services profiles is available, servers should be certified as OpenGIS-compliant (no conformance test methodology exists as of February 2000).
- Linkage to an indexed metadata management system that supports multi-field queries on text, numeric, and extended (e.g. "bounding box") data types, supports AND and OR constructs, and can return entries in a structured form that are or can be converted into a requested report in HTML, XML, and text. This may be a relational database, an objectrelational database, or an XML database, or even a request to a remote catalogue to perform cascading catalogue services.
- Ability to translate public fields/attribute structures into names and structures used in the metadata management system using a national or international vocabulary (ISO 19115, when available)
- Ability to add, update, or delete metadata entries in the metadata management system

Available Software Implementations

The Isite software suite is a reference implementation of the Catalogue server that includes an XML document database and an ISO 23950 server supporting the GEO Profile for use on Windows and UNIX platforms. The U.S. Federal Geographic Data Committee is one of several sponsors that continue to support the development of this open-source software code. Isite supports document types conforming to the ANZLIC (Australia/New Zealand), Directory Interchange Format (DIF), Federal Geographic Data Committee's (FGDC) Content Standard for Digital Geospatial Metadata, and the draft ISO 19115/19139 interpretations, and is used in a number of countries that support these content standards.

Several commercial catalogue services supporting the OpenGIS Consortium Catalogue Services Specification Version 1.0 Web Profile via ISO 23950 are available on the market today. Links to known commercial solutions are posted on the Federal Geographic Data Committee web site (http://www.fgdc.gov/clearinghouse). When Version 2.0 of the OGC Catalogue Services specification is released and conformance testing methodologies are available, validated OGC-compliant software will also be listed from the OpenGIS web site (http://www.opengis.org).

Catalogue Gateway and Access Interface Development

As depicted in Figures 4.3 and 4.4, there is often a need for an intermediary to provide application integration for an end user. Known as "application servers" or middleware, these hosts allow for the storage, construction, and download of user interfaces to end users and communicate with multiple catalogue servers simultaneously -- a feat not supported by many web browsers due to security settings.

Software systems, such as application servers, that integrate catalogue search and other GIS and mapping functions benefit from the community development of software development kits (SDKs) based on standards. SDKs can provide client and server libraries for catalogue search and other services based on standard interfaces. Through component architecture, these SDKs expedite development of advanced software by combining appropriate pieces of software together as needed, reducing the need for a programmer to learn the intricacies of a given service.

A UNIX-based reference implementation gateway from the World Wide Web to multiple ISO 23950 targets is available for non-commercial use from IndexData in Denmark, known as ZAP (http://www.indexdata.dk). A perl-based programming client library to ISO 23950 is also available from the Joint Research Centre in Italy (http://perlz.jrc.it /download). A Java-based distributed search module to multiple ISO 23950 targets from common web servers is also being commissioned as open source software by the US FGDC as is a client-side Java library.

Registering Catalogue Servers

The operation of a growing network of distributed catalogue servers requires the management of server-level information in a central location. This registry server, shown in Figure 4.4, essentially houses server or collection-level metadata for search and retrieval and use in distributed query. In this way a search may be first made of the registry of servers to identify candidate servers to target the query, and as a broker, the registry returns the list of likely targets based on criteria such as geographic and temporal extent and other search limits. A registry facility greatly improves the scalability of a national, regional or global network of catalogues.

In the context of the GSDI, a coordinated registry of catalogue (and other) services is needed. If all catalogues were registered into a common and distributed registry akin to the way the Domain Name System (DNS) works, resolution of appropriate hosts of geospatial information globally will be enabled.

The GSDI hosts a global, seachable registry of catalogue servers using Isite fed by XML generated from an Access database. All geospatial catalogues conforming to FGDC, ISO, or ANZLIC metadata profiles should be registered here. This will be replaced with a conformant OpenGIS Catalogue solution supporting ISO metadata in the coming year (http://registry.gsdi.org/registry). A coordinated registry between the U.S. and Canada is proposed through an interagency agreement between the FGDC/GSDI Secretariat and Geomatics Canada as a model for other countries to follow in managing and cooridnating their own national catalogue entries with the global system.

Recommendations

- ***The Cookbook authors recommend that organisations publish their metadata using OpenGIS Consortium Catalogue Services Specification, Version 2.0.2.***

The baseline standard, HTTP Protocol Binding, better known as Catalogue Service for the Web (CSW) provides for nominal interoperability for search and presentation of records among all implementations. Profiles exist for the explicit search and retrieval of ISO 19115/19139 records (ISO Metadata Application Profile), and a more general-purpose profile called ebRIM (sometimes listed as Web Registry Service). In addition, the ISO 23950/ANSI Z39.50 "Search and Retrieve" Protocol binding is still in common use, as referenced by this standard. Existing reference implementation software for catalogue services allows organisations to participate at a very low cost; commercial implementations allow organisations to scale their collections and applications.

- ***The Cookbook authors recommend that participants register their catalogue servers at the GEOSS Component and Service Registry (CSR).***

The Group on Earth Observation (GEO) hosts a global service registry that acts as a directory of all known web services in the Earth Observation and SDI communities. By listing catalogue services in such a system, publishers can assure that they can be discovered in a trans-national context.

References and Linkages

OpenGIS Catalogue Service Implementation Specification, Version 2.0.2, Open GIS Consortium, (http://www.opengeospatial.org/standards/cat)

Z39.50 International Standard Agency Home Page, (http://lcweb.loc.gov/z3950/agency/)

Chapter 5

From The SDI Cookbook

Contents

Chapter 5: Geospatial Data Visualization: Web Mapping

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Introduction

This chapter documents simple web mapping concepts and tools that enable the visualization of geospatial information from various organisations and servers across the World Wide Web. The linkages with Chapter 4 – Geospatial Data Catalogues, are also explored. Discussed are the current best practices related to on-line mapping, and the progress of the OpenGIS Consortium's (OGC) Interoperability Program[2] (IP) to realize the dream of true inter-operability and disseminating a web mapping specification for the vendors to adopt and promulgate.

Consider these desires:

- Do you want to view your information on a map online? Perhaps either as a simple (one map at a time) view or to overlay views from other sources together to produce a customized map product on your computer screen?
- Do you want to post a map layer from your in-house GIS or image processing system onto the Web for others to see? Do you want to provide views of your metadata so that your clients can picture the data or product you are responsible for?

If the answer to these questions is yes, then you are probably interested in Web Mapping.

Context and Rationale

The rise of the Internet and specifically the World Wide Web (WWW) has created expectations for ready access to geospatial information on the Web through a common web browser. Mapping on the Web includes the presentation of general purpose maps to display locations and geographic backdrops, as well as more sophisticated interactive and customizable mapping tools. The intention of online or Web Mapping is to portray spatial information quickly and easily for most users, requiring only map reading skills. Web mapping services can be discovered through online directories that serve both spatial data (through metadata) and services information (see for example the OGC Catalogue Services draft specification). In fact, web mapping services are often used to assist users in geospatial search systems, showing geographic context and extent of relevant data against base map reference data.

Web Mapping implemented as a set of proprietary systems works fine as long as everyone you deal with both internally within your organisation and externally utilizes this same proprietary software. Because of this obvious particular limitation the Open GIS Consortium developed a non-proprietary web mapping approach based on the concept of interoperability. The topic of this chapter is not complex on-line GIS, but simple web mapping concepts and tools, i.e. part of a portrayal service to show spatial information on-line when the information originates from several discrete data/ map servers (commonly from different organisations).

Open GIS Web Mapping Activities

The sudden rise of web mapping over the last several years (cf. GIS Online : Information Retrieval, Mapping, and the Internet by Brandon Plewe - OnWord Press; ISBN: 1566901375) is demonstrated in the interoperability vision held by the Open GIS Consortium's Interoperability Program initiatives. In the OGC, expert GIS and web mapping technology users work with GIS software vendors, earth imaging vendors, database software vendors, integrators, computer vendors and other technology providers to reach agreement on the technical details of open web mapping interfaces that allow these systems to work together over the Web.

Consensus among vendors in the OGC's Web Mapping Testbed has created ways for vendors to write software that enables users to immediately overlay and operate on views of digital thematic map data from different online sources offered though different vendor software. The Web Mapping Testbed has delivered, among other specifications, a set of common interfaces for communicating a few basic commands/ parameters that enable automatic overlays. This set of interfaces is known as the OpenGIS® Web Map Server Interfaces Implementation Specification[3] and was developed by over 20 participating organisations. A step-by-step cookbook dedicated to the implementation of WMS is available from the OGC: http://www.opengis.org/resources/?page=cookbooks .

The Web Map Server (WMS) specifications offer a way to enable the visual overlay of complex and distributed geographic information (maps) simultaneously, over the Internet. Additionally, other OGC specifications will enable the sharing of geoprocessing services, such as coordinate transformation, over the WWW (See Chapter Seven). Software developers and integrators who develop web mapping software or who seek to integrate these capabilities into general purpose information systems can add these open web mapping interfaces to their software.

"Web Mapping" refers, at a minimum, to the following actions:

- A Client makes requests to one or more Service Registries (based on the OpenGIS Catalogue Services Specification) to discover URLs of Web Map Servers containing desired information.
- Service Registries return URLs and also information about methods by which the discovered information at each URL can be accessed.
- The client locates one or more servers containing the desired information, and invokes them simultaneously.
- As directed by the Client, each Map Server accesses the information requested from it, and renders it suitable for displaying as one or more layers in a map composed of many layers.
- Map Servers provide the display-ready information to the Client (or Clients), which then display it. Clients may display information from many sources in a single window.

The OpenGIS Web Mapping Specifications address basic Web computing, image access, display, and manipulation capabilities. That is, they specify the request and response protocols for open Web-based client / map server interactions. The first of these specifications, described below, are the product of OGC's successful Web Mapping Testbed. They complement the already-available OpenGIS Specifications such as Simple Features and Catalogue Services, as well as ISO metadata standards to provide the foundation on which pending OpenGIS Specifications will build an increasingly robust open environment for Web mapping. Subsequent interoperability initiatives (IP 2000 and IP2001) have defined Web Feature Services, Web Coverage Services, and extensions to the Web Map Servers that allow a higher degree of control over the symbolization[4].

The WMS 1.1.1 specification defines three interfaces that support Web Mapping: ***GetMap, GetCapabilities*** and ***GetFeatureInfo***; these were demonstrated at the conclusion of Phase 1 (May – September 1999) of the Web Mapping Testbed and were released to the public in April 2000. ***GetMap*** specifies map request parameters that allow multiple servers to produce different map layers for a single client. ***GetCapabilities*** explains what a map server can do (so integrators know what to ask for). ***GetFeatureInfo*** specifies how to ask for more information about web map features.

These interfaces provide a high level of abstraction that hides the "heavy lifting" in the Web Mapping scenario. The heavy lifting includes finding remote data store servers, requesting data from them in specifically defined structures, attaching symbols intelligently, changing coordinate systems, and returning information ready to be displayed at the client – all in a matter of seconds.

Servers conforming to OpenGIS WMS 1.1.1 will geo-enable Web sites and mobile devices for many new applications of geospatial technology. Consider any of the application domains listed below. Wherever the purchasers of the technology have chosen not to limit their users to a solution based on single vendor client/server pairs, these uses of geospatial data will depend on interfaces that conform to the OpenGIS Web Map Interface Specification:

- Business siting, market research, and other business geographic applications
- Cable, microwave, and cellular transmission installation planning
- Civil Engineering
- Education/training, distance learning, multi-disciplinary research collaboration
- Electronic libraries, electronic museums and galleries
- Emergency road services and 911 emergency response systems
- Environmental monitoring, global and local
- Facilities management
- Global disaster/emergency/crisis management
- Health care: telemedicine, better/faster care for rural trauma victims, patient monitoring, etc.
- Intelligent vehicle highway systems (IVHS)
- Maintenance of one’s information context and connection (personal logical network) as one moves through space, bridging media and modality; mapping electronic locations of addresses to their physical locations; using concepts of reach space, co-location, and near-by.
- Military applications: surveillance, planning, training, command/control, logistics, targeting
- Municipal public works maintenance and administration
- Natural resource discovery, exploitation, and management
- Navigation
- Precision farming (GPS-guided controlled delivery of nutrients and chemicals based on Earth imagery or automated GPS-located soil or crop sampling)
- Product distribution/warehousing optimization
- Public safety - fire and police departments
- Recreation: hiking, boating, etc.
- Science: climate research, agronomy, biology, ecology, geology, and others
- Security monitoring and intrusion response
- Special wayfinding for elderly and disabled
- Telecommunications network planning -- mobile communications
- Transportation planning
- Urban and regional planning
- Water resource management

There is a productive recent trend within the OGC to use Interoperability Initiatives like the Web Mapping Testbed to rapidly produce OpenGIS Specifications, as opposed to creating all of them through a traditional committee process. IP2000, completed in late 2000, focused on map authoring and publication, integrating graphical data and data elements (legends, symbolization, etc.), clients that can exploit XML-encoded information, further work on catalogue and discovery services, and work on transporting XML encoded data over the Internet.

Organisational Approach

Web based mapping provides the functionality to help discover and visualize spatial information referenced from Catalogue Service Systems. A Catalogue Service System (described in Chapter 4) is implemented through Internet-based software that allows users to inventory, advertise, and access metadata and associated geospatial information within a global framework of servers. Figure 5.1 shows one scenario of a client accessing a Catalogue (actually the catalogue implements a Service Registry) to discover data and web mapping services and then requesting and displaying maps from different servers.

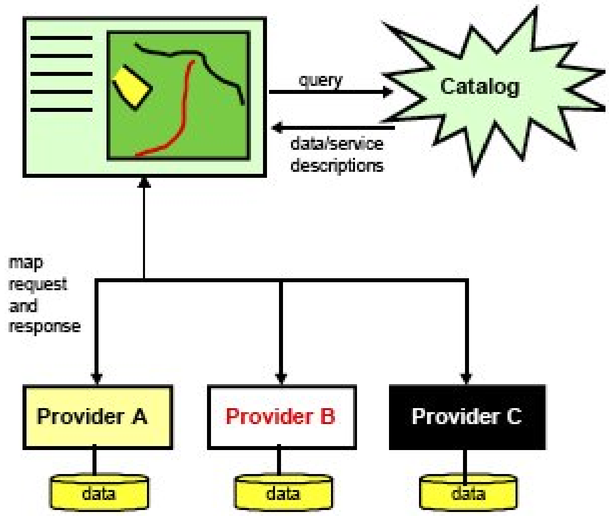

Figure 5.1 - Interaction of web map client with catalogue and map servers

A catalogue service that provides only references to raw geospatial data would be of use to only GIS experts and their software. By making map displays of geospatial information, casual users can interact with and see spatial data that was previously only available to GIS experts.

Figure 5.2 shows one example of a user interface for a Catalogue Service System. Many different GUIs can be built to provide special access for different categories of user. All the GUIs must use the same protocol agreements to interact with the map server software.

The Map Frame in figure 5.2 illustrates the value of specifying the bounding geometry (box or polygon) for the spatial part of the query for retrieval within the Catalogue Service System. Typical dimensions for the query include spatial, temporal, paleotemporal and thematic values. The user also has the option to specify specific servers, or to search all registered servers for the geospatial data of interest.

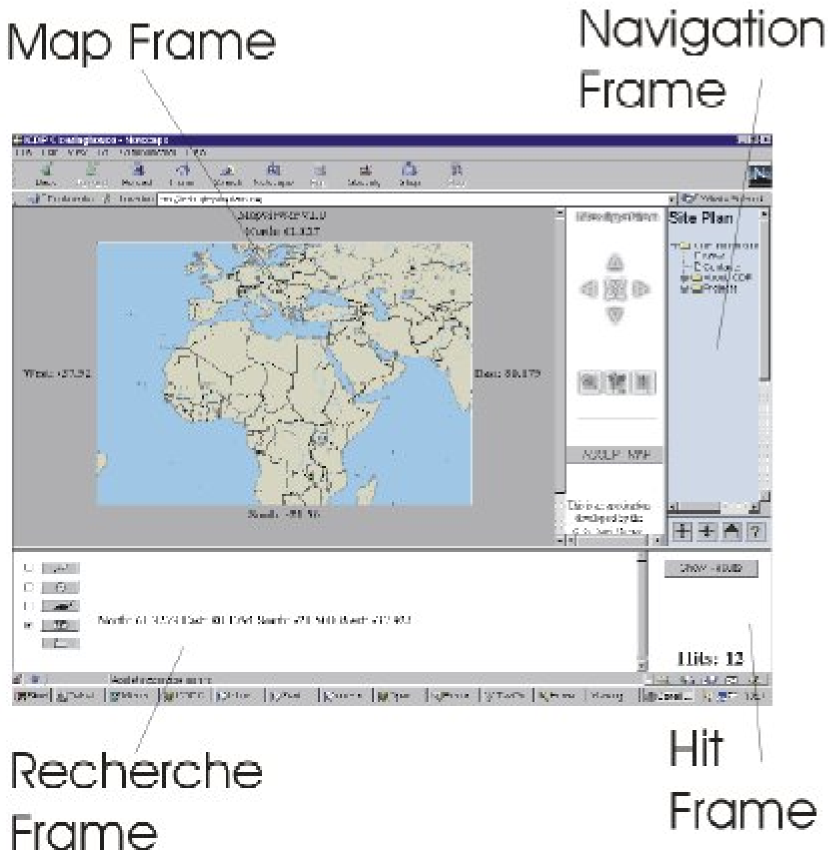

Figure 5.2

The Map Frame can also be used for the presentation of the spatial component of the metadata in maps. The result presentation in a Catalogue Service System can be installed as a hidden search variable for further processing, or as List or Map in a web browser for visual presentation. The resulting presentation should be within the bounding geometry that was specified by the user for the Spatial Query. Often users like to interact with the objects on the maps. They like to have links on an object in a map connect to its metadata and then use a link in the metadata to connect to the real data. This can be accomplished via the GetFeatureInfo interface of the Web Map Server specification.

The success of Web Mapping depends on the use of consistent metadata standards (See Chapter 3). Historically, there have been a great variety of metadata standards developed and implemented across communities. Thanks to the contributions of many mapping organisations worldwide, an ISO standard 19115 for metadata was published in 2003. Over time, organisations will see the value of migrating to a consistent ISO metadata format based on ISO Technical Specification 19139 so that consistent global scale search and access of geospatial data can occur to support on line mapping.

Map Servers

For the concept of Web Mapping to be successful, a near global, truly inter-connected series of map servers must be established through the use of common protocols whether it be in an intranet, an extranet, or an internet scenario. Figure 5.3 provides a notional view of such a server network. Servers supporting on line web mapping will be registered to a Catalogue Service System as noted above.

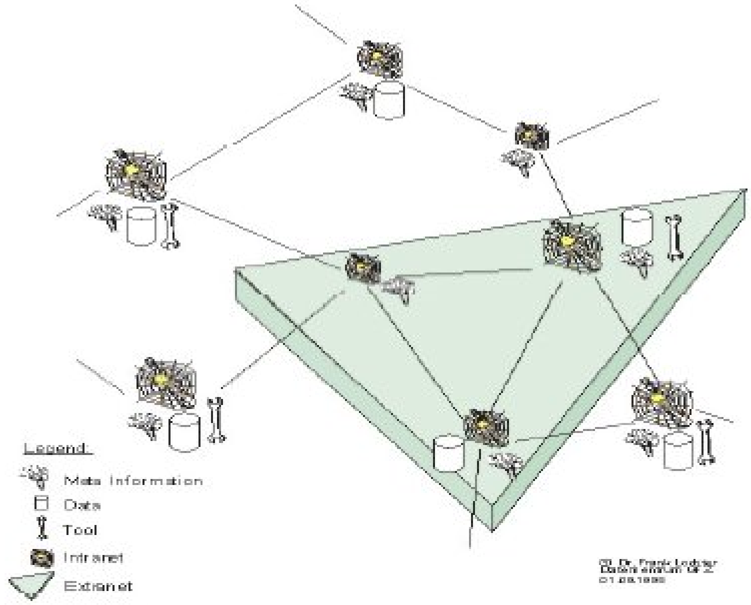

Figure 5.3 - Notional View of Web Mapping Server Network

Implementation Approach

By way of introduction to implementations of Web Map Servers, the following is excerpted from the WMS 1.0 specification[5]:

A Map Server can do three things. It can:

- Produce a map (as a picture, as a series of graphical elements, or as a packaged set of geographic feature data),
- Answer basic queries about the content of the map, and
- Tell other programs what maps it can produce and which of those can be queried further.

A standard web browser can ask a Map Server to do these things just by submitting requests in the form of Uniform Resource Locators (URLs). The content of such URLs depends on which of the three tasks is requested. All URLs include a Web Mapping Service specification version number and a request type parameter. In addition, to produce a map, the URL parameters indicate which portion of the Earth is to be mapped, the coordinate system to be used, the type(s) of information to be shown, the desired output format, and perhaps the output size, rendering style, or other parameters. To query the content of the map, the URL parameters indicate what map is being queried and which location on the map is of interest. To ask a Map Server about its holdings, the URL parameters includes the "capabilities" request type. Each of these will be described in further detail later. We first provide some sample URLs and their resulting maps on the next two pages. Requests to multiple servers can be made to return results that overlap in the same coordinate system so that map data can be viewed together even though it may be hosted and served in different organisations.

The following requests a US National Oceanographic and Atmospheric Administration AVHRR image, shown below:

```
http://map.com/mapserver.cgi?VERSION=1..1.1&REQUEST=getmap&SRS=EPSG%3A4326&BBOX=-97.105,24.913,78.794,36.358
&WIDTH=560&HEIGHT=350&LAYERS=AVHRR-09-27%3AMIT-mbay&STYLES=default&FORMAT=PNG
&BGCOLOR=0xFFFFFF&TRANSPARENT=TRUE&EXCEPTIONS=INIMAGE&QUALITY=MEDIUM
```

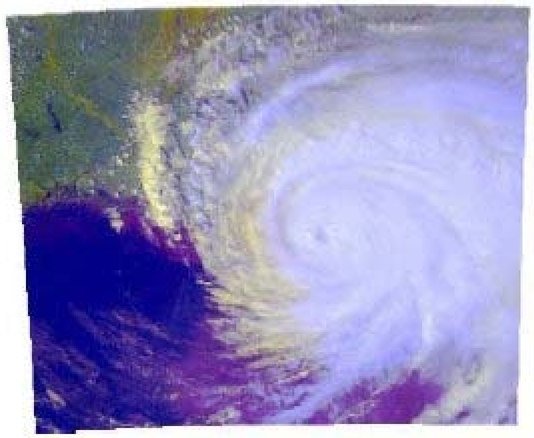

Figure 5.4 - NOAA AVHRR Image of the Gulf of Mexico

This requests three layers, “built up areas”, political boundaries, and coastlines shown below:

```
http://maps.com/map.cgi?VERSION=1.1.1&REQUEST=getmap&SRS=EPSG%3A4326&BBOX=-97.105,24.913,78.794,36.358
&WIDTH=560&HEIGHT=350&LAYERS=BUILTUPA_1M%3ACubeWerx,COASTL_1M%3ACubeWerx,POLBNDL_1M%3ACubeWerx
&STYLES=0XFF8080,0X101040,BLACK&FORMAT=PNG&BGCOLOR=0xFFFFFF&TRANSPARENT=FALSE&EXCEPTIONS=INIMAGE
&QUALITY=MEDIUM
```

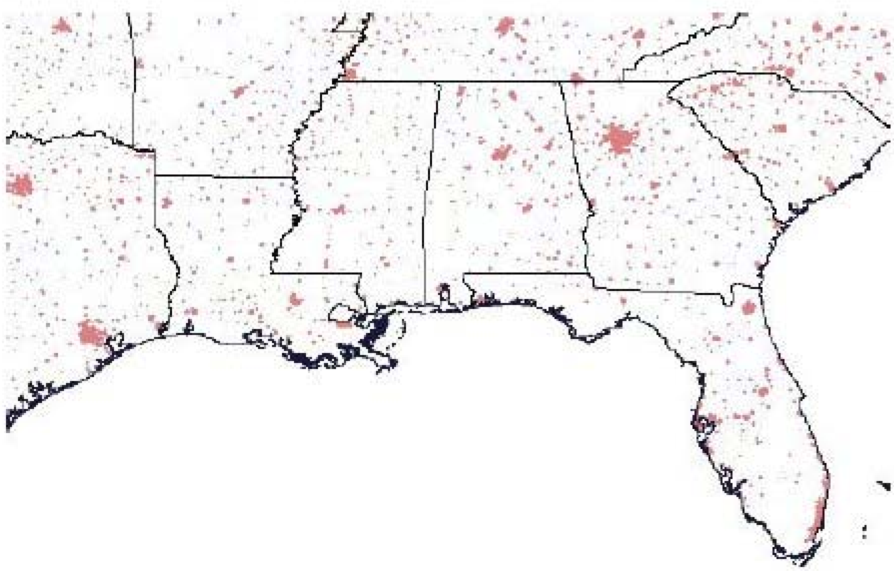

Figure 5.5 Political, Coastline, and Populated Areas, Southeastern United States

Notice that in both of these URLs the spatial information is identical:

```
SRS=EPSG%3A4326&BBOX=-97.105,24.913,78.794,36.358& WIDTH=560&HEIGHT=350
```

Because both maps were produced with the same bounding box, spatial reference system, and output size, the results can actually be overlaid by placing the latter map on top of the former. By enabling the use of image formats that provide for transparency information, maps that are meant to be overlaid over other maps can be produced by Map Servers. In this example, background areas of the second map are transparent (because the URL parameter "TRANSPARENT=TRUE" was supplied). Figure 5.6 shows the result of overlaying Figure 5.5 on top of Figure 5.4 to produce a map from the result of two separate Map requests. Finally, note that in this example the two maps were requested from different Map Servers. By standardizing the way in which maps are requested, clients of Map Servers can tailor which layers to request from which servers, thus building up maps that would not have been practical to assemble without the Web Mapping Interface Specification.

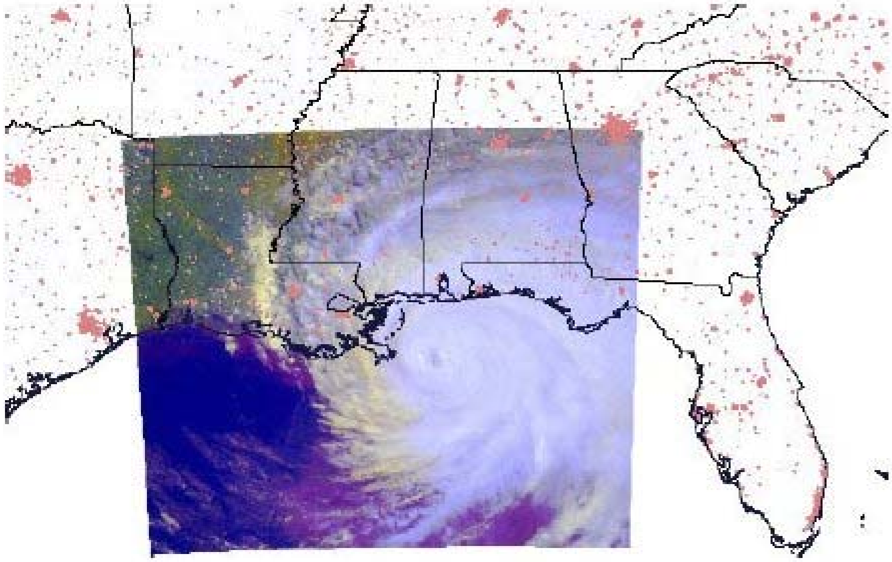

Figure 5.6 - Combined AVHRR Image and Political/Cultural Map

If either of these maps were queryable, a client could request information about a feature on the map by adding to the map URL two additional parameters specifying a location (as an X, Y offset from the upper left corner).

Because each Map Server is likely to have different kinds of information for which it can produce maps, each Map Server must be able to provide a machine-parseable list of its capabilities. That enables the construction of searchable catalogues that can direct clients to particular Map Servers.

Available Software

As a result of the Web Mapping Testbed, a number of GIS integrators and vendors have developed prototype versions of web mapping servers and compatible interfaces. The NASAcoordinated Digital Earth project includes software support for mapping NASA data using the specification (http://digitalearth.gsfc.nasa.gov/). OGC Web Mapping Service-compatible interfaces for ESRI Map Objects Internet Map Server version 1.1.1 and the University of Minnesota "mapserver" product (http://mapserver.gis.umn.edu) have been available as opensource implementations of WMS. An exhaustive list of software that supports the WMS specifications is available from the OGC: http://www.opengis.org /resources/?page=products.

Recommendations

The state of Web Mapping is best illustrated by the progress made in the Open GIS Consortium Interoperability Program Activity. As the result of potentially competing vendors and software producers coming together and identifying a common set of functionality, a non-proprietary specification for rendering geo-referenced graphics has emerged. This allows one to establish a connection to multiple map servers and generate a stack of images that can be used in visual analysis and basic interrogation.

- ***The Cookbook authors recommend the use of the OpenGIS Web Mapping Services Specification, Version 1.1.1 or 1.3***

The OGC Web Mapping Service capabilities provide an excellent starting point in the visual combination of distributed spatial data, the query of features, and now (Version 1.3) the support of time-tagged data sources.

- ***The Cookbook authors recommend that participants register their WMS services at the GEOSS Component and Service Registry (CSR).***

The Group on Earth Observation (GEO) hosts a global service registry that acts as a directory of all known web services in the Earth Observation and SDI communities. By listing mapping services in such a system, publishers can assure that they can be discovered in a trans-national context.

The Cookbook authors invite all prospective organisations to participate in the development, prototyping, and establishment of next generation web mapping services in collaboration with the Open Geospatial Consortium.</i>

References and Links

International Continental Scientific Drilling Program (ICDP). (http://www.icdp-online.de/)

OpenGIS Consortium Initiatives Page (http://www.opengeospatial.org/initiatives/)

OpenGIS Web Map Service (WMS) Implementation Specification Revision 1.3 (http://www.opengeospatial.org/standards/wms)

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[2] *The OGC Interoperability Program began as the OGC Web Mapping Testbed or WMT. Since then it has expanded to encompass a number of activities and is often referred to as IP 2000 or IP 2001, etc. depending on which year the activity falls under.*

[3] *Prior versions of the OGC Web Map Service specification can be found at http://www.opengeospatial.org/standards/wms*

[4] *The OGC Styled Layer Descriptor (SLD) specification defines symbology for features: http://www.opengis.org/docs/02-070.pdf. The OGC Context Specification allows one to define and re-use selected layers in a mapping interface: http://www.opengis.org/docs/03-036r2.pdf.*

[5] *The specification is under revision at the time of this publication, WMS 1.2 is expected to be published by mid 2004.*

Chapter 6

From The SDI Cookbook

Contents

Chapter Six: Geospatial Data Access and Delivery: Open access to data

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Context and Rationale

Access to geospatial data from the consumers point of view is a part of a process of that goes from discovery to evaluation, to access and finally to exploitation. Discovery (find, locate) involves the use of services such as metadata catalogues to find data of particular interest over a specific geographic region. Evaluation involves detailed reports, sample data and visualisation (e.g., in the recent form of web mapping through gifs or simple vector representations of the data) to help the consumer determine whether the data is of interest. Access involves the order, packaging and delivery, offline or online, of the data (coordinate and attributes according to the form of the data) specified. Finally exploitation (use, employ) is what the consumer does with the data for their own purpose.

Typically in the past, the focus of geospatial data access was supplier side with a strong emphasis on technology and community based standards and specifications. With the growth of the Internet, in particular Web based technologies, access has become a demand driven operation. Consumers expect simple discover and access to cheap (or free) data in simple standard formats that can be used in desktop applications. Increasingly non-traditional suppliers are offering geospatial services, an example being Terraserver (http://terraserver.microsoft.com. The ability to leverage off other major developments such as the World Wide Web, and in some cases electronic commerce, has allowed broader participation in the Industry. The further democratisation of access to geospatial data thus enables value-added suppliers to create new data products and services.

The range of issues from an organisational point of view can be categorised two ways: 1) how broad is the client group;

2) how broad is the supplier group. In both cases issues tend to appear and grow as the groups become broader. In general issues revolve around copyright, licences (end user vs. reseller), cost, privacy, data formats and standards.

For example, if the client group is only internal staff then issues such as cost and copyright might not play a factor. As the scope of the client group grows to a limited number of known clients then there are straightforward mechanisms to control access. However, providing broad access to large group of potentially anonymous clients.

Similarly, as the size of the supplier group grows then issues appear. It is easier to establish a common policy for one or two organisations than it is for many. Typically each organisation has a business model (or non-business model!) that reflects its mandate and environment. The types of data and services it provides, the form and representation of the data, the quality and standards for the data all reflect this business model. Trying to bridge these issues between disparate organisations is an exponential problem.

The overlap between information managed by subject-specific communities in possibly parallel infrastructures can compound problems of data discovery and access. This can be viewed from either the consumer or supplier perspective. For example, as individuals in communities such as biodiversity or geosciences attempt to leverage a combined spatial data infrastructure to support their own goals they introduce new factors. These could be new standards or convention that they commonly require, it could be a new attribution requirement on the data not previously realised, or it could be the need to provide common access to data not otherwise visible from a spatial data infrastructure.

Several trends can be noted in the treatment and handling of geospatial data. Typically in the past the first concern of a data custodian has been what format the data is stored or managed in. Increasingly the trend is to move one level up and only worry about the interfaces to the data. This allows the data to be managed in the best manner possible, while providing open, standards based access. A consequence of this, however, is that the content of the data must be of a sufficient quality to support these interfaces. Often existing data is not accurate enough, up to date or lacking in attribution.

Another trend is in the organisation of the data itself. There is an evolution that starts back with traditional paper products. These migrated into discrete digital files that were typically stored offline, e.g., on a tape rack. As mass storage became more affordable these files found themselves living on online media (magnetic or optical) for easier access. This last step is an important one when you couple it with the developing of ubiquitous, wide area internetworking, i.e. the Internet. At this point a supplier was empowered to deliver data online.

More recently the trend has been to merge all the discrete data sets together into a single, seamless data warehouses that have spawned the development of direct data access services. This has been enabled by developments in mass storage and spatial database technology. This step is also proving to be hard on the data, revealing inconsistencies in data accuracy and quality. Recent infrastructure developments allow the creation of virtual data warehouses that federate multiple instances of a data warehouses into a single logical entity.

Organisational Approach

As in any development it is important to understand who the stakeholders are and what roles each will play. For example in most national infrastructures government suppliers are key stakeholders. How they will play in the development and operation of the data access component of the infrastructure depends strongly on government policies regarding data distribution, cost recovery, etc.

Commercial entities will generally play a strong role as providers of tools and services but may also be suppliers of primary and value added data. It is important to understand the relationship between the commercial sector and the infrastructure as whole, e.g. will the commercial sector have a role in planning the infrastructure? What types of business arrangements will be supported in the infrastructure?

The final category of stakeholder is the consumer or end-user. Their use of the data access element infrastructure is dependent on a number of factors including: the functionality of the infrastructure tools, the amount and quality of the content accessible, operating policies, infrastructure business model (will consumers be charged for access?), etc..

In the early stages of the development it is important to specify and review the long term vision for the entire infrastructure to determine where the access components fits and how it ties into other infrastructure elements. At this stage it is helpful to develop some scenarios and use cases that can be presented to the stakeholders and refined as required.

The importance of developing a supportive policy/organisational environment should not be underestimated. Potential stakeholders will only become active participants if they see advantages for their organisations and if they do not feel threatened by the infrastructure. This policy/organisation environment will vary from country to country and will need to be worked out closely with the stakeholder community. The buy-in and commitment from senior management of all stakeholders is critical to the success of the infrastructure as a whole and to that of the access element in particular. The Canadian Geospatial Data Infrastructure (http://www.geoconnections.org/) is an example of an infrastructure implementation that has developed an organisation based on broad stakeholder participation.

Some of the issues that need to be considered in the development of the supportive policy/organisational environment are:

- Distributed/autonomous suppliers
- The management of the data should be done as close as possible to source. This ensures the accuracy and quality of the data.
- Non threatening to mandates
- Commercial and government stakeholders need to feel comfortable as active participants in the infrastructure. They should not feel threatened by infrastructure business models or policies.
- Multiple levels of “buy-in”; low barrier to entry
- The access component of the infrastructure must provide multiple levels of buyin from a low cost option with limited benefits, e.g. basic advertising of products and services, to higher cost options that offer increased benefits, e.g. distributed search connections to the supplier’s inventory. This allows suppliers to choose a level of participation that best meets their business and operational objectives. This is especially important in the early operation of the access component as many suppliers will want to “try” it out and hence may not be prepared to expend much effort until they see how it works.
- Sustainable long term business models
- The access component of an infrastructure must provide an environment that supports a variety of supplier business models. The development of a sustainable business model for the operation of the access component is critical to the long term success of the entire infrastructure.

1. Role of the private sector

The role the private sector as suppliers of data, services, and technology and as potential operators of the access infrastructure must be clearly defined.

2. Marketing and promotion

The access component of an infrastructure must develop a marketing and promotion plan to build up the level of awareness and participation as quickly as possible. It is important to get a critical mass of suppliers so potential participants will see the benefits of joining the infrastructure. Potential benefits to suppliers include:

- Economies of data collection, closest to the source
- Reduced operational costs
- New clients (national and international)
- Data reuse (reuse vs recollection or conversion)
- Common tool and service reuse
- Advertising
- Benefits of “free” portrayal
- Enabling/supporting broad new applications, e.g.disaster management , value added

Implementation Approach

Definitions and Overview

Data Sets

Data sets are described by metadata and maintained within a data store. Foundation and Framework data sets represent fundamental or core data that may be present within a spatial data infrastructure (See Chapter 2). Data sets are composed of collections of features (e.g. roads, rivers, political boundaries, etc.) and/or coverages (e.g. satellite/airborne imagery, digital elevation models, etc.).

Data Stores

Data stores are used to manage data sets. Data stores may be offline or online repositories. Traditional online data stores are file-based repositories, setup for the delivery of pre-defined data sets. Data stores also contain text and attribute data related to a data set. Data warehouses are datastores that provide seamless access and management of data sets.

Spatial Data Warehouse

A spatial data warehouse provides storage, management and direct access mechanisms. Typically, data warehouses ingest data from legacy file-based or data production systems.

Key characteristics of a spatial data warehouse include:

- the access and delivery of arbitrary features, layers, etc.
- seamless repository
- common data model
- application neutral, supporting a heterogeneous application environment
- support of large volumes of data
- multi-temporal support
- common repository for spatial and non-spatial data
- efficient access to large volumes of data

Examples of commercial data warehousing and service solutions for geospatial data include: Cubestore from Cubewerx (http://www.cubewerx.com/), the Oracle Spatial solution, (http://otn.oracle.com/products/oracle9i/datasheets/spatial/spatial.html) and ESRI Spatial Data Engine (http://www.esri.com/) .

Data Access Service

Implementations of data access services include the following:

- Offline (e.g. packaging and physical delivery of data sets in either hardcopy or softcopy)
- Direct to datastore (e.g. softgoods delivery via ftp, specified via e-commerce order request)
- Brokered - provide specification of data access request to secondary (online or offline)access service
- Online data service (e.g. stateful request/response access protocol to data warehouse) supporting online operations such as:
  - Drill down
  - Aggregation
  - Generalisation

In Open Geospatial Consortium (http://www.opengeospatial.org/) Project Document 98-060: "User Interaction with Geospatial Data" the Portrayal model is described. Figure 6.1 describes this model, which illustrates an simple features-based access and portrayal services pipeline.

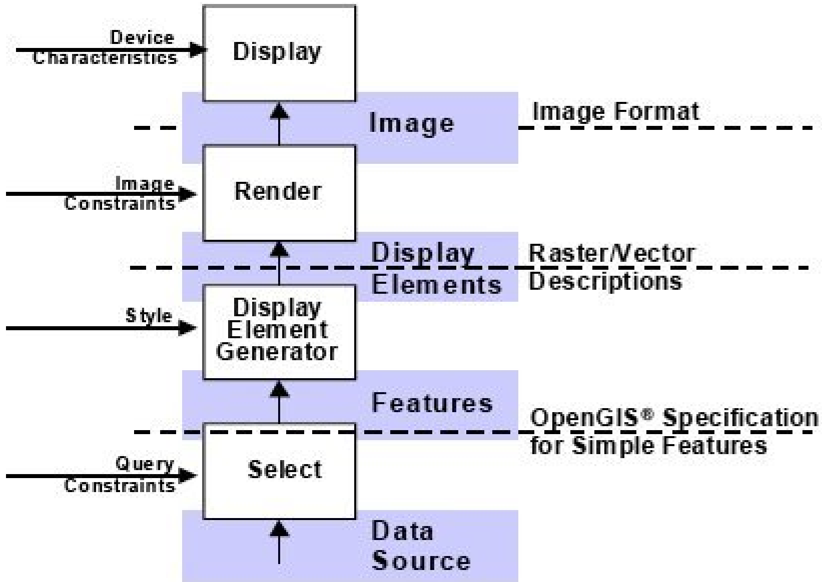

Figure 6.1 - OGC portrayal model

Data Access Client

Online implementations of data access clients include:

- “thin” Internet/Web – client is provided by standard Internet/Web tools (no Java – e.g. Web browser, e-mail, ftp client, etc.)
- “medium” client provided by Web browser with Java, or ActiveX controls
- “thick” client provided by a Web browser plugin, or standalone application (network access via a distribution computing platform such as Corba, DCOM, Java RMI, etc.)
- Traditional GIS type client - access to previously downloaded data set, and direct network access to data warehouse
- “middleware” client – transparent access to consumer via a middleware infrastructure or applications service
- Geoprocessing service – direct access to data for use by a geoprocessing service (e.g. Web mapping in Chapter 5 with interactive portrayal service)

Data Formats

Common spatial data formats include the following:

GIS proprietary (e.g. ESRI, MapInfo, Intergraph, etc.) A good overview of GIS formats can be found at http://www.gisdatadepot.com/helpdesk/formats.html

International and community Efforts have recently been made to minimise the number of geodata formats and to converge towards a reduced set. The Spatial Data Transfer System (SDTS), ISO TC/211 and the DIgital Geographic Exchange STandard (DIGEST) are examples of this trend. There are also exchange formats that allow the use of data outside of closed environments (e.g. Geography Markup Language - http://www.opengeospatial.org/docs/02-023r4.pdf).

Typical native data formats for most GIS applications contain only enough information for the originating GIS application to be able to use it properly. The data formats usually carry the features and maybe some basic projection information. Data Exchange formats are usually more robust. They usually carry information that would allow the use of the data in a variety of systems. Exchange formats usually also carry some minimum metadata to describe the data set as well as data quality statements. Data exchange formats are typically used by producers of data. Due to lack of consensus on specific format standards, spatial data infrastructures often support access to multiple spatial data formats through data access services. However, if it is feasible, the definition of a single community format based on ISO and OGC specifications is ideal to promote information exchange (See Chapter 2).

In the past, supporting a multitude of GIS data formats was very problematic. Currently, most GIS and related access systems support format translation. Examples of commercial support for format translation include: the Feature Manipulation Engine from Safe Software (http://www.safe.com/) and Geogateway from PCI (http://www.pci.com/) An online data access service that combines data access with format translation is the Open Geospatial Datastore Interface (http://ogdi.sourceforge.net).

Unfortunately format translation systems do little to support translation of semantics. The real problem for interoperable data access services, and formats is the lack of common semantics. Semantic translation and multi use feature coding catalogues (e.g. Digest) attempt to address the cross domain semantic support issue (See Chapter 2).

Web Implementation formats

Vector Files A vector file has many advantages that will prove useful for WWW spatial interfaces:

A vector file can be delivered to the client where it can be zoomed and panned without the need to expensively conduct every operation on a WWW server. It is composed of layers that might represent roads, rivers, or boundaries. The layers can be switched on or off. A vector file often allows a mechanism to limit the level of zoom so that spatial data is not displayed as accurate beyond its level of reliability. The size and efficiency of a simple vector file will help with network services and response times. Fortunately, most GIS software programmes can directly produce vector files. A vector file supports functions such as an interactive mapping, symbolization, and coordinate transformation.

There are a three candidate file formats for encoding vector information on the WWW: Simple Vector Format (http://www.w3.org/Graphics/SVG/), Web Computer Graphics Metafile (http://www.cgmopen.org/webcgmintro/paper.htm) and XML-based encoding formats (e.g. Geography Markup Language – GML) that allow for Web-based transfer of feature information, for subsequent styling and rendering via Web client, or client plug-ins. Only GML is specifically designed for the encoding of vector geographic information; the other formats are designed for the exchange of vector graphic information but may have little or no reference to real world or mapped coordinate systems or feature content.

Raster Files Web/internet delivery of GIS raster formats such as ADRG, BIL and DEM (http://www.gisdatadepot.com/helpdesk/formats.html) is often problematic due to the large size of such files, combined with general lack of Internet bandwidth. Typically compressed raster files predominate Web-based portrayals for both vector and raster data. Common compressed Web formats include GIF, JPEG and PNG (http://www.w3.org/Graphics/PNG/) to move single variable panchromatic or color images as raster files.

Relationship to other spatial data infrastructure services

Figure 6.2 illustrates the relationship role of data access in an end-to-end resource discovery, evaluation and access paradigm. 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.

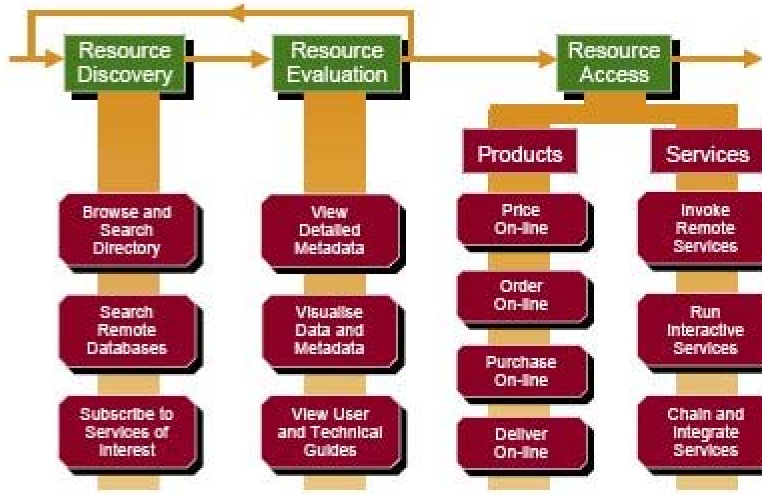

Figure 6.2 – Geospatial Resource Access Paradigm

Mature spatial data infrastructure will allow both application and human exploitation of the resource access paradigm. A key element of future spatial data infrastructures is the ability to broker requests for services, based on discovery and real-time access to online geoprocessing and related services. Future capability for chaining of distributed geoprocessing services is also expected.

A system context for data access is given in Figure 6.3. A data access service provides network access to a data set stored within a data store. Data sets are discovered (and later accessed) via metadata queries from a catalogue client to a data catalogue service (See Chapter 4).

Data sets can be visualised (and later accessed) via Web Mapping services [See Chapter 5], which are complementary to the data catalogue service.

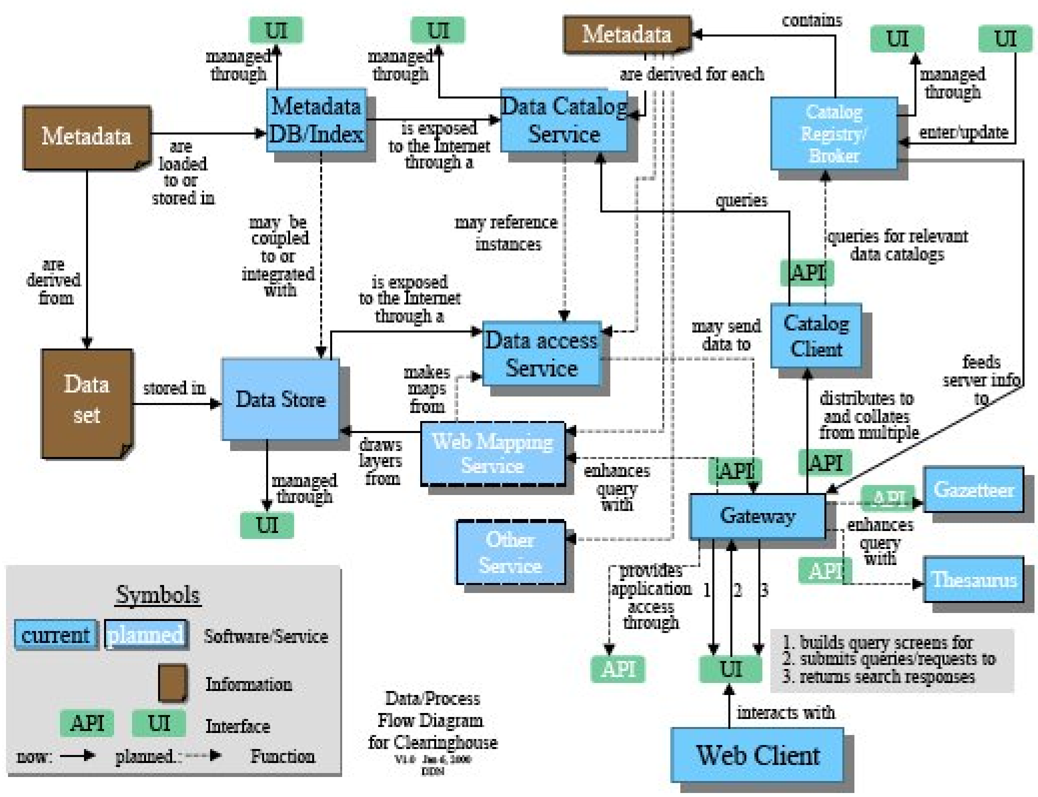

Figure 6.3 – System context for Geospatial data access services

Standards

In general, standards related to geospatial data access are still in their infancy. The standards of most relevance to access components of spatial data infrastructures include those from ISO/TC211, Open GIS Consortium (OGC) and Internet-related bodies including the World Wide Web consortium (W3C) and the Internet Engineering Task Force (IETF).

ISO/TC211

The primary mandate of ISO/TC211 (http://www.isotc211.org) is international standardisation in the field of digital geographic information.

"This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.

These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analyzing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations.

The work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data."

Emerging work on services is currently underway in both ISO/TC211 and the OGC. The definition of services interfaces will allow a wide range of applications access and use of geospatial resources. The OGC Simple Features Access model for SQL has been submitted to ISO for standardisation.

ISO SQL/MM

The purpose of the Draft Spatial Database Standard SQL/MultiMedia (SQL/MM) Part Three Spatial is to define multimedia and application specific objects and their associated methods (object packages) using the object-oriented features in SQL3 (ISO/IEC Project 1.21.3.4).

SQL/MM is structured as a multi-part standard. It consists of the following parts:

Part 1: Framework

Part 2: Full-Text

Part 3: Spatial

Part 4: General Purpose Facilities

Part 5: Still Image

SQL/MM Part 3: Spatial is aimed at providing database capabilities to facilitate increased interoperability and more robust management of spatial data.

Open GIS Consortium (OGC)

The Open GIS Consortium has achieved consensus on several families of interfaces, and some of these have now been implemented in Off-The-Shelf software. All OGC consensus interface specifications carry a pledge of commercial or community implementation by their submitting teams. Phase 1 of the initial OGC sponsored Web Mapping Test (WMT) bed initiative [ref: Chapter 5] was successful in "Web mapping" portrayal of spatial data. An XML-based encoding scheme (Geography Markup Language or GML) for OGC Simple features was also an important output of the Testbed process.

The publication of the OGC Web Feature Service (WFS) Specification in 2002 provided a solution for the standardised request and delivery of vector data. Supporting the OGC "Feature Model" shown in Figure 6.4, the WFS specification (http://www.opengeospatial.org/docs/02-058.pdf) defines the dialogue required to interact with geographic Features via vector data service. GML is used as the primary encoding for vector information returned from the OGC WFS. The use of WFS with various GML application schemas allows for the publication and exchange of spatial data in full vector detail. A detailed OGC Cookbook is published on the OGC website to help the interpretation and implementation of the WFS specification.

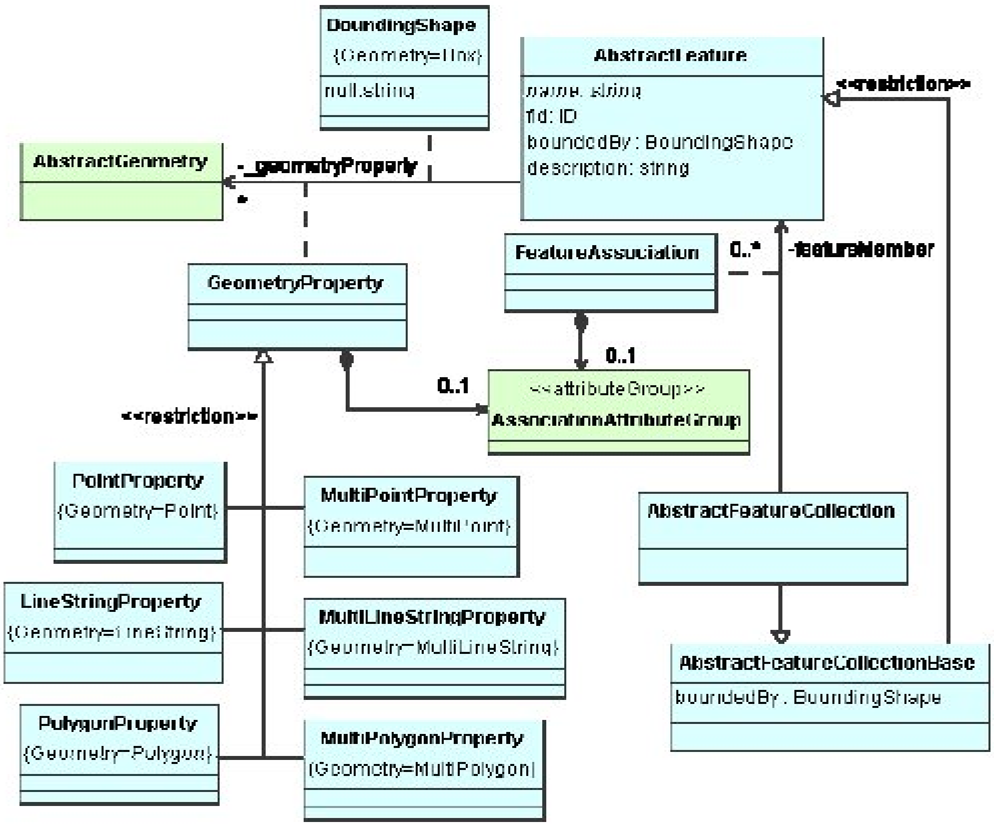

Figure 6.4 – UML Model of the OGC Feature Model

Whereas the WFS provides access to vector information, the request and service of raster information requires a separate specification. The OGC Web Coverage Specification (WCS) was published in 2003. It extends the Web Map Server (WMS) interface to allow access to geospatial "coverages" that represent values or properties of geographic locations, rather than WMS generated maps (pictures). Thus one would receive an array or surface of data values instead of color values. This is useful for keeping the data value behind raw or interpreted imagery, other remotely sensed information, or other more or less continuously varying surfaces of data (e.g. elevation, temperature, constituent concentration). The WCS document is available at: http://www.opengeospatial.org/docs/03-065r6.pdf.

Three Open GIS Simple Feature Access (SFA) interface specifications have also been released to support feature access in relational database environments: one each for SQL, COM-based, and CORBA distributed computing platforms. The SFA and interfaces provide access to and control over GIS features. At the primitive level, the interfaces provide for the establishment of linear and angular units, spheroids, datums, prime meridians, and map projections that give semantics to coordinates. At the intermediate level, they enable the construction and manipulation of geometric elements such as points, lines, curves, strings, rings, polygons, and surfaces, as well as the topological and geometric and other relationships between them. Included are support for common geometric and topological constructs, such as convex hull, symmetric difference, closure, intersection, buffer, length, distance, and dozens of others. At the GIS feature level, the interfaces provide for access to feature collections using geometry or attributes for selection.

Web and Internet related

The Internet Engineering task force (http://www.ietf.org/) develops and maintains specification for many Internet related application, transport, routing and security standards (Request for Comments – RFCs) many of which are related to data access (e.g. http, ftp, smtp).

The World Wide Web consortium, or W3C (http://www.w3.org/) is responsible for the development of common protocols and specifications to further the evolution of the World Wide Web. Activities of the W3C that related to spatial data access include work on Web graphic file formats, XML and metadata.

Related Services

Many services are related to data access. A brief listing follows:

- Discovery and catalogue services [ref Chapter 4]
- Webmapping [ref Chapter 5]
- Electronic commerce related (e.g. http://www.commerce.net/)
- Authentication
- Payment
- Confidentiality (e.g. Secure Socket Layer)
- Public Key Infrastructure
- Delivery and Packaging
- Compression
- Subsetting and subselection
- Container-based delivery systems (e.g. http://www.paradata.com/)
- Data subscription services
- Data and file transport
- HTTP
- FTP
- SMTP/MIME
- Geoprocessing services (e.g. as defined by OGC)
- Distributed Computing Platforms
- CORBA (http://www.omg.org/)
- COM (http://www.microsoft.com/)
- Web/Java/XML

Best Practice Application

GeoGratis (http://geogratis.cgdi.gc.ca/)

One common problem with online access to data through a single infrastructure is the variety of policies and practice in place by the different data custodians. In order to support these different access policies one approach is to develop services to support different basic paradigms. These cases include:

- Custodians who restrict access to particular users would benefit from common user authentication/authorisation services;
- Custodians who charge for data or services would benefit from electronic commerce services;
- Custodians who distribute data free of charge would benefit from an inexpensive mechanism (both time and money) to distribute data.

One example of services to support the third paradigm is GeoGratis that provides common services to support the distribution of freely available geospatial data. GeoGratis provides a single ftp/web access point where consumers can discover and download freely available data sets. As a common online service GeoGratis can be viewed from different perspectives:

- The types of data it makes available;
- The services it provides;
- The distribution model it offers.

GeoGratis makes many types of geospatial data available to the consumer. These data may be national or local in scope, raster or vector, or current or legacy data.

Small-scale national data sets are commonly made publicly available. In the case of GeoGratis, base map data from the National Atlas of Canada is available for download. Additionally many national scale framework data sets are available through GeoGratis. At the other end of the spectrum are data from local test studies/sites that are nominally available free of charge. By offering basic download capabilities GeoGratis supports a wide variety of data types, including raster, vector and tabular. The only restriction is on any value-added service above the basic download capability. A final characteristic of the data available through GeoGratis is the availability of many legacy data sets such as the Canada Land Inventory. These data are typically data sets that suffered through some measure of cost cutting or program termination and as a result are no longer supported. GeoGratis provides a facility to make these data available albeit without background support.

In addition to freely available data GeoGratis provides value-added services. As a basic service GeoGratis provides the download of freely available data. Other basic services that GeoGratis provides is the discovery of available data through a search interface, the evaluation of data sets through detailed metadata and visualisation. Additionally, extra services are provided in support of data download – these include data subsetting, reprojection and reformating for all types of data available through GeoGratis. More advance services include the provision of data warehousing capabilities that support seamless access to large area data sets available through GeoGratis.

Finally, GeoGratis offers a cost avoidance data distribution model. Since GeoGratis is provided as one of many common services supporting data access, this distribution model does not preclude other models, i.e., private access or fee based access. Similarly, GeoGratis does assert that all data should be freely available, but provides an effective service for data that is freely available.

One example of this is the National Atlas of Canada digital data. Originally these data were sold for a nominal fee. However it did not prove cost effective to continue this strategy due to the costs of selling and supporting the data compared to the limited return. Therefore a strategy of cost avoidance was adopted where the data was placed on GeoGratis for free download and support was removed. Access by any other means (such as distribution of the data on CD) was left to the value added private sector community. The result was a dramatic increase in the access and use of these data.

From an implementation and standards perspective, Geogratis provides an excellent "data rich" environment in which to implement emerging spatial data infrastructure standards, in an operational environment. Geogratis currently supports Catalogue-based discovery services via the Z39.50 Geo profile, and is expected to provide future online OGC Web mapping and directaccess spatial data warehouse access services. The new reprojection and reformatting services provided by Geogratis will also be used to exercise the emerging OGC service specifications within an Intranet environment.

Summary and Readiness Analysis

Key organisational issues, related to data access in development of a spatial data infrastructure include:

- Ensuring key government, commercial, and value-added data/related service providers are represented as key stakeholder in the development and implementation of a national spatial data infrastructure
- Collaboration of government data suppliers on coordinated, supportive policies that relate to spatial data access and distribution including: availability of free data, pricing, copyright, and use/integration of electronic commerce
- An access infrastructure and policy that is non threatening to stakeholder mandates
- Support for multiple levels of "buy-in" to the data access infrastructure with a low barrier to entry
- Sustainable long term business models
- Early and clear indication of the role of the private sector
- Early marketing and promotion of the entire spatial data infrastructure program
- Awareness and adoption of international standards

Recommendations

The matrix below illustrates the evolution of data access and related spatial data services. Migration from "classic" towards "infrastructure enabled; standards based; and full functioned" is required to bootstrap a national spatial data infrastructure. Both "top-down" and "bottom-up" implementation strategies are suggested. Early adoption and "best practices" should be followed by key government data providers.

	Classic	Move to online	Infrastructure enabled; Standards-based; Full functioned
Metadata	Ad hoc	FGDC - based	ISO TC211 - based
Metadata Catalogue	Offline, hardcopy Compact disk	Database enabled; Web accessible	Semantic interoperability via search/retrieval protocol OGC catalogue
Visualisation	Offline: fax, hardcopy, Compact disk	Web – accessible, Map enabled	Visual evaluation via OGC WMS
Ordering	Phone, fax	E-mail	Web-based, integrated with e-commerce payment
Product selection	Predefined products	Geographic and layer-based subsetting of predefined products	Selection of arbitrary features, layers and feature collections from seamless data warehouse, using OGC WFS and Filter Encoding
Delivery	Offline: hardcopy	Offline: softgood (e.g. Compact disk)	Online: File-based for network download (note: file may be generated dynamically) OGC WFS
Packaging/ formatting	Offline: hardcopy or softgoods from predefined formats	Online: user specified format selected from pre-generated softgoods	Online: support for user-specified softgood format via dynamic format translation OGC GML
Payment	Offline: traditional consumer	Online credit-based payment to registered list of consumers	Online e-commerce based, supporting "previously unknown" customers (e.g. online credit-card payment)

- ***The Cookbook authors recommend the development and publishing of data schemas using the OGC***

Geography Markup Language (GML) Version 3.2.1 for common re-use data themes.

- ***<b><i>The Cookbook authors recommend the deployment of OGC Web Coverage, Version 1.0 (WCS) and Web Feature Services, Version 1.1 (WFS) for raster and vector data publication, respectively.***

- ***<b><i>The Cookbook authors recommend that participants register their data services with the GEOSS Component and Service Registry (CSR).***

The Group on Earth Observation (GEO) hosts a global service registry that acts as a directory of all known web services in the Earth Observation and SDI communities. By listing data access services in such a system, publishers can assure that they can be discovered in a trans-national context.

References and Linkages

GeoGratis (http://geogratis.cgdi.gc.ca/)

International Organisation for Standards, ISO/TC211 (http://www.isotc211.org)

Internet Engineering Task Force (http://www.ietf.org/)

World Wide Web Consortium, or W3C (http://www.w3.org/)

Chapter 7

From The SDI Cookbook

Contents

Chapter Seven: Other Services

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Context and Rationale

Over the past decade, GIS technologies have evolved from the traditional model of stand-alone systems, in which spatial data is tightly coupled with the systems used to create them, to an increasingly distributed model based on independently-provided, specialized, interoperable GIS services. This evolution was fueled by various factors including the growing role of GIS in today's organizations, the increasing availability of spatial data and its inherent conduciveness to reuse, the maturity of Web and distributed computing technologies, and the key role GIS is expected to play in a promising location-based services market. Furthermore, most users of traditional GIS systems only use a small percentage of their systems' functionalities; Services can provide users with just the functionality and data they need at any time, bypassing the need to install, learn, or pay for any unused functionalities.

Services can be defined as self-contained, self-describing, modular applications consisting of collections of operations, accessible through interfaces, which allow clients to evoke behaviors of value to the user. Clients can invoke services from across a network using standardized protocols independently of platform, language, or object model on which the services or the client were deployed.

By building applications to common service interfaces, applications can be built without a-priori or run-time dependencies on other applications or services. Applications and services can be added, modified, or replaced without impacting other applications. In addition, operational workflows can be changed on-the-fly, allowing rapid response to time-critical situations. This loosely coupled, standards-based approach to system development can produce very agile systems- systems that can be flexibly adapted to changing requirements and technologies

Organisational Approach

The preceding chapters of this cookbook have discussed three types of services that are fundamental to any Spatial Data Infrastructure: data catalogues, online mapping, and access. As described in the OGC Service Framework, a broad range of other geospatial services may exist in SDIs. The OGC Service Framework (shown in Figure 7.1) identifies services, interfaces and exchange protocols that can be utilized by any application. The framework, which can be implemented in different ways, primarily provides a basis for coordinated development of new and extended geospatial services.

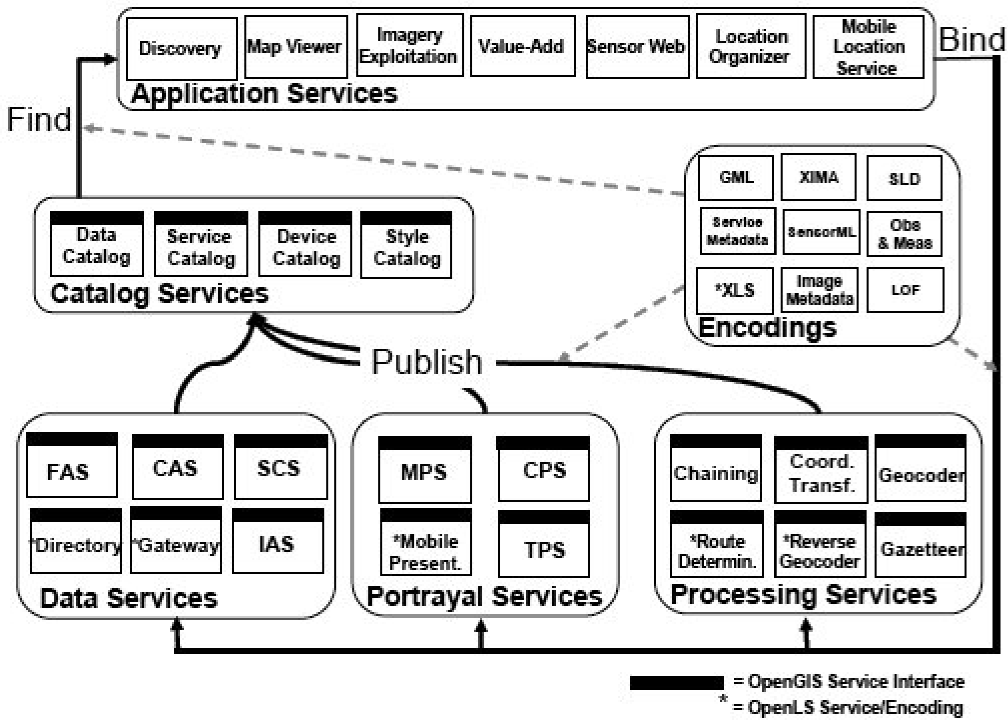

Figure 7.1 - The OGC Service Framework

The OGC Service Framework groups geospatial services into five categories (shown below) corresponding to the OGC services taxonomy top-level domains described in OGC's Service Architecture Abstract Specification (also ISO 19119). By providing a summary of these categories, this section is intended to help you decide on the right mix of services that you need in your applications. When available, applicable implementation specifications for these services will be highlighted.

Service Framework Service Categories	ISO 19119 Service Categories
Application Services	Geographic Human Interaction
Catalog Services	Geographic Information Management
Data Services	Geographic Information Management
Portrayal Services	Geographic Human Interaction
Processing Services	Geographic Processing Interaction

Geospatial Application Services

Application services operate on user terminals (e.g. desktop, notebook, handset, etc) or servers to provide access to the various services described here. They are used by users to access Catalog, Portrayal, Processing and Data services depending on the requirements and the designed implementation of the application. They often provide user-oriented displays of geospatial content and support user interaction at the user terminal.

Catalogue Services

Catalogue Services are described in detail in Chapter Four.

Geospatial Data Services

Geospatial Data services provide access to a wide range of collections of geospatial data stored in distributed repositories and databases. Examples of data services include

- Feature Access Services: provide access and management of feature stores. *Applicable implementation specification: OGC Web Feature Service (WFS; http://www.opengis.org/docs/02-058.pdf)*
- Coverage Access Services: provide access and management of coverage stores. *Applicable implementation specification: OGC Web Coverage Service (WCS; http://www.opengis.org/docs/03-065r6.pdf)*
- Sensor Collection Services: provide access, manipulation and collection of sensor observations. *Applicable implementation specification: OGC Sensor Collection Service (SCS; http://www.opengis.org/docs/02-028.pdf)*
- Image Archive Services: provide access and management of large sets of digital images and related metadata

Data services also provide access to location-based data in the form of the following services *(Applicable implementation specification: OGC Location Services OLS; http://portal.opengis.org/files/?artifact_id=3418):*

- Directory Services: provide access to online directories to find the locations of specific or nearest places, products or services
- Geocoding Services: transform a description of a location (placename or street address) into a normalized description of the location
- Navigation Services: determine travel routes and navigation between two points
- Gateway Services: fetch the position of a known mobile terminal from the network

Portrayal Services

Portrayal services provide visualization of geospatial information. Given one or more inputs, portrayal services produce rendered outputs (maps, perspective views of terrain, annotated images, etc). They can be tightly or loosely coupled with other services such as the Data and Processing services, and can transform, combine, or create portrayed outputs. Examples of such services include:

- Map Portrayal Services: described in detail in Chapter Five.
- Coverage Portrayal Services: *Applicable implementation specification: OGC Coverage Portrayal Service (CPS; http://www.opengis.org/docs/02-019r1.pdf)*
- Mobile Presentation Services

Processing Services

Unlike data services, processing services are not associated with specific datasets. Instead, they provide operations for processing or transforming data in a manner determined by userspecified parameters. Processing services can be tightly or loosely coupled with other services such as the Data and Processing Services. The most common examples of processing services are:

- Coordinate Transformation Services: convert geospatial coordinates from one reference system to another. *Applicable implementation specification: Coordinate Transformation Services (CTS; http://www.opengis.org /docs/01-009.pdf)*
- Image Processing Services, detailed in OGC's Abstract Specification Topic 15, include:
  - Image Manipulation Services: manipulate images (resizing, changing color and contrast values, applying various filters, manipulating image resolution, etc.) and are used for conducting mathematical analyses of image characteristics (computing image histograms, convolutions, etc.).
  - Image Exploitation Services: support the photogrammetric analysis of remotely sensed and scanned imagery and the generation of reports and other products based on the results of the analysis.
  - Image Synthesis Services: create or transform images using computer-based spatial models, perspective

transformations, and manipulations of image characteristics to improve visibility, sharpen resolution, and/or reduce the effects of cloud cover or haze.

- Geospatial Analysis Services: exploit information available in a Feature or Feature Collection to derive application-oriented quantitative results that are not available from the raw data itself.
- Gazetteers: provide access to geospatial data indexed by placename rather than by coordinate locations. *Applicable implementation specification: Gazetteer service profile of a WFS (http://www.opengis.org /docs/02-076r3.pdf)*

Service Chaining

Chaining services can be considered as a special case of processing services, enabling the combination or pipelining of results from different services in response to clients' requests.

Efficient service chaining is critical to your ability to leverage and combine multiple information sources hosted by various service providers. The key to achieving such efficiency relies on the use of standard interfaces and encodings in the design of the underlying services. Service chaining is required when a task needed by a client cannot be provided by a single service, but rather by combining or pipelining results from several complementary services.

Indeed, most GIS applications will require the chaining of multiple geospatial and non-geospatial services. Figure 7.2 shows a typical service chaining scenario where a Coverage Portrayal Service (CPS) fetches several GIS coverages from different WCS services, then mosaics them to portray the resulting composite image of Cambridge, Massachusetts. A processing service reprojects the resultant coverage to another spatial reference system. An overlay service then supplements the coverage with features extracted from a WFS, and sends the result to the client as a rendered map.

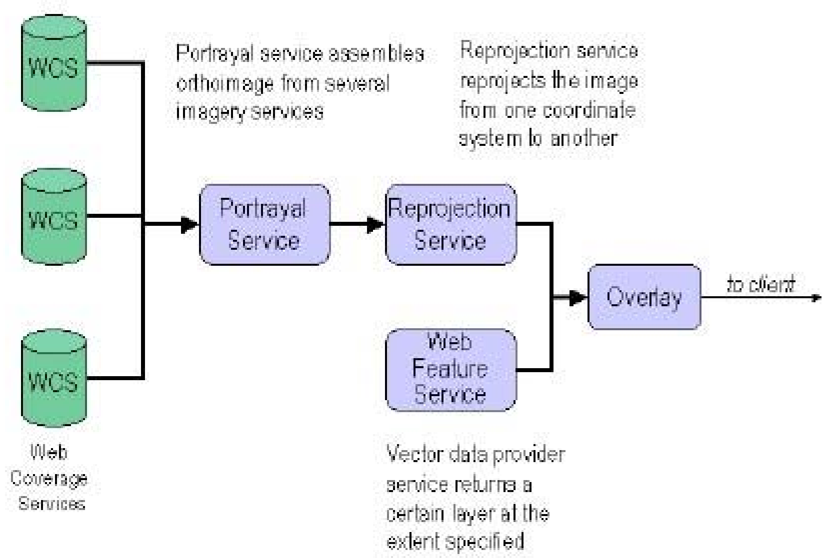

Figure 7.2 – A typical service chaining example

Approaches and technologies to efficiently and scalably construct and express service chains are still areas of active research. In addition, several issues surround the execution and tracking of a typical service chain such as the one shown above, including:

- *Transparency*: How much should the client be exposed to the service chaining complexities? How much should the client be involved in constructing, validating, executing and managing service chains?
- *Tracking*: How should the service chain track and relay to the client the sources of geographic data used along the chain, and the various transformations applied to it? Keeping track of metadata is important because users cannot often trust the data unless they have some information about its resolution, orthorectification parameters, remote sensing origin, etc. Such information is also critical in evaluating the fitness of use of returned data in various applications.

- *Error reporting*: How should services handle errors and report them along a chain to the client? Precise error reporting is particularly critical in the case of synchronous chains (such as the one depicted in Error! Reference source not found..

To date, three general service chaining methods have been identified according to ISO 19119:

- *User-defined transparent chaining*, where the user defines and controls the order and execution of the individual services. This service chaining method requires deep involvement of the client, which may hinder a wide-base adoption of geospatial web services.
- *Opaque chaining*, where the chaining of service is performed by a new aggregate service. The services appear as a single service which handles all coordination of the individual services behind the aggregate service. Aggregate services bundle static (predefined) chains of services and present them to the client as one. The client, however, loses all control over the service chaining process.
- *Workflow-managed translucent chaining* where the execution of the chain is managed by a mediating service. Mediating services can act as gateways to other services by coordinating between multiple services without necessarily storing any data of their own (Alameh, 2003). Mediating services combine the simplicity of aggregate services with the flexibility and control inherent in client-coordinated service chaining. Mediating services can use pre-specified client preferences to search for appropriate data and processing services. With the wide range of possible GIS applications and the different semantics needed in different fields, it is likely that the internal mediating services rules will be tuned to specific application domains. The need for such specialization will likely enable the emergence of a variety of mediating value-adding service providers in the GIS market.

Chaining of geospatial (possibly in conjunction with other non-geospatial services) is still considered an area of active research both from the conceptual and implementation perspectives.

Implementation Approach

While specific GIS software packages may offer one or more of the services discussed so far in a proprietary fashion, there are few existing standards and protocols for providing geospatial domain services in an interoperable manner. Consequently, if you need to implement any of these services in your production environment, it is advisable that you first try to reuse existing interfaces to the extent possible. You should also work with others in your field and with applicable standards bodies to design standard interfaces that can meet your needs. By ensuring that new services fit within the described OGC Service Framework and are consistent with existing standards and abstract specifications, you contribute to the sustainability and extensibility of architectures based on that framework. Furthermore, this enables you to more easily respond to new requirements and quickly deploy new applications while providing a wide range of clients with the flexibility of mixing and matching services when building their own customized applications.

In terms of supporting technologies, work is underway within OGC to define a suite of web service interfaces that have explicit bindings for both HTTP GET and POST (e.g. the WMS, WFS and WCS specifications). In this case, XML is very fundamental as it provides the extensibility and vendor, platform and language independence that are key to the loosely coupled standards-based interoperability. XML is also being used for defining several methods of encodings (e.g. the SLD, GML specifications).

As for service chaining, work is still under way to enable it using existing and emerging XML technologies, such as

- *The Web Services Description Language (WSDL; http://www.w3.org/TR/wsdl)*, which provides a way to describe the messages and operations of a service in an abstract way and bind them to a concrete protocol and message format. A Web service described with WSDL enables programs, also known as proxy generators, to automatically construct a request to that service. By not requiring the calling party (client or another service) to know a priori the interface to any WSDL-described service, WSDL makes both transparent and workflow-managed chaining easier to implement.However, it should be noted that in the case of GIS services, describing the service interfaces is often not enough. In a data-centric field such as GIS, a mechanism is needed to describe the data characteristics that various GIS services can serve or process. Within the OGC, this is currently achieved by requiring each GIS Web service to support a getCapabilities operation which returns, among other information, details about the data supported by that service.

- *The Universal Description, Discovery and Integration (UDDI; http://www.uddi.org)* which enables businesses to quickly and dynamically find and transact with each other. The major obstacle slowing down the adoption of UDDI within the geospatial community is attributed to the fact that UDDI registries do not currently support any type of spatial queries. With spatial queries being at the heart of any GIS application, the ability of not being able to search for services or data by bounding box constitutes a real limitation for users. It remains to be seen whether future versions of UDDI will support such functionality.

• The Simple Object Access Protocol (SOAP; http://www.w3.org/TR/SOAP/) which provides a simple and light-weight mechanism of exchanging structured and typed information between peers in a decentralized distributed environment.

- *DAML-based Web Service Ontology (DAML-S; http://www.daml.org/services)* which supplies Web service providers with a core set of markup language constructs for describing the properties and capabilities of their Web services in unambiguous, computer-interpretable form. DAML-S' support for automatic selection, composition and interoperation of Web services is of particular relevance to service chaining. Such support is possible because DAML-S provides declarative specifications of the prerequisites and consequences of individual service use that are necessary for automatic service composition and interoperation. These specifications have the potential of being used to dynamically identify which services can be chained to each other, and which ones can be substituted for one another for the purpose of answering a specific request.

- *The Business Process Execution Language for Web Services (BPEL4WS; http://www-106.ibm.com /developerworks/webservices/library/ws-bpel/)* which defines a notation for specifying business process behavior based on Web Services. It is a standard promotedby Microsoft, IBM, Siebel, SAP and BEA for orchestrating discrete services into end-toendbusiness processes. Processes defined in BPEL can export and import functionalityby using Web Service interfaces exclusively. BPEL provides a language for the formalspecification of business processes and business interaction protocols. By doing so, itextends the Web services interaction model and enables it to support businesstransactions. BPEL defines an interoperable integration model that should facilitate theexpansion of automated process integration in both the intra-corporate and thebusiness-to-business spaces.

It remains to be seen how the listed technologies (and others) can be leveraged for service description, discovery and chaining within the geospatial domain. The sooner a tested and reliable approach is crafted, the faster the benefits of geospatial services can be reaped. Interoperable geospatial services will be especially beneficial for scientific research and engineering modeling as well as state and federal government settings where tightly coupled hierarchical systems are unlikely to provide the desired breadth and flexibility. Services allow users to freely combine services to create customized solutions with minimal programming, integration and maintenance efforts.

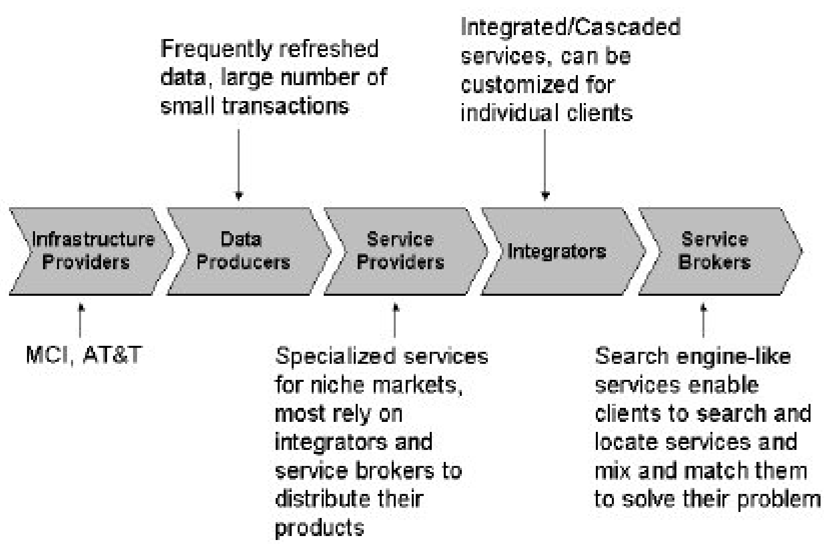

Figure 7.3 – Potential value chain for a service-based GIS marketplace

In such a service environment, having expertise in certain fields or industries can provide you with the advantage of uniquely supplying customized solutions to your partners and clients. As shown in Figure 7.3, in this environment, it will not be necessary for players to build comprehensive systems in order to gain a share of the market. The new environment can open the door to small niche players to enter this market with application specific offerings that leverage their understanding of particular industries or processes.

Recommendations

In light of the described organization and implementation approaches and the importance of interoperability in sustaining a scalable SDI, the Cookbook authors recommend the following:

- ***Comply with existing standard interfaces and encodings when implementing your geospatial services (to maximize other people's access to your data holdings and service offerings);***
- ***Require that your COTS providers support existing standard interfaces and encodings (to enable you to maximize your access to outside data sources and geospatial services);***
- ***Refer to the OGC Service Framework and ISO 19119 Service Architecture when designing new services, in order to make sure that your services fit well within the existing reference architecture;***
- ***When designing new services, try to reuse existing interfaces to the extent possible; You should also work with others in your field as well as with applicable standard bodies (such as ISO, OGC, W3C) to design standard interfaces that can meet your needs;***
- ***Leverage and build on general IT and Web services technologies in order to ensure wider acceptance and use of your geospatial services. In most cases, the more general technologies will need to be extended to address requirements that are unique to the geospatial community. Communication with the general IT and Web services standards bodies is needed when working on these geospatial-specific extensions.***

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Chapter 8

From The SDI Cookbook

Contents

Chapter Eight: Legal and Economic Policy

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Introduction

Several legal issues arise when implementing information infrastructures, including SDIs. Typical are intellectual property rights (IPR) governing access to and use of spatial data, which includes copyright, patenting of software and algorithms, and database protection, in those jurisdictions where such protection exists in law. Privacy regulations if spatial data is used to identify individuals, commercial confidentiality and liability issues also arise. This chapter also reviews cost-benefit analysis (CBA) methodologies that have been used to justify the cost of creating SDIs, at sector, national and regional levels and addresses some of the issues surrounding use of different methodologies.

Context and Rationale

Intellectual Property Rights

This section introduces the reader to the main intellectual property rights (IPR) issues, including copyright, legal protection of databases, and patents for algorithms or methodologies that impact on spatial data use.

Copyright

Review of copyright law goes here. The focus is on how these may impact on SDI stakeholders.

Legal Protection of Databases

Review of the European Database Protection regulations (now in effect in 27 European states)

Patents

Short review of patents, especially for methods and algorithms, goes here, along with examples of important patents that have been issued relating to spatial data. The focus is on how these may impact on SDI stakeholders.

Other Legal Issues

Protecting Personal Privacy

Protecting Confidentiality

Liability

Nearly any human endeavour that delivers a product or service to the public, whether for sale, for hire, or for free, can create liability. A large body of law already exists in many countries for liability and computer software. Liability in relation to data is a much newer phenomenon in regard to both statutes enacted and legal cases previously argued in court. Although laws vary from one country to another, in general, liability for data can arise in four areas:

1. Errors in represented location due to measurement or data manipulation mistakes.

2. Errors in representing otherwise error-free data; for example, graphically showing data at the wrong scale, thus misleading the user (even if done inadvertently).

3. Harm caused to users by unintended or inappropriate use of the data (or of software, in an integrated system), which might or should have been (in the opinion of a court) prevented by the provider.

4. Infringement of copyrights or other IP protections.

Liability falls into three broad categories (Westell 1999a, 1999c; Klinkenberg, 1997):

1. Contract liability (or breach of contract), including breach of express and implied warranties.

2. Negligence.

3. Product liability (or breach of statutory duty regarding consumer protection statutes).

Negligence arises if harm, loss or damage results when a supplier fails to exercise reasonable care to a standard normally accepted in the same situation. Reasonable care has been defined in statute and by courts for many situations. Defects leading to such liability include design faults and marketing misrepresentations; for example, leading potential users to believe that products or services are fit for a purpose for which they are not. Map makers and users of maps have been found to be negligent in past court cases, although such cases are sufficiently infrequent that many practitioners are not unduly concerned.

Liability relating to spatial information raises several questions, because it is often difficult to measure the completeness, accuracy, or reliability of such data as “express terms” in a supply contract. It is important to specify the nature of the data product as completely as possible, to let potential users know (1) what the data were collected for, (2) what they were used for initially, and (3) what they are not suitable for, even though such a list is not likely to be exhaustive. Provision of adequate “metadata” (descriptions of the nature and sources of the product in question) with data should reduce liability.

Note that so far as limiting liability goes, there is potential for a basic conflict of interest among parties negotiating contracts. People contracting for products or services will normally expect that a contract clearly state the purpose of the product or service and provide warranties that the product or service is fit for its intended purpose. In contrast, product or service providers will seek to minimize explicit claims of suitability, to reduce potential liability.

It is possible to release software, data, or advice into the public domain, claiming neither IP nor economic gain, and still be held liable for the product or service so offered. However, anecdotal evidence suggests that, for spatial information services that are offered at no/low cost by public research organizations and that carry appropriate disclaimers, the risk of being held liable may be lower than would otherwise be the case.

Liability in Cadastral Surveying

Another area in which liability issues appear regards spatial data used for legal purposes, such as in cadastral surveys, as shown in this extract from “European requirements for cadastral surveyor activities” (pp 13 – 14) produced by EuroGeographics [www.eurogeographics.org], the European Council of Geodetic Surveyors (CLGE) [www.clge.eu], and Geometer Europas (GE) [www.geometer-europas.eu] – figures in Table 1 below are based on respondents to a study questionnaire, returned from 25 European countries.

[begins]

The majority of cadastral surveyors in Europe are fully responsible for any mistakes they make in their work, yet only very few countries have clear rules or mechanisms for third party reimbursement or compensation for the acknowledged loss arising out of cadastral surveyor’s activities. Therefore the liability of the cadastral surveyor limits itself to sanctions on their level of qualification rather than financial compensation for losses suffered by the customer.

Many surveyors rely upon the results of litigation in the civil courts between the surveyors and clients to provide a solution for negligence instead of purchasing Professional Indemnity Insurance (PII).

When cadastral surveyors are employed by an NMCA their liability is limited to public servant duty. In these cases the State is liable for the cadastral data maintained by the Agency.

In the countries, which replied with a ‘no’ response (the surveyor is not responsible for the quality of cadastral data), a shared responsibility exists. The organisation (State) is responsible externally for the work provided by the cadastral surveyor, although the activity itself (validation of cadastral data) is the responsibility of the professionalism of the cadastral surveyor.

The duration of the surveyor’s liability for the cadastral documents produced can differ, as shown in Table 1, which also highlights that the liability of cadastral surveyors is not well defined in a number of countries. Almost half of the respondents (46 per cent) indicated that there is no maximum period for the liability of cadastral surveyors, while 24 per cent mentioned a lifetime responsibility, which sounds equivocal and might be questioned various courts.

Table 1. Period during which cadastral surveyors are liable for the produced cadastral documents (data)

Time Period	Percentage of respondents
30 years	12%
10 years	6%
5 years	12%
Lifetime	24%
Not defined	46%

[ends]

Licensing

Introduction

The following summary of license considerations may help SDI stakeholders realise the value of licenses and the main terms to be included, if creating a license, or to be aware of, if entering into a license (European Commission 2001):

• Licensing terms are not backed by the international IP treaties nor, in most developed countries, by national IP law. Rather, their use is regulated by the laws of each nation, ranging from privacy protection to consumer protection to national security considerations, or proper use may be defined within the license itself.

• If claiming IP rights, state this clearly in the license. List what rights you are claiming and that you are claiming them. Include confidentiality statements dealing with the disclosure of IP in the products, whether software or data.

• Various open source licenses allow you to surrender specific rights associated with IP protection (for instance, copyleft clauses), while still controlling how the IP is to be used or redistributed.

• Licenses can offer differing levels of protection in different legal jurisdictions and even in regard to different types of products and services in a single country.

• There is much more experience (in law) with licensing software than with licensing data, especially digital data and especially digital data made available via the Internet.

• Examine the termination clauses in a license, listing specific events that can lead to termination of the license, some of which may be automatic.

• Consider use and redistribution clauses carefully; for example, the number of copies permitted to be made by the original purchaser, use on networks versus stand-alone systems, any additional support costs for networked systems, upgrade fees (if any are planned), or use for commercial versus educational purposes.

• Be aware of defensive clauses excluding liability for the different forms of loss or damage that may arise as a result of using the software or data, either due to faults in the product or in its misuse by the end user.

• Be aware that the terms of licenses depend upon the law of the jurisdiction in which the product is sold and that special legal requirements may need to be met for the license to be enforceable, such as the language of the license. For software or data delivered on-line, this can be especially problematic, and involves laws on taxation (both sales and value added taxes), e-commerce rules that may be in place (e.g., recognizing digital signatures), laws on export control, and even laws on currency control.

GNU Public Licenses

To "copyleft" a program, as opposed to claiming "copyright", researchers need to use a specific set of distribution terms, which can be written in many ways. The GNU Web site29 contains much information on different types of open source licenses plus educational material about the entire open source movement. There are also links to the Free Software Foundation, Inc., in the USA, which is one of the driving forces behind the open source movement.

If a researcher or institution develops a new program for which they want to encourage the widest possible use, this can probably best be achieved by making the new product “free software” (as opposed to “shareware”), which everyone can then redistribute and change under the GNU Public License terms. To do this, simply attach the notice (shown below) to the program, typically at the start of each source file, to convey the exclusion of warranty. Each file should have at least the copyright line, a pointer to where the full copyright notice can be found, and contact information for the program author.

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Open Source and Open Geodata

SDI Economics

In this section covering the economics of SDI implementation, we look primarily at cost-benefit analysis (CBA) methodologies that may be applicable to large information infrastructure projects or initiatives, then at the results of applying such methodologies to SDI implementation specifically, at national and regional (trans-national) level. Some of the earliest studies were conducted in Australia and New Zealand from 1990 onwards.

Cost-Benefit Analysis Methodologies

Several cost-benefit analysis (CBA) methodolodies exist for examining projects and programmes. Finding a suitable methodology for investingating the cost-benefit of an entire information infrastructure is more problematic.

Different CBA methodologies are applied in different circumstances, addressing the inherent differences that exist across myriad types of project or programme goals and implementation requirements. A common theme in most such analyses is that costs for implementation are usually much easier to determine or estimate accurately than are matching benefits from the goals, especially where these may be important, but not easily quantifiable in monetary terms.

Historical Cost-Benefit Studies

SDI-related cost-benefit analysis (CBA) studies have been conducted since as early as 1990 - in Australia and New Zealand. Yet most nations that are embarked on SDI implementation programmes or in the process of adopting SDI strategies have not conducted full CBA studies or have investigated only specific components of an SDI, such as implementing a national geoportal. In some cases, lack of a formal CBA has been used as an excuse to proceed with full implementation.

Financing the SDI

Very few countries have provided additional funding from the federal treasury specifically for implementing a national SDI. Two exceptions are the Netherlands and Canada. In this section, we look at current thinking on how to finance SDI development, why the financing decision is not as straight forward as some might think, and the impact on speed of implementation where direct financing has been made available.

Chapter 9

From The SDI Cookbook

Contents

Chapter Nine: Outreach and Capacity Building

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Introduction

This chapter describes the 'softer' elements of a Spatial Data Infrastructure (SDI), focussing on the outreach and capacity building activities that accompany the more technical elements of building a SDI dealt with in previous chapters. Nevertheless, the aspects of implementing a SDI discussed here often present considerable challenges because they depend on the willingness of people in different organisations and institutions to co-operate and share data.

The chapter considers when it makes sense to develop a Spatial Data Infrastructure, how this relates to regional efforts and the Global Spatial Data Infrastructure and how outreach and capacity building activities can be used in the implementation of a SDI.

Contributions from both developed and developing countries have been drawn upon. These are placed along different ends of the spectrum of SDI development; some of these countries have gained much experience in implementing a SDI while others are just beginning.

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Context and Rationale

When we speak of Spatial Data Infrastructure we imply a computerised network of systems serving digital spatial data and data services. This concept presents a paradigm shift to those spatial data users who have long used analogue hard copy maps. While the transition has been rapid in developed countries, there are many countries where this concept is taking root in bits and pieces and very slowly. SDI is not only about the technology but about a way of doing things that presume data sharing and an underlying agreement on data standards and interoperability. There are many managerial, systemic, institutional, legal and political issues that need to be addressed. Capacity Building and Outreach need to cover these issues.

When does a Spatial Data Infrastructure make sense?

The continued advances in remote sensing, mapping and geospatial technologies, including an increasing variety of data acquisition capabilities and low cost and more powerful computing capacity, coupled with the development of geographic information system technology, have enabled and increased the demand for geographic information. As the importance of geographic information in addressing complex social, environmental, and economic issues facing communities around the globe is growing, the establishment of a Spatial Data Infrastructure to support the sharing and use of this data locally, nationally and, in some cases, transnationally makes increasing sense.

Without a coherent and consistent SDI in place, there are inefficiencies and lost opportunities in the use of geographic information to solve problems. Furthermore, as spatial technologies are increasingly being used by diverse organisations in developed and developing countries, a number of obstacles add up to a geographic information bottleneck (see Example 1). Institutional and political will to publish and therefore share data is largely absent in many countries. Institutions generating data tend to husband and sequester data in the name of confidentiality, national security and 'to prevent misuse'. Even when data is shared among government departments it is done with caveats on publishing and therefore sharing the results of the data interpretation. This results in lack of institutional co-ordination, insufficient flow of information, overlapping of initiatives, duplication of field activities and results, and poor management of resources. An additional problem is insufficient qualification of the technical staff. There is a lack of standardised metadata and poor documentation on who is doing what and the types of available information because it is seen as 'unnecessary'. This has a double negative effective. On one hand, potential data and information users have difficulty finding or having access to needed relevant information and, on the other hand, information suppliers do not know the value of what they have which in turn prevents better organisation of information for dissemination and enhanced value of the information.

It is important to take into account that the longer the harmonisation of stand-alone databases is post-poned, the more difficult it will be to make them interoperable. Costs for integrating standalone systems into a SDI concept are increasing exponentially with time and the number of data sets. This suggests that a co-ordinated initiative based on SDI principles should be considered as soon as possible. A feasibility study carried out in Malaysia prior to the implementation of a national SDI concluded that a SDI would present an opportunity with dynamic benefits that would grow over time, culminating in accelerated socio-economic development the nation combined with a reduction in delays in the implementation of projects (http://www.nalis.gov.my/laman/kertas6e.htm).

However, the development of a SDI will rely heavily upon opportunities provided by the sociopolitical stability and the legal context of a country as well as other important institutional set-ups that might become instrumental while installing a dynamic process of information creation and exchange (see Example 1).

A new development arising out of the easy availability of Web 2 services like Google Map Maker and Open Street Maps and GPS enabled devices like cellular phones and PDAs is the possibility of crowd sourcing of data. Crowd sourcing arrives at reliable data through a process of community participation in data collection and editing. In restrictive environments crowd sourcing presents a via media for data availability and sharing which bypasses the 'official' channels. SDI efforts need to recognise this development as an additional source of data particularly in rapidly changing situations like disasters.

Example 1 Summary of Current Conditions in Developing Countries Around the Globe

Awareness of the value of geographic information and applications is growing quickly, in the public and private sectors. Growing awareness of the potential of GIS among public sector institutions, non-governmental organisations as well as the private sector means that the use of geographic information systems is increasing every year. However, often the existing spatial data systems are not technically linked and institutional co-ordination is still weak. Most GIS developments started with the implementation of an information component for specific projects. Systems are not designed to ensure smooth data sharing but primarily to respond to specific needs of the host organisation. They also tend to be vendor driven. Although this has helped to design systems with a demand driven approach, this evolution did not create a favourable context for straightforward data exchange.

Co-operation and co-ordination between public sector organisations is limited. Due to the lack of co-ordination, the different data structures will not be compatible to facilitate data exchange. Although networking relationships exist between people, these are based on individual contacts and are not reflected in an operational co-ordination of activities. There is usually no nation-wide SDI and usually no lead agency has started activities to create one. Many of the systems are still in their installation phase. Where there is metadata at all, different agencies maintain it using different formats and tools. More generally there is a lack of common elements that could facilitate data exchange such as same working scales, same GIS software, and the completion of a national database which could be used as standard basic information layers. In many instances, there is no copyright law and most public agencies need to market their product in order to find additional resources to maintain and update their data. Only very few institutions have already started to define clear data exchange policies to disseminate their information.

Development and implementation are very internal, stove-piped and do not favour data sharing collaboration. The spatial databases being built up are "stand alone systems", using individual philosophies and technologies (concepts, structures, hard and/or software). Most of these implementations are technology and/or donor driven and as such are isolated implementations, insular databases under construction, and related to specific environmental issues. The whole problem is exacerbated in developing countries since different agencies are often supported by a different donor. Each donor tends to encourage its own solution – often resulting in interagency competition instead of co-operation. Few of them are ready to deliver some outputs, none of them are fully operational yet. Worse, when the donor funding tapers off, so does the activity. Communication between the different implementations is usually not possible technically because common communication standards for data exchange are missing. The exchange of information between institutions and teams ranges from limited to non-existent. Often the relation between the implementations is characterised by competition rather than co-operation. Existing systems primarily serve the purpose and mandate of their host organisations, who are only now beginning to co-operate and co-ordinate. There is very limited co-operation and co-ordination between public sector organisations.

Most of the motivation to employ geographic information and tools is still internal to institutions to serve their primary needs. Outreach and education are not being emphasised. The majority of the institutions are motivated by their own mission and therefore to a great extent do not subscribe to national policy objectives (I do not agree with this sentence-Arupdg). Existing systems serve primarily their own clientele, without concern for the needs of other potential users. This leads to the duplication of efforts and sometimes inefficient use of resources, both financial and human. Sharing information in a fully transparent manner is not the main characteristic of the usual communication culture. Communication is instead linked to hierarchy and authority. Since the success of a SDI is based to a large extent on cross-sectoral networking and access to information, the inherent organisational "communication culture" impedes the build- up of an efficient SDI.

There are few national policy initiatives underway to encourage sharing and collaboration on geographic data and practices. There are only a few formalised institutional links to share data. Practically every organisation has its own way of producing digital data. Some departments are developing their own data standards including classification schemes for their own use. The awareness of copyright issues is rising, but there is often a complete lack of policy around information management - it has not been addressed simply because it is not seen as a priority.

Vertical organisation within government and administration is limiting cross sectoral communication. Due to the strong vertical organisation culture of government and administration, there is no real encouragement of cross sectoral communication. Each ministry or department undertakes its own mandate, trying to create it's own database and information system, following it's own needs, point of views and priorities. Information is handled in a strictly vertical direction, following hierarchies. Information seems always to be linked to persons and their status within the hierarchy.

Cross sectoral information exchange is strictly limited to informal organisation. The handling of information is a political issue, a cultural topic.

Access to information is hindered by a lack of transparency Access to information is not only a question of ownership and attitude to communication. Transparency is not yet the main characteristic of communication culture and remains a major problem. Nobody really knows who disposes of what, where what is available or who is in charge to produce what. Without an overall information concept, without clear mandates, tasks and responsibilities, without a metadata-database, access to information remains a casual event, a question of personal relationships and good or bad luck. Users of information have to know about and in some cases hunt for information. To collect precise information one needs either a very good personal network, based on personal relationships, or a lot of time and good nerves. The major technical obstacles to data sharing reside in the lack of application of a national standard for spatial data, incompatible classification schemes and the almost total absence of data documentation or metadata. Additional difficulty stems from restrictions on spatial dissemination for maps of border areas.

These problems are not exclusive to developing countries. A fundamental problem underlying data sharing and distribution is the belief that one gains power and influence from withholding information and controlling it. In fact, true power is held by those who distribute the information and whose information is used by senior political levels. Once this leap of faith is taken, as it has been in several countries, data sharing becomes remarkably easy.

Example 2 The national SDI in the US: Much of what is today's U.S. Federal Geographic Data Committee (FGDC) and the National Spatial Data Infrastructure (NSDI) have roots in the concern by Presidential Administrations since the 1950's to better co-ordinate the operations of agencies engaged in surveying, mapping and related GIS functions across government. Two major activities to drive co-ordination were the Office of Management and Budget published Circular A-16 in the late 1950's, and the activities of a federal mapping task force convened in the early 1970's. The Task Force was charged with studying the possibility of consolidating geographic information (GI) functions across the federal government to reduce potential duplication and overlap, and to potentially reduce costs. Pressures to consolidate Government GI functions continued and in the early 90's the US Government recognised the need to establish a sustaining spatial data infrastructure as part of its National Information Infrastructure. With the advancement of technology and the increase in the personal computers, there was an accelerated explosion of digital information production from a multitude of federal, state, local, other public and private sources. The need for a compatible infrastructure to find, share, and exploit information across jurisdictions became a common goal of many organisations to reduce duplication and improve support to users, and better co-ordinate the operations of agencies engaged in surveying, mapping and related GIS functions. The FGDC was created in 1990. The Committee was created to "promote the co-ordinated development, use, sharing, and dissemination of geographic data". Specific support was requested from several key federal agencies involved with geospatial missions. Today, the FGDC has added more key federal departments, agencies and others will soon become a member as well. The role of other Federal Agencies is expanding as they realise the spatial significance of their social, environmental, economic data, and the FGDC focus now is moving toward getting these data types (such as crime and health data) recognised as national spatial data infrastructure components. The FGDC has also expanded its partnerships to include state, local, tribal governments, and representatives from the GIS industry and academia.

The national SDI in Australia: In Australia, the initial impetus came from the Australia New Zealand Land Information Council (ANZLIC), the peak inter-governmental body for spatial data issues. Each State and Territory and the Commonwealth were represented but there were no industry stakeholders. Some 3 years of the ASDI was spent scoping the size of the tasks ahead and allocating jobs and lead agency status for specific tasks. The recent 12 months have seen the operationalisation of the SDI programs in each of the States and Territories.

Survey of national and regional SDI's: A global survey of many national and regional SDI's can be found at http://www.spatial.maine.edu/harlan/GSDI.html gathering baseline information on the nature and characteristics of the national SDI's that are currently being developed. For each national or regional entry, the following information is provided:

- the type of organisation(s) taking the leadership in the co-ordination and development of the SDI,
- the types, categories or forms of spatial digital data made available through the SDI,

- the technical and organisational access mechanisms of the SDI
- private sector involvement in the SDI
- public domain data sets
- legal mandate or formal orders behind the establishment of the SDI
- the components of the SDI
- most pressing challenges.

Another important resource considering different SDI development strategies can be found at http://www.gsdi.org /canberra/masser.html More infrastructure developments are provided at http://www.gsdi.org/

These sources suggest that the concepts of core data (or framework data), data standards, clearinghouses and metadata are well accepted as parts of SDI's in many nations around the world. From the standpoint of global SDI development, these are areas where we collectively should place our near term efforts in gaining international agreement where possible.

A SDI makes sense at the local, national, regional and global level where the overlap and duplication in the production of geographic information is paralleled by insufficient flows of geographic information among different stakeholders due to a lack of standardisation and harmonisation of spatial data bases. Once the importance of providing geographic information as an infrastructure similar to road and telecommunication networks is recognised, it makes sense to ensure that a consistent Spatial Data Infrastructure at the local, national and global level is developed.

The 'ideal' SDI: The characteristics of what may be described as an 'ideal' SDI are outlined below;

- There is a common spatial data foundation organised according to widely accepted layers and scales (or resolution) that is available for the entire area of geographic coverage (parcel, neighbourhood, city, county, state, nation, etc.) to which other geospatial data can be easily referenced.
- The foundation (or core) data is readily accessible and available at no or little cost from user-friendly and seamless sources to meet public needs and encourage conformance with it by producers of other geospatial data.
- Both foundation and other geospatial data, as required and specified co-operatively by data producers and users, is updated according to commonly accepted standards and measures of quality.
- Thematic and tabular data are also available on terms not incompatible with the foundation data.
- Cost-effective, geospatial data produced by one organisation, political jurisdiction, or nation is compatible with similar data produced by other organisations, political jurisdictions or nations.
- Geospatial data can be integrated with many other kinds or sets of data to produce information useful for decision makers and the public, when appropriate.
- Responsibility for generating, maintaining, and distributing the data is widely shared by different levels of government and the private sector. Governments take advantage of private-sector capabilities available at reasonable prices rather than maintaining dedicated capabilities.
- The costs of generating, maintaining, and distributing such data are justified in terms of public benefits and/or private gains; overlap and duplication among participating organisations is avoided wherever possible.

(United States National Academy of Public Administration 1998)

Organisational Approach

Principles of the GSDI

At the 2nd GSDI Conference in 1997 the Global Spatial Data Infrastructure (GSDI) was defined as *".. the policies, organisational remits, data, technologies, standards, delivery mechanisms,* and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives."

The GSDI is intended to be non-competitive, collaborative, and to build on and unify common activities in the field of geographic information exchanges and harmonisation. The GSDI is envisaged to support trans-national or global access to geographic information and it is seen by many as central to the response to the challenge of global sustainable development. It is an effective promotion of national and regional Spatial Data Infrastructures.

Examples of how these principles are promoted and implemented at the regional and international level are given below.

Example 3 Regional collaboration: The European Umbrella Organisation for Geographic Information (EUROGI) was set up to foster geographic information outreach and capacity building at the regional level. EUROGI's objectives are to support the definition and implementation of a European geographic information (GI) policy and facilitate the development of the European Geographic Information Infrastructure (EGII). It also represents the European view in the development of the Global Spatial Data Infrastructure (GSDI) and is the European regional contact for GSDI. In a more general sense EUROGI tries to encourage the greater use of GI in Europe through improved availability of and access to GI, the removal of legal and economic constraints to use, and the promotion of the use of standards. As an association of associations, EUROGI works towards the development of strong national GI organisations in all the European countries with particular emphasis on organisations within the Central and Eastern European countries.

International collaboration: The United States has been a recognised world leader in the development and use of geographic information and related technologies. Recently, on behalf of the organising committee of a conference on Global Spatial Data Infrastructures, the FGDC conducted a survey of spatial data infrastructure activities around the world. This survey showed that there are a growing number of nations, which are either developing or planning to develop spatial data infrastructures. These initiatives, while reflecting the specific needs of the various nations, were found to have many components in common with each other. These same components are also part of the United States National Spatial Data Infrastructure, which is becoming a model that is frequently looked to and used by other nations as they consider ways in which they can better co-ordinate and use geographic information. The FGDC is increasing its focus on the international and global community to help assure that NSDI development is accomplished so that data, practices, and applications can be shared wherever possible to address transnational, regional, and global economic, environmental, and social issues. The FGDC is an active supporter of the GSDI, it is pursuing nation to nation agreements to foster SDI collaboration on topics of mutual interest, and it is a strong proponent of the formation of a Permanent Committee of the Americas to address the infrastructure issues specific to the nations in the Americas.

Different levels of international collaboration: GeoConnections, the program responsible for implementing the Canadian Geospatial Data Infrastructure (CGDI), believes that international partnerships are important at many levels. For example, the Canadian clearinghouse is interoperable with the US and Australian clearinghouses and the Canadian program has supported the development of access tools that are being reused in the US and Canada. Canadians have been very active in many of the international standards activities and now, as the infrastructures are being implemented, there is a significant opportunity to co-operate with international partners and industry in the development of implementation specifications, such as the Open GIS Consortium Catalogue Services and Web Mapping Testbed.

Realisation of the GSDI

The stakeholders and interested parties in the development of the GSDI were identified at the 3rd GSDI Conference (1998) in Canberra, Australia:

"The achievement of GSDI will depend upon partnerships among many groups including industry, consumers, academia and government. GSDI must develop outreach activities to ensure that institutions and organisations that can and will benefit from an improved global spatial data infrastructure have an opportunity to participate. At this meeting it was obvious that national mapping organisations/agencies, state level mapping organisations/agencies, industry, academia and a variety of governmental agencies are very interested in GSDI development.

- ***National mapping organisations/agencies***

National mapping organisations/agencies play a key role in ensuring that accurate, up-to-date geospatial framework data are developed and maintained. Such data are key to, among others, the promotion of sustainable economic development, improvement of environmental quality, resource management, upgrading public health and safety, modernisation of governments GSDI Cookbook, Version 2.0 25 January 2004 Page 103 either local, national or *regional, and the responses to natural and other disasters. Therefore such organisations play a vital role in facilitating the development of a GSDI.*

- ***Industry***

Industry is working to provide technology, data and services in support of GSDI activities. In particular, industry plays a key role in ensuring that effective information technologies (consistent with standards and specifications being developed by such groups as ISO and OGC) exist and that these technologies support GSDI requirements. Therefore it is imperative that such organisations play an important, proactive role in the development of a GSDI.

- ***Other agencies, organisations and institutions***

There are many other agencies, organisations and institutions that collect and use geospatial data that along with national mapping organisations/agencies and industry can and should play an important role in GSDI activities. It is important here that ways be sought to encourage cooperation, collaboration and communication among as many GSDI stakeholders as possible.

- ***National and regional SDI initiatives***

There are a growing number of significant SDI initiatives at national and regional level that can and will act as a stimulus to GSDI development. Several of these initiatives were highlighted at the 3rd GSDI Conference - national developments in countries such as Malaysia, Hungary, Australia, New Zealand, USA, UK, Canada -regional developments in areas such as South America, the Baltic Sea Region, Europe, Asia and the Pacific. These initiatives are now being documented in several ways and this documentation provides a valuable resource for proponents of the GSDI."

The GSDI acts as an umbrella organisation that brings together national and regional committees and other relevant international institutions. As such, it provides an opportunity for pro-active countries in SDI implementation to be generous with their ideas, knowledge and experience from implementing SDI at various levels. Rather than imposing a regional or national SDI overnight, tangible projects such as the SDI Cookbook provide an opportunity to assist other countries in the development of a SDI. It can be considered a pool of resources that different countries or regions can tap into and contribute to.

Example 4 Pooling resources: The Global Mapping initiative, Globalmap, promoted by the Geographical Survey Institute of Japan, is a key pool of resources for GSDI development to exchange institutional and technological experiences and standards among many countries. The US FGDC, in collaboration with other nations, has helped to seed many common standards and best practices. Japan has adopted its National Spatial Data Infrastructure Promoting Association (NSDIPA) as a reflection of the US NSDI. Other nations have adopted or have based their NSDI's on FGDC practices, standards, and framework concepts. Some of the ISO TC 211 standards are based on FGDC developed standards (for example, Metadata). Globalmap exemplifies a global "framework", ISO TC211 the reference standards environment needed to assure data sharing between jurisdictions.

It is not necessary to implement a national SDI before approaching a regional SDI. Special attention should also be given to regional and international co-ordination and co-operation with other countries and with international institutions and donors. A joint approach to SDI within a particular region, for example, would not only save a lot of energy and expenses. The potential for synergy would also be considerable, since it would be possible to enable cross-border exchange of data and information and supporting infrastructure elements such clearinghouse software and metadata structures.

Standards and models for a common SDI do not have to be reinvented by each country. A common vision and common standards throughout Southern Africa, for example, would improve the efficiency of national and regional SDIs. This would entail effective exchange of experiences and results, a co-ordination and division of work within existing national institutions in the region, including NGOs and representatives of the donors involved, an efficient partnership with a non permanent joint steering committee as a co-ordinating body.

Implementation Approach

How does one build a successful SDI as part of GSDI?

Many success stories can be reported that are encouraging to those just starting out on SDI development. However, it may be equally helpful to know that they are not alone in encountering difficulties. It may take some time until efforts bear fruit and different strategies and approaches may need to be considered to get people on board (see Example 5).

Example 5 Delays in success: As the GI community in South Africa has frequently requested, the technology for capturing and publishing metadata has been put in place by the National Spatial Information Framework (NSIF) directorate in charge of implementing the national SDI. For the users, there are no costs associated with this clearinghouse (the Spatial Data Discovery Facility). However, despite the best efforts by the NSIF, the fact that the clearinghouse is available does not seem to be in people's heads yet and they still come out with statements like "what we really need is ...". Moreover, people do not contribute metadata to be included in the system.

Yet this lack of awareness and participation is likely to be temporary. In a recent survey of the South African GI community, about 70% of the participating organisations considered the clearinghouse provided by the NSIF a very important facility but only a small percentage indicated that they possessed the necessary metadata skills (Wehn de Montalvo 1999). Once these skills are in place, the use of, and contributions of metadata to, the Spatial Data Discovery Facility are likely to increase.

While there is no prescriptive recipe for building a SDI, the following aspects have emerged as 'lessons learned' from the international arena of SDI developments. They may need to be adapted to the specific political system and social context within which a SDI is being developed.

- **Build a consensus process: build on common interests and create a common vision**
- **Clarify the scope and status of the SDI**
- **Exchange best practices locally, regionally and globally**
- **Consider the role of management in capacity development**
- **Consider funding and donor involvement**
- **Establish broad and pervasive partnerships across private and public sectors**
- **Develop clearinghouses and use open international standards for data and technology**

Creating a Common Vision: A common vision can be an extremely powerful management tool, especially in complex projects, where multiple parties have to co-operate in order to reach a consensus. A vision of the future nation wide SDI could help to streamline future activities towards a mutual objective. A mutual objective can open perspectives and offer security in periods of change.

Even in contexts where the community of technicians involved in GIS development is small enough to allow all the members to know each other, there often is no apparent willingness at the institutional level to co-ordinate and harmonise the development of the systems. The development of a SDI will require cultural and organisational changes so as to manage the whole shifting process. This entails mobilising resources so that people in different organisations can adjust.

Example 6 Creating a common vision: The Australian experience in establishing a national SDI shows that getting people on board has been a long process and has been driven by ANZLIC in terms of awareness raising and making the major components of the ASDI more tangible. Informal collaboration is fairly smooth. As the number of Australia's spatial data stakeholders is quite small, most people know one another, so ideas and knowledge get exchanged quite easily. Formally, ANZLIC is the formal process to endorse collaboration activities, but in reality people just go to the individuals or agencies who have worked in specialist areas to get advice and help. The ASDI is therefore not too regimented. The States, Territories and the Commonwealth are all working together on most national implementation projects such as the Australian Spatial Data Directory (ASDD), Australia's fully distributed metadata directory.

Masser (1999) has summarised the objectives of most national SDI's. These are intending to promote economic development, to stimulate better government and to foster environmental sustainability. A selection of SDI vision statements is provided below.

Example 7 ***Selected vision statements of SDI initiatives:***

Colombia (ICDE): http://www.igac.gov.co/indice.html Europe (EUROGI): http://www.eurogi.org/objectives/ Finland (NGII) http://www.nls.fi/ptk/infrastructure/vision.html United Kingdom (NGDF): http://www.ngdf.org.uk/ United States (NSDI): http://www.fgdc.gov/nsdi/strategy/goals.html

But a common vision for a SDI may be missing or hindered by reasons such as culturally based resistance. In many instances, information is linked to personal power and tends to be strictly controlled in a top-down manner. This "personalised" approach to information may be one important reason for a lack of a shared SDI approach and also hindering the various stakeholders to produce a shared common vision of a national SDI. High-level commitment and support may be crucial in implementing a change in culturally-bound attitudes.

A common and shared vision about spatial data collaboration and co-operation may fundamentally change the landscape for a nation wide exchange of data and information. In order to get the various stakeholders on board, it may be essential to insist on joint development of a common vision. This may entail a cultural change in the attitude towards information and the exchange of information, a new approach how to manage and share information. The process of getting the concerned parties involved to accept and to actively support the idea of a SDI will need both a strong lead and a lot of creativity in order to minimise unnecessary resistance and not to de-motivate or suffocate creative initiatives.

The vision needs to be developed jointly and shared with the conceivable stakeholders and indicate the incentives for developing a SDI so that people are mobilised to change their behaviour in accordance with the shared vision.

A participative approach to co-operation and co-ordination should be considered in order to build on common interests. This also entails initiating a participative process among the representatives of the already existing database systems. It would make sense to bring the up to now independent system owners, stakeholders, donors, representatives of international organisations active in the field of GIS, soft- and hardware suppliers, and database managers, including their technical staff, to sit together at a round table in order to develop a common concept of a nation wide SDI.

The common standards and procedures the stakeholders will have to agree on will not necessarily fit into their actual database set up but a participative approach and a transparent decision making process will help them to understand the basic questions and to accept the resulting needs for change. Participative processes and transparent decision making are strong arguments to motivate the independent parties to invest their resources in a common project.

The vision needs to be communicated widely using various media to reach all stakeholders. Plans should be developed and implemented regarding the dissemination of information on SDI activities that are under way, including the information about the SDI components, available technological best practices, and the promotion of the use of existing technologies and standards to support the development of a SDI, for example by establishing WWW pages on the Internet or using printed media or CD-ROM where Internet connections are limited.

SDI Scope and Status Clarification: Two broad categories with respect to the status of a national SDI can be identified (Masser 1999), i.e. a SDI resulting from a formal mandate (as was the case in the US, for example) and a SDI growing out of existing spatial data co-ordination activities (as was the case in Australia). While a formal mandate benefits from the provision of funds, existing co-ordination activities provide a base for collaboration. The scope of a SDI may be all-inclusive or focusing on a subset of stakeholders, such as public sector, private sector, or NGOs, with voluntary or mandatory participation. Regardless of which category a SDI falls into and regardless of the breadth of its scope, both should be clarified as early as possible.

An active co-ordination body (committee or commission) to co-ordinate tasks and provide leadership during the process of creating a national SDI should be considered. This would need to be sufficiently empowered to carry out the co-ordination task. The coordinating agency should be able to carry other data generating agencies with it and allay their fears of losing control of their data. The coordinating agency mandate should clearly define its coordination role as 'one among equals'. In order to implement a SDI, it may not be necessary to establish new organisations and institutions.

Instead, existing ones could be strengthened. This would require a revision of the mandates of that institution to ensure that it is well equipped to deliver.

However, the promotion of an existing institution to the co-ordination body for a SDI needs to be carefully considered. The credibility of the organisation as a nodal agency should be considered. The institution needs to be chosen carefully so as to be aware of potential conflicts of interest that may be perceived between the institution's existing mandate and the additional SDI-related activities. For example, a National Mapping Organisation may end up carrying out the SDI co-ordination task and policy development while also acting as a major data producer. This may hamper the support for the SDI initiative from potential participants that could perceive it as biased. Example 8 demonstrates that although it may take some time for the co-ordinating body to gain support, a crucial element to success is how its mandate is perceived.

Example 8 Perceived mandate: In Portugal, the national SDI (SNIG) is co-ordinated by the National Center for Geographic Information (CNIG). CNIG is not a major data producer, like many agencies in other countries that are responsible for co-ordinating a national SDI. Development of the SNIG was slower than expected mainly due to lack of available digital GI and the incipient computer technologies used by most GI producers. The fact that the CNIG is not a major data producer facilitated the interactions with the GI producers, as they recognised the role of the CNIG as being a complementary one that did not harm their own mission.

The task of promoting and developing a SDI is not restricted to the public sector. In Japan, for example, the private sector is a major driver behind the establishment of a national SDI (see Example 9).

Example 9 Private sector involvement: In 1995, the Government of Japan established a Liaison Committee among Ministries and Agencies on GIS that is to provide SDI-like functions in the Government in implementing a national SDI in Japan. Private companies in Japan set up the National Spatial Data Infrastructure Promoting Association (NSDIPA), a non-profit organisation to promote the concept of national SDI in Japan. The activities of NSDIPA are aimed at gaining wide awareness of the necessity of the National Spatial Data Infrastructure. It is a group that strives towards the benefits of society and fosters a new information services industry by demanding activities of the government, municipalities and other organisations and by sharing this information with both the public and private sectors.

The representatives of all major sectors or interest groups should be involved. The co-ordinating body, once nominated and appropriately mandated, can then produce a series of activities which need to be accomplished with deadlines and output milestones. The implementation process should be approached in a multi-disciplinary and multi-sectoral way. All related organisations will have their role to play in the SDI development process.

Working groups constitute the platforms for more collaboration among stakeholders by pooling resources and harmonising initiatives to avoid duplication. The involvement of stakeholders is a key issue for the future development of a SDI.

Exchanges of Best Practice and Awareness Creation: Lessons in awareness creation about SDI can be drawn upon from various countries. These suggest that presentations and publications are just some of the activities that can be pursued to advocate and advance SDI development. Networks of communication (see Example 10) can also play an important role. A list of activities includes:

Outreach through support for SDI from high-profile individuals.

Promotion of SDI principles through presentations.

- Education through workshops, training courses and material.
- Provide "train-the-trainer" technical workshops to explain the origins, purpose, and strategies for implementation of the SDI-endorsed standards.
- Use pilot projects to demonstrate the value of spatial data and a SDI to improve decision making
- Discussion groups on management issues like IPR, copyright, pricing policy, access policy.

Establish networks of communication to enable participants to exchange experiences with SDI implementation. Facilitate information sharing through newsletters, web pages, and publications: regularly inform interested parties of SDI-sponsored activities and initiatives. Provide a forum for debate, analysis and the identification of issues relevant to SDI development.

- Help interested parties or groups to use the spatial data clearinghouse to locate sources of data, training and expertise.
- Offer interested parties the opportunity to participate in Working Groups and Subcommittees, as appropriate.

Example 10 Networks of communication: EUROGI, the European Umbrella Organisation for Geographic Information, seeks to raise awareness of the value of GI and improve the sharing of knowledge between members themselves and between EUROGI and the European Commission. Communication is facilitated through on-line discussion forums and EUROGI directories where people are able to tell others about their activities by completing a form to add information to a directory or search a directory to read about other peoples' activities.

Examples of how demonstration projects can be used to create awareness of the usefulness of a SDI are detailed in Example 11.

Example 11 Community Demonstration Projects: The FGDC has worked with the Administration and Federal Agencies to promote several Community Demonstration Projects (http://www.fgdc.gov/nsdi/docs/cdp.html) across the country. These NSDI based pilots are designed to demonstrate the value of spatial data and the NSDI to improve decision making in communities. The Demonstration Projects address a number of issues including flood management, local/regional crime management, Citizen-based land use analysis, environmental restoration. The NPR and the FGDC jointly queried FGDC membership to seek interested communities, offering only in-kind federal help (federal staff, training, etc but no dollars) to maturate the projects. Shortly after the selections, the six selected communities joined together to apply for a grant under the Government Information Technology Services Board (GITS). They were awarded over $600,000 dollars as part of their grant request. These projects are expected to report back in May 2000, with the detail of each effort utilised to help articulate the value of NSDI to enhance place-based decision-making, and to help communities understand the costs and processes associated with establishing NSDI operations.

Community-based capacity building: In 1998, the FGDC working with OMB and its federal agency representatives began a $40M multi-agency budget initiative to accelerate the application of the NSDI to improve the decision-making power of communities in addressing livability issues. The Community Federal Information Partnership (CFIP) (http://www.fgdc.gov/nsdi/docs/schaeferbrief/index.htm) was first announced by the Vice President as part of a Sustainable Communities Speech delivered in 1998 at the Brookings Institute. The C/FIP would provide grants to communities to activate capability and tools for place-based decision-making, and would provide federal agencies with additional funding to help make their spatial data more available for public access. The outcome of CFIP for fiscal year 2000 is still being worked through the congressional budgeting process at the time of this writing.

Exchange of best practice: The FGDC has developed metadata, Clearinghouse, data Standards training, and has developed and offers metadata tools. Assistance is provided by FGDC and FGDC trained partners to local, state, federal, tribal, and international organisations seeking to establish or improve their SDI.

The Role of Management in Capacity Development: An important barrier to change is an organisation's capacity to adopt new standards and technologies. While the introduction of specialised software, for example for the creation of a geospatial catalogue, is relatively easy, its effective use depends on the technical capabilities as well as organisational support. Awareness creation of SDI components should be considered down to the lowest level and with strong management support and leadership. Capacity development should be a prime concern of senior management. It includes the theoretical issues and the practical hands-on capabilities to implement the SDI components.

This issue of building local capacity will to be a major constraint to the success of a SDI in many developing countries. As job specific technical competencies will be stipulated, it will be necessary to review positional titles, remuneration packages and salaries. The staff rotation system in the "Department of Geological Surveys" in Zimbabwe is a case of "best practice" in how "brain drain" can be avoided and serves as an example of how staff can be motivated within a

"Learning Organisation". This system is designed to enhance the capacity of personnel within the department, therefore reducing the need for external recruitment of technical staff.

The personnel resources for SDI in many countries are very limited since most of the GIS implementations being built up are understaffed. A pool of qualified staff has to be created if the projects are to become sustainable. What makes it difficult for countries such as Zimbabwe, for example, is not only the number of specialists required, but also the working conditions offered. "Brain-drain" is a serious problem: the fact that skilled personnel are leaving their jobs too often, too soon. Human capacity development and long term career planning should be of prime concern to senior management. It includes the training, theoretical issues and practical handson capabilities to implement projects and programs, as well as the working conditions. Working conditions need to be considered not only with respect to salary, but even more importantly with respect to the work climate, motivation and professional perspectives.

Example 12 Compensating for high staff turnover: One of the US NSDI Community Demonstration Projects is taking place in the Police Department in Baltimore, Maryland. The Police Department has come to realise that a SDI is good for managing vital crime data in addition to the classic mapping data that many rely on for the base mapping. The Baltimore Police budget is tight, they have a high turnover in staff. By capturing metadata and using clearinghouse capabilities, they can better assure the proper management of critical crime data used by the department and throughout the region as part of a regional crime management collaboration between community police organisations.

Senior management of all concerned institutions should consider the development of standards a priority. They should closely supervise technical work groups and assure that the desired results will be produced. Matters like the standardisation of data and the harmonisation of classification schemes cannot be left to technicians alone because they entail political decisions. Senior management should be acknowledged as a driving force behind the build-up of a SDI.

Funding and Donor Involvement: Funding and adequate resources can present a major constraint to SDI development when awareness of the importance of SDI is lacking at the local, national or regional level and there is no existing SDI-like initiative or a mandate to develop a SDI to which sufficient funds have been assigned.

Nevertheless, in order to ensure funding, it may more persuasive to potential funders to have something to show already (for example, a clearinghouse system) rather than a concept document alone. This does not have to involve huge costs since clearinghouse components are available free over the Internet (Chapter 4). In addition, justification for the limited cost of this initial development may well be found within existing projects or initiatives (for example, documenting data holdings is a part of sound information management).

Innovative use of resources can ensure that funds stretch a long way. For example, with a 'carrot and stick approach', incentives can be created for the adoption of SDI principles. Using small, non-repeating grants to stimulate the development of the application layer of the SDI can work well where there is broad base of existing expertise that can be encouraged (see Example 13).

Example 13 Program of Grants: The FGDC in the US has maintained a relatively small but persistent Cooperative Agreement Program of Grants (CAP) to help communities validate and initiate NSDI concepts (http://www.fgdc.gov/publications/publications.html). The FGDC initiated the CAP program to provide seed money to stimulate co-operative activities among organisations to begin implementing the NSDI. Rooted in the premise that building the NSDI is a shared responsibility and collaborative efforts are essential for its success, the CAP program has worked to seed 270 NSDI resource sharing projects across the county involving more than 1300 organisations. These projects have resulted in helping state governments, libraries, universities, local government organisations, and private sector entities to become stable contributing sources on the NSDI. While the FGDC funding level for the CAP has been somewhat limited ($1 - $2M yearly), annual funding has been persistent since 1994, and recently the number of grants awarded has been increasing – communities appear to be doing more with less.

Reports of different SDI funding mechanisms from Australia and Portugal suggest that the provision of central funds is an important contributor to accelerated SDI development (see Example 14 and 15).

Example 14 Decentralised funding: In Australia, there is no major national funding allocation for the ASDI (unlike the

US and Canada). Each jurisdiction (States, Territories and Commonwealth) are all financing their own programs. The States and Territories in Australia are each developing their SDI's, so in fact the ASDI is all the individual jurisdictional SDI's puzzled together. This approach has some drawbacks. It would be more coherent if a national SDI pool of funds was available to draw on and bring influence to bear. Industry groups are not really engaged in Australia yet to the same degree as in the US or Canada. Making the ASDI politically attractive for large scale national funding has not occurred yet but continuing efforts are under way. One notable success was the establishment of the Australian WWW Mapping Consortium as a full member of the OpenGIS Consortium (OGC). 23 Australian industry, R&D and Govt Groups have all come together to share ideas and work on an "Australian Web Mapping Testbed" which making good progress, allowing them to provide some new input into the OGC process.

Example 15 Centralised funding: The creation of the Portuguese national SDI, the SNIG, was endorsed by public funds. The approval by the Portuguese Government and by the European Commission (at the end of 1994) of a program integrated in the Regional Development Plan 1994-1999 did cover a specific budget assigned to the support of the SNIG development. Part of the funding was used to speed up the creation of digital geographic information, namely for conversions of existent geographic information into digital formats, and for the purchase of satellite data and existent digital topographical data for local GIS implementation in municipalities. Another part of these funds was used to provide major public data producers with Internet servers, routers and communication infrastructures. A small fraction of the funds is still being used to build WWW interfaces and applications to facilitate the access to geographic information available at the different institutions integrated in the SNIG network. In the Portuguese case, funding was a major factor that helped the fast development of SNIG since 1995. It did accelerate a process that would have taken years to grow up. At the present moment, a total of 117 public institutions, including almost all GI producers, have joined the Portuguese spatial data infrastructure.

GIS implementations in developing countries are often functioning under special conditions that need to be considered during the initiation of a SDI at national or regional level. In many countries the lack of local financial resources means that GIS implementations are not financially sustainable and therefore depend primarily on donor funds. Usually donor support for these projects is provided under certain conditions such as a time limit for implementation after which there are no further disbursements of funds. The future of many of these systems is uncertain beyond the end of international assistance.

Another aspect of donor-funded GIS implementations is that often the projects have been initiated by donors according to their own objectives and little attention has been paid to the requirements and capacities of the host organisations. The result is that there is insufficient coordination of the technical support and funding activities of different donors. In some cases donors may not be willing to work with each other and this can impose limits on the co-operation or data exchange between projects that are funded by different donors. A lack in capacity to coordinate donor activities coupled with competition among the donors themselves can hamper a SDI initiative.

Under these conditions, the co-operation with donors is a critical aspect of the development of a national SDI. While the existing co-operation should not be exposed to strain, a co-ordinated SDI-based approach would change the priorities for GIS implementations. This potential conflict could be avoided if donors would be invited as partners to take part in the participative process defining the components of a nation wide SDI.

In order to develop (or renew) a national SDI in a (multi) donor-funded GIS context, a useful approach has been developed by Ryerson and Batterham (2000). This approach entails an evaluation of GIS projects with regard to:

- clients' needs and desires,
- an assessment of the recipient country's capabilities in terms of meeting those needs,
- an assessment of related activities by other donors,
- an assessment of current technology and its direction,
- donor country capabilities and capacity if the aid is tied, and
- costs.

The issue of building up local capacity will continue to be a major constraint to the success of a SDI in many countries. Long term projects require not only long term financing but also long term planning in the field of human resource capacity building. What requires to be worked on is the issue of sustainability of the initiatives with respect to capability to keep up with the technology shifts and capacity of local personnel. The build-up of a GIS implementation is a long term investment, taking many years until return on investment is visible. Therefore, the ever scarce budget resources are likely to be invested in more urgent projects with prospects of short term successes and returns. This means that participants of such a SDI will remain dependent on donor funds for quite some time.

Example 16 Initially funded by Donors, the SADC Regional Remote Sensing Unit (RRSU) in Harare, Zimbabwe, has been integrated in the organisational structure of the Southern African Development Community (SADC) since 1998. The Unit is funded by the 14 Member-states (Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Secheylles, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe), and still receives some additional donor contributions.

The SDI work implemented by the RRSU was never part of the original work plan. It was identified when GIS technology was to be used for basic analytical procedures. This could not be done because the data sets were incomplete or incompatible. At the time the SDI work started, the Unit was still depending on donor assistance and technical assistance from the FAO. Consequently, changes had to be made to the work programme, something which had to be discussed with the donor and technical assistance partner.

From the regional and international partners in the development (the data suppliers) of the RRSU spatial data sets, no financial contributions were required.

The RRSU spatial data sets were originally developed for GIS-based applications in support of early warning for food security. However, the data sets are being recognised as one of the major spatial data base developments in the SADC region, and for this reason, the RRSU continues to attract donor funding. The spatial data base activities were originally not foreseen as a major task - but this has changed considerably over the years. (http://www.zimbabwe.net/sadc-fanr/intro.htm)

Broad and pervasive partnerships across public and private sectors: Co-operation and partnerships across different levels of the public sector and with the private sector can be helpful at every stage of SDI development to collect, build, share, and maintain spatial data.

Since no one organisation can build a SDI, collaborative efforts are essential for its success. The FGDC in the US encourages federal, state, local, and tribal governments, academia, the private sector, and non-profit organisations to work together within a geographic area to make geospatial data available to all. So-called 'cooperation groups' are formed that enable all parties to participate in, and contribute to, the national SDI in the areas of their strength and expertise. Guiding policies and procedures for these cooperation groups have been developed (http://www.fgdc.org/funding.html). Co-operation among Federal, State, local, private, and academic sectors is expected to be based on shared responsibilities, shared commitment, shared benefits, and shared control aiming at improving the spatial data delivery system (see also Example 17).

Example 17 The task of building relationships to further the implementation of the NSDI in the US has been a large and continuing effort. The effort has been made difficult by the fact that organisations, functions, and responsibilities are diverse and spread out across the country. Initial efforts concentrated on FGDC initiatives to build relationships with Coordinating Groups that have formed to represent issues within the States, and with Organisations and Associations that represent levels of government of key interest groups nationally. This has helped focus the work of the different groups and has established strong linkages with some of the key elements needed for a long-term national network of partnerships. The FGDC's efforts has also been helped by the fact that many in the United States recognise the value of geographic information to the decision making needs of communities. Geographic information is collected at all levels. Most of the data originates at the local level, but very important types of data come from other levels, including complete information of an issue or topic that transcends jurisdictional boundaries (region or state). Thus there is a growing level of support for policies, interfaces, standards, and relationships that enable government, companies, organisation and citizens to interact and share in the collection and dissemination of geographic information across jurisdictions.

In the Canadian context, public and private-sector partnerships focus on partnering and leveraging the resources of the private sector to accelerate access to spatial data and technology development. GeoConnections, the program responsible for implementing the Canadian Geospatial Data Infrastructure (CGDI) has placed particular emphasis on partnerships between the federal and provincial and territorial governments and the private sector and academia. Programs focus on working across governments, and with stakeholders and the private sector to advance the amount of information accessible through ‘clearinghouse’ systems, the development of data frameworks to ease data integration, fostering advanced technology and application development, and building supportive policies to speed industry growth. To this end, guiding principles for the provincial and territorial government agencies involved in geomatics have been agreed upon (see box).

Canadian Geospatial Data Infrastructure: Principles for Data Partnership (http://www.geoconnections.org/english/partnerships/index.html)

1. Data should be collected once, closest to the source and in the most efficient way possible, with a view towards increasing the vertical integration of the data.
2. Geo-info data should be as seamless as possible, with co-ordination across jurisdictions and boundaries when possible.
3. Data should be collected, processed and maintained according to international standards to maintain data integrity across databases, and to enable the addition of value, further enhancement and easy access and use.
4. Upon agreement, partners should contribute equitably to the costs of collecting and managing the data, and should be allowed to integrate the resulting information into their own databases, for their own use and for further distribution to their stakeholders.
5. There should be an attempt to harmonise terms and conditions for use where practical. In the absence of such agreement, each agency should be free to establish its own terms and conditions for such information.
6. Agreements between agencies will normally be negotiated on a case-by-case bilateral or multi-lateral basis, according to these principles of partnership.
7. Partnerships between agencies should be simple and support the principles of the CGDI, open to the participation of interested stakeholders within any level of government, the education communities or the private sector.
8. A group or agency within each province and within the federal government should be designated to promote and co-ordinate the development of a common geospatial data infrastructure, both within its jurisdiction and between jurisdictions.
9. CGDI is national in scope, and must meet the needs of a wide range of geospatial user communities, data producers and different areas of the private sector.
10. CGDI must consist of a set of co-ordinated and interrelated policies, practices and possibilities that build on the vision.

Develop clearinghouses and use common standards for data and technology: The technical underpinning of a SDI is a common framework of standards, tools and services based on these standards. In this three-tier model, applications work with metadata and data content and services that exist on the enabling infrastructure. The following technical elements are important components of a SDI:

- quality metadata,
- residence of metadata in on-line directories,
- good data management,
- access to services on-line,
- their documentation in directories and
- reference implementations of software to demonstrate capabilities.

For existing and emerging standards and free- or low-cost software solutions based on these standards, please consult Chapters 2-7. (include links?)

The development of the Portuguese Spatial Data Infrastructure serves as an example of the importance of outreach activities that parallel the implementation of the technical elements of a SDI (see Example 18). The Portuguese SDI differs from other SDI's by having a centralised metadata catalogue. Usually metadata is organised in a distributed way. Nevertheless, the example demonstrates that in order to gain support for the system (i.e. increasing the number of users of the system), new interfaces were developed according to feedback from the users themselves and through the development of tools that are more devoted to the needs of citizens. The Portuguese experience also shows that a SDI can be developed incrementally with improvements implemented step by step.

Example 18 User involvement in the technical implementation: In 1990 the Portuguese government created SNIG, the Portuguese GI infrastructure, as a national public service (http://snig.cnig.pt). The main goal of SNIG was to ensure the connection of Portuguese users and producers of digital geographic information through a network. This goal implied the development of catalogues describing the available geographic information. By that time, the majority of public agencies were more concerned with the production and organisation of digital geographic information than with the dissemination process. It was felt that data producers were not prepared to manage their own metadata registers. Thus, the creation and maintenance of the metadata that currently supported the SNIG was organised in a centralised way by its coordinator, the National Center for Geographic Information (CNIG). By the end of 1994, taking advantage of the multiple opportunities for publishing data offered by the World Wide Web, the Portuguese GI metadata catalogues were implemented in a Relational Database Management System and CNIG started to build an HTML interface to allow the query of the metadata and the retrieval of the available data sets. The SNIG network was finally launched on the Internet on May 3, 1995. The main concern was to connect users to the available digital data sets, creating an operational system that could be improved in the following years. Therefore, the metadata catalogues were not based on any metadata standards. Common sense, some guidelines provided by the CORINE Catalogue of Data Sources Project and the identification of the main geographic information sources were used to design the database. During this stage, the system structure and design was mainly oriented towards the professional user.

Subsequently, the creation of new metadata catalogues obliged to rebuild a new WWW interface. While the first SNIG interface was developed without the implementation of formal usability studies, usability testing was required to support further developments of the SNIG. In order to rebuild the SNIG site, qualitative research involving users was carried out for the first time. The research was designed to answer to the following questions:

- Which would be SNIG potential users groups?
- What geographic information options would users need?
- What would the users be looking for in an infrastructure such as SNIG?

The main results of this research pointed out that it would be necessary to develop a friendlier interface. The new interface should adopt informal and non-technical terminology and include search engines by terms and geographic location. The need of more geographic information for non-professional use and the adoption of more common data formats were also stated. It would also be important to include raster images to illustrate the available information. In July 1999, an alternative SNIG user interface was launched (GEOCID). GEOCID is more appealing and information oriented, avoiding complex tasks and navigating routes to access to the data. In addition, new applications were developed based on the information citizens are interested in. An application that allows the user to navigate through Continental Portugal, select specific locations and download the part of the orthophoto he is visualising on screen was developed. The launch of GEOCID was a big success (http://ortos.cnig.pt/ortofotos/ingles/).

Recommendations: Outreach and Capacity Building Options for Implementing a SDI

By overcoming inefficiencies, a coherent and consistent SDI can ensure that geographic information may be used to address complex social, environmental, and economic issues. The following guidelines indicate some of the outreach and capacity building activities that can be used to foster the implementation of a SDI:

- A practical step to take in the development of a national SDI is the development of a

vision, detailing a vision of the desired future and a clear sense of how SDI components could serve that future and help to realise it. This also involves setting clear priorities and defining a strategy or policy to accomplish the vision.

A workshop organised with the stakeholders to define and create a national co-ordinating body, considering its structure in terms of an existing or newly created institution, working groups and/or committees. In countries where GIS implementations are highly dependent on donor involvement in terms of funding and technical expertise, donor representatives should be considered as stakeholders and included in the process of building a SDI. The co-ordinating body needs to be mandated to manage the required activities and devise an action plan to coordinate the activities. Consideration needs to be given to the necessary resources for implementing strategy, policy or plans and activities, considering staff, technical know-how, material, and funding opportunities such as innovative partnerships. Formal working groups should be organised around well defined objectives, strategies, plans, programmes, and actions, and not simply for informal and limited consultations. These working groups would be made up of interested parties and experts to deal with specific aspects of SDI such standards (metadata, exchange), national data sets, policy, clearinghouse and how to assimilate existing technological solutions into the local context.

- Awareness creation of SDI components should be considered down to the lowest level and with strong management support and leadership.
- Plans should be developed and implemented for the dissemination of information on SDI activities under way, including the information about the SDI components, available technical best practices, and the promotion of the use of existing technologies and standards to support the development of a SDI, for example by establishing WWW pages on the Internet or using printed media or CD-ROM where Internet connections are limited.

Measures should be taken to monitor, analyse and participate in, developments at international levels that affect the use of standards and supporting technologies in the national context. This entails assigning clear administrative responsibility for tracking key developments are the international level and within the GSDI community. Within SDI development, the role of donors should be clarified to support activities by way of following local priorities such as interoperability of different GIS implementations rather than wishing to be associated with a particular type of activity irrespective of cost effectiveness or fit with the broader institutional or national objectives.

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Chapter 10

From The SDI Cookbook

Contents

Chapter 10: Standards Suites for Spatial Data Infrastructure

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The core of this chapter was originally published as “Doug Nebert, Carl Reed and Roland M. Wagner, Proposal for a Spatial Data Infrastructure Standards Suite: SDI 1.0, *Research and Theory in Advancing Spatial Data Infrastructure Concepts* (ed. Harlan Onsrud; Redlands, CA: ESRI Press, 2007), http://gsdidocs.org/gsdiconf/GSDI-9/papers /TS19.1paper.pdf

> The successful implementation of Internet-based spatial data infrastructures (SDI) requires the specification and adoption of a compatible suite of standards to enable interoperability. The proliferation of new standards and new versions of old standards raises issues of dependency and compatibility that may impede the implementation of SDI architectures. This chapter proposes how to specify a suite of geospatial standards with an exemplar suite of SDI standards. The process is designed to facilitate the description and acquisition of compatible technology for SDIs worldwide. The application of a common set of standards for SDIs may reduce life cycle costs, enhance interoperability, decrease implementation risk, and improve services, particularly in the developing world. Building on these concepts, the Appendix to this chapter sets forth *Requirements for SDI Best Practice Implementations*.

Introduction

For over twenty years, SDI activities have been progressing at the local, regional, and national levels. Spatial data infrastructures are the realization of technical and human efforts to coordinate and provide geospatial information and services for multiple purposes. The SDI Cookbook (Nebert 2004) introduces SDIs as follows:

> The term “Spatial Data Infrastructure” (SDI) is often used to denote the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data. The SDI provides a basis for spatial data

discovery, evaluation, and application for users and providers within all levels of government, the commercial sector, the non-profit sector, academia, and by citizens in general.

A SDI may be defined in broad social terms as a framework for collaboration. The technical framework, including the effective use of standards, for a SDI enables interoperability for the access and exchange of geospatial resources. The problem is that too many current SDI activities operate as independent application “silos” with little (or no) interoperability between them. To often, individual SDI initiatives define standands best practices without regard as to how thier neighbor's SDI use those same standards. Interoperablity across independent SDI's require agreements on which standards are used, what version of a given standard is used, and so forth. Without these agreements, severe limits are imposed on our ability to implement a virtual global SDI (GSDI).

Problem statement

In 2005, after a year of concentrated effort, the U.S. National Geospatial Intelligence Agency (NGA) announced approval of an OGC spatial data infrastructure 1.0 (SDI 1.0) specification baseline. The problem NGA then faced was how to carefully consider and specify the actual baseline of standards (including versions) and interdependencies between the standards. Further, there was then no general reference architecture for defining a framework as to how these standards work together to enable a standards-based SDI.

Dozens of SDI initiatives are implementing a variety of international standards for data and service discovery, data access, visualization, and analysis. The use of different versions of these standards limits interoperability between systems and initiatives. Further, different SDI initiatives are using different content models for key data themes, such as land cover and land ownership. Guidance on best practices and approaches to solving these interoperability issues is critical to our ability to define and implement a GSDI.

Scope and objectives

This chapter focuses on the identification of compatible, mature geospatial standards that will allow maximum technical interoperability based on general evaluation criteria. For the purposes of this chapter, we term this compatible suite of standards SDI 1.0. The chapter also proposes a candidate suite of standards for future SDI deployments or enhancements. SDI 1.0 is intended for all SDI communities interested in providing and accessing geospatial data over the Internet. Transnational SDIs, also known as global geospatial data infrastructures (GDI), are loosely defined environments in which participants interact to develop and share geospatial content and services to the common benefit of a nation or, in the case of Europe, a continent.

Background and rationale

A coordinated SDI standards suite is intended to manage the complexity of available standards and version change and to encourage globally compatible solutions.

Complexity. Nearly 100 standards can be identified that can be considered as part of the architecture and deployment of interoperable geospatial solutions, including various standards in information and communications technology community. The selection of an appropriate technical architecture can be daunting, and independent selection of standards may lead to incompatibilities between adjacent SDI implementations. The definition of a relatively small suite of standards allows a shorthand reference for nominal capabilities in an SDI environment, with provision for identifying optional supplemental standards.

Evolution cycles. Standards evolve and are changed based on new requirements and implementation experience. Too often thse changes are rarely coordinated with changes in other normatively referenced standards. Therefore, the identification of a specific set of standards (and their version numbers) that are known to work well together is of great benefit to implementers and adopters. Adapting to frequent changes in standards is expensive and prone to issues of incompatibility. Minimizing the number and frequency of version changes is a goal of this proposal. The intent of having an SDI standards suite version number, i.e., 1.0, is to document such compatible versions. The SDI 1.0 suite will iteself need to be incremented in the future to incorporate revisions of the standards used in the suite.

Global compatibility. Through the identification of a common set of standards for SDI usage, the development of software that supports an SDI in one part of the world can be readily deployed for another SDI. This broadens the market reach of solution providers and reduces the cost of software development through targeted support of specific standard versions.

Standards considered

Geospatial standards are primarily developed by the International Organization for Standardization (ISO) Technical Committee 211 (TC 211) and the Open Geospatial Consortium (OGC). Their are often dependent on other industry standards, such as those of the World Wide Web Consortium (W3C) and OASIS, which develop e-business standards. International standards for country codes and coordinate reference systems existed prior to the 1990s, but the more detailed standardization efforts began in earnest in 1994 with the formation of TC 211 and the OGC.

The geospatial standards development process has advanced over the past twelve years largely in the context of the World Wide Web and its emerging standards and infrastructure. Including underlying Internet standards, well over 75 standards may be relevant to the geospatial domain. Versions of these standards exist in various states—development, endorsement, implementation, or deprecation – so deployment of all standards in a coordinated manner is not practical. Further, there is no assurance that they will function well together.

The identification of a common set of standards is already a practice in national SDI/GDI contexts. The Canadian Geospatial Data Infrastructure (CGDI) recognizes and promotes the use of a selected suite of standards through its Technology Advisory Panel. The U.S. National Spatial Data Infrastructure (NSDI) supports selected standards through its Geospatial One-Stop portal, geodata.gov. In both national contexts, such standards allow for the federation of a large number of provider-operated services and for data to be discovered, visualized, and accessed by Web browsers and software applications.

Criteria for inclusion

Given the number of geospatial standards and the versions of these standards, definition of a compatible suite reduces risk and enhances interoperability among and between SDIs. Inclusion of a standard in SDI 1.0 is based on the following criteria:

Evidence of implementation. The adoption of a standard is dependent on many factors, such as simplicity, market need, educational materials, policy, and so forth. In terms of SDI 1.0, there is a requirement for stability and evidence that a given standard is widely implemented and supported in both commercial and open source technology. Documenting evidence of implementation helps determine which standards need to be included in the baseline. The approach has a focus on reducing costs and risks while increaseing value by leveraging existing services and content.

Commercial and noncommercial software solutions and documentation (publications, how-to guides, and workbooks) are useful metrics in identifying mature standards. For example, the OGC web site lists implementing products that have implemented OGC standards. Also, several OGC members have developed tools that search the Web looking for publicly available OGC Web Service-enabled servers. Based on this search capability, there are over 1000 operational instances of the OGC (r) WMS Interface Standard (Refractions, 2006) (these numbers do not include instances of OGC standards that are hidden behind a firewall).

Dependencies. Standards rarely are monolithic or stand-alone and frequently have implicit and explicit dependencies on other standards. Hierarchies of standards, such as the Open Systems Interoperability (OSI) stack, describe vertical hardware, operating system, protocol, and application relationships. There are horizontal and containment relationships or dependencies as well. The latest version of a standard is not necessarily the one that will work with a selected set of other standards. Successful application of standards must clearly define the type, context, and version of related standards and their usage. Dependencies on other standards that are not mature or as widely adopted may cause problems with interoperability. Minimizing the number of dependencies can facilitate migration to newer versions of standards, considering that related standards may evolve on an independent schedule.

Stability and conformance. The implementation of technical standards to ensure interoperability requires that the standards have some means of being assessed or tested for conformance or compliance. The availability of tests—testing service, assessment methodology, model assertions, or testing software—promotes the adoption of interoperable solutions. An example of a compliance testing environment is the OGC CITE capability for testing WMS and WFS compliance (http://www.opengeospatial.org/resources/?page=testing).

Core or supplemental status. Whereas several geospatial standards appear to be common and required to implement local, regional, and national SDIs, a number of other standards may be optional. The "core" standards should be viewed as the most widely implemented standards that provide baseline functionality in an SDI. Supplemental standards may not be required for SDI implementation, but identify optional, well-known capabilities.

Reference matrix. Table 1 lists the standards used by four major SDI projects. The first group are formal standards referenced by SDI initiatives, whereas the last five represent prototype implementations not yet approved as final standards. The CGDI selections represent both endorsed and recommended standards. The U.S. NSDI selections represent the standards required by the Geospatial One-Stop portal in its interaction with community data and services. The NRW (North Rhein-Westphalia [Germany]) selections represent a combination of standards in use by the local GDI project as well as a cross-border project operated in a partnership with the Netherlands. The Catalonian selections represent current technology implemented in the first phase of the SDI. This table is not intended to be an exhaustive exploration of adopted standards but illustrates commonality and differences between national and regional SDI environments.

Table 1: Standards used in SDIs

Standard	Canada CGDI	U.S. NSDI	GDI NRW	Catalonia
Formal				
OGC Web Map Service	•	•	•	•
OGC Web Feature Service	•	•	•	•
OGC Filter Encoding	•	•	•	
OGC Style Layer Descriptor	•		•	
OGC Geography Markup Language	•	•	•	•
OGC Web Map Context	•	•		•
OGC Catalogue Service 2.0 Z39.50 protocol binding	•	•		
FGDC Content Standard for Digital Geospatial Metadata	•	•		
OGC Web Coverage Service	•	•		•
OGC Catalogue Service 2.0 HTTP protocol binding (CS-W)	•	•	•	
Tentative				
OGC Web Coordinate Transformation Service				
OGC Gazetteer Profile of WFS	•	•		
OGC Web Pricing and Ordering Service			•	
ISO metadata DTS 19139			•	

OGC Web Processing Service	•

Foundational Standards

Table 2 lists fundamental standards on which the geospatial standards may be dependent. Not all of these standards are required for implementation of SDI 1.0 standards, but they may be required or expected to be present in a community's operating environment.

Table 2: Foundations for SDI standards

W3C Recommendation: eXtensible Markup Language (XML) Version 1.1
W3C Recommendation: XML Schema Version 1.0
W3C Recommendation: Hyper Text Transport Protocol (HTTP) Version 1.1
W3C Recommendation: Simple Object Access Protocol (SOAP) Version 1.2
W3C Note: Web Services Description Language (WSDL), Version 1.1
Oil and Gas Producer (OGP, formerly EPSG) Geodetic Parameter Dataset, Version 6.9 (2006)
Geographic Tagged Image File Format (GeoTIFF) Version 1.0
JPEG-2000 (ISO/IEC 15444-1:2004)
Information retrieval (Z39.50)—application service definition and protocol specification (ISO 23950:1998)

Information content standards. The following standards apply to information content:

ISO IS19115/DTS 19139 metadata standard. Metadata standard ISO 19115:2003 contains an abstract model represented in UML depicting the content and relationships of descriptions of geographic data and services. The 19115 standard does not provide guidance on the encoding or exchange of metadata but serves as a guide for what information should be documented for data and services. ISO Draft Technical Specification 19139 was scheduled for release in late 2006. The primary content of interest in this specification is a set of XML schema documents that can be used in the validation and structuring of compliant ISO metadata, derived from the 19115 metadata model.

Although a number of software packages and systems claim to support 19115 metadata, the delayed availability of the official encoding in DTS 19139 means that there will be few compliant implementations until the new schemata are adopted and implemented. Due to the lack of implementation practice, 19115/19139 should be considered supplemental to the SDI 1.0 standards suite.

FGDC Content Standard for Digital Geospatial Metadata. The U.S. Federal Geographic Data Committee (FGDC) approved version 1.0 of the Content Standard for Digital Geospatial Metadata (CSDGM) in 1994 and version 2.0 in 1998. The standard includes only an abstract model of content, relationships, obligation, and repeatability of properties that describe geospatial data. The FGDC has published schemata (XML document type declaration and XML schema documents) on its Web site to facilitate the validation and processing of metadata according to the standard. A metadata parser (mp) program is available from the U.S. Geological Survey for stand-alone and Web usage to validate metadata according to this standard. Extensions for biological and remote sensing data are available as well.

CSDGM is the most widely deployed metadata standard in the world. As of March 2006, over 8 million metadata records existed on the Internet in searchable collections that support the CSDGM. Metadata collections supporting this standard have been developed for 32 countries in at least four languages: English, French, Spanish, and Portuguese.

Since its acceptance as an international standard in 2003, ISO 19115 has been slowly replacing the CSDGM internationally, with validation through ISO DTS 19139 XML encoding. By 2008 the ISO metadata standard will likely supersede CSDGM in a future SDI standards suite version. Until there is wide adoption and deployment of 19115/19139, CSDGM remains a primary vehicle for the description of geospatial data used in SDIs. It is recommended for inclusion in the SDI 1.0 standards suite.

OGC Geography Markup Language. The OGC Geography Markup Language (GML), also an ISO International Standard (19136 and OGC GML 3.2.1), provides a means of encoding geographic features and their properties using XML. GML is the expected packaging for features requested from an OGC Web Feature Server (WFS). Data encoded in GML versions 2 and 3 can be validated using XML schemas published with the standard and maintained in a schema repository by OGC.

The OGC community uses two major versions of GML that are different and are not backwardly compatible. Version 3.1.1 is currently the most widely deployed, as it is frequently paired with implementations of WFS, although the WFS standard does not preclude the service of GML 3.2.1-encoded data. GML 3.1.1 is being widely used to express basic data themes, known as framework data in the United States, and for similar data modeling efforts in Australia.

Given its prevalence, GML version 3.1.1 is recommended for the core SDI 1.0 standards suite. GML 3.2.1, , is recommended as a supplement to the SDI 1.0 standards suite. We expect 3.2.1 to see broader implementation in 2009.

OGC Filter Encoding specification. The OGC Filter Encoding (FE) specification is used to express a query, or filter, using a predicate language or terms and operators that are stored in XML elements. FE is used in the request messaging sent to WFS and in the query sent to the OGC Catalogue Service CS-W. OGC hosts reference XML schema documents that can be used to validate queries structured according to the standard. FE version 1.1 was approved in 2004 and is recommended for inclusion in the SDI 1.0 standards suite.

OGC Styled Layer Descriptor. The OGC Styled Layer Descriptor (SLD) standard defines the structure of an XML file that applies rendering or symbolization rules to features. An SLD can be invoked as an argument to a Web Map Service (WMS) to present a requested map according to submitted style rules. SLD support is an optional feature of WMS and as such should be considered supplemental to the SDI 1.0 standards suite.

OGC Web Map Context. According to the OGC adopted-specifications page, “The ... Context specification states how a specific grouping of one or more maps from one or more map servers can be described in a portable, platform-independent format for storage in a repository or for transmission between clients. This description is known as a ’Web Map Context Document‘ [WMC] or simply a ’Context.’” Version 1.1 of WMC is coordinated with WMS version 1.1.1. Like the SLD, WMC version 1.1 support is an optional feature of WMS and as such should be considered supplemental to the SDI 1.0 standards suite.

Service and interface standards. The following standards apply to access to geospatial information and build upon the information content standards above.

OGC Catalogue Service specification. The Catalogue Service specification provides both an abstract model and protocol-specific solutions for the discovery of geospatial resources. Catalogues contain some form of metadata (searchable descriptive information) and a query interface (for returning the metadata properties to the requestor). Often embedded in these metadata are links to actual data or services that allow the catalogue to act as a referral service to other information resources.

Three protocol bindings are described in Catalogue Service version 2.0: CORBA, Z39.50, and HTTP, the latter also known as Catalogue Services for the Web (CS-W). The HTTP binding requires the declaration of an additional application profile to define the specifics of interaction within a community. Two major application profiles have been approved: one for a general registry information model (ebRIM) and the other for data and service objects based on the semantics and structures of ISO 19115/19119/19139 metadata. Schemas for metadata responses are published with the draft profile documents and can support limited validation testing. A formal OGC compliance test suite has been formally developed or endorsed. A third ad hoc profile of CS-W has been drafted to query and present FGDC CSDGM metadata. Given the early stages of adoption and uncertain interoperability of these CS-W profiles, the CS-W protocol binding is recognized as an emerging candidate for a future SDI standards suite and is recommended as a supplement to the SDI 1.0 standards suite.

Of the three protocols, Z39.50 (also adopted as ISO 23950) has been implemented most widely, with over 400 registered servers from seven vendors supporting the geospatial query and response rules. Although no official conformance suite exists for the protocol, Z39.50 server compliance is tested by the FGDC using online query tools and a validation suite executed within the Geospatial One-Stop portal. OGC Catalogue Service Z39.50 protocol binding is recommended for the SDI 1.0 standards suite.

The following issues impede adoption of Z39.50 in a suite of Web service standards: Z39.50 is TCP/IP-based and is therefore not a conventional Web service, it requires the use of a unique TCP/IP communication port that is not commonly configured for public access, and it requires operating a different service and software than those used by other Web protocols. Given these issues and increased implementation testing of CS-W, it is likely that CS-W and its application profiles will supersede Z39.50 as the preferred standard in the future.

OGC Web Map Service. By far the most popular and widely implemented of the geospatial standards, the OGC Web Map Service (WMS versions 1.1.1 and 1.3; ISO 19128) supports the request and display of maps derived from data accessed by the service. Maps, delivered as graphical images (GIF, JPEG, TIFF, etc.) may be requested from one or more WMSs overlaid in browsers or client applications. Features ”behind” the map can also be queried, and their properties can be returned to a requesting client. As discussed above, SLD and WMC files are used optionally to interact with the rendering or recall of maps, respectively.

Schemas for validating the “capabilities” of an XML file returned from a WMS service exist, and compliance testing is available through the OGC for assessing WMS performance on all key functionalities.

WMS version 1.1.1 is the most widely deployed (ISO 19128, however, is harmonized with WMS version 1.3 but is not yet widely deployed) and is recommended for inclusion in the SDI 1.0 standards suite.

OGC Web Feature Service. According to the OGC adopted-specifications page, “the OGC Web Feature Service allows a client to retrieve and update geospatial data encoded in Geography Markup Language (GML) ... from multiple Web Feature Services. The ... interfaces must be defined in XML ... GML must be used to express features within the interface ... the predicate or filter language will be defined in XML and be derived from CQL [Common Query Language] as defined in the OpenGIS Catalogue Interface Implementation Specification.” The WFS provides an abstraction of the underlying data store, expressed in GML, as defined through GML application schemas referenced by the service.

The most common implementation of WFS is version 1.0. However, the number if WFS 1.1 implementations is rapidly growing and in 2009 will surpass the number of WFS 1.0 implementations. WFS 1.0 implementations typically return features encoded using GML 2.1 or GML 3.1.1. A growing number of services based on WFS 1.1 It is recommended that WFS version 1.0 be included in the SDI 1.0 standards suite, with required support for GML 2.1 and GML 3.1.1 response encoding.

OGC Web Coverage Service. The OGC Web Coverage Service (WCS) “...extends the Web Map Server (WMS) interface to allow access to geospatial ’coverages’ that represent values or properties of geographic locations, rather than WMS generated maps (pictures),” according to the OGC adopted-specifications page. WCS can return different representations of continuous data surfaces (coverages) for any location: grids, triangulated irregular networks (TINs), point sets. Most commonly, however, the form of coverage most often returned is a grid in a declared coordinate reference system and common format such as GeoTIFF. WCS version 1.0 (with Corrigendum) has been available since 2003 and is recommended for inclusion in the SDI 1.0 standards suite for the exchange of raster or grid data (not rendered imagery).

Candidate SDI 1.0 standards. Table 3 lists the standards for SDI 1.0 and for future versions.

Table 3: Core, supplemental, and future SDI standards

SDI 1.0 core standards	**Future SDI standards**
OGC Web Map Service 1.1.1	
OGC Web Feature Service 1.0	OGC Web Map Service 1.3
OGC Filter Encoding 1.1	OGC Web Feature Service 1.1
OGC Web Coverage Service 1.0	OGC GML 3.2.1
OGC Geography Markup Language 3.1.1	OGC Catalogue Service 2.0.2 HTTP protocol binding (CS-W)
OGC Catalogue Service 2.0.2 Z39.50 protocol binding	ISO DTS 19139:2006 metadata
FGDC Content Standard for Digital Geospatial Metadata (CSDGM, 1998)	
SDI 1.0 supplemental standards	

ISO metadata standard 19115:2003 and ISO DTS 19139:2006
OGC Catalogue Service 2.0.1 HTTP protocol binding (CS-W) ebRIM and ISO Profiles
OGC Geography Markup Language 3.2.1
OGC Styled Layer Descriptor 1.0
OGC Web Map Context 1.1
OGC Catalogue Service 2.0 HTTP protocol binding, CS-W

Discussion

Establishing an SDI standards baseline serves many market purposes. Some fundamental relationships that best illustrate the need for a well-defined and -managed SDI 1.0 and some of the market and policy forces dictating the requirements for an SDI standards suite are discussed below. Analogies to other information technology communities that faced a similar set of issues and market drivers are also drawn.

Evolution of the SDI standards suite. The coordination of the release cycles of the various standards is currently limited. This lack of coordination can impede maintenance of operational capabilities as new versions of standards are made available. The problem is compounded when interdependent standards are not revised and released in a coordinated manner. This situation is not much different from issues related to software product development and release cycles. Therefore, one major reason for having a well-defined and agreed-to SDI standards suite is to support software (and standards) life cycle management.

Any release of a new version of the SDI standards suite needs to be predictable and coordinated. Backward compatibility is a key requirement for preserving customer investments in the overall technology. Exceptions to backward compatibility may be tolerated by users if the relationship of new functions creates enough value to fully compensate customer investments in change management. These considerations also apply to new versions of SDI applications.

The period between standard releases is also relevant to software life cycle management. Factors that need to be considered include relationship investments, the added value of the new suite, return on investment, and the ability to enhance SDI applications in a timely manner. A new SDI suite needs to add enough value to justify upgrading an SDI application or portal. Based on previous studies, we know that the initial investment in using SDI 1.0 will add value and reduce life cycle management costs (NASA, 2005). Over time, more and more users understand the value and potential of using a standards-based approach. The value may be expressed as money but could also be measured by other indicators. Only if the first generation has generated enough value and passed the return on investment (ROI) decision point will new investments for implementing the next generation of the SDI suite be available. The expression “generation of value” applies to SDIs and SDI applications. Although the longevity of a given version of an SDI standards suite cannot be determined yet, the concept of generations is helpful for identifying which functions should be included in the first release and which could be moved to a future release (candidates).

SDI zones. User interface requirements, pricing, processing functions, security, and rights management requirements can vary broadly from region to region. These variations are due to local customer requirements, government policies, legal systems, and so forth. A monolithic approach may not work for an SDI that crosses jurisdictional boundaries. This market force is very similar to what the telecommunications industry has to deal with on a daily basis. In telecommunications, standards-based infrastructures effectively deal with different policy, tax, legal, and pricing requirements by accommodating regional variations.

SDIs face similar regional variations. We call them “SDI zones.” Rather than forcing every jurisdiction to use the same SDI implementation, architecture, and policy framework, we suggest creating SDI zones to meet local requirements while maintaining interoperability between zones. The advantages of distinct but connected zones are lower dependencies and reduced risks of bottlenecks. If an SDI zone or a connection to it is not operational, other zones are not affected directly. The current SDI 1.0 design should take zones into account and offer a zone-to-zone connection mechanism.

Different zones may implement different versions of the SDI standards suite, or they may implement the same version at different times. Therefore, the connection mechanism also needs to connect zones with different versions.

Zone compatibility. Applications often address a specific user need and thereby create great value for that specific purpose. A classic example in the PC world is graphics programs for professionals. On the one hand, these programs create enormous value for the professional; on the other hand, the number of potential (professional) users and their total investment potential are relative small.

Compatibility between SDI zones is a key requirement for selling an application to a larger market. Conversely, the number of (addressable) early adopters for a specific application has a direct impact on the willingness of developers to invest.

SDIs versus SDI applications. Although the interface between an infrastructure and an application is often expressed technically, it can be defined at a specific point in the value chain on the basis of organizational and economic criteria. Electricity, a classic example, is produced in a power plant, distributed over a network, and then used in an application, e.g., a radio or a heater. The infrastructure interface is located at some well-defined point behind an electric meter. Therefore, the responsibility of the infrastructure ends at this interface point, where the downstream power supply is measured for upstream money compensation.

Using this analogy, an SDI is a transport mechanism for spatial data and services. Therefore, a defined gateway is needed to act as the organizational interface between the SDI operator and the SDI application customer.

The distinction between operating systems (OS) and applications in computers provides another analogy. This distinction is defined by a set of application programming interfaces (APIs), that connect programs and allow software applications to be written. The suppliers of operating systems often are not the suppliers of applications. In operating systems, a specific function can be augmented and made reusable if many applications use it. Classic examples are video and audio drivers. These functions were once considered application specific, but because they were used by many applications, a standardized API was eventually included in the operating system.

Another well-known example is SUN's Java Developer Kit (JDK). Although it consists of a large number of functions and interface specifications, the package is released with a single number, e.g., JDK 1.4. Application developers and operators can simply define the requirements and state, "JDK 1.4 is required." The Java Community Process (JCP) is used for new projects, demonstrating the value of collaboration between institutions.

In the future, the concept of SDI should include SDI applications as well as the SDI interfaces. OGC's Geospatial Decision Support (GeoDSS), for example, could easily be implemented using an SDI 1.0 standards suite coupled with the OASIS Business Process Execution Language (BPEL) standard. The GeoDSS application would load data from different repositories, perform an analysis, load more data, perform another analysis, and so forth. However, the requirements for service chaining are outside the scope of SDI 1.0. A future generation of SDIs could include additional functions.

Governance. SDI 1.0 requires an international consensus process to properly define, document, and manage the standards framework in order to ensure that the needs of the many constituents are properly represented. A structured and open process will facilitate dialogue, approval of the SDI 1.0 framework and future revisions, and effective life cycle management.

GSDI, INSPIRE, ANZLIC, CGDI, GDI NRW, the U.S. NSDI, and various e-government initiatives can provide an excellent forum for refining SDI 1.0, having identified best practices for developing standards-based SDIs and having played active roles in the OGC.

The OGC Architecture Working Group could take responsibility for documenting and reviewing the standards baseline for SDI 1.0. The formal vetting of the SDI 1.0 framework would occur in the OGC Architecture Board (OAB), a key OGC committee responsible for enforcing consistency and ensuring proper life cycle management of the OGC standards baseline. Life cycle management rigor will ensure that SDI 1.0 is coordinated effectively and that revisions are carefully considered and documented.

Conclusions

SDIs are becoming a major resource for access to geospatial data and services. Partnerships between the public and private sectors are paying off in higher returns on investment. Perhaps even more importantly, SDIs are contributing to sound decision making, enhanced e-government applications, and better services and are poised to take the next step in their evolution: SDI networks. SDI networks are necessary for emergency preparedness and response, counterterrorism, monitoring of and response to pandemics, and environmental protection. In order for these transnational applications to be effective, SDIs (or SDI zones) must interoperate. The interoperability can be achieved only through consistent and structured implementation of interface and encoding standards. This article proposes a suite of standards for all SDIs.

We recommend that the concept of an SDI standards suite be considered by the global SDI community as an important work item. OGC members agree that SDIs need a well-defined and -managed suite of standards. We therefore propose that the OGC take formal responsibility for providing life cycle management and documentation of the suite and that the global SDI community take responsibility for defining the actual standards.

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Appendix A

Requirements for SDI Best Practice Implementations

As designated by the Global Spatial Data Infrastructure Association

To be designated as a ***SDI Best Practice Implementation*** by the Global Spatial Data Infrastructure Association and have the right to use the designation, an implementation must:

1. meet minimum interoperability requirements by implementing and adhering to a set of core standards of any annually issued *Recommended Minimum Software Standards Suite for Spatial Data Infrastructure* by the GSDI Association as set forth under section I below, and
2. meet minimum accessibility requirements by implementing and adhering to the *Spatial Data Infrastructure Minimum Accessibility Requirements* as set forth under section II below.

I. Recommended Minimum Software Standards Suites for Spatial Data Infrastructure (issued annually as needed)

A. 2008 Recommended Minimum Software Standards Suite for Spatial Data Infrastructure (SDI-REMSSS 2008)

Software Products: A single software product may meet the standards in one or more of the three categories of standards listed in Table 1 at the end of this document. By example, a single software product might meet both the requirements of OGC WMS 1.1.1 and OGC WMS 1.3. Many software products that support a recent standard will also support previous versions of the same standard.

Implementations: For a Spatial Data Infrastructure implementation to be designated by the GSDI Association as a ***SDI Best Practice Implementation***, it must support at a minimum the ***core standards*** listed below. These core standards listed have been shown to interoperate effectively in numerous implementations. The implementation may additionally support supplemental standards and future candidate core standards as shown in Table 1 as well as other standards not listed but these are not required to gain designation as an ***SDI Best Practice Implementation***.

SDI-REMSSS 2008 Core Standards

OGC Web Map Service 1.1.1

OGC Web Feature Service 1.0

OGC Filter Encoding 1.1 (used in conjunction with WFS)

OGC Geography Markup Language 3.1.1

Plus

OGC Catalogue Service 2.0 HTTP protocol binding, CS-W and

OpenGIS Catalogue Services Specification 2.0.2 - ISO Metadata Application Profile (1.0.0) (Note: supports ISO Metadata Standard 19115:2003 and ISO DTS 19139:2006)

Or

OGC Catalogue Service 2.0 Z39.50 protocol binding and

FGDC Content Standard for Digital Geospatial Metadata (CSDGM, 1998)

Thus, to be designated as a SDI Best Practice Implementation under the 2008 standards, the implementation must offer at a minimum a *web map service, a web feature service and a catalogue service for* ***significant proportions of its data holdings*** meeting the listed core standards.

II. Spatial Data Infrastructure Minimum Accessibility Requirements (issued annually as needed)

Implementations: For a Spatial Data Infrastructure implementation to be designated by the GSDI Association as a ***SDI Best Practice Implementation***, it must support at a minimum the ***GEOSS Data Sharing Principles*** for its web map service, web feature service and catalogue service as applied to significant proportions of the SDI's data holdings. For the latest version of the principles, consult http://xxx.xxx

Further, the GSDI Association ***highly recommends and encourages*** adherence to the GEOSS Data Sharing Principles for ***all*** SDI holdings with appropriate exceptions as noted in the principles.

III. Applying for Designation as a SDI Best Practice Implementation

SDI implementations are assessed for designation as a *SDI Best Practice Implementation* through information provided by an appropriate organization representative to the *GIK Network*. Based on the information provided, a review team will approve or disapprove the designation and may investigate the matter further. The team will NOT at this time pursue a formal Compliance Testing Program. Those SDI's approved as meeting the minimum requirements for a *SDI Best Practice Implementation* will be so designated on the *GIK Network* web site and the SDI hosts will be allowed and encouraged to use the designation on their own web sites.

∗ Abbreviations are as specified at http://www.opengeospatial.org/resource/products

2009 Recommended Minimum Software Standards Suite for Spatial Data Infrastructure (REMSSS-SDI 2008)	
SDI-REMSSS 2009 Core Standards	**OGC Abbreviation for Standard***
OGC Web Map Service, Version 1.3	WMS
OGC Web Feature Service, Version 1.1 or OGC Web Feature Service (Transactional)	WFS or WFS(T)
OGC Filter Encoding ,Version 1.1 (used in conjunction with WFS)	Filter
OGC Geography Markup Language Version, 3.2.1	GML
OGC KML, Version 2.2	KML
OGC Web Coverage Service, 1.1.2	WCS
plus	
OGC Catalogue Service, Version 2.0.2 HTTP protocol binding, CS-W and	CAT CSW
OpenGIS Catalogue Services Specification 2.0.2 - ISO Metadata Application Profile (1.0.0) (Note: supports ISO Metadata Standard 19115:2003 and ISO DTS 19139:2006)	CAT2 ISO AP
or	
OGC Catalogue Service, Version 2.0 Z39.50 protocol binding and	CAT Z3950
OpenGIS Catalogue Services Specification 2.0.1 - FGDC Application Profile supporting FGDC Content Standard for Digital Geospatial Metadata (CSDGM, 1998)	FGDC AP
SDI-REMSSS 2008 Supplemental Standards	
OGC Styled Layer Descriptor, Version 1.0	SLD
OGC Web Map Context, Version 1.1	WMC
OpenGIS Sensor Model Language, Version 1.0.0	SensorML
OpenGIS Sensor Observation Service, Version 1.0.0	SOS

Chapter 11

From The SDI Cookbook

Contents

Chapter Eleven: Case Studies of Interdisciplinary Coordination

Editor: open

Introduction

While Chapter 8 has outlined the elements of outreach and capacity building needed to form a viable national and global SDI, this chapter provides some examples of SDI implementations from a national, regional, and global perspective. The documentation of case studies is an effective mechanism to help convey the underlying factors that led to the growth of spatial data infrastructures. This chapter will highlight some of the success stories, shortfalls, and issues that characterise the state of the National and Global Spatial Data Infrastructures today. Contributors from both developed and developing countries have provided case studies for this chapter. Wherever possible, authors have attempted to cite the major factors leading to success or shortfalls in a particular case study. The reader should note that this chapter will grow to include greater comparative information as more case studies are examined and incorporated. For this first publication of the SDI Cookbook, single national and regional case studies are examined.

Local Case Study – Within nations, localities are increasingly addressing decision-making through the use of geographic information and tools. The ability for spatial data infrastructure to deal with local as well as broader national issues is essential. A case study from the United States involving crime management is highlighted as one of many examples of local communities that are benefiting from the investment in SDI towards improved community service. Our thanks go to Mr. John DeVoe of the US Department of Justice (mailto:john.devoe@usdoj2.gov) and the staff of the Baltimore Police Department for their contributions.

National Case Study - the Colombian experience in developing and harmonizing geographic information systems is examined. Its main purpose is to contribute to identify best practices in Spatial Data Infrastructures as a means to increase geographic information availability, access and use to support making decisions and to promote sustainable development. A team of authors from Colombia's IGAC provide a comprehensive assessment of the Colombian experience in establishing a national SDI. Acknowledgements go to Santiago Borrero Mutis (sborrero.igac.gov.co), Iván Alberto Lizarazo Salcedo (mailto:ilizaraz@igac.gov.co), Dora Inés Rey Martínez (mailto:direy@igac.gov.co), and Martha Ivette Chaparro (mailto:mchaparr@igac.gov.co) for their contributions to this chapter.

Regional Case Study - A case study from the SADC Regional Remote Sensing Unit, which is part of the SADC Regional Food Security Programme, facilitates training programmes and technical support in the field of remote sensing and GIS in support of early warning for food security and natural resources management. This case study is provided as an example of how a focus on critical regional issues yields elements of infrastructure valuable for cooperating nations. Camille A.J. van der Harten (mailto:cvanderharten@fanr-sadc.co.zw), Senior Adviser, SADC Regional Remote Sensing Unit, Harare – Zimbabwe provides an outstanding overview of that effort, its successes, and issues.

Global Case Study - For the global case study, the authors reviewed the major organisations, systems, and processes that are operating to achieve one or more aspects of the Global spatial Data Infrastructure. Although a true GSDI is not a reality today, a review of the current areas of emphasis is in order. Thanks to the members of the Digital Earth Team Tim Foresman (mailto:foresman@umbc.edu) and Gerald Barton, and the University of California Santa Barbara / Global Map team (Jack Estes (mailto:estes@geog.ucsb.edu), Karen Kline (mailto:(kline@geog.ucsb.edu) for their contributions.

Local Case Study

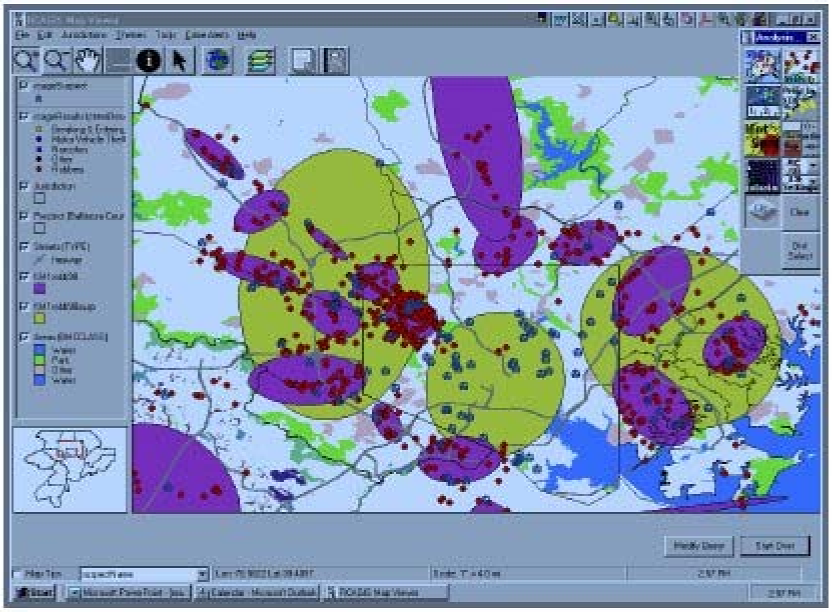
In this chapter, the authors have highlighted some national, regional, and global case studies that are helping to contribute to the GSDI. This section is intended to illustrate one example of the successes at the local level to advance the ability of communities to improve their decisionmaking through the use of spatial data infrastructure.

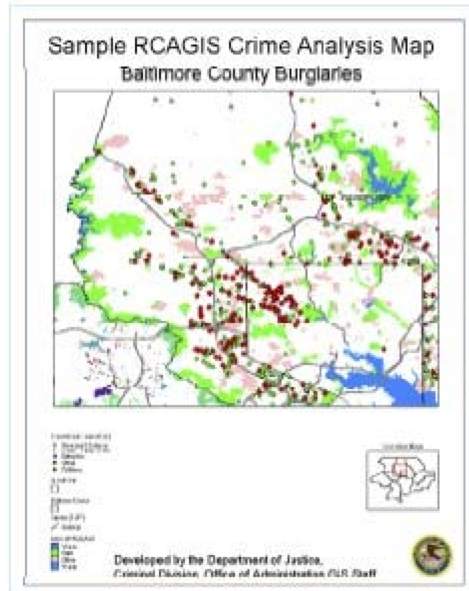
Background, Context and Rationale

The reduction of crime in communities across the United States is a major goal to assure safe and liveable communities. Although crime types and rates vary from locality to locality, the use of geographic data and tools is rapidly becoming a key resource to better understand and more effectively deal with crime. In the United States, community safety and policing are primarily functions of local and state governments. Recently, Baltimore City, Baltimore County, and other neighbouring law enforcement organisations realised that cooperative analysis of crime trends regionally would reveal a more complete picture of crime trends. As a result, the City of Baltimore, Baltimore County and other police departments in the Mid-Atlantic area of the United States came together to target and reduce the amount of crime by identifying and implementing methods to standardise their approach to the management and use of crime data and related geospatial information.

Organisational Approach

In the early 1990's, the United States Department of Justice, recognizing the value of geospatial data and techniques in managing crime, established partnerships with local law enforcement organisations to illustrate the value of GIS applications in the identification, visualisation and analysis of crime trends locally and regionally. These early partnerships were also designed to show industry the potential market for applications to better address crime management. The success of these early efforts, led to the creation of larger regional partnerships to address crime issues using geospatial data and geospatial applications. Law enforcement organisations working collaboratively in the region helped the US Department of Justice develop the requirements for a Regional Crime Analysis GIS application. Participating communities agreed to use the RCAGIS crime mapping, analysis, and reporting applications developed under contract by the Criminal Division, United States Department of Justice. Additionally, Baltimore City applied for and received designation of this effort as a National Spatial Data Infrastructure (NSDI) Community Demonstration Project. This designation brought in additional support from the Federal Geographic Data Committee and the Vice President's National Partnership for Reinventing Government.

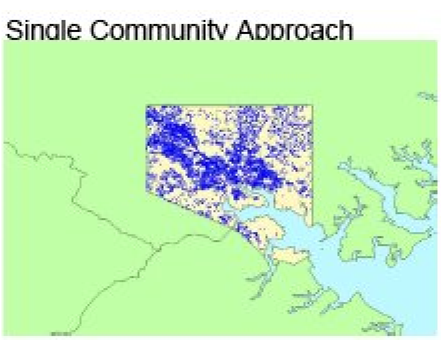


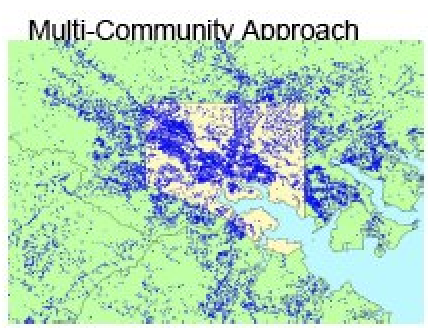


Implementation Approach

The Regional Crime Analysis GIS (RCAGIS) was developed to provide police officers, crime analysts, investigators, chiefs/commissioners/sheriffs, and managers a powerful, yet easy to use crime mapping, analysis and reporting application. RCAGIS is designed to assist police departments in their tactical and strategic responses to crime and to help create an environment where police department personnel assume responsibility for increases and decreases in the amount of crime. RCAGIS operates in a PC environment and uses ESRI's MapObjects. MapObjects was chosen because it is relatively inexpensive to implement on a moderate to wide-spread basis.

RCAGIS seamlessly integrates CrimeStat, a very powerful spatial statistic tool developed by Dr. Ned Levine, of Ned Levine and Associates. The RCAGIS programming code is available, free of charge, through the Criminal Division, United States Department of Justice homepage (http://www.usdoj.gov/criminal/gis). . Through this cooperative partnership, the DOJ and local police departments in the Baltimore – Washington area standardised the format for crime incident data and the methods of mapping, reporting, and analysing crime.





With the success of the RCAGIS program comes the need to address how to manage the growing volume of geographic data that are produced by police departments or other local government agencies in the region. Through support from the US Federal Geographic Data Committee, and the designation of Baltimore as a NSDI Community Demonstration Project, training and technical assistance was provided to the Baltimore City Police Department to implement metadata standards and practices. Additionally, spatial data clearinghouse nodes will be established to inventory and advertise Baltimore City Police Department's designated geographic data. The posting of metadata allows the law enforcement community to know what geographic data is available in the area. Additionally, metadata and clearinghouses can accommodate both public access to data, and the management of data restricted only for law enforcement use due to local policy.

The RCAGIS program has helped localities to improve collaboration on issues of mutual importance. The program illustrates to law enforcement staff the value of metadata and clearinghouses in improving the ability to inventory and share information. By standardizing data elements and the metadata that describes this data, law enforcement organisations have improved their ability to communicate issues across jurisdictional boundaries, see the broader implications of crime, and devise more comprehensive solutions to apprehend offenders, and to reduce crime trends overall. Finally, by using clearinghouse resources, law enforcement will be able to discover and apply additional environmental, social, and economic data sets to enhance police departments' crime analysis and tactical and strategic responses to crime, thereby reducing the amount of crime and residents' fear of crime in our communities.

Recommendations

Establish expanded partnerships - A broad multi-jurisdictional view of crime is often necessary to understand overall crime trends. Indeed issues related to crime, the environment and the economy are not typically contained within community boundaries. Partnerships and collaboration through the sharing of data, standards and processes enhances the ability to understand and manage patterns of crime that are significant to the larger area. Partnerships with the federal government provided expertise, training to deal with many issues, and also provided some funding to advance this effort as well.

Educate spatial data managers and users on the value of SDI practices - metadata, clearinghouses, and standardisation are concepts that until recently were very unfamiliar to the law enforcement community, and will not be readily adopted unless the appropriate level of education and outreach is applied to illustrate the value of metadata and standardisation to assure data accessibility, quality, availability, and overall management.

National Case Study – Colombia

Background, Context, and Rationale

As with many nations around the world, the major drivers for geographic information infrastructure in Colombia stem from the nation's programs for governance to address national issues related to the environment, the economy, and social issues. Drivers also include private sector interests in the major areas of Colombia's Economy. Furthermore, Colombia understands that issues of national importance often extend beyond its borders, so the growth of the national infrastructure must accommodate collaboration regionally and potentially globally. This case study will focus on the efforts of Colombia to establish a national SDI, and discusses the steps Colombia has taken to assure SDI compatibility to address regional and global issues such as those raised via the UN Agenda 21.

Initiatives to coordinate SDI actions in Colombia at a national level face significant constraints like decreasing budgets, inter-organisational barriers, lack of high level support, limited capacity for research and development and lack of knowledge about the geographic information market, among others. Despite these restrictions, experience has shown that specific steps to define and implement a national geographic information strategy can be accomplished, providing that government agencies decide to work together, reduce costs, avoid duplication of efforts, and recognise the role that the private sector and academia can play. User demands can trigger the necessary partnerships and alliances to produce and share information.

The Colombian Spatial Data Infrastructure (ICDE) is defined as the set of policies, standards, organisations and technology working together to produce, share, and use geographic information about Colombia in order to support national sustainable development. The ICDE is a young but promising, initiative. The lessons learned through its design and development may be useful. Due to the fact that it lacks a formal mandate to build the Colombian NSDI (as compared to the U.S. case), the ICDE has followed an empirical approach, in which design and development are not completely separated and well-defined stages are utilised. The ICDE has struggled to gain visibility and support while under pressure to show results.

The ICDE must be understood as an initiative that is under construction, in which practice is used to refine the concepts. Various government organisations, private companies, and universities are laying the ICDE building blocks. The IGAC, DANE, IDEAM, INGEOMINAS, ECOPETROL and the Ministry of the Environment, among others, have made valuable contributions. While work on standards and data production has been remarkable, yet still insufficient, reaching agreements on policies and high-level support seems to be the major area requiring further efforts. This document explains why the ICDE, the Colombian NSDI, was born and how its family is taking care of it and helping it to grow.

Quick Overview of Colombia

The republic of Colombia, located in northwestern South America, encompasses a total area of 2,070,408 square kilometres, of which 1,141,748 are on the mainland. In 1992, the population of Colombia was approximately 36.2 million people. The country is a rich mix of peoples, including Mestizo (European-Indian), European, African-European, African, African-Indian, and Indian descent. The main language in Colombia is Spanish, but over 200 indigenous Indian languages are also spoken.

Colombia has a democratic political system and Santa Fe de Bogotá is the capital city. The major industries are textile production, coffee, oil, sugar cane and food processing. The GDP in Colombia is US $172 billion. Inflation currently runs at about ten percent.

Colombia is the fourth-largest country in South America and the only one with coasts on both the Pacific and Caribbean oceans. It shares borders with Panama (to the northwest), Venezuela (east), Brazil (southeast), Peru (south) and Ecuador (southwest). The Colombian territory also includes the San Andrés and Providencia island groups, 700 km. (435 m.) northwest of the mainland, in the Caribbean Sea. The archipelagoes are 230 km. (140 m.) east of Nicaragua.

Three Andean mountain ranges run north and south through the western half of the country (about 45% of the total territory.) The eastern sector is a vast lowland, which can be generally divided into two regions: a huge, open savannah in the north, and the Amazon in the south (approximately 400,000 sq. km.).

Colombia has the highest number of plant and animal species per unit area of any country in the world. The country's network of reserves includes 33 national parks, six small reserves, known as “santuarios de flora y fauna”, two national reserves and one special natural area. Their combined area constitutes 7.9% of Colombian territory.

Geographic Information in Colombia

Most geographic information on the Colombian territory is produced by government agencies that have specific mandates. The DANE is responsible for conducting the census, both social and economic. The IDEAM is in charge of hydrology, meteorology, and environmental studies. The INGEOMINAS works in the area of geoscience, environmental mining, and nuclear energy. The IGAC carries out topographic mapping, cadastre, soil, and geographic activities. All these institutes are very experienced in their respective areas, both in terms of the time they have put in, as well as the amount of valuable information produced throughout the country. Over the past decade, pursuant to presidential decrees, these Colombian agencies have developed modernisation processes for structural and resource reorganisation in order to fulfill their institutional goals and the community's needs. New technology has been incorporated into the production flow, people have been trained, and agencies are furnishing digital products to users.

Aside from the above-mentioned agencies, some companies share a small, but increasing, portion of the geographic information market. They provide products and services to the government and private sector, and help to produce topographic and thematic mapping and develop GIS applications.

In the 1990's, an awareness of the benefits of geographic information started to grow among municipalities, environmental agencies, oil companies, and the utilities sector. Seeking to meet legal requirements[6] or business challenges, some people turned their eyes toward geographic data. A demand for digital base maps was born and grew quickly, although not always supported by adequate funding. It has taken time to convince users that the government cannot provide new digital products for the low cost of duplication, as for analogue information.

Unfortunately, high-level government decisions currently do not benefit from geographic information. Despite increasing recognition of its role to generate knowledge, provide added value to identify problems, assist in proposing alternatives and defining a course of action, geographic information discovery, access and use have not spread as desired. Indeed, government agencies face budgeting constraints for the funding of production and maintenance of their databases. In most cases, government agencies must attempt to find ways to accomplish their principal functions and achieve a minimum level of cost recovery.

National GIS Projects

With a view to fulfilling their mandates, government agencies are carrying out various initiatives to develop national information systems in the areas under their jurisdiction.

Environment Information System for Colombia (SIAC) - According to Law 99 of 1993 and Decrees 1277, 1600 and 1603 of 1994, the Ministry of the Environment shall lead the coordination of the National Environment Information System (SINA) and establish the Environment Information System (SIA), and the IDEAM shall manage the implementation and operation of the SIA and advise the CARs[7] to do the same in their areas. Other research institutions (INVEMAR, SINCHI, John Von Neumann, Alexander Von Humboldt) shall contribute to system implementation throughout the national territory with the aim of providing timely and sufficient environmental information to support policies and decision-making.

At the provincial level, some CARs have also developed environment information systems, most of them successfully. However, these various developments lack convergence and coordination.

At the present time, the Ministry of the Environment is initiating a system for the planning, design, and development process, to harmonise efforts and strengthen and consolidate the SIAC. This system targets water resources, pursuant to the National Environmental Policy, which establishes water as its principal focus. The Policy also involves the community in the development strategy through their participation in the area of information appropriation.

The National Environment Information System (SINA) – The IDEAM has developed the SINA's basic module and provides information in real-time about environmental status and changes. Some of its products are: *Environment in Colombia, Natural and Socio-economic Impacts due to the Pacific Hot and Cold Phenomena – el Niño and la Niña, The National Water Study, Offer-Demand Relations and Sustainability Conditions, Vegetation and Land Use, Morphogenic Systems and the Stability of the Geological Morphostructure and Superficial Formations.*

The National Geoscientific Information System (SING) - Under *Decree 1129 of 1999*, the INGEOMINAS shall conduct research and generate basic information for geoscientific knowledge and the improvement of the Colombian subsoil. To this end, the INGEOMINAS shall survey, obtain, compile, integrate, validate and provide in digital and standardised format, subsoil information, including geology, geophysics, geochemistry, geomechanics, nonrenewable resources and geology-based hazard monitoring. The INGEOMINAS will develop the SING as an integral part of the Colombian Geographic Information System.

The INGEOMINAS has produced several digital atlases over the past few years, in the areas of geology, geochemistry, gravimetry, geological hazards, metallogenesis, geochemical anomalies and mining activity.

The National Geostatistical Information System (SAIG) – According to Decree 2118 of 1992, the DANE shall manage the SAIG. The SAIG fosters the integration of social, demographic and economic statistical information obtained from census taking, surveys and administrative records, using current technology to store, query and analyse information.

The SAIG engages in the following tasks: design and methodology for census-taking, surveys and research on social and economic data, such as quality of life, construction, national home surveys, the consumer price index, national population and housing census, and collection of information for planning; development and control. Other tasks include definition and updating samples, processing information, analysis, and publication of results.

The National Geostatistical Framework links statistical information with the corresponding geographic sites. It is made up by political / administrative groups and geographic sectors oriented toward statistical activities. It attempts to improve social welfare, sustainable development and Colombia's competitiveness.

The IGAC Geographic Information System (SIGAC) - *Decree 2113 of 1992* empowers the IGAC to draft and update the Official Map of the Republic of Colombia, develop policy, and undertake national government programs in cartography, agrology, cadastre and geography. This is done through the production, analysis and distribution of geo-referenced environmental and cadastral information, which is aimed at supporting planning and territorial ordering processes.

The IGAC has developed the Integrated Geographic Information System, which is designed to build and maintain national digital databases in topography, soils and cadastre. It began to be implemented in 1995.

The conceptual model of the IGAC's (SIGAC) Integrated Geographic Information System included the following aspects:

- Design and implementation of an integrated Data Model for the 1:2,000 and 1:25,000 scales. In this model, the real world is represented by a Digital Landscape Model (DLM) (primary model), where the different objects are classified, coded and transformed through a cartographic work into a secondary model, the Digital Cartographic Model. The objects are categorised in terms of themes, groups, and object classes.
- Creation of the Spatial Database according to the Data Model. The data structure simplifies spatial analysis and linkage of geographic objects to external data in order to be available for multipurpose use. The topographic data are entered into the system using the analytical restitution of the photos. Digitising the existing maps captures the cadastral and soil information. The SIGAC structure and content includes: land fixed points, photogrammetric fixed points, land transport, aerial transport, shipping transport, engineering structures, vegetation, water streams, water bodies, relief, buildings, land ownership and territorial and administrative boundaries.
- Establishment of data–exchange formats for internal and external users of the system.
- Definition and establishment of standards.

Some of the main tasks performed by the SIGAC are: calculations, surface intersections, interpolations and topographic modelling; land registration; land valuation; production of soil homogeneous zones; derivation of physical and geo-economic homogeneous zones; and production of land use maps. The principal products supplied by the SIGAC are: topographic maps at different scales, cadastral maps, soil maps, land registration certificates, land use maps, physical homogeneous zone maps, geo-economic homogeneous zone maps, land homogeneous areas for cadastral purposes, land suitability classification maps, land capability classification maps, digital terrain models, and statistical information regarding buildings, parcels, owners, etc.

Until now, the IGAC has made great efforts to bridge the gap in basic map availability and currency. Coping with adverse meteorological conditions and taking advantage of the new geoinformation technologies, the IGAC is trying out new data sources, procedures, and products. Despite some achievements, more R&D is still needed. A great deal of topographic and cadastral digital maps have been produced, focused on 1:2.000 scales for cities and towns and 1:100.000 scales for rural areas.

The National Oil Company Information Infrastructure (GEODATA) - Recognizing that the current manner of conducting the oil business in Colombia is too expensive and time consuming, ECOPETROL has entrusted the ICP (its research center) with the task of defining policies and standards and developing an infrastructure to manage geographic information, according to new technologies and customised to company needs. Its most ambitious project has been the development of a distributed data repository to provide a common, high-quality warehouse for Colombian primary and interpreted petrotechnical data. The data warehouse will ultimately aim to be Colombia's official repository for petrotechnical data on oil exploration and production. Primary petrotechnical data includes all non-interpretative data that may be used by the industry in its day-to-day work.

The Coffee Information System (SICA): The Colombian Coffee Growers Federation (FEDERACAFE) is a non-profit institution. It was created in June of 1927 and currently unites almost 300,000 producers.

The FEDERACAFE has developed strategic plans to improve the competitiveness of Colombian coffee and to provide research and development programs on improved technologies for production, the post-harvest process, coffee quality, the management capacity of coffee producers, and marketing to increase the demand for Colombian coffee.

One of the programs that has been developed is the Coffee Information System (SICA). This system permits the coffee authorities, the Federation and the producers to base their work on strategic and updated information that allows them to design policies and programs to improve competitiveness, the sustainable development of Colombian coffee production, and the welfare of the coffee producers.

The SICA includes the following elements:

The coffee plantation structure (plots, areas, number of plants, varieties, borders, brightness, meters above sea level). Socioeconomic aspects of coffee growers and their housing.

The Federation has developed a specialised Software “SICA” or AFIC (Attention for Farms and Coffee Growers).

Despite the developments described above, it is clear that each institution has built its information systems independently and that national policies and guidelines were non-existent at the time they started these processes. Due to this, interorganisational links have not been strengthened as needed, the roles of the agencies have not been clarified, and analogue-digital data conversion activities may have been duplicated. Digital databases were built autonomously and problems soon arose: data were out-of-date and incomplete, heterogeneous in content and quality, poorly documented, hard to find and difficult to integrate. Client needs were not recognised as required. An awareness of these problems led to the need for standardisation.

First steps towards a national geographic information strategy

The IGAC, which is in charge of the national databases on topography, cadastre, soil and geography, developed in 1995 a geographic object classification scheme for use in different scales. Other institutions adopted the IGAC scheme and added their own objects. This was the first step to achieving order in-house. Around the same time, ECOPETROL, the national oil company, started its project Geodata, which focused on geographic data standards and metadata. Both initiatives pushed forward the creation of a national committee in charge of defining geographic information standards. Under the auspices of ICONTEC, the Colombian body for standardisation and certification, and with coordination by the IGAC, more than thirty entities from government, the private sector and academia contribute to this committee. Until now, efforts have been concentrated on geographic metadata, basic object cataloguing, quality, and terminology.

As user understanding of GIS capabilities grew, an understanding of the need for homogeneous and consistent data also grew. Government agencies began to understand their role was changing: they had to become information providers and not only data producers. Private companies started to share an emerging digital geographic information market. Partnerships developed to produce and update topographic and cadastral data. The IGAC and other institutions convinced some city authorities to fund digital database projects on a fifty-fifty cost sharing basis between municipalities and the Colombian government. The results demonstrated the benefits of sharing costs and information.

However, interorganisational cooperation alone could not accomplish SDI objectives, nor would it be done by Colombian agencies acting alone, without broader participation by industry, academia and local governments. Cooperative efforts would have to be augmented by national policies and guidelines to clarify the roles, responsibilities, priorities, and legal issues, such as copyright, prices, liability and custodianship.

A high level team drafted some government policies on information in 1996[8], producing policies that emphasised the need to manage information like a strategic national resource. These policies viewed the use of information technology as a means to promote social welfare and citizen service, and to link government agencies with outside sectors. Nonetheless, specific policies on geographic information were still missing.

As a consequence of the above, geographic information availability and access were not optimal. Furthermore, geographic information was not being used to its full potential for decision-making and to support sustainable development. A national strategy for geographic information was needed, to focus on the following priorities:

Definition of basic policies. Production of fundamental data. Documentation of geographic data. Improving access to users. Education and consciousness raising.

Subsequently, the ICDE concept was born in late 1995. The ICDE was influenced by American and European concepts yet retained a local flavour. This local flavour was required to address unique Colombian characteristics: a developing country and government, a nation rich in biodiversity, mineral resources, natural hazards and socioeconomic problems, and the Andean region, which is challenging to map due to meteorological conditions. Early success in the standardisation work done by technical teams and increasing demands by government users to account for programs using national information encouraged public agencies to deal with the remaining issues.

Organisational Approach

In 1998, the Colombian government defined as a priority the establishment of a long-term multilateral alliance between Colombia and The United States, the “Environmental Alliance for Colombia” (Alianza Ambiental por Colombia), aimed at the promotion of technical, scientific, managerial, informational, financial and political cooperation for the knowledge, conservation and sustainable development of Colombian natural resources[9]. The Alliance’s mission and priorities include:

Management of ecosystems Cleaner production Environment Information System Supply and demand of environment products and services Water

A round table was set up on each of the above issues under the aegis of the Ministry of the Environment. The Directors of the IGAC, DANE, INGEOMINAS and IDEAM were called upon to participate and coordinate actions to support decisions on the environment. The discussion quickly moved to the need to strengthen interorganisational links, increase information production and sharing, improve the status given by the Colombian government to geographic information, and define a national geographic information strategy.

In November 1998, an Inter-Institutional Committee was set up to create consensus on different topics. The government agencies in charge of geographic information production agreed to work jointly to define policies, guidelines and strategies to foster the production and publication of geographic data in Colombia and facilitate data integration, use and analysis by the agencies’ information systems[10]. The committee also decided to promote carrying out actions to develop autonomous information systems in a coordinated and harmonised way as integral part of a national geographic information system. The Committee agreed to coordinate actions in the following areas:

Definition of guidelines and strategies to produce, process and make available geographic information. Definition of products under the aegis of each agency, taking into account user needs. Strategies for standardisation of products/processes. Strategies for the development of telecommunications and information technology infrastructure. Legal and business strategies. Organisational strategy and roles to develop the Colombian Geographic Information System (ICDE). Strategies to build the National Geographic Information Network. Communication and marketing.

The Organisational Strategy will define the actions to be carried out by different agencies in order to implement the agreements on internal structure, organisational culture, and technical infrastructure. The Organisational Strategy will define a clear outline of the responsibilities of each agency in the development and implementation of the ICDE including: interaction, mechanisms for the joint development of projects, and linking to other public and private institutions.

As noted above, action by the Ministry of the Environment, and its viewpoint as a user, triggered the first interorganisational meetings and helped diminish some communication barriers. Major government producers continued to look for better ways to interact and gained valuable insights. However, their collective desire to produce a document with organisational strategies by the end of 1999 could not be achieved. The restructuring process of state institutions that the Colombian government began in mid-1999 focused the agencies' attention inwards, as they struggled against functional instability and turned the inter-agency activity to their own operational issues[11].

Some government agencies that are major users of geographic information, like ECOPETROL, FEDERACAFE and EEPPM, are very interested in playing a role in ICDE development. Indeed, contributions by them to standardisation and their investment in production and updating basic geographic data projects have been valuable. Some have suggested that they attend the next meeting of the Inter-Institutional Committee to enrich the process and widen the scope of the initiative.

In addition, "spontaneous" regional interorganisational initiatives are emerging. Two noteworthy cases are the Aburra Valley Geographic Information System (SIGMA) and Bucaramanga Tecnópolis – Ciudad Digital (the geographic information system for the Metropolitan Area of Bucaramanga). In both cases, municipal authorities and utility companies (water, sewage system, natural gas, telephone, power) agreed to jointly plan, gather and update basic geographic information to support local decision-making. Major geographic data producers have been invited to support technical definitions, but they are not the project leaders.

Implementation - Approach

Components of the ICDE

The Colombian Spatial Data Infrastructure (ICDE) is defined as the set of policies, standards, organisations, and technology working together to produce, shares, and uses geographic information on Colombia in order to support national sustainable development. Main ICDE components may be defined as: administrative information policies and guidelines, geographic information standards including metadata, fundamental data (framework), and a national geographic information network.

The ICDE has been oriented to addressing development on a priority basis, initially emphasizing two basic areas: **Production and documentation of fundamental data (framework):** Linkage of efforts and resources from different institutions, taking advantage of IT, fulfilling standards and useroriented product technical specifications and focusing on national priorities and programs. **Development of mechanisms to increase access to data and use by the community:** Facilitation of metadata queries, data discovery, and recovery. In order to achieve this, development of a legal framework defining both producer and user rights and duties, i.e. copyright, liability, access, and privacy. Two factors are relevant to this effort: Building the national metadata repository and linking distributed metadatabases via the INTERNET.

Development of the national geographic information network to promote the availability of geographic information products and services.

Implementation of the ICDE

Progress

With respect to the implementation of the ICDE components, the major agreements to date include the following: Government data producers have agreed to coordinate gathering seamless digital basic databases covering the whole Colombian territory, prioritised as follows:

1:100,000 scale 1:500,000 scale 1:25,000 scale

Some projects are being developed jointly by the IGAC and other institutions using partnerships, which share the costs (through joint investment) and benefits of producing and updating maps, cadastral information, and soil and agrology information. A national geographic metadata standard was defined in March, 1999 (Norma Técnica Colombiana NTC4611), based on ISO/TC211 and FGDC work. Major producers have started to document their data sets according to this standard. The ICP, with the assistance of NCGIAUCSB, has developed metadata and clearinghouse node software tools and has decided to distribute these nationally as a means to stimulate document acquisition, storing and queries. Significant attention is being given to education and training, since it has not been easy to convince people to add a new process (documentation) to the production line. The difficulties encountered in implementing the process have led to the definition of "minimum metadata" as alternative to the complete standard. Other issues are being discussed in the standardisation process: Quality of geographic information. Object catalogue for basic geographic data. Satellite geopositioning. Geosciences. Terminology.

Government producers have improved their communication and technology infrastructure. For example, Internet WEB sites have been developed for each institution. (For more information, please access their pages: ECOPETROL-ICP: www.ecopetrol.com.co, DANE: www.dane.gov.co, IGAC: www.igac.gov.co, INGEOMINAS: www.ingeomin.gov.co, IDEAM: www.ideam.gov.co, MINAMBIENTE: www.minambiente.gov.co, FEDERACAFE: www.cafedecolombia.com). Information services are being developed and implemented and GIS online pilot projects are starting. However, keeping in mind that large sectors of the Colombian community have not yet linked to the INTERNET[12], the major agencies continue to develop traditional paper and hard copy products.

Currently, the private sector is involved in helping to produce and/or update geographic data for the Colombian NSDI, or when a government agency decides to hire a firm to publicise some part of the data collection's work. Out-sourced work is estimated to account for about 50% of the total. The commercial sector is also being hired by national and local government to install, operate, and maintain their network infrastructure (cabling, routers, switches, etc.) and/or to disseminate data. Until now, the private sector has not produced or publicised geographic data to a larger public at any charge, but it seems probable that this will occur in the near future.

In terms of the need for international cooperation, the first ICDE project has been defined by the Inter-Institutional Committee and is to be considered by the American Government in the framework of the *Environmental Alliance for Colombia*[13]. The estimated time for the project is three (3) years. It focuses on improving the ability of institutions to effectively support policy formulation and decision-making on environmental issues, within the general framework of supporting sustainability in national development. The project has three components: Production of national basic cartography (1:100.000 scale). Development and strengthening of a national geo-spatial information network. Strengthening institutional skills for the generation of integrated environment information services. The project's total budget is about US $32,000,000.00. This amount would be funded by national investment and international support.

Issues

Although significant progress has been made, many issues remain to be addressed in order to accelerate the implementation of the ICDE:

Organisational issues: There is no formal mandate to build the ICDE and an institution with the authority to lead the process. Informal initiatives fail to break interorganisational barriers and do not encourage broader participation.

Furthermore, institutions continue to focus on the development of geographic information suitable for their own needs and thus, it becomes difficult and costly for other users to “reuse” geographic data.

Policy Issues: There are no formal agreements or processes underway to address privacy, access, use, pricing, and liability. Agencies have autonomous approaches to these subjects, especially in the areas of pricing and copyright. In practice, digital geographic data sets are sold off-line on a single-license basis at prices ranging from 1% to 5% of the production cost. Analogue data sets (photos or maps on paper) are sold at the cost of duplicating them. Private firms mainly produce customised geographic data and charge their clients about 130% of the production cost. In general, this type of data is not available to the public.

User Needs: A user needs study does not exist. A survey of this type would assist in better focussing the efforts and priorities of the ICDE.

Cost-Benefit Study: Similarly, little information is available in Colombia regarding the costs and benefits of geographic data in decision-making. This information is essential to demonstrate clearly the benefit of joining to implement the ICDE to government, business, and citizens.

Conclusions

In developing countries, government agencies in charge of geographic information have the combined challenge of improving performance, learning to cooperate through partnerships within the limitation of budget restrictions, and satisfying increasing user demands. Otherwise, they will be unable to accomplish their goal of providing valuable information to support increased knowledge and national policy. A national spatial data infrastructure initiative seems to be the most suitable strategy to promote long-term multi-sector alliances, not only among government agencies, but also with the private sector and academia, so that all the stakeholders win.

The Colombian Spatial Data Infrastructure (ICDE) is a sound initiative for the promotion of geographic information production with national coverage that will encourage mass use by society and improve sustainable development. Some achievements have been attained and interorganisational barriers are being broken. The ICDE "empirical" approach has been the way to cope with a challenging context and to gain consensus while demonstrating the practical benefits. Nonetheless, the time has come to gain high-level support. The incipient partnerships must be strengthened and coordinated. It appears clear that it is necessary to establish a national geographic information coordination center with a national mandate to guarantee that all participants continue in the right direction.

Positive results should encourage the ICDE stakeholders to renew their efforts, taking into account that initial success depends on the following:

Management: Major producers and users of geographic information must be in charge of running the initiative in a coordinated way and based on national needs. A framework for information management must be established as a key principle to govern interorganisational behaviour.

Participation: A very large number of public and private institutions, non-governmental organisations, academic groups and research centers, or think tanks, must be included. A careful and user-oriented cost-benefit study must be undertaken.

Support: The ICDE must find support from government at high levels to ensure the necessary definitions and funds for the project.

Technical cooperation: The ICDE must be based on lessons learned from most advanced NSDIs, and should be linked strongly to regional and global initiatives to ensure that nations can jointly address issues extending beyond national boundaries.

Research and Development: Appropriate technology needs to be adopted or adjusted through research and development activities.

Recommendations

Seek and acquire high-level government support for the national SDI. The ICDE development process must be accompanied by high-level government support, such as a presidential decree or Ministerial Council Order. Otherwise, the momentum of the Colombian agencies alone will not be sufficient to keep the engines moving for very long.

Define national guidelines for managing geographic information, not only for use in government, but also where this involves the private sector and academia.

When defining basic agreements to stimulate cooperation and focus efforts for the National SDI, these topics must be addressed: Agreement on the definition of the National SDI. Clarification of the objectives. Agreement on the key principles, rules and responsibilities. Coordinating body Role of each organisation Basic policies and guidelines for managing and sharing information Funding

Early on, develop the first stage national geographic information network through the use of internationally compatible standards and practices. Given that the ICDE is a long term, ambitious project, efforts must be concentrated on developing the first phase of the Colombian geographic information network: a metadata-based clearinghouse, in order to achieve the National Directory of Geographic Information. With a national geographic metadata standard defined and with the development and testing of some customised metadata software tools, the Colombian producers of geographic information now have the challenge of making decisions on documenting their data sets and setting clearinghouse nodes. "Actions speak louder than words".

Study for the Southern African Development Community (SADC) region

Background, Context, and Rationale

A compatible SDI can encourage region-wide collaboration on issues that often disregard national boundaries. While formal regional SDI initiatives are just recently in the discussion or formation stages, there are a number of illustrations of how a regional Spatial Data Infrastructure approach can make a positive difference in dealing with often-difficult issues such as food security. The Permanent Committee on Geographic Infrastructure for Asia & the Pacific is just one example of a regional SDI implementation addressing the joint spatial issues of member nations.

The Southern African Development Community (SADC), which was established in 1980 as SADCC, is promoting regional cooperation in economic development. SADC member nations include: Angola, Botswana, Democratic Republic of Congo, Lesotho, Malawi, Mozambique, Mauritius, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. SADC has adopted a Programme of Action covering cooperation in various sectors, including food, agriculture and natural resources management. Its secretariat is formed by the Food, Agriculture and Natural Resources (FANR) Development Unit in Harare, Zimbabwe. To effectively address the issues of early warning for food security and natural resource management, a regional spatial database has been developed to assure the timely collection, management and dissemination of critical information and knowledge to the SADC Member-States and other stakeholders.

The SADC Regional Remote Sensing Unit (RRSU) started as the Regional Remote Sensing Project (RRSP) in 1988 and received technical assistance from the Food and Agriculture Organisation (FAO) of the United Nations and financial support from the Governments of Japan and the Netherlands. The technical assistance from the FAO came to an end in June 1998 and since that time SADC RRSU has been gradually integrated in the organisational structure of the SADC FANR Development Unit. The RRSU is financed by the SADC Member States and receives additional financial and technical assistance through a bilateral agreement between SADC and the Government of the Netherlands. The RRSU is a centre of technical expertise, which can facilitate training programmes and technical support in the field of remote sensing and GIS in support of early warning for food security and natural resources management. On an operational basis the RRSU is using low resolution high temporal satellite information to produce information products on rainfall occurrence and vegetation development which is being distributed through the Regional and National Early Warning Units, but also through its own publications, reports and web-site. A variety of training courses and national and regional workshops are organised to create a core of trained experts in the SADC region. An important activity of the RRSU is the development of spatial databases, which are being distributed on CD. The RRSU database includes at present all the basic thematic information (administrative boundaries, infrastructure, land cover hydrology, soils, elevation etc.), as well as the satellite image archive, agricultural statistics, and climate information. In order to develop these information systems further, the RRSU has strategic partnerships with a number of institutes in the SADC region, but also in Europe and the USA. The RRSU spatial database is recognised as a regional (and often a national) standard, and because of this the RRSU is a recognised partner in a number of EIS related activities in the SADC region. At a regional level the RRSU collaborates with the South African National Spatial Information Framework (NSIF) on the development of metadata, which will have a regional outlook.

Genesis of the Regional Early Warning Infrastructure

From the time of its establishment, the RRSU has been working on the use of satellite information to monitor rainfall occurrence and vegetation development in support of early warning for food security. The satellite data covers the whole SADC region and the operational pixel size of the raster images is 7.6 km. With the increased use of GIS technology and the availability of ever-faster computers and more user-friendly GIS software programs, there was a need to harmonise and standardise spatial data sets, not only the raster satellite images, but also the vector database.

In the early nineties most digital spatial data available in the SADC countries originated from small projects. Spatial data available from the Surveyor General Offices was often not in digital format, or in an inaccessible digital format. As a result, many Government offices, small projects, universities, NGO's, started to digitise their own spatial databases.

One of the tasks of the RRSU is to introduce GIS technology. The main problem it faced during the introduction of this technology in the region was the lack of a consistent spatial database for the SADC region. For example, national and sub-national administrative boundaries hardly existed in digital format, or were incomplete. For existing data, there was no cross-boundary compatibility. Other data on infrastructure, basic land use, and hydrology did not exist or was scarce. A soil map had been prepared for a number of SADC countries, but the digital format used made it impossible to use the data for further GIS analyses. The satellite images in raster format from the Meteosat satellite (for climate monitoring) and NOAA satellite (vegetation monitoring) were in a rare geographic projection, the Hammer Aitoff projection, which was hardly supported by any of the than more popular GIS software programs.

The task at hand for the RRSU was to start a number of activities to develop standards for the digital databases and the objective was to develop a standard raster and vector database for the SADC region, which would allow easy use and analytical procedures in a GIS environment and facilitate regular updates.

Organisational Approach

Overall Leadership - The SADC RRSU provided overall leadership for this regional activity. The RRSU identified needs and formulated the plan; implemented development with strategic partners; assessed availability of data; organised the data collection; ensured evaluation and quality control of the outputs; and distributed the output.

Development was accomplished by the SADC RRSU. Technical partners in the development were the Office of Arid Land Studies of the University of Arizona, and the University of Stellenbosch. Both Universities were responsible for technical tasks, which were implemented under a contractual agreement. Development of the digital spatial databases involved the processing of data, creation of basic data layers, preparation of documentation, and the development of the system on transportable media with a user-interface to view and analyse the data.. As a starting point, several layers of the Digital Chart of the World (DCW) were used, as well as the Africa Data Sampler (ADS) prepared by the World Resources Institute (WRI, Washington - USA). The WRI provided the RRSU with a pre-release of the ADS in 1994 in order to facilitate a first review of the available data. The internationally available data was merged with existing national digital data sets. Where necessary, hard-copy maps were digitised, corrected and georeferenced. This was done by the University of Arizona, while at a later stage the University of Stellenbosch was contracted to review and correct the soil database.

The RRSU was responsible for the processing of all satellite image raster data into a 6-minute geographic projection.

Using this standard format, data from different satellites, or the same satellite, but received by different data acquisition systems, are in the same geographic format and can be used together with the vector data in a wide range of GIS applications.

Since 1994, the development has gone through several phases and has resulted in a uniform and standard satellite (Meteosat and NOAA) image database; a standard and uniform thematic vector database at the scale of 1:1million. A first version of the vector database was released on CD in 1995. In June 1997 the first version of the "RRSU CD" was released, which included also all satellite data, agricultural statistics, and basic climate information. An update was released in March 1998. The RRSU CD also includes a software facility to view and analyse the data, called "WinDisp". This program was developed with financial support of a number of partners, including the RRSU. A next release is expected in the first half of 2000. More recently, in June 1999, the RRSU has produced a second CD with a detailed regional climate database in raster and tabular format, including information on rainfall, temperature and evapotranspiration.

In addition to this, the Harare based: Aquatic Resource Management for Local Community Development Programme (ALCOM), used the hydrology layers from the RRSU spatial database to develop a comprehensive hydrological data base and watershed map for Southern Africa which is fully compatible with the standard format established by the RRSU.

Other major stakeholders in the development phase included: (i)The National Early Warning Units (NEWU's); and (ii) the National Meteorological Departments (NMD's) in the SADC countries who played an important role in evaluating the data sets and provided suggestions for corrections or better data. Other major data contributors included organisations such as: (i) the World Resources Institute; (ii) USGS Eros Data Center; (iii) FAO; (iv) UNEP GRID; and (v) the USAID Famine and Early Warning System (FEWS). Regional or national level data was provided by: (i) the NEWU's; (ii) NMD's; (iii) National Remote Sensing Centre's; (iv) Environmental Councils; and (v) various Government Departments in the SADC member states. User beneficiaries include Government institutes; Ministries; national, regional and international organisations; private trading and industrial sector; banking and finance groups; large-scale and small-scale farming organisations; and NGO's.

Review and evaluation of the effort for meeting the needs of SADC members was performed by the SADC RRSU; the National Early Warning Units and National Meteorological Departments in the SADC countries. The review and evaluation process included making data available for evaluation; conducting workshops/meetings to introduce the databases; collection of evaluation comments/reports; and ensuring incorporation of corrections/additions.

Distribution of the database, tools, meta-data, and viewing and analysing software was accomplished by the RRSU. The RRSU make data available in a user-friendly format on CD, sponsor workshops/meetings and maintain an internet web-site to create and maintain awareness, encourage and act on suggestions and recommendations, and are responsible for regular updates of the data bases. The new historical database was distributed to all contact points in the SADC Member States. Backstopping missions and regional workshops were used to inform the contact points about the changes and the characteristics of the new data format.

Traditionally, Internet accessibility in Africa has been significantly low compared to other regions of the world. Although Internet accessibility is improving rapidly in the SADC region, the RRSU will continue to distribute the data on CD. The reason for this is that: (i) the size of the RRSU spatial data sets are to big to be used operationally over the Internet (even with high speed access), and (ii) using the data structure on the RRSU CD and the include software, the data can be viewed and analysed. However, at present the RRSU is improving its local Internet connectivity through the installation of a radio-link to one of the major Internet Service Providers (ISP) in Harare. With this installation in place FANR (and the RRSU in particular) will have the possibility to offer their data bases on-line over the Internet using their own server capability. However, it should be noted that even when data is offered over the Internet: (i) many stakeholders will still have limited access; and (ii) the specific analytical capability offered on the RRSU CD will not be available.

Users include many of the stakeholders noted above, which include the National Early Warning Units and National Meteorological Departments in the SADC countries. A range of government institutes; Ministries; national, regional and international organisations; private trading and industrial sector; banking and finance groups; large-scale and small-scale farming organisations; and NGO's use the system as well.

Finally, although the RRSU used contractual agreements with the University of Arizona and the University of Stellenbosch for development, collaboration with other partners was basically established through informal agreements. Data was normally provided as part of a mutual agreement, in that the RRSU would correct/update the data sets and return it in the new format to the data providers.

Programme Successes and Issues

The success is obvious. The RRSU databases provided on CD are in high demand. The capability is considered by many to be the regional standard and even in many SADC countries it is considered to be the best and most complete data set available. However, there is no formal regional SDI structure for the SADC region, though informal initiatives are undertaken to reach consensus. A good example is the collaboration between SADC RRSU and the National Spatial Infrastructure Framework (NSIF) in Pretoria - South Africa. Together with a number of other stakeholders in SADC, and the remainder of Africa, a number of activities are being launched to formalise a SDI policy body.

Implementation Approach

The RRSU has introduced a regional standard for spatial data, which is now being adopted in a number of SADC countries. This data standard has been presented during different meetings. An example is the SADC Environmental Information Systems (EIS) network. During a meeting of representatives of the SADC EIS Network in November 1997 a number of very general recommendations were made about the scale and format of spatial data. The RRSU spatial database was used as an example. However, at the same meeting it was agreed that this format should be used as a common data "exchange" format and that it is up to the countries to decide what format is used at national level.

On behalf of the SADC EIS Network, the SADC Environment and Land Management System (ELMS) has been working on a data policy document, which will be available by early 2000.

In conclusion, the RRSU database development essentially introduced regional standards, which are now being adopted by SADC member countries. Although the standardisation efforts were driven largely by the need to establish viable RRSU databases for early warning for food security, is clear that there are more potential applications of the data against different issues (such as natural resources management). The RRSU spatial databases were prepared in response to critical and specific needs for the SADC member nations with regards to early warning for food security. Without a clearly defined and consistent SDI nationally and regionally, the RRSU worked with members and stakeholders to establish the core infrastructure components needed to accomplish development and implementation objectives. The following is a chronology of events and actions completed to complete the Early Warning effort:

In 1994, the RRSU began work with stakeholders to assess the need for uniform data standards for the SADC region, and to identify the partners needed to accomplish the development. This included the preparation of contracts in some cases.

- In 1995 development focused on the collection of data for the vector database. As noted above, data came from a number of sources, with data provided compliant with international standards, along with other non-compliant data that needed to be processed to an acceptable standard format (implemented by the University of Arizona). Database development and evaluation also occurred at this time, including the review and correction of the SADC Soils database (implemented by the University of Stellenbosch). At a regional workshop in September 1995, new data standards for raster data were introduced and accepted.
- Throughout 1996, database information was distributed and reviewed by member nations. Due to the lack of regionally consistent data standards and formats, data had to be converted to the native format of member countries for review. Evaluation results were reviewed and documented. From June to December 1996, the transfer of IDA analytical functions to the application software WinDisp (financed by the RRSU and implemented by the University of Arizona) was accomplished.

Based on evaluations provided by stakeholders, changes were made to the vector database in early 1997. A user-friendly interface was developed for the user application, and other structure and file naming issues were resolved. Member nations each received a pre production CD for review during this period. By summer of 1997, the completion of the CD was announced, and distribution commenced.

- By early 1998, RRSU had issued an updated version of the Early Warning system, and had begun routine maintenance and update of the data sets to ensure information utility for the region. In conjunction with South Africa, RRSU commenced training on metadata creation and implementation.

The RRSU spatial data base program has been of major benefit to the SADC region. With agriculture recognised by member nations as a major area of mutual interest, the SADC now promotes regional cooperation and economic development through a Program of Action covering cooperation in various sectors. These sectors include those related to food, agriculture and natural resources. Food security and natural resources management is one of the main pillars for economic development and social welfare in the region.

A solid, harmonised and uniform regional spatial database contributes to an improved information in support of managing scarce resources, which are required to secure food security and human well being in the region. In addition, the FAO Global Information and Early Warning System (GIEWS) are using the data from the RRSU spatial databases. Moreover, the GIEWS Internet web site links directly into the SADC FANR Web-site, a good example of sharing information and not duplicating it!

Conclusions

The RRSU database activity has helped focus the SADC region on establishing the basic elements of a national and regional SDI. However, further progress toward a healthy and responsive regional SDI will depend on the resolution of a number of important issues. Several of the major issues facing the region are summarised below:

Telecommunications Infrastructure - Although the initial RRSU spatial database program has focused on establishing standards for data exchange, efforts are underway to establish improved dissemination capabilities via the Internet. However, until the telecommunications infrastructure is more available to stakeholder organisations, SDI delivery will be limited to physical products, information and services such as the CD-ROM based applications and data associated with the RRSU program. However, it should be note that the RRSU spatial database a rather big in size and in order to work with the data on an operational basis the CDROM will be the most applicable medium for distribution.

National and Regional SDI Policy - From and organisational and policy point of view, formal SDI policies and practices as the national and regional level are still forming. At this stage there is a need to create higher level of awareness of the benefits of a compatible SDI for the region and its nations. Furthermore, there should be a formal review or survey of the specific state of each member nation in terms of SDI development or plans. The RRSU took every opportunity to demonstrate the need for a uniform SADC database. And, much of the RRSU’s success has been accomplished through informal contacts, which have contributed to the process of awareness and willingness to share critically important data sets to this regional initiative.

Data ownership and pricing policy - There are still unresolved issues regarding data ownership and pricing policies. This has been particularly true with climate data. The NMD's in the SADC region are following the advise of the World Meteorological Organisation (WMO) that climate data should be made available on a commercial basis. Since the NMD's are SADC institutes they have made data available to the RRSU in order to develop a regional tabular database and create climate (raster) layers to be used for analytical purposes and research. The RRSU is not in a position to distribute these tabular data sets or climate layers. What will be done is that the RRSU will train the NMD's in the concept of creating these databases and data layers. The NMD's will than be able to distribute the databases.

Recommendations

Education and Awareness – Establish a clear program of education and awareness building to gain support of national policy makers across the region. This program should include the assessment of each member nation, and the identification of issues and areas of focus to establish compatible SDI’s that address both national and regional issues

Organisation and Partnerships – further work needs to be accomplished in getting a basic and flexible structure for SDI development at both the national and regional levels. Formation of a more formal SDI Committee for the African continent with appropriate regional sub elements may help further organise and encourage collaboration

Funding – Long-term commitment of funding must be obtained to develop, implement, and maintain a regional SDI on a continuing basis. While external funding sources have resulted in measured success in the SADC region to meet specific objectives, pervasive funding from both internal and external sources must be secured to assure that a compatible SDI is created for the region. One major lesson learned through the RRSU program is that funding for data maintenance must be included in SDI operations to assure that spatial information remains relevant to decision makers.

Standards – Member nations of the SADC must continue to identify standards that create compatibility for data content and metadata throughout the region. Regional standards should be based where possible on existing international standards, and when new standards are needed, SADC members should participate where possible in the formalisation of standards at the international level when appropriate.

Telecommunications – The lack of Internet access among member nations continues to be a major issue for the region. Continued focus on expansion of Internet services and increased access by member nation users of spatial information and services must be supported. Because the improvement of Internet access in the region will take some time to develop, the availability and distribution of data, as well as meta-data, should be done using other sources as well. Therefore the distribution of this type of information on CD-ROM, using the latest digital technology should be considered.

Policies on data ownership and licensing - There is a need for a clear data policy in the region which include sections on intellectual property rights, distribution mechanism and pricing of data. This should be addressed not only within the SADC region, but also as a major initiative of the GSDI to achieve a greater understanding of the international and global implications of data ownership, licensing, and usage.

Global Case Studies – Activities Contributing to a Global Spatial Data Infrastructure

Mindful of the critical social, environmental, and economic issues shared regionally and often globally, the assurance of a Global Spatial Data Infrastructure to enable cooperating nations and organisations to collaborate on issues and solutions is extremely important. Without a global reference environment where a consistent set of policies, standards, best practices and co-operating organisations guide national and regional spatial data infrastructure development, we run the risk of being unable to effectively and jointly address pressing issues in the global context.

Today, there are a number of major initiatives that address one or more of the components of the Global Spatial Data Infrastructure as defined by the GSDI Committee in March 1999. Indeed, the GSDI's success is dependant on the successes and compatibility that many of these programs bring to the global marketplace – technology, data, standards, resources, organisational mission, and distribution. This section of outlines some of the major the contributors toward a GSDI. The Digital Earth Initiative, launched in the United States, China and other nations is reviewed as an example of a program that has the potential to focus and accelerate research and development programs needed to achieve the vision of a Digital Earth (www.digitalearth.gov) and the critical supporting infrastructures needed at the local, national, and global levels. Finally, this section includes a discussion of remaining areas of challenge toward the formation of a pervasive GSDI.

GSDI Defined

At the 2nd GSDI Conference in 1997, the multi-national GSDI Steering Group defined the Global Spatial Data Infrastructure as:

"… The policies, organisational remits, data, technologies, standards, delivery mechanisms, and financial and human resources necessary to ensure that those working at the global and regional scale are not impeded in meeting their objectives..."

An Overview of GSDI Infrastructure Elements

Given this definition, it is important to note that a number of programs address various aspects of the GSDI at a global level. This section summarises some of the major programs that have contributed to a Global Spatial Data Infrastructure. This list is by no means exhaustive, and in fact has been abbreviated to provide examples of the work that is being accomplished towards a GSDI.

For example, the International Steering Committee for Global Mapping is working to produce a Global Map, to be released in 2000. The United Nations has had in place since the 1980s a Global Resource Inventory Database and other similar resources. The International Geosphere Biosphere Programme is working to provide global environmental data sets to scientists. The Open GIS Consortium (www.opengis.org) is working to promote technological and computing advances that can support the development and use of environmental data and their accompanying infrastructures. The International Standards Organisation Technical Committee 211 (http://www.statkart.no/isotc211/welcome.html) is developing a metadata standard.

The International Steering Committee for Global Mapping (ISCGM) (http://www1.gsimc. go.jp/iscgm-sec/index.html) was created as a response to Agenda 21 from the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. Chapter 40 of Agenda 21 was a call for global environmental data. As a result, the Japanese Geographical Survey Institute/Ministry of Construction took the lead on the project and formed the ISCGM in 1994. Membership in ISCGM is comprised of representatives from national mapping agencies, nongovernmental agencies, and academia. The result is a project involving sixty-five different national mapping agencies and other organisations from every continent on the earth. The goal is production of Global Map, which will contain elevation, vegetation land use, drainage systems, transportation networks, and administrative boundaries, all at the nominal scale of 1:1,000,000. In the process, focus on a strategic plan, specifications, and data policy has been necessary.

In addition to UNCED, the United Nations has other organisations that play a role in the creation and dissemination of environmental data. Often, these organisations have mandates to create and make these data available. The primary environmental data organisation of the UN that comes to mind is the United Nations Environment Programme (UNEP) Global Resource Inventory Database (GRID) (www.grid.unep.org). GRID was formed "to assist UNEP and its partners by contributing environmental data and information, as well as methodological techniques for handling such data, to enhance the scientific basis for decision making and help advance sustainable development initiatives." GRID is a network of sites located around the world, all of which provide environmental data. UNEP/GRID is composed of a variety of sites (Arendal, Norway; Bangkok, Thailand; Christchurch, New Zealand; Denmark; Geneva, Switzerland; Kathmandu, Nepal; Moscow, Russia; Nairobi, Kenya (headquarters); Ottawa, Canada; Sao Jose dos Campos, Brazil; Sioux Falls, USA; Tsukuba, Japan; Warsaw, Poland). Each site provides some global data sets, but most often, they have a specific focus. For example, the Kathmandu site focuses primarily on mountain related issues and data.

In addition to UNEP/GRID, the United Nations Educational Scientific and Cultural Organisation (www.unesco.org) has played a role in the development of global soils databases. In addition to UNESCO, the UN Food and Agriculture Organisation (FAO) (www.fao.org) played a leading role in the development of the 1:5,000,000 global soils database in the 1970s. FAO also has several programs within its jurisdiction, including the Global Information and Early Warning System, which "monitors the crop and food outlook at global and national levels to detect emerging food shortages and assess possible emergency food requirements." The FAO's Forest Resources Assessment (FRA) is a decadal tree census, and is used to help determine rates of deforestation. The United Nations Development Programme (UNDP) (www.undp.org) also has an interest in global data set development efforts and has supported research in this direction.

The International Geosphere Biosphere Programme (IGBP) is a programme within the International Council of Scientific Unions (ICSU). Within the IGBP is the Data and Information System (IGBP-DIS) (http://www.cnrm.meteo.fr:8000 /igbp/index.html). The goals of IGBP-DIS are "to describe and understand the interactive physical, chemical and biological processes that regulate the total Earth system, the unique environment that it provides for life, the changes that are occurring in this system, and the manner in which they are influenced by human actions."

IGBP research currently focuses on six key questions that are addressed by eight Core Projects:

How is the chemistry of the global atmosphere regulated and what is the role of biological processes in producing and consuming trace gases? How will global changes affect terrestrial ecosystems? How does vegetation interact with physical processes of the hydrological cycle? How will changes in land-use, sea level and climate alter coastal ecosystems, and what are the wider consequences? How do ocean biogeochemical processes influence and respond to climate change? What significant climate and environmental changes have occurred in the past and what were their causes? Three crosscutting Framework Activities that include assists the integration of IGBP Core Projects:

IGBP Data and Information System (IGBP-DIS) Global Analysis, Interpretation and Modelling (GAIM) Global Change System for Analysis, Research and Training (START), addressing regional research initiatives and needs, jointly with the IHDP and WCRP.

Examples of the data available through these efforts include the global land 1 km AVHRR data set, the IGBP DISCover data set developed from the AVHRR data, as well as the global FIRE data.

The OpenGIS Consortium (http://www.opengis.org/) is an organisation "whose mission is to promote the development and use of advanced open systems standards and techniques in the area of geoprocessing and related information technologies."

The International Standards Organisation Technical Committee 211 (ISO/TC211) (http://www.statkart.no/isotc211/welcome.html) goal is "standardisation in the field of digital geographic information." According to their web site:

- This work aims to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the Earth.
- These standards may specify, for geographic information, methods, tools and services for data management (including definition and description), acquiring, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations.
- The work shall link to appropriate standards for information technology and data where possible, and provide a framework for the development of sector-specific applications using geographic data.

The organisations and activities shown here do not cover all the activities described in the Global Spatial Data Infrastructure definition. ISCGM is focusing on the data, standards, and organisational commitments to generate and maintain a global framework of key geodata themes. The Open GIS Consortium is interesting in promoting technological advancements and standards. The ISO/TC211 is aiming toward the standardisation of environmental metadata. And the Digital Earth Initiative (discussed in detail below) is working to link together many of these activities to focus research, development and partnerships necessary to advance capabilities needed to sustain the Digital Earth vision. Together, these different, and seemingly disparate, activities can create a greater whole that can benefit many different people and organisations.

A cube illustrates the contributions and relationships of the various organisations around the world that have helped shape the GSDI. National and regional SDI efforts represented on the one side of the cube illustrate the major resources, technology, metadata / data standards, and best practices shared internationally. Many of the standards, technologies and practices have been adopted or have influenced international standards are shown on a second face of the cube. On the third face of the cube are organisations and activities, which have contributed to specific areas of the GSDI. FAO / GRID have produced global soils data, the Global Map aims to provide a consistent global set of geographic coverages, along with the commitment of nations to maintain the data. The Open GIS Consortium and International Standards Organisation bring data and metadata standards to the global community for use by all nations and organisations.

Indeed, the efforts of these organisations have yielded key elements of the GSDI, many of which have become part of the overall GSDI reference environment needed to help gain compatibility at a transnational and global level. However, much more work needs to be accomplished to address the remaining technology, policy, and resource issues that are limiting the implementation of the GSDI. The Digital Earth initiative is discussed below as one example of an activity focused on addressing some of the major challenge areas related to GSDI.

The Digital Earth - a Case Study in the Genesis of a Global Spatial Data Infrastructure

In 1998, United States Vice President Al Gore communicated a vision for the future and the way citizens would interact with global information resources to better comprehend the complexity of our planet and our interactions with it.

A United States Digital Earth Interagency Working Group developed consensus that the Digital Earth Initiative involves a national and international effort to plan and build a cooperative use, Internet-based infrastructure to use vast quantities of geo-referenced data and information resources, Earth science data, and cultural and historic data. This query based and visually oriented data will be used by federal, state, local and tribal government communities, academia, and the private sector for scientific applications, practical decision-making, education, journalism, and other citizen accessible applications. As user interface prototypes become available, it will also be possible to interact with Digital Earth through Internet portals around the country, and obtain a better level of access and interoperability with the Earth's geospatial, social, and economic data (www.digitalearth.gov).

Success of Digital Earth is directly correlated to the soundness of the infrastructure it uses as a foundation. In addition, myriad protocols and standards arriving with the World Wide Web must be accounted for in the development process. Network infrastructure for Digital Earth will be based on the U.S. National Spatial Data Infrastructure (NSDI) and the Global Spatial Data Infrastructure (GSDI). Leveraging of these programs is required to ensure full utilisation of best practice for creation of a core infrastructure.

One of the major challenges for Digital Earth is to construct the organisational structure that will enable citizens, industry, academia, and government interaction in developing the initiative. These communities must then coordinate the focus of research and development requirements to create the Digital Earth. Identification of technology, organisational, policy, and other barriers to success needs to be well articulated among the various organizing bodies to better implement solutions. The Digital Earth initiative will work to focus the resources of its partner organisations to accelerate solutions to barriers that prevent or limit the achievement of the Digital Earth vision.

The Digital Earth must also achieve a strong public-private partnership to link industry and other non-government organisations with government. Government agents must continue to conduct policy and technical meetings to support the PPP and the international community. At present, the U.S. has a federal government structure in place and is working with industry, non-governmental organisations (NGOs), and academia to nurture a sustaining membership for the PPP. At the international level, the Chinese have instituted the international Digital Earth symposium (the first held in Beijing, December 1999, with 25 countries) to be held biannually.

A characteristic of Digital Earth for outreach and education is the public engagement value through the application of impressive 3D visualisation and immersive-interactive computer technology display stations. Museums have experienced much success in capturing the public's attention with Digital Earth displays that provide global perspectives of the planet using satellite monitoring technology. As the demonstration, test beds, and scenarios increase the Digital Earth content, the public, including industry and education, can be expected to increase awareness and support of this initiative. This enhances support of the cross cutting program, that is GSDI and NSDI, which have less connectivity with the popular media.

- Development of a strategic plan with a support community is requisite. A useful scheme for defining the major components, or development areas for the Digital Earth Initiative helps in focusing resources where they are most needed. Six development areas have been identified as follows:
- Visualisation and Exploration (focused on the methods, hardware, and software for viewing and exploring Digital Earth data; involves the user community through the information science and human factors researchers and Information Technology companies);
- Education and Outreach (focused on the users, scenarios, and partnerships that add value and relevance to the DE; involves the user community through museums, schools and the media);
- Science and Applications (focused on the development and validation community for Digital Earth content; involves the user community through scientists, state and local governments, and commercial application developers);
- Advanced Display Sites (focused on the projects, test bed prototypes, and facilities through which the Digital Earth gets tested and used; involves the user community, such as NASA centers and museums);
- Data Access and Distribution (focused on the gathers and distributors of georeferenced data; involves the user

community through network bandwidth providers and Earth Science Federations (e.g., DAACs));
- Standards and Architecture (focused on the infrastructure and interoperability protocols for a sustainable Digital Earth; involves the user community through organisations such as CEOS, OGC, FGDC, and NMOs).

Digital Earth is dependent upon many factors in the technology fields that may cross cut through any one of the six development areas. Assessments of the technology challenge will remain a consistent part of the Digital Earth initiatives so that as technology gaps are identified; resources can then be marshalled to address these gaps. Coordination with the National Academies of Sciences must be maintained to conduct assessment in computer technology, web networks, advanced algorithms, remote sensing, as well as the mapping sciences. The following technology development areas have been highlighted for the Digital Earth Initiative:

- Computational Science (e.g., high-speed computing for modelling and simulations; integration and overlaying of diverse sources of geo-referenced information, interactive 3-D visualisation, display and navigation, computation of information products on demand);
- Mass Storage (e.g., distributed active archives with real-time access of large, multi-resolution data sets);
- Satellite Imagery (e.g., 1 meter to one kilometre seamless resolution for the planet);
- Broadband Networks (e.g., high-speed networks and public access nodes for transmission, interaction, and collaboration);
- Interoperability (e.g., Internet and World-Wide-Web standard protocols); and
- Metadata (e.g., advances in automated database documentation software).

The success of the Digital Earth Initiative is heavily dependent on the continued progress of national, regional and the global SDI initiatives and other global geospatial programs discussed in this Cookbook. The impacts of policies, technologies, and organisations at local, national, and international scales are interdependent and therefore complex. Digital Earth provides an overarching vision for the future that may well benefit the creation and maturation of the GSDI and associated programs through the collaboration of efforts for these challenging developments.

More information on the Digital Earth Initiative can be found at www.digitalearth.gov. A draft version of the Digital Earth Reference Model (DERM) can be found at www.digitalearth.gov/derm/.

Summary - Furthering the Global Spatial Data Infrastructure

The case studies and recommendations in this chapter, along with the information provided elsewhere this document have detailed the many initiatives underway that are contributing towards the objectives of the GSDI. However, much more work needs to be accomplished if the GSDI is truly to be a global resource from which all nations and organisations can access resources to build compatible infrastructures. Further advancements in data, standards, delivery, and technology are needed. However, a much more focused effort needs to be placed on outreach and education, resources, policy and legal issues related to SDI development if GSDI objectives are to be achieved.

In responding to these needs, the GSDI Steering Group has initiated a number of initiatives in calendar year 2000 to further advance the objectives of the GSDI:

Business Case Study - Emphasis is being placed on the development of a Business Case for Spatial Data Infrastructures. The study will identify the economic, social, environmental, and disaster management benefits that can be achieved through development of compatible national and regional SDI's, and the global SDI.

Address Legal and Economic Issues– The GSDI Steering Group has formed a Legal and Economic working group to focus on addressing the implications and potential solutions to legal and economic (funding) mechanisms that underpin the GSDI

Improve Outreach and Communications – the Communication and Awareness Working Group will focus on developing and implementing the programs necessary to raise awareness, articulate the value and secure additional support for the GSDI.

Your support of the Committee and working groups is encouraged. Nations must be able to establish Spatial Data Infrastructures that address internal matters of concern, while providing the ability to work at the transnational and global levels to address the important issues such as those outlined by the UN Agenda 21, the Kyoto Protocol. Please contact us at www.GSDI.org, and help us achieve our goals. Together, we can establish and SDI that allows us all to act locally, nationally, and globally.

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[6] *According to recent legislation (Ley 388 de 1997), municipalities must set out a territorial ordering plan to define and regulate land use. Geographic data are key to ensure compliance with the law.*

[7] *Regional Autonomous Corporations are environmental administrative units in charge of the management of renewable natural resources and sustainable development in their jurisdiction (major river watersheds).*

[8] *Políticas de tecnología informática para el sector público colombiano ("IT Policies for the Colombian Public Sector"), DNP, COLCIENCIAS, DANE, 1996.*

[9] *In October, 1998, in Washington, Colombian President Andrés Pastrana officially launched the Alianza Ambiental por Colombia.*

[10] *Document: "Proposal for the Design and Implementation of a Colombian Geospatial Information System" (Cartagena, May 6 & 7, 1999)*

[11] *In the first quarter of 1999, the Colombian President was authorized by Congress to remove, join and restructure state agencies. The deadline was June 1999. Among other reforms, the IGAC was reassigned to the DANE. Nevertheless, the Constitutional Court recently declared these government decisions unconstitutional. Functional uncertainty continues.*

[12] *23 people of every 1000 had access to computers in Colombia in 1996 (Knowledge for Development, World Bank, 1998-1999).*

[13] *This project was proposed to the U.S. delegation to the Environmental Alliance for Colombia meeting in Cartagena, on May 6, 1999. An agreement between Colombia and the USA has not yet been achieved.*

Chapter 12

From The SDI Cookbook

Contents

Chapter 12: Terminology

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INTRODUCTION

'If we are to understand each other, we must comprehend a common language.'

The truth in this statement would be apparent to anyone who has visited a foreign country for the first time. The initial encounter with an unfamiliar national language can be a bewildering and threatening experience. The sudden inability to effectively communicate quickly frustrates even the simplest tasks and pleasures. A single burning question repeatedly goes through your mind; 'Why didn't I take those language lessons before I left?'

Clearly a common language is an essential prerequisite to effective communication between any two people or cultures. However, a simple knowledge of a language's vocabulary is not sufficient to guarantee effective communication. A word can have several meanings depending on the context in which it is used. Similarly, a concept can be referenced by several words, each communicating a different connotation or level of severity.

A comprehension of a language's subtleties and nuances is therefore needed if it is to be used effectively and unambiguously. The use of the wrong word can offend or mislead, leading to the classic 'failure to communicate'. This in turn can cause misunderstanding, dysfunctional outcomes and even hostility. The precise use and comprehension of words by both communicating parties is vital.

The issues associated with the correct use of a language can extend far beyond day-to-day communication. Every field of endeavor, from engineering to cookery, has its own language and vocabulary. In order to participate in discussions on the subject, it is necessary to understand both the terms and the context in which they are to be used. The imprecise use of a technical or professional language (for example, by using two terms interchangeably when, in fact, they have distinctly different connotations) gives rise to the same traps and dangers associated with the inappropriate use of a spoken language.

The risks in failing to have a common understanding of both spoken and technical languages are therefore clear. However such risks can compound considerably when it is necessary to translate a technical term from one language (for example, English) into a totally different language (for example, Mandarin Chinese). The different cultures, language structures and character sets give rise to some very real problems in ensuring that the term has precisely the same meaning in both languages. The issue becomes one of mapping the term in both languages to a clearly identified unique common concept. This, in turn, places considerable emphasis on the philosophy of concepts and the progressive decomposition of complex concepts into their base conceptual components.

The following paragraphs will consider the development and management of terminology in the field of Geographic Information. The discussion will consider the principles that are applied when selecting and defining concepts, terms and definitions, with particular emphasis on the requirements of the International Organization for Standardisation. This will be followed by instances of terminology implementation in practice.

THE CONTEXT AND RATIONALE OF TERMINOLOGY

The development of terminology involves the simultaneous consideration of three inextricably linked processes, being

The identification of a concept The nomination of a term for that concept The construction of a definition for that term that unambiguously describes the concept

The three processes are guided by the objective that, for each concept, there will be a single term (and vice-versa) and for each term there will be a single definition (and vice versa).

From the outset it should be stated that it is not the objective of the terminology process to ‘reinvent the wheel’. There are terms and concepts that are found in general language dictionaries and have definitions that correspond to definitions in the field of geographic information. Similarly, there are terms and concepts that have already been defined in International Standards or can be found in similar documentation. These should be adopted whenever possible, avoiding the unnecessary proliferation or duplication of terms.

Quite often, however, there are instances where the definitions in general language dictionaries are insufficiently rigorous or concise to describe the concept. In such cases, it is appropriate to refine or adapt the concept, term and definition as appropriate.

Identification of Concepts

The identification of concepts is arguably the most important part of the terminology process. It is also the most complex and demanding part. The complexity stems from the fact that a concept rarely exists in isolation. It is very often built on a number of simpler concepts, giving rise to a hierarchical concept system.

Consider, for example, the concept of:

spatial referencing by coordinates,

which is

the description of position by means of 1-, 2- or 3-dimensional coordinates.

This is dependent on the concept of a:

coordinate reference system,

which is

a coordinate system which is related to the real world by a datum.

This, in turn, combines the concepts of:

coordinate system

which is

a set of mathematical rules for specifying how coordinates are to be assigned to points.

and

datum

which is

a set of parameters that defines the position of the origin, the scale and the orientation of the coordinate axes

Further decomposition of ‘coordinate system’ and ‘datum’ into component concepts is possible (for example, into ‘coordinate’, ‘origin’, ‘scale’, ‘axis’) as is aggregation into other more complex concepts (for example, ‘Cartesian coordinate system’, ‘compound coordinate reference system’).

A concept system, therefore, comprises a set of concepts that are distinct but closely related to each other. Each concept is capable of separate description and may also be capable of further decomposition. However collectively they are components of a broader concept.

The concise decomposition and identification of concepts is an essential precursor to the allocation of terms and the articulation of definitions. The development of a concept system usually proceeds in a top-down fashion, starting with the identification of the broader concept (for example, spatial referencing by coordinates). The process of decomposition ceases when the concepts become so basic that they do not need to be defined.

Terms

The objective of the terminology process is to identify a single term for each concept. The term is referred to as the ‘Preferred Term’ and is adopted as being the primary descriptor for the given concept. Sometimes there may also be a shortened form of the Preferred Term, referred to as the Abbreviated Term. This is an equivalent but more convenient version of the term formed by omitting words or letters from the full name.

Three other classifications also need to be mentioned, being “Admitted Term’, Deprecated Term’ and Obsolete Term’. An ‘Admitted Term’ is a synonym for a preferred term. Typically such terms are national variants of the preferred term and should be identified as such in any register or dictionary.

A ‘Deprecated Term’ is one that has been judged undesirable for use in relation to a particular concept. An ‘Obsolete Term’ is one that is no longer in common use.

The selection of terms needs some care. A term should not be a trade name or the name of a research project. Similarly, it should not be a colloquial term (i.e. a local informal term used to describe a formal term).

To avoid ambiguity, there should be a single definition associated with each concept. It may be necessary to refine the terminology in some instances to ensure that its field of application is understood. Consider, for example, the term ‘object’ which has broad application in the information technology field. It is sometimes necessary to identify a specific type of object that is characterised by particular attributes, relationships or behaviour. In such cases, the term can be adapted to ensure that it is specific to the particular concept. In the case of ‘object’, two adaptations might be: spatial object object used for representing a spatial characteristic of a feature

and

geometric object spatial object representing a geometric set.

The realization of the one-to-one correspondence between concept, term and definition is not always immediately possible, particularly in instances when multiple terms have been used interchangeably for long periods of time. An example is provided by the terms **geodetic height** and **ellipsoidal height**. Both terms have the same definition (distance of a point from the ellipsoid measured along the perpendicular from the ellipsoid to this point positive if upwards or outside of the ellipsoid). The two terms continue to be used interchangeably and there appears to be no consensus on which is preferred

Definitions

The role of a definition is to precisely describe the content of an identified concept. It should be as brief as possible, containing only that information that makes the concept unique. It should also focus on what the concept encapsulates rather than what it excludes. Thus the following definition for lexical language would be considered unsatisfactory.

language whose syntax is expressed in terms of symbols defined as character strings rather than letters from then Greek alphabet

Deleting the final seven words provides a more satisfactory outcome.

language whose syntax is expressed in terms of symbols defined as character strings

A definition should neither be too broad or too narrow and should only describe a single concept. It may be complex, referring to other concepts (either basic or elsewhere defined) through their terms. However it should not include the characteristics of other concepts as part of its text. Should this happen, then the decomposition process has not been undertaken correctly and must be reviewed. For example, consider the following proposed definition for **data quality element**.

quantitative component documenting the quality of an identifiable collection of data.

It does define the concept. However, it also describes a second concept through the words *'identifiable collection of data'*. This should be given its own term and definition, resulting in the following:

dataset - *identifiable collection of data*

data quality element - *quantitative component documenting the quality of a dataset*

The relationships between concepts should be evident in the structure of the definitions. In particular, the structures should reflect the connections between the concepts and the delimitations that distinguish them from each other. Consider the following terms and definitions:

conformance assessment process - process for assessing the conformance of an implementation to an International Standard

conformance clause - clause defining what is necessary in order to meet the requirements of the International Standard

conformance testing - testing of a product to determine the extent to which the product is a conforming implementation

conformance test report - summary of the conformance to the International Standard as well as all the details of the testing that supports the given overall summary

All four are concerned with quality assessment. **Conformance assessment process** is the toplevel concept, being the process for assessing the conformance of an implementation to an International Standard. The other three terms identify distinct lower level concepts that are incorporated into the process, being a statement of requirements, the test itself and the subsequent report. The relationships and structures are evident in the terms and associated definitions.

The validity of a definition can be tested through application of the substitution principle. This involves replacing the term by its definition in the body of a text in which it is used. If the substitution does not affect the meaning of the text, the definition is valid. If such is not the case, the definition needs to be reconsidered.

The substitution principle can be particularly useful for identifying instances of circularity in definitions. If one concept is defined using a second concept, and that second concept is defined using the term or elements of the term designating the first concept, the resulting definitions are said to be circular. Such instances do not clarify the understanding of the concepts involved and must be avoided.

THE ISO 19100-SERIES STANDARDS

The International Organisation for Standardisation, through its technical committee ISO/TC 211, is developing a family of International Standards for geographic information. The standards are collectively referred to as the ISO 19100-series. A member of the series, ISO 19104 Geographic Information – Terminology, will provide rules for writing definitions and for the structuring of terminology records. These are being applied in all other members of the series.

ISO 19104 defines twelve fields that may be included in a terminology record. Five of the fields are mandatory and must be included in all conforming implementations. The remainder may be excluded from profiles of the standard or simply not populated if it is appropriate to do so. The fields are as follows:

entry number [mandatory] – an arbitrary value implying no structure or hierarchy;

preferred term [mandatory] – the term to be associated with the concept;

abbreviated term – if preferred, the abbreviated term shall precede the full form, otherwise an abbreviated form shall follow the full form;

admitted term(s) – national variants shall be followed by a country code as defined in ISO 3166-2, numeric 3-digit code is used for the IT-interface (i.e. stored in the database), while the meaning of this code is presented in the human language used by the user (i.e. the human interface);

definition [mandatory] – if taken from another normative document, a reference shall be added in square brackets after the definition; or, if referring to another concept in the vocabulary, then that concept shall be named by its preferred term and presented in bold face characters;

deprecated or obsolete terms (in alphabetical order);

references to related entries;

examples of term usage;

notes – may be used to provide additional information, (if a definition has been adapted from a source, this may be explained in a note);

beginning date of the instance [mandatory];

terminological data type [mandatory];

ending date of the instance.

ISO19104 also makes allowance for the designation of term equivalents, these being the preferred, admitted and abbreviated terms in languages other than their definition language. Such equivalents shall be preceded by:

the numeric 3-digit country code as defined in ISO 3166-2 if needed; and the Terminology alphabetic-3 digit language code as defined in ISO 639-2 (e.g. "fra" for French, "deu" for German).

IMPLEMENTATION APPROACHES

Some Current Implementation Instances

The most commonly encountered approach to terminology implementation is the provision of a glossary of terms as part of a publication or through a web site. Typically the glossary will list the terms and definitions and may provide references to the sources of the definitions in some instances.

There are many examples of such listings (including the Glossary within this document). For example, the Digital Geographic Information Exchange Standard (DIGEST) version 2.1 includes a terminology listing in Part 1 of its documentation. Similarly, the Association for Geographic Information and the University of Edinburgh Department of Geography host an on-line dictionary of GIS terms. The dictionary includes definitions for 980 terms compiled from a variety of sources which either relate directly to GIS or which GIS users may come across in the course of their work. It includes definitions, references to related terms plus references and further reading. Searching can be done from an alphabetic list or through a search by category. A list of acronyms is included.

Clause 4 in each of the ISO 19100-series standards contains the terminology for concepts that are used or developed within that standard. The clauses are fully compliant with the provisions of ISO 19104 Geographic Information – Terminology. In addition, ISO/TC 211 have sponsored development of an on-line terminology repository that can be freely accessed via the Internet. The repository lists all terms, definitions, notes and examples included in the ISO 19100-series standards. It is an attempt to make the terminology as widely available as possible and thus promote the consistent use of terms and concepts.

Registries and the Need for Unique Identification

In the preceding sections, considerable emphasis has been placed on the principle that there should be a one-to-one relationship between a concept, its term and its definition. In the vast majority of instances where this is possible, it is tempting to consider the term to be the unique identifier for the concept. The term and the concept are both unique and are closely linked to each other. Why shouldn't the term be considered to be a unique identifier?

In fact, there is no reason at all why this should not be the case <u>provided the term never needs to be translated into a different language</u>. If, however, translation is required, it then becomes necessary to ensure that the original and translated terms can both be unambiguously linked to the original concept. The use of a unique identifier that is associated with all translations of the term provides a mechanism for doing this. The original term provided through the authoring language is not suitable as the identifier.

At the time of writing, ISO/TC 211 is considering the issue of unique identification as part of its deliberations on Cultural and Linguistic Adaptability. In particular, it is considering the establishment of a terminology register in which all listed terms would have a unique registration identifier. A number of options for unique identification have been proposed, ranging from a sequential number based on the order of registration, though to more complex numbering schemes. The main consideration, however, is that the identifier be unique and that its association with its concept never change.

REFERENCES AND LINKAGES

ISO 704:2000, Terminology Work – Principles and Methods

ISO/TC 211 N 1320: Text for DIS 19104, Geographic Information – Terminology, as sent to ISO Central Secretariat for issuing as Draft International Standards, September 2002.

The Digital Geographic Information Exchange Standard (DIGEST), Edition 2.1, produced and issued by the Digital Geographic Information Working Group (DGIWG), September 2000.

Annex A

From The SDI Cookbook

Annex A. Abbreviations and Terminology used in the GSDI Cookbook

Abbreviations

ANZLIC, Australia and New Zealand Land Information Council
API Application Programming Interface
COM, Component Object Model
CEN, Comité Européen de Normalisation
CORBA, Common Object Request Broker Architecture
DIGEST, Digital Exchange Standards
DIF, Directory Interchange Format
DTD, Document Type Declaration
FGDC, Federal Geographic Data Committee
FTP, File Transfer Protocol
GEO, Geospatial Metadata Profile
GIF, Graphics Interchange Format
GIS, Geographic Information System
GML, Geography Markup Language
HTML, HyperText Markup Language
HTTP, HyperText Transfer Protocol
ISO TC/211, Technical Committee 211 of the International Organisation for Standarisation
JPEG, Joint Photographic Expert Group
OGC, Open GIS Consortium
OGDI, Open Geographic Datastore Interface
PNG, Portable Network Graphics
SDTS, Spatial Data Transfer Standard
SQL/MM, Spatial Database Standard SQL/MultiMedia
TCP/IP, Transmission Control Protocol/Internet Protocol
UML, Unified Modeling Language
URL, Uniform Resource Locator
UNIX, UNiversal Interactive eXecutive
VPF, Vector Product Format
W3C, World Wide Web Consortium
WKB, Well-Known-Binary
WKT, Well-Known-Text
WWW, World Wide Web
XML, Extensible Markup Language

Glossary of Terms

Actor <UML term>
Coherent set of roles that users of an entity can play when interacting with the entity. [ISO 19103]

Application Programming Interface (API)
Any set of routines generally available for use by programmers. GSDI Cookbook, Version 2.0 25 January 2004 Page 158 [1] (http://www.cknow.com)

Example: An operating system has APIs for a variety of disk/file handling tasks.

Note: APIs are written to provide portable code. The programmer only has to worry about the call and its parameters and not the details of implementation, which may vary from system to system.

Attribute
Property which describes a geometrical, topological, thematic, or other characteristic of an entity. [ISO 19117]

Bandwidth
The amount of data that can be sent through a network connection, measured in bits per second (high bandwidth allows fast transmission or high volume transmission) [Computer User High Tech Dictionary www.computeruser.com/resources/dictionary/index.htm]

Bayesian Probability
The Bayesian Probability Theorem relates observed effects to the a priori probabilities of those effects in order to estimate the probabilities of underlying causes. [from http://www.singinst.org/GISIA/meta/glossary.html]

Buffer
Geometric object that contains all direct positions whose distance from a specified geometric object is less than or equal to a given distance [ISO 19107]

Catalogue
A single collection of metadata entries that is managed together.

Catalogue Service
A service that responds to requests for metadata in a Catalogue that complies with certain browse or search criteria.

Note: The metadata may be for dataset instances (e.g., dataset catalogue) or may contain service metadata (service catalogue).

Catalogue Entry
A single metadata entry made accessible through a catalogue service or stored in a catalogue.

Clearinghouse
A distributed network of geospatial data producers, managers, and users linked electronically. [from Executive Order 12906, http://www.fgdc.gov/publications/documents/geninfo/execord.html]

Note: A clearinghouse incorporates the data discovery and distribution components of a spatial data infrastructure.

Client-Server
An architectural approach to organising and distributing resources within a networked computer system. [from http://www.ethoseurope.org/ethos/Techterm.nsf/All/CLIENT+SERVERS]

Note 1: Under a Client-Server arrangement, resources such as files, databases and printers are managed by servers. Request for access to these managed resources is generated by clients. When a server fulfils the request of a client it is said to have serviced the client.

Note 2: See also medium client, thick client, thin client

Closure
union of the interior and boundary of a topological or geometric object

Convex Hull
Smallest convex set containing a given geometric object

Coordinate
One of a sequence of N numbers designating the position of a point in N-dimensional space

Core Data
A data set that is necessary for optimal use of many other GIS applications, i.e. that provides a sufficient spatial reference for most geo-located data.

Examples: The geodetic network. The spatial cadastral framework.

Note: Core may refer to the fewest number of features and characteristics required to represent a given data theme.

Coverages
Feature that acts as a function to return one or more feature attribute values for any direct position within its spatio-temporal domain [ISO 19123]

Curve
1-dimensional geometric primitive, representing the continuous image of a line [ISO 19107]

Data Dictionary
A collection of descriptions of the data objects or items in a data model for the benefit of programmers and others who need to refer to them. [from http://www.searchwebservices.techtarget.com]

Note: When developing programs that use a data model, the data dictionary can be consulted to understand where a data item fits in the structure, what values it may contain, and basically what the data item means in real-world terms.

Data Management
The process of planning, coordinating and controlling an organisation's data resource. [from http://www.comp.glam.ac.uk /pages/staff/tdhutchings/chapter5/sld007.htm]

Data Set
A specific packaging of geospatial information provided by a data or software producer, also known as a feature collection, image, or coverage.

Data Store
On-line or off-line repository of data sets.

Note: A data store can take many forms, including a file-based repository and a data warehouse. A data store may also contain text and attribute data related to a data set.

Data Warehouse
A single, complete and consistent store of data obtained from a variety of sources and made available to end users in a way they can understand and use in a business context. [Data Warehouse, Barry Devlin, Addison Wesley Longman Inc, 1997]

Datum
Parameter or set of parameters that serve as a reference or basis for the calculation of other parameters. [ISO 19111]

Example: In the case of a geodetic datum, the semi-major axis and flattening are the parameters that define size and shape of a spheroid. These, in turn, are used to generate parameters for the calculation of geodetic coordinates (latitude, longitude, height) as well as distance and direction.

Direct Position
Position described by a single set of coordinates within a coordinate reference system. [ISO 19107]

Example: The latitude, longitude and height of a survey mark within the WGS84 coordinate reference system.

Discovery Metadata
The minimum amount of information that needs to be provided by a data supplier to convey to an inquirer the nature and content of the data resource that it holds.

Note: Discovery Metadata falls into broad categories to answer the ”what, why when who, where and how” questions about geospatial data.

Distance
The length of the path between two points. [Dictionary of Mathematics, J.M McGregor Pty Ltd, 1981]

Document Type Declaration (DTD)
A set of rules that define the structure and elements in an XML document encoding. [from ISO 19118]

Entity
An object that exists and is distinguishable from other objects [Database System Concepts, H.F. Korth and A. Silberschatz, McGraw-Hill International Editions]

Example: 300 Richmond Rd, Netley, South Australia is an entity since it uniquely identifies one particular place in the unverse.

Note: An entity may be concrete, such as a person or a book, or it may be abstract, such as a holiday or a concept.

Extensible Markup Language (XML)
A document creation language developed to replace HTML. [2] (http://www.cknow.com)

Note 1: XML was developed by the World Wide Web Consortium

Note 2: XML both works to specify document structure and, like HTML before it, markup.

Note 3: XML can be used to specify data set structure and to transfer data sets.

Feature
Abstraction of real world phenomena [ISO19101]

Note: A feature may occur as a type (for example, bridge) or an instance (for example, Sydney Harbor Bridge).

Feature Catalogue
Catalogue containing definitions and descriptions of the feature types, feature attributes, and feature associations occurring in one or more sets of geographic data, together with any feature operations that may be applied.

Fundamental Data
A dataset for which several government agencies, regional groups and/or industry groups require a comparable national coverage in order to achieve their corporate objectives and responsibilities.

Note: Fundamental data are a subset of the framework.

Framework
Basic geographic data incorporating the most common data themes that geographic data users need, as well as an environment to support the development and use of those data.

Note 1: The framework’s key aspects are:

specific layers of digital geographic data with content specifications procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and institutional relationships and business practices that encourage the maintenance and use of data.

Note 2: The framework represents a foundation on which organisations can build by adding their own detail and compiling other data sets.

File Transfer Protocol (FTP)
A client/server protocol for exchanging files with a host computer [Computer User High Tech Dictionary www.computeruser.com/resources/dictionary/index.htm]

Geodetic Control
A set of points on the surface of the Earth, the positions of which have been accurately determined using surveying and computing techniques that take into account the Earth's curvature, topography, gravity field and atmosphere.

Note 1: Geodetic control points are established to provide consistent and compatible data for surveying and mapping projects spanning moderate to large areas or distances. Objects located with respect to these points can be relied upon for known position and accuracy.

Note 2: The positions of geodetic control points are described by geodetic coordinates.

Note 3: Geodetic control points are usually permanent physical monuments placed in the ground and precisely marked, located, and documented. However, a suitable natural or manmade feature may also serve as the physical point.

Note 4: Geodetic control points are usually related to each other through the development of a geodetic control network that serves as the foundation for map and survey data registration and integration. [In part from http://www.bayfieldcounty.org/LandRecords/geodetic.htm]

Geodetic Coordinates
Coordinate system in which position is specified by geodetic latitude, geodetic longitude and (in the three-dimensional case) ellipsoidal height [ISO 19111]

Geographic Information
Information concerning phenomena implicitly or explicitly associated with a location relative to the Earth [ISO 19101]

Geographic Information System (GIS)
A computer system capable of assembling, storing, manipulating, and displaying geographically referenced information, i.e. data identified according to their locations. [from http://www.usgs.gov/research.gis/title.html]

Note: Practitioners also regard the total GIS as including operating personnel and the data that go into the system.

Geography Markup Language (GML)
An XML encoding for transport and storage of geographic information including both the spatial and non-spatial properties of geographic features [from ISO 19136]

Geospatial Data
Data that identifies the geographic location and characteristics of natural or constructed features and boundaries on the Earth. [from Executive Order 12906, http://www.fgdc.gov/publications/documents/geninfo/execord.html]

Note: Geospatial data may be derived from, among other things, remote sensing, mapping, and surveying technologies. Statistical data may be included in this definition at the discretion of the collecting agency.

Geospatial Metadata Profile (GEO)
An application profile of Z39.50 written to support search of metadata using the U.S. Federal Geographic Data Committee's Content Standard for Digital Geospatial Metadata [1] issued in June 1994. [FGDC]

Note: The profile is based on ANSI/NISO Z39.50-1995 Information Retrieval (Z39.50): Application Service Definition and Protocol Specification

HyperText Markup Language (HTML)
The set of markup symbols or codes inserted in a file intended for display on a World Wide Web browser page. [from http://www.searchwebservices.techtarget.com]

Note: The markup tells the Web browser how to display a Web page's words and images for the user. Each individual markup code is referred to as an element (but many people also refer to it as a tag).

HyperText Transport Protocol (HTTP)
The set of rules for exchanging files (text, graphic images, sound, video, and other multimedia files) on the World Wide Web. [from http://www.searchwebservices.techtarget.com]

Interoperability
Capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units [ISO 19118]

Intersection
The point at which two or more lines cross each other or a set of points that two or more geometrical figures have in common. [Dictionary of Mathematics, J.M McGregor Pty Ltd, 1981]

ISO 23950 Information Retrieval (Z39.50): Application Service Definition and Protocol Specification.
An International Standard specifying a client/server based protocol for Information Retrieval.

Java
A cross-platform programming language from Sun Microsystems that can be used to create animations and interactive features on World Wide Web Pages. [Computer User High Tech Dictionary www.computeruser.com/resources /dictionary/index.htm]

Map Projection
Coordinate conversion from a geodetic coordinate system to a plane. [ISO 19111]

Note: A map projection allows the systematic representation of the curved surface of the Earth on a flat sheet of paper or computer screen. Inherent in the projection process is the distortion of one or more characteristics of the representation, being scale, area or angles. It is important to select a projection that minimizes the distortions in the geographic area of interest.

Map Server
A server that accesses spatial information and renders it to the client suitable for display as one or more layers in a map composed of many layers.

Medium Client
A client that combines the advantage of leveraging most of the work in the server while also exploiting some local computing power. [from Nadia Moertiyoso and Nin Choong Yow, Nanyang Technical University, Singapore]

Note 1: Examples of this architecture are Java applets on common desk top environments

Note 2: See also client-server, thick client, thin client

Metadata
A formalised set of descriptive properties which is shared by a community to include guidance on expected structures, definitions, repeatability, and conditionality of elements.

Note 1: Metadata allows a producer to describe a dataset fully so that users can understand the assumptions and limitations and evaluate the dataset's applicability for their intended use.

Note 2: In the context of geographic information, metadata is applicable to independent datasets, aggregations of datasets, individual geographic features, and the various classes of objects that compose a feature.

Metadata Entry
a set of metadata that pertains specifically to a data set.

Metadata Schema
Conceptual schema describing metadata structure and dependencies [ISO 19101]

Multi-Media
Communication that uses any combination of different media, and may or may not involve computers. Multimedia may include text, spoken audio, music, images, annimation and video [Computer User High Tech Dictionary www.computeruser.com/resources/dictionary/index.htm]

Neural Network
A network of many simple processors that imitates a biological neural network. [Computer User High Tech Dictionary www.computeruser.com/resources/dictionary/index.htm]

Note: Neural networks have some ability to "learn" from experience and are used in applications such as speech recognition, robotics, medical diagnosis, signal processing and weather forecasting.

Object-Oriented Programming
A type of non-procedural programming where the emphasis is on data objects and their manipulation instead of processes. [3] (http://www.cknow.com)

Note: In object-oriented programming, objects are data structures encapsulated with routines (called methods) that work on the data. Only the methods can work on the data. Objects are grouped into class instances. The method code can change so long as all the interfaces remain the same. Classes are arranged in a hierarchy and methods in one pass to others in line (inheritance).

Object
Entity with a well defined boundary and identity that encapsulates state and behavior [ISO 19107]

NOTE: This term was first used in this way in the general theory of object-oriented programming, and later adopted for use in this same sense in UML. An object is an instance of a class. Attributes and relationships represent state. Operations, methods, and state machines represent behavior.

OGC Web Mapping Testbed
An OGC-sponsored initiative to prototype web-mapping technology that led to the development of OpenGIS Web Map Service Interface Implementation Specification version 1.0.0 Open Geographic Datastore Interface (OGDI) An application programming interface that uses standardised access methods to work in conjunction with GIS software packages (the application) and various geospatial data products [4] (http://ogdi.sourceforge.net)

OLE DB
Microsoft's strategic low-level interface to data across an organization.

Ontology
A controlled, hierarchical vocabulary for describing a knowledge system [5] (http://magpie.ucalgary.ca/magpie /help/magpie_ontology_definition.html)

OpenGIS
Transparent access to mixed geodata and geoprocessing resources in a networked environment. [from http://www.tgic.state.tx.us/tac/ogc.ppt]

Note: Interoperability established by OpenGIS standards is intended to enable web users to combine data from many locations by eliminating obstacles created by platform differences.

Orthoimagery,
Aerial photography from which distortion and ground relief has been removed so that ground features are displayed in their true planimetric positions.

Paleotemporal
The recording of time intervals that are related to the geological time scale

Parse
The analysis of a statement in a human or artificial language so that it can be used by a computer. [Computer User High Tech Dictionary www.computeruser.com/resources/dictionary/index.htm]

Note: Parsing is used to convert natural language statements into high-level programming language, and to covert high-level programming language into machine language.

Point
0-dimensional geometric primitive, representing a position. [ISO 19107]

Polygon
A plane figure bounded by a number of straight sides. [Dictionary of Mathematics, J.M McGregor Pty Ltd, 1981]

Portrayal
Presentation of information to humans. [19117]

Prime Meridian
Meridian from which the longitudes of other meridians are quantified [ISO 19111]

Note: In almost all instances, the prime meridian is the Greenwich Meridian.

Profile
Set of one or more base standards or subsets of base standards, and, where applicable, the identification of chosen clauses, classes, options and parameters of those base standards, that are necessary for accomplishing a particular function [ISO 19106]

Projection
See 'map projection'

Raster
Usually rectangular pattern of parallel scanning lines forming or corresponding to the display on a cathode ray tube

Schema
Formal description of a model [ISO 19101]

Semantics
The study of the meaning of linguistic expressions. [from http://www.eecs.umich.edu/~rthomaso/documents/general/what-is-semantics.html]

Note: The language can be a natural language, such as English or Navajo, or an artificial language, like a computer programming language.

Service Entry
The metadata for an invokable service or operation, also known as operation or service metadata.

Simple Feature
Feature restricted to 2D geometry with linear interpolation between vertices, having both spatial and non spatial attributes [ISO 19125-1]

Spatial
Of or relating to size, area or position [Collins Concise Dictionary]

Spatial Data
Data concerned with the size, area or position of any location, event or phenomenon.

Spatial Data Infrastructure
The technology, policies, standards, and human resources necessary to acquire, process, store, distribute, and improve utilization of geospatial data. [from Executive Order 12906, http://www.fgdc.gov/publications/documents/geninfo /execord.html]

Spatial Data Transfer Standard (SDTS)
A standard developed by US government agencies to promote and facilitate the transfer of digital spatial data between dissimilar computer systems, while preserving information meaning and minimizing the need for information external to the transfer.

Spatial Database Standard SQL/MultiMedia (SQL/MM)
A database standard that supports abstract data types in the form of full-text and documents, image, sound, animation, music and video.

Spheroid
A body or curved surface that is similar to a sphere but is lengthened or shortened in one direction [Dictionary of Mathematics, J.M McGregor Pty Ltd, 1981]

Note - Spheroids used to represent the shape of the Earth are wider at the equator than between the poles.

Stakeholder
A stakeholder in a program is any person or institution who has a controlling influence in the program benefits in some way from the program has an interest in the process and/or outcome of the program has resources invested in the program, or has other programs that may depend on the effectiveness of the language program. [from http:/www.sil.org /lingualinks/literacy/ReferenceMaterials/GlosaryofLiteracyTerms/WhatIsAStake holder.htm]

Stove-Pipe(d)
A term used to catagorise computer-based systems that have been developed to perform specific functions in a stand-alone capacity and are thus ill-suited to data sharing with other systems.

Note: the term is also used when describing organizations that have highly compartmentalized structures and procedures.

String
A sequence of text characters. [The Unified Modeling Language User Guide, G Booch et al, Addison-Wesley]

Surface
2-dimensional geometric primitive, locally representing a continuous image of a region of a plane [ISO 19107]

Symmetric Difference
The set of elements that comprise two sets or objects but omitting the elements that lie at the intersection of the sets or objects.

Note: Given two sets A and B, the symmetric difference is their union minus their intersection.

Tabular Data
Data that is stored in a tabular format.

Example: A database table. A table of statistics in a hard-copy report.

Temporal
Of or relating to time. [Collins Concise Dictionary]

Thick Client
A client that is functionally rich in terms of hardware and software. [from http://www.ethoseurope.org/ethos /Techterm.nsf/All/CLIENT+SERVERS]

Note 1: Thick clients are capable of storing and executing their own applications as well as network centric ones. Thick client typically refers to a personal computer.

Note 2: See also Client-Server, Medium Client, Thin Client

Thin Client
A client that has limited local resources in terms of hardware and software. [from http://www.ethoseurope.org/ethos /Techterm.nsf/All/CLIENT+SERVERS]

Note 1: A thin client functionally requires processing time, applications and services to be provided from a centralised server. Network computers are prime examples of the development of thin clients.

Note 2: See also Client-Server, Medium Client, Thick Client

Tile
A subset of a mapping or geographic information data set, the subset being defined by a specific geographic boundaries.

Note: A map sheet that comprises part of a standard map series is sometimes called a map tile. Earlier geographic information systems divided their data stores into tiles to work around file size limitations.

Topology
A branch of geometry describing the properties of a figure that are unaffected by continuous distortion [Collins Concise Dictionary]

Note: In GIS, topology is mostly concerned with identifying the connectivity of networks and the adjacency of polygons.

Transmission Control Protocol/Internet Protocol (TCP/IP)
A communication protocol used to ease communication between computers over a network. [6] (http://www.cknow.com)

Note 1: TCP/IP is the primary protocol used on the Internet (TCP/IP is really a suite of protocols).

Note 2: You will also often see "TCP/IP" address (or just IP address). This is a unique numbered address expressed in dot notation most often (e.g., 64.121.76.4).

Unified Modeling Language (UML)
A schema language that is used to develop computer-interpretable (data) models [Derived from ISO 19103]

Uniform Resource Locator (URL)
An Internet logical address. E.g., http://www.cknow.com/ [7] (http://www.cknow.com)

UNIX, (UNiversal Interactive eXecutive)
A multiuser and multitasking operating system developed by AT&T in the early 1970s. [8] (http://www.cknow.com)

Use Case <UML Term>
A description of a set of sequences of actions, including variants, that a system performs that yields an observable result of value to an actor [The Unified Modeling Language User Guide, G Booch et al, Addison-Wesley]

User Interface
The set of components that allow a computer and its user to communicate with each other. Note: The computer screen is

part of the user interface, as is the keyboard and mouse.

Vector
Quantity having direction as well as magnitude [ISO 19123]

Vector Product Format (VPF)
A US military data transfer format.

W3C
see World Wide Web Consortium

Web Coverage Server (WCS)
A service that supports the networked interchange of geo-spatial data as coverages containing values or properties of geographic locations. [from OGC 02-024]

Note: The WCS provides access to intact (unrendered) geo-spatial information, as needed for client-side rendering, multi-valued coverages and input into scientific models and other clients beyond simple viewers.

Web Feature Server (WFS)
A service that can describe data manipulation operations on OGC Simple Features (feature instances) such that servers and clients can "communicate" at the feature level.

Note: A Web Feature Server request consists of a description of the query and data transformation operations that are to be applied to WFS Web-enabled spatial data. The request is generated on a client and is posted to the WFS server. The WFS Server interprets the request, checks it for validity, executes the request and then returns a feature set as GML to the client. The client then can use the feature set.

Web Map Server
A service that can produce maps drawn into a standard image format (PNG, GIF, JPEG, etc). based on a standard set of input parameters.

Note 1: This specification standardizes the way in which maps are requested by a client and the way that servers describe their data holdings.

Note 2: The resulting map can contain "transparent" pixels where there is no information and thus several independently drawn maps can be laid on top of each other to produce an overall map. This is possible even when the maps come from different Web Map Servers.

Note 3 The WMS specification also supports use of vector-based graphical elements in either Scalable Vector Graphics (SVG) or Web Computer Graphics Metafile (WebCGM) formats.

Well-Known-Binary (WKB)
A binary encoding format that can be used to describe the representation of geometry.

Note: The use of WKB for describing simple (2D) features is included in ISO 19125 Geographic Information – Simple Feature Access – Part 1: Common Architecture

Well-Known-Text (WKT)
A text-based encoding format that can be used to describe the representation of geometry.

Note: The use of WKT for describing simple (2D) features is included in ISO 19125 Geographic Information – Simple Feature Access – Part 1: Common Architecture

Windows
A family of operating systems produced by Microsoft.

World Wide Web (WWW)
The global, seamless environment in which all information (text, images, audio, video, computational services) that is accessible from the Internet can be accessed in a consistent and simple way by using a standard set of naming and access conventions. [9] (http://www.cio.com/WebMaster/sem2_web.html)

World Wide Web Consortium (W3C)
A non-profit-organisation responsible for the development of standards (recommendations) for the Word Wide Web [Software AG]

XML-Schema
A XML language for describing and constraining the content of XML documents

Z39.50
See ISO 23950.